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ON-FARM WATER MANAGEMENT PROJECT
SRI LANKA
FINAL EVALUATION REPORT

by

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On-Farm Water Management - Project Review

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EXECUTIVE SUMMARY

Problem - The On-Farm Water Management Research Project at Kalankuttiya was designed to develop methodologies for land preparation, farm and field layout, methods of irrigation, cropping systems, field channel and structure design, and water delivery procedures that could be utilized for new irrigation projects and rehabilitation of older units within the Mahaweli development area. Of particular concerns were farming systems, methods and techniques that would assist farmers in growing crops, particularly on upland areas and soils, during periods of either deficient, average or excessive rainfall, under variable conditions of restricted or ample irrigation water supplies.

Progress - The research progress was hampered, primarily due to a lack of personnel which were not assigned as originally planned. Initially, expatriate advisers were available through a consulting firm and some progress was made under this arrangement. Later, a competent Agricultural Engineer and Irrigation Specialist was contracted after the project was more than one-half through its four-year time span. Less than half of the planned GSL personnel were assigned.

The progress was approximately as follows for the specific activities: A. Methods of Land Preparation and Leveling - progress was excellent with several farms leveled and shaped for improved irrigation applications. An excellent publication was prepared; B. Methods of Irrigation - good progress was made in using graded terraces with furrowed basins and graded furrows; C. Crop and Soil Management - some progress was made using upland crops on Red Brown Earth soils as a replacement for paddy rice. The research did highlight problems of drainage, irrigation methods, crop variety, weed control, and marketing of alternate crops; D. Demonstration and Training Activities - very little progress; E. Water Balance (Hydrology) - late progress was made on the ground water hydrology of the research area but very little progress on the surface water hydrology; F. Structures and Flow Measurement Activities - the progress was minimal with only a survey made and reports prepared on the status of water control, distribution, delivery and measurement on farm ditches.

Evaluation - Overall, progress on the research as originally planned and as modified at the mid-term point was about one-half of the projected expectation. However, in several areas there was excellent progress, namely, land leveling and forming, and irrigation methods. New information was obtained on drainage requirements, graded furrow systems, with limited data on yields and net returns of alternate upland crops, irrigation structures and delivery systems.

In contrast, there was little progress on the demonstration and training phases of the project. Reports were lacking for many phases of the research. Some of the reports were in progress to be completed by September 30, 1982. Portions of the research were poorly planned so that the results could not be analyzed because of the number of variables introduced.

Recommendations - The USAID support of the OFWM project is to terminate on September 30, 1982 as originally specified, except for the possibilities of funding special projects that might be proposed. It is recommended that the project at Kalankuttiya be continued on a reduced basis by the GSL agencies and USAID support with certain phases transferred to other locations. Particularly, the research on crops and cropping systems would be placed at the Agricultural Research Station at Maha Illuppallama. Research on crop varieties, insects, crop diseases, etc. would be accomplished by the Department of Agriculture and the University of Peradeniya.

Those areas where new USAID support are proposed include (in order of priority):

1. Water Balance (Hydrology Study) - An expatriate Irrigation Engineer with experience in ground water and drainage studies is needed (see pages 17, 28, 29 of report).

2. Water Distribution System for Upland Soils - The project would be jointly sponsored by GSL and USAID. USAID would provide an expatriate Irrigation Engineer with wide experience in irrigation system layout and drainage engineering (pages 20 and 28).

3. Improvements in Design, Construction and Operation of Farm Ditches - An expatriate Agricultural Engineer with considerable experience with irrigation systems would be required together with GSL staff (pages 19 and 27).

There are three subject areas where workshops are needed:

1. Irrigation water management (see page 33)

2. Land forming and leveling (pages 7 and 35)

3. Farm irrigation structures (pages 19 and 35)

BASIC PROJECT IDENTIFICATION DATA

1.	Country:	Sri Lanka
2.	Project Title:	On-Farm Water Management
3.	Project Number:	383-0042
4.	Project Dates:	
	a. First Project Agreement:	August 31, 1977
	b. Final Obligation:	August 31, 1977
	c. Project Activity Completion Date (PACD):	September 30, 1982
5.	Project Funding ($ Million)	
	a. A.I.D. Bilateral Funding:	$0.8 Grant
	b. Other Major Donors:	None
	c. Host Country Counterpart Funds:	$0.27
	TOTAL	$1.07
6.	Mode of Implementation:	
	Contracts	Chemonics (Host Country) June 21, 1978
		A. T. Corey (PSC) May 30, 1981
7.	Project Design (A.I.D. and Contractor):	AID Team
8.	Responsible Mission Officials:	
	a. Mission Director:	S. J. Littlefield
	b. Project Officer:	Herbert G. Blank
9.	Previous Evaluation and Reviews:	Mid term Evaluation by W. D. Kemper November 12, 1980
10.	Cost of Present Evaluation:	
	a. Direct Hire:	
	b. Contract:	Agroskills $ 2,080 A. R. Robinson $15,845 Total $17,925

PROJECT REVIEW

I. Project Participants, Inception and Funding

The Government of Sri Lanka and USAID signed a Project Agreement for On-Farm Water Management Research on August 31, 1977. The initiation of this Project was by the Land Use Division of the Irrigation Department and Mahaweli Development Board. The technical assistance required for the Project planning and implementation was provided to the Government of Sri Lanka by Chemonics International Consultancy Division of Chemonics Industries. Chemonics contractual agreement was to provide a field team consisting of long and short term experts through the Mahaweli Development Board and the Irrigation Department. Funding by the USAID amounted to $800,000. The fund breakdown was as follows: expatriate advisors $450,000; foreign training $100,000; special studies $100,000 and equipment $150,000.

The Government of Sri Lanka through the Irrigation Department and Mahaweli Development Board would provide funds for local personnel, buildings, equipment, operations and other miscellaneous expenditure.

II. Problem Definition, Basic Assumptions and Justification

The ultimate objective of developing irrigation systems is to provide the farmers with sufficient water to achieve high crop yields. Irrigated rice uses water far in excess of its requirement. With the facilities provided for upland cropping in the Mahaweli H area, where farmers have been allocated 1-hectare size farms, an inefficient system of water use is likely to occur resulting in reduced crop yields unless measures are introduced for better water management. The farmers on the Red Brown Earth soils are commonly at or near the heads of irrigation field channels and they physically have first access to the water supply. These soils, by their nature, have high infiltration rates and loss of water by seepage and deep percolation is substantial. Despite the high infiltration rates the farmers are inclined to grow flooded rice in any season when water is available in the farm ditches. This results in: (1) inadequate water control, (2) waste of water due to drainage, (3) unequal flow of water along the farm ditches and (4) lack of water to farmers at the lower end of the ditch, all causing loss in production.

On the other hand, growing of flooded rice is less risky than upland crops. The crop management, processing, storage and a marketing infrastructure for rice are already available. For upland crops, where capital requirement is high, technical know-how on crop management and storage has to be developed and marketing facilities are not satisfactorily organized.

From a national point of view, cultivation of flooded rice in Red Brown Earths with high infiltration rates, leads to a waste of highly valuable Mahaweli water, and deprives water from better rice lands which occur in the lower slopes of the landscape. Further, high infiltration causes water

The Project Agreement was amended in March 1980 to reflect the research actually underway and immediately planned at the research site (Kalankuttiya) and to modify the project budget. The amended agreement covered the program at the experimental farm of about 35 acres extent and an adjoining demonstration area of similar size. The demonstration area is operated by local farmers on 1-hectare allotments with land leveling assistance and advice from the staff of the research farm.

The amended Agreement included the same stated purpose as the original Agreement, but a somewhat modified list of specific activities as they were stated follows:

1. Methods of Land Preparation: This will include graded, 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 farmer's 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 systems 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 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 Measurements: 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.

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It should be noted that the specific activity of the amended Agreement was not in complete accord with the original statement for No. 7 since the systematic study of field channel design and water delivery procedures was removed. Actually, the Research Farm was equipped with a permanent field channel and it was not practical to vary its design.

The revised Work Plan approved in January 1981 added several new Special Studies to the specific activities listed above. Most of the new activities started at the end of 1981 Yala season and are continuing. These Special Studies are listed as follows:

A. Land Preparation and Leveling (specific activities 1 and 2)

   a. Land leveling equipment drawn by bullocks.

   b. Equipment for forming furrows.

B. Methods of Irrigation (3)

   a. Cost analysis of flat basins, raised beds, furrowed basins on bench terraces, and ridge and furrows on graded terraces.

   b. Water distribution efficiencies of the above methods.

   c. Optimum design of graded furrow systems for water distribution and erosion control.

   d. Optimum frequency for irrigating upland crops.

C. Crops, Cropping Systems and Tillage (4)

   a. Constraints to adoption of acceptable cropping patterns.

   b. Development of no-till farming systems.

   c. Effect on soil physical properties with adoption of no-till farming.

   d. Development of multiple cropping systems.

D. Water Balance (6)

   For a complete water balance study of the entire watershed of about 500 acres, which includes the experimental and demonstration farms, the following information is needed: Mapping of the surface topography, water table and underlying bedrock determining hydrologic properties of the aquifer; measuring rainfall, water delivered, surface and sub-surface in-flow and runoff, and evapotranspiration.

Special Studies under the Water Balance Project included:

a. Volume of water from irrigation and rainfall that enters the ground water and leaves the area as ground water flow.

b. Control of the water table with artificial drains.

c. Salinization of the area.

d. Effect of water table elevation on yields of upland and lowland crops.

E. Structures and Flow Measurements (7)

An evaluation of performance of existing structures.

F. Demonstration and Training (5)

a. Provide training for Extension Service staff.

b. Participate in farmer education meetings.

c. Extend and enlarge the demonstration farm program.

For those special projects listed under sections A through D above, consultants; employees of the Agriculture Department, Irrigation Department and Mahaweli Development Board; and graduate students were to make the studies and report on the results.

IV. Progress, Evaluation and Recommendations on Activities

A. Methods of Land Preparation and Land Leveling

a. Progress

Procedures have been developed and tested for formation of level, benched and graded terraces. A report "Leveling Small Farms to Bench Terraces" was published and is available for use. This is an easily understood report specifically prepared for use in the dry zone. It does not contain economic data on costs of land preparation. The economic data are limited and as yet unpublished except in seasonal reports.

Considerable experience has been gained in leveling land for the 1-hectare farms in the study area using bucket scrapers pulled with 35-65 h.p. farm tractors. A land leveling crew has been trained to carry out all the steps including design and operation of equipment. Operations

have been carried out on the Research Farm and on 10 demonstration farms in Mahaweli System H. Costs have ranged from 4 to 6 thousand Rs/ha for moderately sloping land.

Investigations have been carried out to develop bullock-drawn equipment for land leveling, with emphasis on use of a small scraper. To date, the results have not been promising due to equipment problems and excessive animal and man-hour requirements. Bullocks are not able to work under prolonged dry land conditions. The development of a better scraper is continuing.

Terrace slopes in the range of 0.2 and 0.6 percent, with zero cross slopes, have been found to provide the necessary surface drainage for upland crops while giving adequate protection from erosion. Furrowed basins formed by placing cross checks at intervals along graded terraces have been successful.

Terrace widths of at least 30 feet are needed to provide space for operating equipment. Widths up to 60 feet have been used on the research and demonstration farms. Excessive cuts due to shallow top soils must be avoided and this will limit the terrace widths.

The graded terrace system developed at the research farm permits efficient and convenient irrigation and cultivation of upland crops. The land area occupied by bunds is reduced in half from those for level basins, from 24 to 12 percent. Graded terraces used for flooded rice require cross checks or bunds placed at appropriate intervals and the surface between checks should be nearly level.

Level basins do not provide the surface drainage needed for upland crops (especially chillies) except in very dry seasons. Ridge and furrow systems have been successful. Raised beds in level basins have been briefly investigated and offer possibilities for good surface drainage but require deep cross channels.

b. Evaluation

The progress on land forming, preparation and leveling has been excellent. A leader and crew have been trained to perform the entire procedure of surveying, design, earthmoving and leveling. Experience has been gained in the use of level and graded bench terraces for production of upland crops during the Yala and Maha seasons. Surface drainage requirements for various upland crops during the two seasons under different land forming systems have been observed. This has resulted in new information on the requirements of different crops.

The cost of land forming and leveling is quite high and deserves continuous study of ways to accomplish an adequate job with reduced costs.

c. Recommendations

(1) Continued efforts are needed to train additional Extension Service personnel, technicians and crews for land preparation and leveling, (2) Graded bench terraces should be emphasized at this time over other methods of land forming for irrigation of upland crops, (3) There should be continued study of additional systems, such as raised beds in flat basins, for upland crops in both Maha and Yala seasons. These studies should include graded furrows and furrowed basins also. Information is still lacking on all the above systems for upland conditions.

There seems to be conflicting views on what is already available and known in Sri Lanka on land leveling and land forming, particularly for upland crops and conditions. A symposium - workshop should be planned and held as soon as possible to review the state-of-the-art and recommend future programs in this important area.

B. Methods of Irrigation

a. Progress

In the original project outline, various types of furrows, basins and furrow-basins within terrace bench systems were to be tested. Information on length of furrow, width, slope, size and discharge were to be collected. Various methods of construction and maintenance of furrow systems were to be studied.

The revised Work Plan of November 1981 continued the original study and added soil erosion to the concerns. Particular attention was to be given to finding surface application procedures for upland soils (RBZ) that would make best use of limited water during dry seasons and permit control of excess water and soil erosion during the rainy season. The revised plan also listed specific new studies as follows: (1) cost analysis of new methods, (2) water distribution efficiencies under each, (3) optimum design for efficient furrow irrigation and erosion control and (4) optimum frequency for irrigation of upland crops.

Optimum size of furrowed basins and stream sizes for upland crops were determined in earlier studies. Stream sizes three times larger (15 l/s) could be used for irrigating terraces with graded furrows compared to basins and the time to irrigate reduced to one-third.

It was found that terrace slopes in the range of 0.2 to 0.6 percent provide the necessary surface drainage for upland crops while giving adequate protection from erosion. Level basins were not successful except in very dry periods.

Graded terraces with cross checks placed at frequent intervals can be used for flooded rice. Terraces that have been used for rice need slight releveling before being used again for upland crops.

The frequency of irrigation study for upland crops has not yielded useable information. The results were confused due to variable rainfall patterns and water table fluctuations. The special study to further define optimum stream size and slope of furrows for efficient irrigation and erosion control is currently in progress but no results are available.

During the 1980 Yala season, a comparison of yields of upland crops under: (1) furrowed basins and (2) graded furrows indicated higher yields in all cases under graded furrows. Similar studies in other seasons have been inconclusive because of the introduction of too many variables.

b. Evaluation

The furrowed basin system of irrigation was selected for intense study for growing upland crops on RBE soils. Adoption of this system by farmers is said to be progressing. However, the graded furrows have not been generally accepted and simplified procedures are necessary (as pointed out in the mid-project evaluation). It has not been shown conclusively that farmers can or cannot handle the graded furrow system. Therefore, it cannot be determined at this time that the basin system is the best one for them.

Most all the studies relating crop yield to irrigation method have not given information that is useable for yield comparison directly, because of the number of other variables introduced in the same experiment.

c. Recommendation

Farmers should be directly involved in the study and selection of alternate irrigation methods for upland crops on RBE soils.

In several meetings, the question of utility of raised beds instead of furrows within basin systems has been discussed. Raised beds may provide the surface drainage needed for some upland crops and should be tried.

Future studies must be designed so that crop yield as a direct function of irrigation method can be determined. Past studies have been confused with too many imposed variables.

This research should be carried out jointly with the Research Station at Maha Illuppallama.

C. Crop, Soil and Water Management

a. Progress

Investigations have been conducted to identify crops that would be suitable alternatives for flooded paddy, with potential for providing similar or better economic returns. The crops tested were chillies, soyabean, cowpea, black gram, green gram, cotton, sugarcane, onions, tomato and brinjal. Attempts were also made to grow upland paddy under unflooded culture on RBE soils to satisfy farmers desire to grow at least one crop of paddy.

Trials have been carried over the three Maha and Yala seasons to evaluate crops, cropping patterns and systems, date and method of planting, fertilizer application, pest and disease control, weed management, no-till farming methods and irrigation schedules on the yield of subsidiary food crops and upland paddy. In each season comparisons were also made on the yield performance of flooded rice grown on LHG soils.

The data collection has been inadequate in the first two years of the program. In subsequent years a considerable amount of data have been collected. These data pertain to land preparation, seeding, weed, pest and disease control, irrigation, cost of labour, cost for operation of machinery, total production costs, gross and net returns. The detailed results have been presented for Maha 1979/80 and Yala 1980. The reports for Maha 80/81, Yala 81 and Maha 81/82 are being prepared by the Project Director. The data collected from the research farm agree with those reported by the Agriculture Research Station, Maha Illuppallama, confirming the potential for growing the above listed crops on RBE soils.

In addition to the work of the OFWM Project, a more systematic approach to the development of appropriate cropping patterns and systems suitable to the Mahaweli H area was initiated as a special project in Maha 1981/82 under the direction of Dr. S. H. Upasena. The research sites were demonstration farms adjacent to the OFWM Project and trials were conducted with farmer participation. The specific objectives were to test practices for rice growing on RBE and LHG soils. A detailed report on results is to be presented in the seasonal report, Maha 1981/82.

An evaluation of no-till farming is underway, but the crops are in very poor condition due to weed growth. According to the Project Director, seeding could not be done properly due to faulty equipment. The effect of no-till farming on soil physical properties, although planned as a special study,

has not yielded results. The identification of constraints at the field level on the acceptability of proposed crops, cropping patterns and systems has been initiated although conclusions from these studies are not yet available.

The major findings of the research are as follows: Average rice yields (4000 - 4700 kg/ha) on Low Humic Gley soils are better than those on Reddish Brown Earths because the former hold water in the basins better than in the latter group of soils. In the RBE, rice yields are related to water availability. The performance of upland paddy has not been satisfactory. The major constraints so far has been difficulties in weed control and moisture stress. The grain yields are reduced due to high percentage of empty grains when moisture stress occurs at ripening. Irrigation once in three days is needed which promotes much waste of water. Local paddy varieties are not available for specific use under upland non-flooded conditions and breeding for such varieties is one alternative with germplasm available at the International Rice Research Institute, Philippines. This should, however, be a long term objective. Agronomic practices which may help to obtain a reasonably good paddy crop should be investigated and this too will be long term research.

Of the other crops, soyabean, chillies, cotton, onions, sugarcane, groundnut and various types of vegetables all have the potential to give economic returns which are comparable or even better than paddy. Soyabean and groundnut have an ability to stand water stress and temporary high water tables to some degree. The marketing of soyabean will be greatly facilitated when the processing plant under construction at Maha Illuppallama is completed and will then be an attractive alternative to paddy in both seasons. The soyabean has given the highest returns of any crop tested (Rs. 18,687/ha). Upland crops other than paddy require very few irrigations. Their water requirement is less than half (1.5 - 2.3 ac. ft) of that for flooded rice (4.6 ac. ft or more) and saving in water use is possible when these crops are adopted.

A tabulation of the cost of production, yield and returns for various crops tested (Table 1) shows their potential under upland conditions.

b. <u>Evaluation</u>

The OFWM Project has collected considerable data on crops and cropping that confirm the results obtained in other areas of the Mahaweli. Recent findings indicate the possibility of growing upland rice on Reddish Brown Earth provided water is supplied adequately to satisfy infiltration and evaporation losses. In the case of other crops, high yields and returns comparable to lowland rice could be obtained with better crop management practices. This is primarily in relation to water, pest, disease and weed control. However, there is no

Table 1. Cost of Production, Yield and Net Returns of Crops Grown at the OFWM Project

Crop	Cost of Production Rs/ha		Yield Kg/ha	Price Rs/Kg	Net Returns Rs
Maha 79/1980					
Paddy (Upland) Var. MI 62/355	4080		2048	1.91	168 - Loss
Yala 1980					
Paddy (Upland)	5100		4840	2.37	6400
Chillies	13449		1548	25.30	25456
Brinjal	7667		14213	1.65	15786
Soyabean	6229		2361	4.95	5459
Maha 1980/81					
Lowland Paddy					
BG 11-11	5467		4559	2.75	7069
BG 34-8	4470		4037	2.75	6633
Upland Paddy					
BG 34-8	6524		2196	2.75	485 - Loss
BG 11-11	6714		1870	-	1571 - Loss
Soyabean	6237		1269	6.60	2140
Blackgram	8298		401	2.00	7496 - Loss
Ground nut	7494		885	4.95	3115 - Loss
Maize	5042		286	2.00	4468 - Loss
Yala 1981					
Lowland Paddy	4880		4720	3.70	12584
Chillies	14756	Dry	5133	21.00)	12458
		Green	266	1.00)	
Soyabean	7077		1585	7.00	4014
Cotton	5781		1128	8.75	4093
Maha 1981/82					
Lowland Paddy*	5141		4593	3.43	10613
Upland Paddy					
276/5	5384		1607	3.70	562
H - 4	6045		1611		84 - Loss
Soyabean*	5435		2193	11.00	18688
Ground nut*	9399		1720	11.50	10381
Soyabean	6271		906		977

*Cropping systems data provided by Dr. S. U. Upasena

cropping system and package of practices developed for the Maha season which would give the farmer, within his operational capability, the desired security and incentive for encouraging upland crops other than paddy rice.

The high yields obtained in research plots may not be achieved under farmers field conditions, as reflected in yield comparison between research project and demonstration fields. The yield gap is over 50% and indicates that farmers field constraints are enormous. No progress has been made in no-till farming, identification of constraints to the adoption of cropping systems, and in the use of multiple cropping systems. This is primarily because the research commenced only during Maha 1981/82 and it is premature to make any evaluation at the present stage.

Recommendations

The Dry Zone Agricultural Research Station has been conducting cropping systems research under the on-farm cropping systems program since 1971. Recently some similar trials have been carried out in the Mahaweli Project H-304. The results obtained with their trials and those of the OFWM Project show similar trends with seasonal variation.

The staff of the Research Station are qualified in cropping systems research and in general crop, soil and water management procedures as applicable to the dry zone conditions. It is, somewhat, a duplication of effort of cropping systems work undertaken by the OFWM Project which lacks staff, technical know-how and its own extension services. It is more realistic that cropping system research, with special reference to those practices so far identified by the OFWM Project, be undertaken by the Department of Agriculture. Specific cropping systems research should be continued with emphasis on upland crops with highest potential (e.g. soyabean, groundnut, cotton, sugarcane), taking into consideration the resource base of the farmers.

No-till farming as a means of soil and water conservation will have considerable application in Mahaweli areas, and for the entire dry zone. Research in other countries have shown good potential for economic crop production in marginal moisture areas with no-till or minimum tillage practices. In view of escalating fuel and machinery costs for land preparation, it is recommended that research on no-till farming be given attention. This research should be undertaken in close collaboration with the International Institute of Agriculture - Sri Lanka Project, presently operating from the Dry Zone Agricultural Research Station, Maha Illuppallama.

Mahaweli Authority should have frequent dialogue with the research officers of the Department of Agriculture and specific

research that is needed for the Authority should be clearly spelled out in a Master Plan. The implementation of research should be closely monitored, evaluated, and adaptability of promising practices should be tested under farmer field conditions prior to recommendation.

There are certain constraints to the implementation of intensive cropping programs in the Mahaweli area. They should be considered when developing cropping systems.

(1) Tillage and draft power - Early tillage is not possible due to water issue schedule and delays crop establishment. Late planting adversely effect long-aged crop varieties. Therefore, short-aged varieties would perform better than long-aged varieties. Shortage of tractor and animal power is a serious problem.

(2) Weed and pest management - Weeds and pest are very important factors limiting crop production and would be a most difficult problem to over come. The herbicides and agro-chemicals are expensive and farmers do not have liquid cash to purchase them. Therefore, integrated weed and pest management should be attempted, and varieties resistant to pest and diseases should be recommended.

(3) Water management - There is no organized water management. Water theft by farmers near the irrigation field channels is a common practice resulting in severe shortages of water for farmers at the tail end of the ditch. A system for water control should be introduced. Sometimes property alignment make it impossible to lead water into the fields and farmers themselves have made modifications to the farm ditch to overcome this problem. Therefore, in some instances, re-alignment of land boundaries may be required.

(4) Availability of good seed - There has been a serious problem in obtaining good quality seeds. If the Department of Agriculture, Seed Production Section is unable to supply the required seed, an interim arrangement to produce seeds for the Mahaweli area may be an urgent necessity.

(5) Marketing services - Marketing services are not organized, and farmers growing perishable crops face considerable problems in disposing of their produce. It will be doubtful whether farmers will grow upland crops unless a good marketing infrastructure is developed.

(6) Resource availability - The farmers do not have sufficient liquid cash for organized cropping and financial support will be needed at the early stage.

D. Demonstration and Training Activities

a. Progress

Organization of demonstrations at the commencement of the Project has received considerable farmer opposition. However, after land leveling operation in Yala 1980 and 1981, some farmers in the vicinity were convinced and requested their fields be remodeled for irrigation, indicating possible adoption of this new technology. At present there are 10 demonstration turnouts, 5 adjacent to the research farm and the others in different parts in the Mahaweli H area. The Extension services, provided since Yala 1981, have been inadequate and ineffective due to limited resources both in terms of personnel and equipment. It is planned to strengthen the extension effort in the 1983 Yala season with the cooperation of the unified Extension service of the Department of Agriculture. A number of field days have been organized for field staff and preliminary plans have been completed by the Project Director. The activities planned under this category during the remainder of the project period include:

(1) Provide training for officers of the Extension services assigned to the Mahaweli Authority (from the Department of Agriculture) in on-farm water management practices developed at the Research Farm.

(2) Provide officers from the staff of the Research Farm to attend farmer education meetings sponsored by the Extension service, to give lectures and to answer farmers' questions relating to water management.

(3) Extend the demonstration farm program to encompass as many farms as time and facilities permit at locations scattered throughout the Mahaweli Area H-1.

b. Evaluation

There has been a delay in organizing the demonstrations and farmer training activities due to lack of equipment and personnel and the progress is insignificant. It is beyond the capacity of the small staff at the Research Farm to cover extension and training activities in addition to their primary assignments. Due to the above inadequacies, the overall impact is far below the expectations. Further, some information provided by the OFWM was already known to the farmers.

c. Recommendations

(1) Training - The adoption of any new technology depends on the successful transfer of the extension message to the farmers. The achievement therefore is a function of the suitability of new technology and the training and experience of the extension staff. It is an impossible task for the OFWM Project to provide extension services on all aspects of crop, soil and water management to the farmers. Further, since unified Agricultural Extension Services of the Department of Agriculture are already in operation in the dry zone, it would be a duplication of similar functions. It is recommended that farmer training, demonstrations and all other extension functions be undertaken by the unified Extension service, although extension officers should be exposed to package practices proposed by the OFWM Project. Additional training areas worth considering for both Agriculture Extension staff and Irrigation staff would be on rotational water issues and maintenance of field channels. The training center of the Irrigation Department at Galgamuwa, 10 miles away from the research farm, and facilities available at the OFWM Project could be utilized for this purpose.

(2) Demonstrations - The practices in the demonstrations should include:

(a) Land leveling and systems of land preparation for proper irrigation operation.

(b) A selection of appropriate irrigation systems.

(c) Provision of adequate drainways.

(d) Selection of crops based on soil types, season, water availability and the system of irrigation to be adopted.

(e) Crop and soil management practices for optimum crop yields.

The availability to organize such package practices and its success depends on the selection of progressive farmers. Therefore, farmers in the area who are willing to change from traditional cropping to new technology should be selected to encourage change of the attitudes of the non-participant farmers. The number of demonstrations should be increased and spread out widely for the transfer of the extension message in a minimal period of time.

(3) Others - Quick and accurate information on any extension effort could be gained by the involvement of Post-Graduate students, and the proposal in the 1980 Mid-project Evaluation Report is again endorsed. Research assistantships should be provided in the broad areas of agricultural engineering, agricultural economics and extension, cropping systems and soil management practices. The research topics selected should be of a specific and problem solving nature so that field problems that arise in the operation of the program could be answered in a short period of time. This effort should be continued over several seasons to strengthen the research base on new technology on which adequate information is not presently available.

E. Water Balance (Hydrology)

a. Progress

Details of this program were given in the original Work Plan, the revised Plan of November 1981 and was given particular emphasis in the Mid-project Review. The primary objective is to determine problems of high water tables, drainage and salinity that may develop with prolonged irrigation of upland (RBE) soils.

A complete inventory of the water inputs and outflows from the 500 acre experimental area is necessary for this study. Include would be measurements of rainfall, water delivered, canal seepage, surface and ground water runoff, ground water flow to the area and evapotranspiration. Other information needs are mapping of: (1) surface topography, (2) water tables and (3) underlying bedrocks. The hydrologic properties of the aquifer are needed. Observations of the effect of water table elevations on crop yield are required. Salinity measurements of the ground water are needed. Special projects proposed include: (1) Volume of water from irrigation and rainfall that enters the ground water, (2) Control of water tables with artificial drains, (3) Salinization of the area, (4) Effect of water table elevations on yield of upland and lowland crops.

Because of shortage of trained personnel, work did not get underway on the Project until late in 1981. Observation holes were drilled over the area and data for mapping the water table are being taken on a weekly basis. The hydraulic characteristics of the aquifer were determined from pumping tests. The special study of drainage is underway but no reports are available.

Continuous flow measurements of canal, ditch and drain flows have not been made. The construction of flow measuring

devices and structures are not complete. Seepage estimates have been made using observation well readings near canals but ponding and/or inflow-outflow measurements have not been made.

b. Evaluation

The information to be obtained from a complete water balance study is vital to an evaluation of the On-Farm Water Management study. The lack of surface flow measurements at this stage of the Project is unfortunate and essentially results in limited water balance information. Seepage measurements on the small canals would be helpful although it is obvious that irrigation is the main source of flow to the ground water.

The observations of the water table elevations over the area with the 70 observation wells and the determination of aquifer characteristics from pumping tests are giving excellent information on the ground water hydrology of the area. The data show that the principal source of recharge to the ground water is flooded paddy land on RBE soils. The high water tables resulting from paddy cultivation seriously effect the production of the upland crops in both the Maha and Yala seasons on the Research farm. Conversely, when adjacent lands are not flooded, the water tables are not excessively high even after heavy rainfall.

No information is available on the special projects at this time except for limited data on water table elevations and crop yield. These data are almost impossible to analyze because of the many contributing variables. The artificial drain study is in progress with no reports or conclusions available. A thesis on the subject is almost complete.

c. Recommendations

All interested agencies and personnel are in agreement that the water balance study is vital to the Project and must be carried through to completion. With the USAID assistance to the Project scheduled to terminate on September 30, it is vital that some form of project continuation be developed. In addition to Sri Lanka Agency support, a special project for possible USAID funding might be proposed.

The continuation of the water balance (hydrology) study is strongly recommended. The intensive study as outlined in section a. should cover the entire 500 acre watershed of which the Research Farm and demonstration farms are parts. Instrumentation for all measurements should be completed with great haste. The observations should cover a period of three years, but at least until a range of conditions have been encountered during Yala and Maha seasons. Observations will commence with present water management conditions and continue after the introduction of improved practices such as controlled irrigation and control of seepage from channels.

F. Structures and Flow Measurement Activities

a. Progress

The Mid-project Evaluation Report gave extensive recommendations on farmer participation in the operation of the distribution system and also needs for improved channels, structures and water measurement. A plan was advanced for this participation. The use of simple measuring structures on the experimental project was urged. Generally, the report proposed that a study to develop improved on-farm irrigation structures be undertaken at the Research Farm at Kalankuttiya. However, the Steering Committee of the OFWM Project recommended that the Project be dropped in favor of an evaluation of the performance of existing structures throughout Sri Lanka. In view of the already large program of research and lack of facilities for studying structures, this was a wise decision.

The evaluation study of structures are reported in "Control of Water Within Farm Turnouts in Sri Lanka" by Arthur T. Corey and "Control of Water Within Farm Ditches" by A. T. Corey and G. G. W. Gunetilleke. These reports cover observations and evaluation of structures in Mahaweli System H and a less extensive study of several older systems.

b. Evaluation

The evaluation study together with observations of channels and structures in System H gives information on the present status of water control, distribution, delivery and measurement on farm ditches. The following observations relate to the problem:

(1) Designs of drops, checks and turnouts need to be improved.

(2) The quality of construction is poor.

(3) Maintenance procedures are inadequate.

(4) Unauthorized modifications and damage to structures are common.

(5) Water measurement structures either do not exist or are not operated properly.

(6) Better systems are needed for conveyance (pipes, lined channels) and for control (headgates, drops, checks, turnouts).

As a general observation, the farm size structures are poorly designed, constructed and used. Except for the evaluation report, the OFWM Project has not advanced the improvement of systems. Actually, system misuse can be widely observed even on the experimental and demonstration farm systems.

c. Recommendations

Although the OFWM Project has not directly contributed to research on structures and water management, it has developed an awareness of the need for new information. A new project possibly funded partially by USAID should be proposed to specifically concentrate on "Improvements in design, construction and operation of farm ditches". The Project should include:

(1) A Symposium - Workshop needed to review the state-of-the-art for small channel design, structures and water measurement. The meeting should also determine the areas for research needs.

(2) Review of small farm structure designs throughout the world to select better designs to be used in Sri Lanka. The study would also include water measuring devices.

(3) Incorporate the new designs into improved ditch systems to include: turnouts, checks, drops, and measuring devices. Two systems should be initially designed and studied (a) farm ditch operated on a strict rotation basis i.e. 1 cfs flow with two farmers each receiving 0.5 cfs for 12 hours (10-20 farmers on the ditch), (b) farm ditch operated on a continuous flow basis.

(4) Design, construct and operate a pipeline irrigation system (possible use of plastic pipe) for (a) rotation and (b) continuous flow systems for water delivery.

(5) Make a thorough study, select and test water measuring devices that will give a reasonably accurate measurement and also be acceptable to the farmer.

(6) Compare all the alternate systems given in items 3 - 4 for costs, reliability, operation and farmer acceptance.

(7) Develop and initiate a procedure for inspection, monitoring and maintenance of farm ditches.

Because of problems of operating farm systems with structures that are initially improperly designed and located in the ditch system, consideration should be given to the use of temporary structures. Of particular concern are turnout structures that are not correctly sized or placed. After a period to time, possibly two or three years, properly designed and located permanent structures would be constructed so that the water could be delivered efficiently and correctly to the farms.

For new land developments, there is a need for "split" or "dual" distribution systems that can deliver water separately for upland crops and for paddy (lowland rice). The system would separately serve the well-drained and the poorly-drained soils. The distribution system would provide optimum use of water for crops on RBE soils while making it impossible to grow flooded rice. A draft proposal for research entitled "Water Distribution for Upland Soils" has been prepared by Arthur T. Corey and R. S. John. The project site is available in Mahaweli System B, Zone 5, Blocks 501 and 507. It is recommended that the project be jointly sponsored by USAID and the GSL Mahaweli Economic Agency, Department of Agriculture, Department of Irrigation and the Extension Service.

CONCLUSIONS AND RECOMMENDATIONS

The research project was designed to develop methodologies for: land preparation; farm and field layout; canals and structures; methods of irrigation; crops, soil and water management including weed and insect control, crop varieties, and irrigation requirements. Of particular concern were farming systems, methods and techniques to assist farmers in growing crops on upland areas. Crops other than upland paddy rice were to be stressed.

The project which was initiated in 1977 had an USAID grant of $800,000. The USAID support is to terminate on September 30, 1982. As of June 30, 1982 the following commitments had been made from USAID funding (funding from Government of Sri Lanka sources were not available): technical assistance $463,000; commodities and equipment $122,000; special studies $45,000; training $63,000; for a total of $693,000.

An estimated percentage completion of planned activities for the on-farm water management project follows:

Activity	% completion, July 1982
Methods of land preparation and land leveling	90
Methods of irrigation	50
Crops, soil and water management	70
Demonstration and training	20
Water balance	50
Structures and water measurement	10

In addition to the above planned major activities, fifteen special projects were initiated in November 1981 as sub-projects. Only about half of these projects were initiated with two completed and five with reports pending.

I. Conclusions

The research project has produced several significant findings and developments although some of the results are negative and reports are not available for others. Several reports are being prepared and will be available by September 30, 1982.

A. Research Results

1. A satisfactory method of leveling land for 1 hectare farms has been developed with the use of a bucket scraper, land plane and farm tractor (Publication available). Animal drawn equipment is under development but has not been successful.

2. Level basins do not provide surface drainage needed for upland crops (particularly chillies) except in very dry seasons.

3. Graded terrace slopes in the range of .2 to .6 percent have been found to provide the necessary surface drainage for upland crops while giving adequate protection from erosion. These terraces are being used on several demonstration farms.

4. Graded terraces can be used for flooded rice but cross checks must be placed at frequent intervals and land between the checks must be nearly level (optimum size of basin and stream size have been determined).

5. Frequency of irrigation studies of upland crops have not yielded useable information since the results were confounded with variable rainfall patterns and water table fluctuations.

6. Investigations have shown that on RBE soils during the Yala season, soyabean, chillies, cotton, eggplant, onion, tomato and sugar cane can be grown with potential economic returns somewhat comparable to lowland paddy - particularly soyabeans. However, there is no crop (or cropping system) that is likely to provide the security desired by farmers operating 1-hectare allotments other than flooded rice for two seasons. A system to provide reasonable security and incentives for upland cultivators is not yet available.

7. Cultivation of flooded rice on RBE soils should be discontinued. Mixing of upland crops with paddy often results in failure of upland crops due to high water tables.

8. Plant disease, pests and weed control are major problems for cultivation of upland crops. No-till cropping was not successful.

9. Research on the hydrology (water balance) of the study area is not complete since surface flows have not been measured. However, ground water studies have progressed so that the ground water hydrology is being observed, including water table fluctuations and natural drainage. Hydraulic characteristics of the aquifer have been determined. Drainage design studies for alleviation of high water table are near completion.

10. Surveys showed that small water control structures were not designed, constructed, or operated properly. The structures were poorly designed and were not placed in the system in the proper places. Turnouts are designed for the demand system, yet continuous flow is the common delivery. A dual system is being considered for upland and for lowland crops. Initial

temporary structures leading to more permanent ones after 2-3 years are proposed for new developments. The additional use of pipelines, similar to Sect. 404 systems, is contemplated.

11. Demonstrations and farmer training activities have been delayed due to staff inadequacies and poor organization. The overall impact appears to be insignificant.

B. Problems in Conducting the Research

1. Scope of the project as given in the original project agreement of August 1977 and amended on March 10, 1980 was much too broad.

2. The mid-project evaluation (Nov. 1980) which should have narrowed the scope and sharpened the objectives, actually recommended broadening the program even further.

3. The revised work plan of November 23, 1981 reflected the recommendations of the mid-project evaluation. Existing projects were slightly modified as special projects were added. The additional special projects were to be carried out by consultants and employees of the Irrigation Department, Agricultural Department and Mahaweli Development Authority on a part time (spare time) basis. About half of these special projects (15) have been initiated with only two completed, and five in a report preparation stage.

4. Personnel - The original project agreement stated that "the principle investigators for the project will include a Soil Scientist and an Irrigation Engineer from the Irrigation Department and an Irrigation Agronomist from the Agricultural Department. A farm manager, Agriculturist, will be in charge of the site. He will be assisted by two professionally qualified engineers, three technically trained assistants ....." "An expatriate irrigation specialist will be assigned full time to the project".

   a. Due to staffing constraints, the Irrigation Engineer and Irrigation Agronomist were never assigned to the project.

   b. During the life of the project there have been two Project Directors. The present director (Soil Scientist) spends only part time at the Research Farm with his principle duties at the Land Use Division of the Department of Irrigation, Colombo.

c. The "two professional qualified engineers" to assist the Farm Manager (Project Manager) were never assigned to the project.

d. There have been four Project Managers since the start of the project. The present Manager has been on site only since July 1, 1982 and is apparently highly qualified.

e. Expatriate advisors were originally furnished under a contract with Chemonics International Consulting Division. Chemonics furnished an Agricultural Engineer (Machinery) for 19 months and an Agronomist for 14 months. The contract with Chemonics was terminated in 1981.

f. The mid-project report recommended that more permanent personnel be supplied by the GSL along with short term expatriates with backgrounds in hydrology, irrigation-engineering and extension. The permanent personnel were never assigned and one expatriate in hydrology and irrigation engineering was contracted in June 1981.

g. The expatriate irrigation and hydrology specialist has done an outstanding job in assisting and directing several phases of the research program. However, he arrived too late in the project life to complete the broad research activities, particularly that on "Water Balance". Special projects under his direction will be completed.

5. Program - as pointed out in item 1 the research program as originally outlined and as amended, was much too broad even under full staffing. The mid-project evaluation (item 2) recognized this restraint and advised adding more special projects staffed with GSL consultants and other employees on part time assignments.

a. The original project agreement detailed a Coordinating Committee (Steering Committee) for overall coordination and to decide framework of research, monitor progress, suggest and approve changes. The Committee was to meet six times a year. The committee met on 8/9/81, 3/3/82 and again on 8/6/82 (about every six months).

b. The project agreement also specified a technical committee (technically in charge of the research activities) to meet at least monthly. There was no evidence that this committee was formed or was active.

c. There seemed to be no communication and/or coordination with research projects of similar nature being conducted at two nearby locations, Trials Unit Block 404 and Maha Ulluppallama.

d. There is no evidence that farmers, farm leaders, or Extension Service Specialist were consulted on the problems covered by the research program.

e. Much of the research was conducted in a manner that made the results difficult to analyze. For instance, an experiment on effect of land preparation, field layout and furrow width on yield of upland rice contained the following variables: [1] three cross slopes, [2] seven longitudinal gradients, [3] three irrigation methods, (furrow, furrowed basins, flat basins), [4] four furrow widths, [5] two rice varieties and [6] several different dates of planting.

f. Much of the research has not been analyzed or reported. The last progress report that is available is for Yala 1980. Seasonal Report 3 - Maha 1980/81 is now (August 1982) being prepared and is not yet available for review. There are, however, some isolated reports on individual projects completed as recent as May 1982.

II. Recommendations

A. Future Research Programs

The team for the final evaluation of the USAID portion of the On-Farm Water Management Project in Sri Lanka was given guidelines in an initial briefing. The USAID Director stated that the current project would terminate on September 30, 1982 as originally scheduled, and there could be no extension. However, it was stated that consideration of possible funding for special projects arising from the general project would be possible. With these guidelines in mind, the team studied the project accomplishments, unfinished activities and projected research needs with the purpose of continuing the project by GSL agencies and possible limited USAID support.

Plans for continuation of the work by GSL agencies are being made. Recommendations have been projected and discussed by USAID, Mahaweli Economic Agency and the Irrigation Department. The draft report "Continuation of Research at Kalankuttiya" by A. T. Corey, July 19, 1982 and also "O.F.W.M. Research Projects

at Kalankuttiya (An Evaluation)" by A. T. Corey and Ken Lyvers, July 10, 1982 gives plans for future work. The steering committee of the O.F.W.M. research project met on August 6, 1982 and discussed the future program for the project. Recommendations endorsed by the review team are given in this report.

As stated, the original scope of the project was much too broad and accomplishments have been limited, primarily because of shortage of professional staff. For the continuing program, it is foreseen that portions of the study will be placed at other locations and with other agencies that are better equipped to continue the effort. The following tabulation and discussion of future program is arranged by projected location and agency:

Kalankuttiya (Mahaweli Economic Agency and Irrigation Department).

1. The research area at Kalankuttiya should be expanded from a field channel to a distributary size unit to provide additional information for wider replication in Mahaweli areas.

2. Convert the present Research Farm into demonstration allotments operated by private farmers who would plant upland crops only on RBE soils. These farmers would work closely with the Extension Service and with research personnel at Maha Illypalama.

3. Develop the portion of the Watershed occupied with RBE soils entirely for upland crops by proper leveling and grading.

4. Additional land leveling crews can be trained by those already skilled.

5. Complete the water balance (hydrology) study[1/] by installing and operating water measuring devices on all surface inflow and outflow points for the watershed and continuing, simultaneously, the ground water observations for a period of 2 to 3 years.

6. Continue the study of drainage needs and designs for alleviation of high water tables particularly during the Maha season.

7. The hydrology and water balance study should be complimented with determinations of redox potentials for effects on soil aeration due to high water tables and excess rainfall.

1/ Highest priority project, Mahaweli Economic Agency

8. Develop designs and operational procedures for farm ditches, pipelines, control structures and water measuring devices[1/].

   a. Farm ditches operated on a rotation basis
   b. Farm ditches operated on a continuous flow
   c. Pipe line (plastic pipe) with rotation of water
   d. Pipe line for continuous flow
   e. Pipe line for a demand system
   f. Compare the above with respect to cost, farmer acceptance, reliability
   g. Develop procedures for inspecting, monitoring and maintenance

The studies of pipe line systems would supplement and extend the research accomplished and underway at the pilot project Area H, 401:404.

The study outlined in the above item 8 could constitute a possible special project for a request to USAID for partial funding. Items funded would be salary for expatriate advisers, one-half time for two years with equipment, travel expense, etc. to total about $250,000.

Professional personnel from GSL required for the study would be the present Project Director (full time); present Project Manager; Engineer for developing designs for pipe lines, channels, control structures and measuring flumes; Engineer to supervise construction and to devise drainage systems; Land Leveling Technician and crew of survey assistants and machine operators; and other assistants as required. The present staff of laborers, data takers, etc. would be reduced in numbers.

Maha Illuppallana (Agriculture Department and Mahaweli Development Authority)

Since the Research Centre at M.I. is well equipped to conduct research in dry area crops and soils, several phases of the present OFWM project should be transferred there. To this point there have been parallel efforts on several of these studies with no obvious coordination between the two research locations. The specific activities from OFWM to be transferred to M.I. responsibility are:

1. Crop, water and soil management

2. Selection of crops and cropping systems for upland area[2/]

3. Methods of irrigation

4. Demonstration and training

1/ 3rd highest priority, MEA

2/ 2nd highest priority, MEA

Agricultural Department and University of Peradeniya (MDA funding)

1. Control of plant disease, weeds and plant pests

2. Research in extension and marketing

Item 1 covers subjects that are much too broad and specialized to have been undertaken by the OFWM project. The research under items 1 and 2 require highly trained researchers and the two agencies should be financially supported to conduct this research.

Mahaweli System B, Zone 5, Blocks 501 and 502 (Mahaweli Economic Agency, Department of Agriculture, Department of Irrigation, Extension Service, USAID)

This project is in its formative stages and a proposal has been drafted entitled "Water Distribution for Upland Soils" by A. T. Corey and R. S. John. The purpose of the project is to develop water distribution systems for projects that include well-drained as well as poorly-drained soils. Specific objectives are:

1. Devise dual irrigation systems that separately serve upland and paddy land areas.

2. Design a system that provides ample water for RBE soils while making it impossible to grow flooded rice on the same land.

3. Develop drainage systems to prevent high water tables on upland soils.

4. Determine optimum size of allotments for upland cropping on RBE soils.

5. Provide a model for training farmers and extension personnel in efficient irrigation of upland crops.

6. Provide training for land leveling and irrigation system construction crews.

It is recommended that the project be jointly sponsored by the GSL and USAID. The GSL agencies would include the Mahaweli Economic Agency, Department of Agriculture, Department of Irrigation and Extension Service and would provide most of the staff required. USAID would provide an expatriate irrigation specialist with wide experience in system layout and drainage engineering and should have Extension experience.

U.S. Agency for International Development

It is recommended and urged that USAID consider a program of providing an expatriate Water Management Consultant and advisor

for continuing phases of the On-Farm Water Management Project and related projects. Dr. A. T. Corey has been with the project in its later phases and has accomplished an outstanding amount of progress in a short time. He should be urged and given the opportunity to continue his assistance. This continuation might be after several months in the USA to finish up committments there. In addition to the OFWM project, there is need for the advisor to assist in GSL and other agency projects such as the FAO Water Management Project in System B. If Dr. Corey is no longer available for the assignment then another Water Management specialist should be contracted for this assignment.

B. Activities under Scope of Work for Final Evaluation (See Appendix 2)

Under the scope for the evaluation, several subjects were listed which were to be answered individually. These specific activities are answered as follows:

1. An evaluation of the project is the subject of the entire report.

2. The summary and assessment are given as separate sections of the evaluation report.

3. Liability/Utility of Raised Beds vs. Graded Furrows

Some farmers in the Mahaweli area grow upland crops on raised beds in level basins to provide drainage. The raised beds are needed as level basins do not provide good surface drainage in both seasons, except perhaps in very dry seasons. Some crops such as chillie, which cannot tolerate high water tables, are adversely affected and often fail to produce any yields. These beds are about 2½ - 3 ft. wide, 6 - 9 inches high and of variable lengths. The farmers prepare them using mammoties and no machines are required for their construction. According to the OFWM project, ridge and furrow systems on graded terraces allows efficient irrigation and better drainage than raised beds. The use of raised beds in level basins has commenced recently, but the comparative advantage for crop growth or their economics have not yet been assessed. The raised beds require deep cross channels to permit good drainage. Therefore, comparative studies on these systems of layout for efficient irrigation and economic analysis should be made.

4. Larger Distributary Units in System H

The OFWM project was initiated to investigate the possibilities of utilizing RBE soils for cultivating crops other than flooded rice to make the best use of Mahaweli water. Some crops have

yielded equal or higher economic returns than flooded rice under upland conditions. However, farmers desire to grow flooded rice on these soils whenever water is available to avoid high capital investment and risk associated with the growing of alternate crops. The farmers are not motivated to change from paddy to other crops as no charge for water is made and this results in an unequal distribution of water. The farmers at the head of the farm ditch receive more water than those at the end. There is little water control and rotation of water is not possible in the present system of water distribution.

Although the OFWM project has gained some information on irrigated agriculture on upland soils, the use of a 35 acre area with a previously constructed farm ditch has limited the replicability of the research to other areas of Mahaweli. In order to better utilize the research already conducted and plan appropriate research for the future with a wider application, it is suggested that the Kalankuttiya farm be expanded from a single farm ditch area to that of a distributary canal unit under the auspices of the following agencies:

(1) Mahaweli Economic Authority and Irrigation Department

(a) Land leveling and grading the upland areas with provisions for drainage for upland crop cultivation.

(b) Design and construct an improved water distribution system to include better structures and water measuring devices.

(c) Complete the water balance study already undertaken.

(2) Department of Agriculture/University

(a) Test viable upland cropping systems on a number of locations over Yala and Maha seasons to include an economic analysis. A package of practices for upland cropping will be an urgent requirement as rice varieties suitable for upland cropping are not available at present.

(b) With a larger unit for irrigation and crop production, farmer participation will be mandatory to test the proposed systems.

5. Irrigation and Water Management Research Program - System B

The findings of agricultural research in the North-West Dry Zone do not necessarily apply to the different soil and climatic conditions that occur in System B. The soils of

System B are predominately Non-Calcic Brown Soils which have not been extensively cultivated in Sri Lanka. They can be generally classed as low-land soils, usually poorly drained, and possibly best suited for paddy farming. Research will be required to determine the best cropping patterns and optimum on-farm irrigation layouts. The FAO has planned and will shortly (August-September 1982) initiate an experimental program and project for System B.

The following listing covers the FAO projected program and output from the program.

(1) Establish an experimental farm (500 acres) in System B at Aralaganwila near Pimbarettewa tank in the north-east dry zone.

(2) Initiate Water Management studies to include: optimum on-farm irrigation layout; land forming criteria; alternate on-farm irrigation and drainage systems; crop water requirements; economic returns for water, land and labor; and farm water management.

(3) Conduct studies to include land clearing, leveling and cultivation techniques. Feasibility studies of mechanization of land preparation, harvesting and processing.

(4) Determine suitable crops and cropping systems for System B.

(5) Establish integrated crops-livestock-fish farming systems.

(6) Establish registered/certified seed production.

(7) Provide training programs for farmers and professional staff.

(8) Issue manuals and leaflets on research results and recommendations.

The above very ambitious four year program has just (August 1982) received approval for initiation and staffing according to FAO sources. There is no staff at the present time. There will be one expatriate adviser on the projected professional staff which includes:

Project Coordinator (Resident Project Manager)
Irrigation Agronomist
Research Officer/Agronomist
Agricultural Engineer/Development Officer
Training Officer
Farm Manager
Water Management Adviser

There is a very close correspondence between the objectives of this FAO project for System B and the OFWM project which has been in progress in System H at Kalankuttiya. In fact, many of the objectives correspond exactly with the exception of the addition of livestock-fish farming and certified seed production.

The broad objectives in several subject fields of the FAO project and the limited professional staff shown, leads to the projection that the project will not be successful except in isolated phases. In discussions with the FAO Representative (Mr. Istran Ozorai) the experiences of the USAID-OFWM project were related. Mr. Ozorai gave the assurance that USAID would be consulted regarding the conduct and progress of the FAO project.

In view of the above project, it was not deemed necessary to detail another irrigation and water management research project closely linked to System B.

6. Piped Irrigation System - Systems H & B

The piped irrigation system in Section 404 of System B was designed to be partly a demand system with farmers free to turn water on and off. The system consists of a holding reservoir, outlet works, constant downstream level gate, main canal, inlet structures for the concrete pipelines, line valves, flow meters, air vents, float valve stands and turnout structures for the farms consisting of concrete boxes with V-shaped discharge end. Orchard valves are used in the turnout boxes to control the flow. With the possible exception of the turnout boxes, the pipelines are of standard design.

Because of construction problems and non-familiarity with concrete pipe construction, there have been leakage problems with the system. It is reported that most of the problems have occurred because of improper bedding and banding of the pipe when it was installed. A test in January 1982 indicated that 30 percent of the flow in the pipeline system was lost by leakage.

The only report that was made available in Sri Lanka to the review team to assess the advantages and disadvantages of the pipeline system was a draft paper entitled "First Interim Evaluation Report - Demand Irrigation Schedule Pilot Project, MDB Area H - 404, D-1; 401, D-1, Prof. J. Merriam, 23rd April 1982". The author points out that yields under the demand schedule pilot project pipelines were much higher than from the other systems. He also points out that the pipeline system costs about Rs 5,800/acre

whereas ordinary D Canal field channels cost about Rs 3,500/acre. He attributed an increase in yield under the Demand Schedule pipe system of 25 bu/acre (at Rs 70/bu), for an increase of RS 1,750/acre, to be due to improved water management and not water volume nor farmer capability. He further stated that the extra cost of the pilot project (Rs 2,300/acre) was nearly paid in one drought season by increased yield.

The review team leader contacted Prof. J. Merriam after returning to the USA and obtained more information on the status of the "Demand Irrigation Schedule Concrete Pipeline Pilot Project". The initial results from the project are very encouraging although the study has been troubled with faulty pipelines leading to excessive leakage. Additional pipeline systems are to be constructed beginning in September 1982 with great care to prevent leakage.

It is recommended that a pilot pipe irrigation system for demand irrigation scheduling be installed in System B similar to the systems in H using plastic and/or asbestos-cement pipe. With proper care for installation, the system should not have the severe problems of leakage that have troubled the 404 project. The construction should be closely supervised by an expatriate who is very familiar with irrigation pipeline construction.

After the pilot project has been in place for about two years, with experience in operation, then the design and construction of larger pipe systems in System B are recommended. Since the downstream development of System B will be spread over 4 to 5 years, this schedule is possible. Properly designed and operated pipe systems can be very effective for efficient and equitable delivery of irrigation water and this is particularly important to Sri Lanka. It is practically impossible for someone to modify or enlarge the outlets from the piped system. The orchard valves in the systems should be sized so that each farmer gets the maximum flow allotted to his farm with the valve completely open.

7. Symposium - Workshop on Water Management

The OFWM project has been successful to a certain degree in obtaining research information on water management in the Mahaweli area in spite of constraints due to lack of qualified staff and equipment and other logistics. There had also been little communication and coordination among the agencies involved and refining of methodology or changes in the direction of research with lessons learned has not been accomplished. Some aspects of applied research needs constant dialogue with farmers such as land leveling, methods and power sources to be used. Layout of lands for irrigation, acceptability of new

technologies and package of practices for upland cropping which affects farmers directly and constraints to their acceptance has not been given sufficient attention. The research conducted has been somewhat isolated and limited in scope due to problems associated with the many variables making it difficult for an analysis of data. Most of the research data has not been reported, and not available for review, except for isolated papers written on individual projects. Further, research data obtained from 1979/80 to 1981/82 seasons has not been evaluated and no assessment has been made to find out whether the data could be transmitted for farmer adaption through the extension services. Some research is on-going and no recommendation could be made, while other phases such as package practices for cropping on RBE's in the Maha season etc. has yet to be investigated. Differences of opinions on the adaptability of some of the practices have been expressed. This deserves some attention prior to embarking on future research. Although the agencies that would handle various aspects of water management, irrigation, structural designs, cropping systems etc. has been identified, there is a need for a detailed discussion on what was done and what should be undertaken in the future.

A symposium - workshop to review the present stage of development and to determine future actions is an urgent need.

The following areas are suggested for inclusion in the workshop on a priority basis:

a. Methods of land leveling (machines vs. bullocks), land preparation for irrigation such as raised beds and the ridge furrow system.

b. Methods of irrigation including the feasibility of dual distributory systems for upland crops and paddy. The pipe line irrigation (Demand Irrigation Schedule) feasibility.

c. Irrigation structures, review of structural designs, construction and operation of farm ditches, new designs for rotational irrigations, water measuring devices.

d. Water balance studies, water table, controlled irrigation and seeping losses.

e. Cropping patterns and systems, package of practices for upland cropping and multiple cropping. Crop rotations on lowland paddy lands.

f. Extension services, on irrigation methodology and constraint to adaption of new technology.

Two symposium - Workshops with narrow subject fields as given in a and b above are urgently needed. These are discussed in the project review report under IV.A., Methods of Land Preparation and Land Leveling c. Recommendations and IV.F. Structures and Flow Measurement Activities c. Recommendations. The session on land preparation and leveling is particularly appropriate at this time since new information is available and much land preparation is in progress.

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Crops and Cropping Systems for the Mahaweli Area

The land classification of the gross and net irrigable area (ha) in Systems H, B and C are as follows:

System	Poorly Drained		Well Drained		
	High Potential ha	Low Potential ha	High Potential ha	Low Potential ha	Total ha
H	13,750	4,530	19,950	-	32,230
	(12,000)		(14,000)		(26,000)
C	11,000	18,800	3,600	12,000	45,400
	(9,300)		(11,100)		(20,400)
B	23,480	25,340	4,540	8,760	62,120
	(34,330)		(2,580)		(36,910)
Total ha	48,230	48,670	28,090	20,760	139,750

Note: Net irrigable areas are given in parenthesis.

It is seen that well drained land predominates in Systems H (19,950 ha) and C (15,600 ha). In comparison, System B has 48,820 ha of poorly drained lands, and 13,300 ha of well drained lands. At present in System B, paddy dominates all other crops, with irrigation supplied by major and minor irrigation schemes and also under rainfed cultivation in the lowland flood plains. The major paddy growing areas are Batticaloa (72%) and Polonnaruwa Districts (28%). In the former district, paddies are grown mainly under rainfed culture and in the latter a high proportion of paddy land irrigated. Depending on the availability of water, cropping intensities differ widely during Yala and Maha seasons, understandably higher in the Maha than in the Yala season.[1/] Most farmers grow improved rice varieties, mostly 4-4½ months varieties in Maha and short-aged varieties in Yala. However, in Batticaloa district farmers traditionally use old improved varieties such as H_4 for effective control of weeds, due to differential competitive abilities.

Most of the upland crops on well drained soils are devoted to "chena" or shifting cultivation. In these chenas, during the Maha season, mixed cropping of cereals such as kurakkan, soyabean and maize, cassava, mustard, banana,

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1/ Maha season - October to mid January when nearly 70 percent of the annual rainfall occurs - about 430 mm. Yala season - mid March to mid May - about 200 mm rainfall.

papaw, vegetables etc. are planted with the onset of Maha rains. Some farmers grow soyabean, tobacco, chillies and cowpea and other pulses which earn considerable cash income.

Seseme (gingelly) is a Yala season crop, broadcast sown around February/ March. In homesteads, subsidiary food crops as well as fruit trees are grown.

A. System B - Soils and Crops

The principal soil groups in the System B are as follows:

1. Reddish Brown Earths (RBE)
2. Non Calcic Brown Soils (NCB)
3. Low Humic Gley Soils (LHG)
4. Recent Alluvial Soils (RAL)
5. Old Alluvial Soils (OAL)
6. Solidized Solonetz (SS)

The upland soils are Reddish Brown Earths (16%) and Non Calcic Brown Soils (12.1%) which are well drained. In the lowlands the RBE, NCB, LHG, OAL, SS and RAL soils are sandy loam or sandy clay textured and are imperfectly to poorly drained.

1. Suggested Crops for Irrigable Areas (Poorly Drained LHG Soils)

The feasibility studies indicate a net irrigable area of 34,330 ha - which is available for double cropping with paddy and 1800 ha of irrigable uplands. Thus it is clear that System B would primarily be a paddy growing area, with very high potential rice yields. The average paddy yields vary from 4-5 t/ha, but the potential yields when improved varieties are grown could be as high as 7-8 t/ha. In the irrigable areas, paddy could be double cropped and the following improved varieties could be suggested.

Variety	Season (months)	Potential yield with good management Kg/ha
BG 34-8	3	7.2
BG 34-6	3½	7.2
BG 94-1	3½	7.1
BG 90-2	4	7.2
BG 11-11	4½	8.9
H 4	4½	5.7

In varietal selection preference should be given for short season varieties, 3-3½ months, to avoid plant water stress

at the end of the growing season which may occur due to water shortages in some years.

This will be particularly important during the Yala season. It is also desirable to establish the crop early in the Maha season to gain advantage of the Maha rains. Transplanting is a better method of stand establishment in both seasons, and weed control will be necessary if high yields are to be achieved.

2. Upland Areas

The upland irrigable areas are small in System B. A wide range of crops are possible, depending on soil characteristics, farmers resource base and marketing infrastructure. All these factors have to be considered and an economic analysis should be undertaken prior to the recommendation of any particular crop or cropping system. The soils are highly permeable and upland paddy or flooded paddy will therefore be unsuitable and, if practiced, leads to lower yields than lowland paddy. The crops that have a potential in difference soil series are as follows:

(1) Sugarcane: - Potential high, in RBE, NCB and Alluvial soils, could be grown in well to imperfectly drained soils. The constraint in System B is the lack of large extents of land which, operationally, will be uneconomic.

(2) Cotton: - Good crops of seed cotton could be obtained in Yala in RBE and NCB soils. Cotton is unsuitable for shallow, poorly drained NCB soils and frequent irrigations will be needed. Agronomic requirements of cotton is very specific and unless they are provided optimum yields levels may not be realized.

(3) Tobacco: This crop is virtually a monopoly of the Ceylon Tobacco Co. Ltd. Its production, marketing, processing and manufacture etc., are handled by the company. The problem is in relation to curing which requires firewood. Destruction of forest is usually associated with tobacco curing in most tobacco growing districts. Tobacco barn owners, who are in cooperatives should be advised to produce their own fuelwood for curing of tobacco.

An important consideration when growing tobacco is the rotation of crops. After 2 or 3 years of tobacco cultivation, a crop rotation should be practiced. The desirable crops are soybean, pulses and other subsidiary food crops.

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(4) Soyabean: - A high potential crop which could give economic returns equal to flooded rice if properly managed. The future of this crop appears bright due to the availability of marketing facilities, and the processing factory being constructed at Maha Illuppallama will need a year round supply of seeds.

Soyabean is suitable for both Maha and Yala seasons and yield performance on well to imperfectly drained RBE soils in System H has been excellent. On NCB soil the crop may yield less than in RBE soils. In poorly drained soils yields are low, and in LHG soils nodulation is very poor, weed control is difficult. In the present circumstances, it has several advantages over other legumes. They are: (1) marketing facilities are assured, (2) less inputs in terms of Nitrogen fertilizer as the crop could be inoculated with rhizobia for fixing atmospheric nitrogen. (3) cultivation poses no serious problems except that the yellow mosaic virus which may adversely affect yield, (4) rotated with other crops eg. cotton followed by soyabean or tobacco followed by soyabean, and in 2-3 year rotation in the intervening period with other subsidiary food crops, (5) tolerate short periods of moisture stress as well as rise in the water table in heavy rain periods, both in Maha and Yala seasons.

(5) Groundnut: - Groundnut could be grown in the Yala season on well drained RBE or NCB soils in rotation with cereal crops and cotton. It could also be grown in the Maha season. At present groundnut has no export market and locally, they are used in confectionery industry. The export potential however could be high, provided quality of peas could be maintained. The present varieties lack the quality required for an export market and new varieties may have to be introduced.

(6) Chillies: - Chillies have a local market and the price per Kg. has been stabilized around Rs. 12/o. There is also an export market for green chillies in the Middle East as demonstrated in the Rajangane scheme. Presently available

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varieties appear acceptable for export. Chillies are sensitive to high water tables and raised beds may be a requirement for successful cultivation, and hence more suitable for well drained soils in both seasons. On imperfectly drained soils, chillie yields will be lower than on well drained soils and in these soils care should be taken to avoid water table reaching the rootzone. For this reason chillies should not be grown on Humic Gley soils, as there may be high soil moisture levels due to rainfall and seepage.

(7) Maize and Sorghum: - The biggest constraint to the expansion of the livestock industry in Sri Lanka is the lack of animal feed associated with their high cost. Maize and sorghum are excellent animal feeds. There is also a government price floor to encourage its cultivation. Marketing facilities, although not satisfactory at the present stage, could be improved when production increases. Both these crops could be grown in the Maha season, while sorghum could be grown with a few irrigations in the Yala season too, as it has drought resistant characteristics. Sorghum could also be ratooned over 2-3 seasons. Maize and sorghum should be grown on well drained soils and imperfectly drained soils. In the latter soil type crop may be adversely affected if too much rain is experienced in any season. Drainage should be good for both crops and hence the crop is not suitable for LHG soils.

(8) Cowpea, Green gram, Black gram: - The grain legumes enjoy a good local market as they have been traditionally consumed by people in Sri Lanka. They are high protein crops (23% Protein) which could alleviate the protein malnutrition widely prevalent among this local people as in many other Asian countries. The short-aged legume crops which could be grown in both Maha and Yala on uplands as well as in imperfectly drained paddy fields in most areas in Yala season are excellent rotation crop. In upland farming, crop rotations are mandatory if soil is to be preserved for continuous cropping. Therefore legumes will occupy a permanent place in upland cropping systems, both under irrigation and rainfed conditions. Generally these crops

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are not suitable for ill drained LHG soils in any season.

(9) Onions (Bombay and Red):- Both Bombay and Red onions are Yala crops, as they do not tolerate high water tables. They are not recommended for poorly drained soils. There is an assured local market for onions.

(10) Vegetables: - Vegetables are grown widely on uplands in the Maha and Yala seasons in the dry zone areas. There is usually a glut during the season and prices are very low. Further, due to their perishable nature crop losses are heavy unless transport and marketing facilities are available. The present marketing infrastructure for vegetables is completely unsatisfactory. The future for some of these crops however appear to be promising as there is an export market for some; such as okra and ghirkins. The possibility of other crops gaining export status cannot be excluded and attempts should be made to explore new markets.

(11) Gingelly (Seseme): - This crop which has been grown traditionally as a Yala crop due to its exceptional ability to tolerate drought conditions. Usually it is grown around February/March with onset of the first Yala rains. The yields are lower under rainfed conditions, however high yields have been obtained under irrigation. This crop has a place in a crop rotation in years when water supply is uncertain. At present there is an export market, but the lack of a variety with white or black seeds has been a serious draw back. In the export market, the preference is for white colored seeds, and such varieties should be either introduced or bred locally.

(12) Other Crops: - There are many other crops that could be grown in most areas of the dry zone. Some of them include cassava, banana, passion fruit, coconut, mango, cashew, caster, lime and citrus species. These crops are restricted mainly to the home gardens. Some of them have an export potential, while most could provide the raw materials for the establishment of agro-based industries which could operate

under small to medium sized scale. In order to utilize the potential of these crops, marketing and processing should be properly organized. Since many of the crops mentioned are medium or long aged crops, once established, the care needed will be very little. It would be desirable to incorporate some of these crops and even fuelwood trees into the major cropping systems so that the farmers could not only get a balanced diet but a year round income. Such an approach will help to preserve the surrounding forest which is often logged for fuelwood.

3. Cropping Patterns and Cropping Systems

The cropping patterns and systems should be developed based on the soil and climatic factors, physical resources available to the farmers and marketing infrastructure. Although some of these requirements are presently not available, it is anticipated that over all requirements for crop production, transport, marketing and processing facilities will be available when the irrigable cropping gets fully established. The following suggestions could be made based on the above assumptions.

(1) Drained Low Lying Area and Flood Plains:

Paddy followed by paddy, double cropping in Yala and Maha seasons. The variety selected should be short-aged. As this is the pattern in existance, farmer resistance would be virtually nil, but attempts to increase yield per unit area should be the long term objective.

(2) Uplands:

The experience learned from research conducted in the Mahaweli H area has been liberally used in suggesting the following annual cropping patterns.

Maha Season	Yala Season
Soyabean	Tobacco, Chillies Soyabean, Onions
Groundnut, Vegetables	Cowpea, Black gram, Green gram
Groundnut	Cotton
Sorghum, Maize	Pulses
Cowpea, Black gram, Green gram	Chillies

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B. Systems H and C - Soils and Crops

The soil and climatic conditions are more or less similar in both Systems H and C, hence similar crops and cropping systems have been suggested. The experience gained in research pilot projects at the Maha Illuppallama Agricultural Research Station, Catchment "C" and the OFWM project at Kalankuttiya has been used in making the suggestions.

The principal soil groups in both systems are Reddish Brown Earths, varying from well to imperfectly drained soils in the uplands while the low lying areas of the landscape contain the poorly drained Low Humic Gley soils which could retain high content of moisture.

1. Crops, Cropping Patterns and Systems

The general requirements in determining cropping patterns and systems will be similar to that described for System B. The details of each crop, and its applicability for different soil types have also been discussed in the same section.

(1) Poorly drained low lying areas (LHG Soils) Maha and Yala Seasons:

Paddy crop is best adapted to these soils. Short-aged varieties are preferred to improve water use efficiency. Those recommended are BG and MI varieties, as they have performed well in pilot projects. In crop management, early establishment of the crop to gain advantage of Maha rains, transplanting, proper weed control and use of blast resistant varieties should be given serious consideration. In the Yala season, depending on drainage, short-aged pulses could be grown. These will include soyabean, cowpea, green gram, black gram and vegetables.

2. Well to Imperfectly Drained Areas (RBE Soils)

As in Systems B, many crops could be grown on upland soils in the Maha and Yala seasons. They are as follows:

Maha Season	Yala Season
Soyabean	Soyabean
Groundnut	Chillies
Maize	Tobacco
Sorghum	Cotton
Chillies	Onions
Cowpea	Cowpea
Black gram	Black gram
Green gram	Green gram

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Rice crops are generally not adopted to well or imperfectly drained soil in any season under upland conditions. The use of short-aged rice varieties such as BG 34-8 has been attempted in the OFWM Research farm with discouraging results. The low rice yields have been due to high weed infestation as existing varieties are unable to compete, and frequent occurrences of moisture stress leading to poor growth and grain filling. If moisture stress occurs at ripening stage % of empty grain will be more, leading to reduced grain yields. Therefore, the local rice varieties are not suitable for upland cropping and if they are grown, water usage is high as frequent irrigations will be required. Under these constraints paddy cannot be recommended for upland well drained soils. However, most farmers prefer to grow paddy in the upland well drained soils due to the following important reasons:

(1) High risk involved in growing subsidiary food crops, their intensive nature of management, occurrence of pest and disease unlike in paddy or sugarcane.

(2) Rise in ground water table which frequently occurs in the Maha and in Yala seasons. Crops such as chillies fail completely under these circumstances.

(3) Poorly organized market facilities which discourage farmers from growing subsidiary crops. After one or two seasons of failure, farmers revert back to growing paddy on upland soils.

Sugarcane is a potential crop in both systems, however, in System H where lands have been already distributed into 1 ha farms sugarcane will be less suitable as small units will be uneconomical to operate. The transport cost to the factories also could be high. In System C it will be a profitable crop if large areas could be devoted for its cultivation. It is worth considering the proposal made by the Mahaweli Economics Authority to increase the farm size in Systems B and C into contiguous blocks for farming crops such as sugarcane on a commercial scale.

3. Suggested Cropping Patterns

Maha Season	Yala Season
(Well and imperfectly drained soils)	
Cotton, Chillies, Vegetables	Paddy
Cotton Chillies, Vegetables	Maize, Sorghum
Soyabean, Other Pulses, Onions	Paddy
Soyabean, Pulses, Onion	Chillies
Tobacco, Chillies, Cotton, Vegetables	Soyabean, Pulses

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(Ill drained soils)

Paddy Paddy

The most important aspect in the selection of the rotation will be the age of the crop and the time of field establishment. It will be very crucial in the case of imperfectly drained soil in relation to water table fluctuation with the Yala and Maha rains.

On-Farm Water Management Project - Scope of Work

Assess progress made with the On-Farm Water Management Project and assess what work should be continued by GSL after the conclusion of AID's input to the project. Methodology for carrying out additional research should be suggested as well as staff and consultant requirements, equipment estimates, cost estimates, etc. Special emphasis will be given to the research currently planned under FAO auspices in both Mahaweli System B and C and additional research and related work in Mahaweli System H which might facilitate or assist with planned construction and other work for the future, especially in System B.

Specific activities under the Scope include the following:

1. Assist in an evaluation of the overall project

2. Provide a summary and assessment along with "technical briefs" of the work done and lessons learned to date under the project to include: land preparation and leveling; crops, cropping systems and tillage; water balance; methods of irrigation; on-farm irrigation structures; and success of farm's external extension efforts.

3. Assess the liability/utility of raised beds vs. graded furrows for upland crop production and articulate additional adaptive work which may be required to determine economics of using either system throughout Mahaweli.

4. Assess whether or not a larger, possibly distributary size unit in System H which is tilled by farmers, should be chosen for certain work such as: improved cropping systems and tillage; better operations and maintenance through farmer organizations(s); land leveling; improved farm delivery structures and channels; and other improved practices including irrigation deliveries, which have been at least partially tested under the OFWM project at Kalankuttiya.

5. Provide a detailed methodology along with budget and personnel requirements (both Sri Lankan and expatriate) which would be required to carry out an improved irrigation and water management research program closely linked with System B.

6. Review the Piped Irrigation System in place in part of System H and report on the advantages and disadvantages of using such a system on a larger scale in System B.

7. Assist with planning/conducting a workshop on "How to Improve Water Management in Mahaweli", which would recommend priority actions for the future.

On-Farm Water Management Project - Methodology Used for Review

The team leader for the review, A. R. Robinson, Consulting Engineer, spent one day at USAID, Washington being briefed for the review. He discussed the project with Mike Korin, USAID, Sri Lanka, who was in Washington on home leave, John Gunning, Desk Officer for Sri Lanka and Dr. Max Lowdermilk, USAID, Washington who had recently visited Sri Lanka. At that time Robinson received a brief amount of written material relating to the project. Robinson arrived in Sri Lanka on July 17 and the initial meetings were held in the USAID office in Colombo, Sri Lanka on July 19-20. At these meetings the scope of the project was reviewed and guidelines for the review given.

Dr. H. P. M. Gunasena, Dean, Faculty of Agriculture, University of Peradeniya was the other member of the review team. Dr. Gunasena covered t Agronomic and Extension phases of the project and Robinson, the Engineering and Irrigation phases. This arrangement proved to be a very efficient one, since Dr. Gunasena and Mr. Robinson were both based in Kandy for much of the review period so that there was good communication.

The team members spent two separate sessions at the Research Farm at Kalankuttiya, during the first and third week of the review, interviewing researchers and viewing the research. Additional meetings were held in Colombo on two separate days with responsible personnel from the Mahaweli Economic Agency and the Department of Irrigation. Visits were made by the team either together or separately to other research stations, the pipeline project, land development areas, irrigated farms, and individual farmers all within the environs of the Mahaweli project, particularly Sections H, B and C. A meeting of the Steering Committee for the OFWM Project was attended by the review team on August 6. Meetings were also held with FAO regarding the proposed water management research project in sections B, Berger/IECO Engineering Consultants for the design of the irrigation phases for System B and the Canadian Advisor - Mahaweli Development on the design of improved irrigation systems. A considerable amount of time was spent reviewing reports and available materials relating to the OFWM project. As specified in the contract, Dr. Gunasena also prepared a report on "Crops and Cropping Systems for the Mahaweli Area" which is Appendix 1 in the report.

An in-progress briefing was held for USAID on August 6 and a session on draft conclusions and recommendations on August 13. As specified in the contract, a draft report was left with USAID, Sri Lanka before the team leader left for the USA on August 15. Mr. Robinson and Dr. Gunasena edited the report, made additions and corrections and had a final copy back to USAID, Sri Lanka by about September 15, 1982.