

PROJECT ASSISTANCE COMPLETION REPORT

On-Farm Water Management, Project 383-0048

September 30, 1983

I. BACKGROUND

A. Project Purpose

To develop methodologies regarding land preparation, farm and field layout, and field channel design and water delivery procedures which result in increased production per unit of water that can be utilized in new irrigation projects and rehabilitation of older ones.

B. Project Description

The specific project objectives as stated in the Project Paper dated May 13, 1977, were as follows:

1. Development of land preparation and farm irrigation techniques with respect to soil, topography, crop climate and farmer constraints paying special attention to crop water requirements, use of rainfall, frequency of irrigation, irrigation and drainage methods and cropping patterns.
2. Development of techniques for scheduling and controlling water within the field channel system to ensure adequate and timely delivery of water to all farms within the system paying special attention to farmer group participation in water utilization, methods of sharing the field channel discharge, and measurement and control of water.
3. Development of design criteria and operational procedures which will permit rice to be grown with upland crops on the same farm or the same field channel system.
4. An understanding of the extension, institutional and administrative requirements to extend the technologies to farmers throughout the irrigated zones of Sri Lanka.

The original Project Agreement was amended on March 10, 1980 and included a more specific list of activities. See Annex 1.

C. Financial Data

- a. AID Grant \$800,000
- b. AID Loan - None
- c. GSL Contribution \$272,000

D. Project Dates

1. PP submitted May 13, 1977
2. Grant Agreement signed August 31, 1977  
Amendment 1 signed March 10, 1980
3. PACD September 30, 1982, extended to March 31, 1983.

E. Contracts for Services

1. Contractor: Chemonics  
Contract Amount: \$232,000  
Contract Signed: June 21, 1978  
Contract Completion Date: June 30, 1980  
Contract Terminated: January 29, 1980
2. Personal Services Contractor: A.T. Corey  
Contract Amount: \$100,000  
Contract Signed: May 30, 1981  
Contract Completed: September 30, 1982

II. REPORT

A. Present Status

At this point all project inputs have been supplied. AID technical assistance was completed on September 30, 1982. The PACD was extended to March 31, 1983 to allow completion of two procurement actions. These two shipments have now arrived in country. A final evaluation was conducted in July 1982 which estimated the percentage completion of planned outputs as follows:

<u>Activity</u>	<u>% Completion, July 1982</u>
Method of land preparation and land leveling	90
Method 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. As of the present time a total of 8 reports have been received and one additional report is in draft form.

B. Financial Summary

USAID Inputs to the Project

The funding and other inputs provided by USAID to the Project can be summarized as follows:

	<u>Planned (\$000)</u>	<u>Expenditures (\$000)</u>	<u>Quantities</u>
Technical Assistance (1)	465	404	50 pm LT & 9 pm ST
Commodities (2)	135	141	4 vehicles + misc. and others
Special Studies	100	23	8 completed
Training	100	66	7 received ST training
TOTAL	<u>\$800</u>	<u>\$634</u>	

- (1) Technical assistance was initially provided by Chemonics Consulting Division in a Host-Country Contract with the Irrigation Department. This included an agriculture engineer for 19 person months, an agriculturist for 14 person months, and two short-term consultants for a total of 6 person months. A later Personal Services Contract between the Irrigation Department and a Water Management Research Advisor (Dr. A.T. Corey) was for 17 person months. USAID also provided 3 person months of short-term consultancy for the mid-project (October-November of 1981) and final evaluation (July-August 1982).
- (2) A complete listing of commodities/equipment procured under the project is available with USAID/GSL.

GSL Inputs to the Project

	<u>Planned (\$000)</u>	<u>Expenditures (\$000)</u>	<u>Quantities</u>
Personnel	102	171.1	Average 20 permanent staff, 65 casual laborers, data collectors, etc.
Buildings & Equipment	46	207.2	3 research station buildings, 2 staff houses, 4 tractors
Operations & Miscellaneous	124	162.5	POL, Seed, Fertilizer chemicals, etc.
In Kind	-	70.0	30 irrigated acre research farm
TOTAL	<u>\$272</u>	<u>\$610.8</u>	

C. Project Accomplishments

The following summary of project accomplishments is extracted from the evaluation report prepared by A.R. Robinson and H.P.M. Gunasena.

The research progress was hampered, primarily due to a lack of personnel which were not assigned as originally planned. Initially, expatriate advisors 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:

1. Methods of Land Preparation and Leveling - progress was excellent with several farms leveled and shaped for improved irrigation applications. An excellent publication was prepared;
2. Methods of Irrigation - good progress was made in using graded terraces with furrowed basins and graded furrows;
3. 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;
4. Demonstration and Training Activities - very little progress;
5. 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;
6. 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.

D. Progress towards Achievement of Project Purpose

A literal reading would indicate that substantial progress toward achieving the project purpose has been made. Methodologies were developed regarding land preparation and leveling. Farm and field layout research concentrated on using graded terraces with furrowed basins and graded furrows. Little emphasis was placed on field channel design and water delivery procedures despite recommendations of the mid-term evaluation. The Steering Committee of the project dropped this recommendation in favour of an evaluation of the performance of existing structures throughout Sri Lanka. The final evaluation noted that "In view of the already large program of research and lack of facilities for studying structures, this was a wise decision."

In AID project design a hierarchical system of defining project elements is followed. The Goal is defined as an overall sector or program development objective. The project purpose is the solution to a problem or related group of problems. Generally, in AID project design the "purpose" level is considered in some ways a "higher level" of achievement than in the design of this project. Typically for a research project "development of methodologies" would be an appropriate output of the project. At the purpose level would be wording such as "adoption by appropriate authorities and/or farmers of the research results" while the goal would be, for example, "increased production".

Over the past several years there has been a noticeable shift in emphasis by Mahaweli officials from paddy to subsidiary crop production. This is evident in the restrictions placed on paddy production in System H in Yala and the plans for subsidiary crop production in Systems B and C. There is some evidence that, with this emphasis, greater reliance will be placed on the results from the research farm at Kalankuttiya. To date there has been no evidence that farmers have adopted the major recommendations of the project concerning graded terraces with furrow irrigation. In System H in areas where farmers on well drained soils have been restricted from growing paddy in Yala, subsidiary crops, primarily chilies, are being produced on level basins with attendant drainage problems as identified by the project.

The project has continued with GSL funding through 1983 with emphasis being placed on completion of a water balance study. The primary objective of this study is to determine problems of high water tables, drainage and salinity that may develop with prolonged irrigation of upland soils. Progress on this component of the project continues to be slow. In conclusion, the "higher level" project purpose, i.e. adoption of research results, has not been achieved. Although there is now greater thought being given to irrigated upland crop production, a follow-up program to the OFWM Project has not been implemented. Such a program would be required to further refine research results and would be required if these results are expected to be adopted.

#### E. Recommendations

Two evaluations were held at the approach of the PACD. The first<sup>1/</sup> contained eleven recommendations concerning future jointly sponsored research (See Annex 2). A number of these recommendations stem from what appeared to be a lack of staff and lack of commitment from the GSL for this research effort. Other recommendations relate to a lack of specificity in the research efforts and inflated expectations from a relatively minor research effort. Of particular concern in these recommendations is the need for more emphasis on the production of irrigated secondary or upland type crops and the fact that Sri Lanka has not made the commitment in terms of training, equipment and organization to methods of irrigation other than the traditional basin system.

The second evaluation<sup>2/</sup> contains a set of recommendations for a continuation of research work at Kalankuttiya (See Annex 3). On these

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<sup>1/</sup> OFWM Research Project at Kalankuttiya (An Evaluation) by A.T. Corey and K. Lyvers, July, 1982.

<sup>2/</sup> On-Farm Water Management Project, Sri Lanka - Final Evaluation Report by A.R. Robinson and H.P.M. Gunasena, July, 1982.

eight recommendations little has been accomplished since termination of the AID involvement on September 30, 1982. Work has continued on the study of drainage needs and minimal progress has been made on the installation of water balance equipment. The lack of progress on the project after the termination of AID involvement appears to substantiate the conclusions from the first evaluation, that the GSL has made an inadequate commitment to the Project.

F. Continuing Monitoring Responsibilities

According to the Standard Provisions Annex of the Project Grant Agreement, unless agreed to in writing, AID financed goods must continue to be used so as to further the objectives sought in carrying out the Project. AID extended the PACD for the purchase of commodities which would be used by the GSL beyond the PACD. AID should continue to monitor the progress of the Project to ensure that recently as well as previously purchased commodities are used to meet the objectives of the Project. Furthermore, AID has a continuing interest in seeing that research results are obtained and are incorporated in other AID funded irrigation efforts. This monitoring should continue until the conclusion of the Water Balance Study, which has been estimated to require 2 to 3 years of data collection. It is estimated that monitoring should continue at least through 1985 and be carried out by the MWRD Office using existing staff.

G. Review of Data Collection Results

Data collection and reporting of results from Kalankuttiya farm commenced with the Maha season 1979-1980 and is reported in seasonal reports<sup>1/</sup>. To date only two seasonal reports have been finalized, remaining reports are in progress. The delay in the submission of these reports is a factor in the slow progress made under the Project. In addition to the major activities, fifteen special research sub-projects were initiated in November, 1981. Of these, research was carried out and results were reported on 6 topics (See Annex 3 for a list of titles). An additional report has been prepared on land leveling of small farms<sup>2/</sup> and various reports were prepared by consultants, originally Chemonics and later A.T. Corey. These reports are available at the MWRD Office of USAID/Colombo and the Land Use Division of the Department of Irrigation.

The results of the research effort have been summarized in the final evaluation report. These results are included as Annex 4.

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- <sup>1/</sup> Returns to Upland and Lowland Rice Crops in Maha 1979-1980 by Willie D. Joshua, Joanne T. Hale and W.J.K.V. Ranjit and Seasonal Report Number 2 - Yala 1980 Results by S. Dimantha, W.J.K.V. Ranjit and Joanne T. Hale.
- <sup>2/</sup> Leveling Small Farms to Bench, Terraces by Willie D. Joshua and George C. Knierim.

#### H. Summary of Lessons Learned

The following are lessons learned based on the two evaluations undertaken and the Project Officer's experience with the Project.

1. A careful evaluation of available staff is required in the design of a research project. Commitment of that staff is required during the life of the Project.
2. The Scope of Project should be suited to the talents of available staff supplemented by planned technical assistance.
3. As problems become apparent during the Project relating to inadequate staff and as it becomes apparent that adequate staff will not be forthcoming, consideration should be given to narrowing the scope and sharpening the objectives of the Project.
4. Research should be conducted in a manner such that results can be readily and timely analyzed and reported. Reams of data collected on experiments containing numerous variables create problems in data analysis and delays in reporting.
5. Capabilities of various research organizations should be thoroughly investigated. Parallel research efforts with lack of coordination between organizations should be avoided. Limits to the scope of research to be conducted should be established for each research facility to avoid duplication of research efforts.
6. The impact of a research project is unlikely to be felt unless necessary follow-up and outreach programs are carried out. This project pointed out the difficulties of managing the cultivation of upland crops and flooded rice in alternate seasons in level basins (See Annex 5). The Sri Lankan farmer's preference for growing flooded rice for at least one season is well known. To expect farmers to give up their traditional rice cultivation system is unreasonable unless a viable alternative which provides reasonable security and incentives can be demonstrated. The initial research begun in this project needs to be followed up with more extensive work on land leveling, cropping systems, water balance and drainage studies and eventually development of a pilot demonstration area where farmers and extension personnel can be trained in efficient irrigation of upland crops. Unless this effort is made the research carried out under this Project is unlikely to have a measurable impact.
7. Research of this nature calls for close collaboration and participation with related agencies, e.g. in this case the Department of Agriculture Research and Extension Division.

REVISED AMPLIFIED DESCRIPTION<sup>1/</sup>

On-Farm Water Management Research

A. Project

The major purpose of this project is to develop methodologies regarding land preparation, farm and field layout, and field channel design and water delivery procedures which will result in increased production per unit of water. The results will be applicable to both new irrigation projects and rehabilitation of older ones. Specifically the project consists of an "experiential farm" of about 50 acres and adjacent "demonstration area" occupied by 2.5 acre farmers in the Kalawewa area where the following activities will first be tested and demonstrated and then carried out in Mahaweli.

1. Methods of land preparation: This will include ungraded, contour, bench and flat terraces. Various methods of construction will be tried to determine the economics and degree of precision obtainable.
2. Land levelling: Small soil scrapers and land planes (both tractor drawn and those pulled by bullocks) will be built and used to level the experimental farm and farmers' land in the demonstration unit. Techniques and procedures developed will be replicated, at least on a pilot basis, in the Mahaweli area.
3. Methods of Irrigation: Various types of furrows, basins and furrow-basin systems will be tested to determine the best type of irrigation application system to fit each type of terrace and cropping pattern.
4. Crop, Soil and Water Management: Combined with the testing of methods of irrigation, there will be an evaluation of methods of planting, weed control and irrigation requirements for various crops, especially upland rice.
5. Demonstration and Training Activities: The better terracing, furrowing and other improved water management and irrigation techniques learned on the experimental farm will be tried on the demonstration unit with farmers and then in other areas of Mahaweli in farmers' fields.
6. Water Balance: A complete water balance study will be made of the distributary serving the test area.

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<sup>1/</sup> Amendment Number 1 Project Grant Agreement for On-Farm Water Management Project, March 10, 1980.

7. Structures and Measurement: Locally made structures and measuring devices will be installed to evaluate their quality as water control and/or measuring devices.
8. Special Studies: Various types of special water management and irrigation related studies will be conducted by Sri Lankan institutions financed by this grant.

RECOMMENDATIONS<sup>1/</sup>

As a result of the experiences and findings from this Grant Agreement, a number of recommendations relating to future jointly-sponsored research are presented. These are:

1. The names and qualifications of all prospective investigators who have agreed to serve on any particular project should be known to the contracting parties before specific objectives and the scope of work are put in final form, and before the contract is signed.
2. The scope of work for future projects should not be broader than can be handled (with a reasonable chance of success) by the people actually available. People with a long experience in high-level field research are needed to estimate what is "reasonable" in this respect, and they should have substantial experience with conditions in Sri Lanka.
3. Care should be taken to see that future research is handled by the appropriate operating agency and that the research is not a duplication of what some other agency is already doing. In the latter case, it would be more logical to provide additional financial and manpower help to the agency already involved rather than setting up an independent project competing for the available manpower.
4. As a case in point, it would seem logical to provide help directly to the Agriculture Department and the Extension service to handle the specific activities 3 (Methods of Irrigation), 4 (Crop, Soil and Water Management), and 5 (Demonstration and Training Activities) that were undertaken independently under the OFWM Research Project.
5. The problems of controlling diseases, pests and weeds for upland crops in Sri Lanka are major ones. It is naive to expect solutions to such problems to result from a brief independent research effort like the OFWM Project. Support should be given to the Agricultural Department and the University of Peradeniya to conduct continuing high level research programs to solve these problems. The selection of appropriate crops and cropping systems is in somewhat the same category. The latter should more logically be undertaken by the Department of Agriculture and (to some extent) already have been. The criticism has been raised (with some validity) that the information provided by the OFWM Project in regard to crops was already known.

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<sup>1/</sup> From "OFWM Research Project at Kalankuttiya (An Evaluation)" by A.T. Corey and K. Lyvers.

6. Sri Lanka is not yet ready for massive program in preparing land for new methods of irrigation. The personnel have not yet been trained, and the equipment and organization needed for such a program are not now available. Furthermore, the administrators of the agencies involved are not yet fully convinced of the type of program which would be most feasible.

The Expatriate Consultant has written a report to the Mahaweli Authority and other agencies giving his ideas concerning what should be their policy in this regard. Briefly, the suggestion is that the Mahaweli Agency should support the small group of people trained to do this work (by the present Project) and should help them to train additional crews. In addition, an effort should be made to encourage private contractors to equip and train crews to do this kind of work on a private basis. This should provide the possibility of farmers getting land leveling work done privately and at the lowest possible cost. Also, if a large public program should (at some future date) be considered feasible, the manpower and organization for such a program would be available.

7. Especially for new land development, an independent special research project is needed to solve problems relating to the water distribution for upland crops under schemes that also supply water for flooded rice cultivation. A way needs to be devised to economically "split" the distribution systems so that it will be impractical for farmers on the upland soils to grow flooded rice, and (at the same time) to provide these farmers with the incentives to take the risks and make the investments needed for this kind of enterprise.

Research needs to be undertaken to discover what institutional and legal changes are needed and what allotment sizes are required to make cultivation of upland crops attractive for the appropriate farmers. Adaptive work also needs to be undertaken to discover how to design and operate a water distribution system to facilitate the production of upland crops and obtain the maximum benefit from the available water. Furthermore, additional cropping or "farming systems" research (by the Agriculture Department) is needed to help determine the appropriate mix of crops for these upland farmers.

8. It would be desirable to expand the present "pipe line project" to include the use of plastic pipe and other alternative procedures for delivery of water over low-lying areas while preserving head to make farm outlets operate satisfactorily. Perhaps the latter project could be incorporated with that recommended under item number 7 and that these two projects could be centered at (but not necessarily confined to) the 500-acre watershed that includes the Research Farm at Kalankuttiya.

9. As Sri Lanka approaches self-sufficiency in rice production, much more emphasis must be given to production of secondary or upland type crops which are most suitable for the Reddish Brown Earths (RBE) and Non-Calcic Browns (NCB) soils which are predominate in much of the Dry Zone. Use of these crops would save water and reduce fertilizer requirements (especially if a nitrogen fixing legume is used in rotation) and produce crops which are urgently needed and more suited to soils in Sri Lanka. This program should include a combination of the following:
- (a) An extensive upland (subsidiary) commodity research program coupled with a "farming system" approach, along with a marketing system and price structure which will support this program. (This program should be under the Agriculture Department.)
  - (b) A land leveling or preparation of terraces on properly graded slopes which would allow farmers to produce these crops and control drainage.
  - (c) Development of upland rice varieties (improved varieties can be obtained from IRRI and IITA) which should allow upland farmers to produce upland or unpuddled rice during the Maha with other upland crops in the Yala.
  - (d) In new irrigation systems which have extensive RBE or NCB soils, the land should be reserved exclusively for upland crops and should be properly graded (.2 to .6 slope) to permit proper drainage and cultivation of these other crops.
10. In newly developed irrigation schemes, an intensive trial should be conducted to build temporary structures and other construction at the field channel level for the first two years. After this time the implementing agency should resurvey, design and reconstruct permanent canals and structures at the field channel and farmer level.
11. 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 and other areas of the country. These adaptive aspects can be divided into two major categories as follows:
- (a) Engineering by Mahaweli/Irrigation Department:
    - (1) Operation, management and maintenance of a larger unit with active farmer involvement through farmer irrigation associations.

- (2) Land leveling and properly grading upland areas of the distributory command areas so that adequate drainage and cultivation of upland crops can be promoted.
  - (3) Improve water distribution through improved structures and water measuring devices.
  - (4) Complete the water balance study currently underway to include surface drainage.
- (b) Agronomic Aspects by Agriculture Department at Maha Illuppallama:
- (1) Development of additional farming or cropping systems including good upland rice varieties in the Maha and other upland crops in the Yala which can be fully adopted and are economical under small farmer conditions.
  - (2) Development of additional farming systems which include upland crops in both Maha and Yala which can be fully adopted and are economical for use by small farmers. This has particular importance if good upland rice varieties adapted to Sri Lankan conditions are not available within 1-2 years.

SPECIAL STUDIES

Completed as of August 1, 1983

1. Final Report on Cropping Systems Component Contract by Dr. S.H. Upasena.
2. Small Farm Leveling and Development Using Animal Drawn Implements by Dr. Sarath Ilangantileke.
3. Groundwater Hydrology in the Mahaweli System H by Dr. A.T. Corey and P.H. Jayawardana.
4. Control of Water on Farm Ditches in Sri Lanka by Dr. A.T. Corey and G.G.W. Gunatillake.
5. Land Preparation - Furrow Farming by K. Ramanan.
6. Preliminary Studies on Application of No-Till Farming Systems for Irrigated Agriculture by M.D. Piyathilake.
7. Investigations on Graded Furrow Layout on Reddish Brown Earths by W.J.K.V. Ranjith.
8. Salt Content Estimation in the Mahaweli System "H" area by S. Gamini Ranjith de Silva.

RESEARCH RESULTS<sup>1/</sup>

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.

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<sup>1/</sup> From "On-Farm Water Management Project - Sri Lanka, Final Evaluation Report" by A.R. Robinson and H.P.M. Gunasena.

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.

LESSONS LEARNED<sup>1/</sup>

It cannot be claimed that the Project has solved all (or even any) of the problems it has undertaken to investigate. The project was too large in scope and too undermanned to accomplish all the objectives even in the unlikely case that this were possible. However, the broad scope of the objectives along with the pilot nature of the activities undertaken has served a very useful purpose. It has clearly identified major problems associated with irrigation of upland crops in the Central Dry Zone of Sri Lanka.

The Project has shown which areas represent the main constraints to profitable use of water here and indicates that a series of more narrowly focused investigations are needed to actually solve these problems.

Important lessons include the following:

1. The cultivation of upland crops and flooded rice during alternate cropping seasons on the same land is very difficult (if not impossible) to manage for consistently successful operations, under the soil types and other conditions existing in the Central Dry Zone.
2. 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 needs to be developed.
3. Level Basins do not provide the surface drainage needed for upland crops (especially chillies) except in very dry seasons. 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.
4. Graded terraces can be used for flooded rice, but cross checks must be placed at appropriate intervals and the land between the checks must be nearly level. Also, terraces that have been used for flooded rice must be leveled (slightly) before being used again for upland crops.
5. A satisfactory method of leveling land for one hectare farms has been developed with the use of a bucket scraper, land plane and farm tractor. This type of equipment is essential for properly leveling land and to prepare land on a large scale for upland crops.

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<sup>1/</sup> From "OFWM Research Project at Kalankuttiya (An Evaluation)" by A.T. Corey and K. Lyvera.

6. To make the optimum use of water, soils and fertilizer nitrogen available for the Central Dry Zone, the cultivation of flooded rice on RBE (and Non-Calcic Browns) soils needs to be discontinued. In particular, the mixing of upland crops and flooded rice on adjacent lands during any one season often results in failure of the upland crops due to high water tables.
7. Pest, disease and weed control are major problems for cultivation of upland crops in the study area.
8. The control of water in farm ditches (that supply soils with both large and small infiltration rates) is very difficult and has not been satisfactorily accomplished anywhere in Sri Lanka. A way of providing separate water distribution systems for upland soils and flooded rice soils needs to be found - at least at the farm level.