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RURAL IRRIGATION WORKS STUDY
FINAL REPORT

MAIN REPORT
VOLUME 1: CHAPTERS I, II, III

ENGINEERING CONSULTANTS, INC.
ENGLEWOOD, COLORADO, U.S.A.

PLANNERS, ENGINEERS AND CONSULTANTS LIMITED
DACCA, BANGLADESH

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ABBREVIATIONS

BADC	=	Bangladesh Agricultural Development Corporation
B/C	=	Benefit-Cost Ratio
BRRI	=	Bangladesh Rice Research Institute
BSC	=	Bangladesh Shipping Corporation
BWDB	=	Bangladesh Water Development Board
CAD	=	Command Area Development
CARE	=	Cooperative of American Relief Everywhere
DEM	=	Directorate of Extension and Management
DTW	=	Deep Tube-Well
ECI	=	Engineering Consultants, Incorporated
FAO	=	Food and Agricultural Organization
GOB	=	Government of Bangladesh
HYV	=	High Yielding Variety
IRDP	=	Integrated Rural Development Program
KSS	=	Krishi Sambaya Samities (Agricultural Cooperative Society)
LLP	=	Low Lift Pump
MRD	=	Ministry of Local Government, Rural Development and Cooperatives
PEC	=	Planners, Engineers, and Consultants
RWP	=	Rural Works Program
SAE	=	Sub-Assistant Engineer, RWP
SDE	=	Sub-Divisional Engineer, RWP
STW	=	Shallow Tube-Well
TCCA	=	Thana Central Cooperative Association
TIP	=	Thana Irrigation Program
USAID	=	United States Agency for International Development
WAPDA	=	Water and Power Development Authority
WB	=	World Bank
XEN	=	Executive Engineer RWP

CURRENCY EQUIVALENTS

US $ 1 = Taka 15.00
Taka 1 = US $ .067

WEIGHTS AND MEASURES

1 acre (ac)	=	.405 hectare (ha)
1 bigha (bi)	=	.33 acre (ac)
1 sq mile	=	640 acres (ac)
1 maund (md)	=	82.28 pounds (lbs)
1 maund (md)	=	37.3 Kilograms (kg)
1 metric ton (ton)	=	26.8 maunds (md)
1 seer (sr)	=	2.06 pounds (lbs)
1 cubic foot per second (cusec)	=	0.283 cubic meters per second

GLOSSARY OF TERMS

Aman	=	Rice sown/planted during March to July/August and harvested in November or December.
Aus	=	Rice sown/planted during March and April and harvested in July and August. T. aus = transplanted aus; B. aus = broadcasted aus.
Beel	=	Marsh or lake; also spelled bill or bil.
Boro	=	Winter rice, planted during November and December and harvested during April to June.
Char	=	Newly formed sandy alluvial tract.
Drain	=	Canal to provide drainage or irrigation water.
Khal	=	Narrow natural channel of water.
Kharif	=	Summer season or rainy season.
Kutcha	=	Temporary, lower grade or dirt structures.
Paddy	=	Unhusked or rough rice (oryza sativa).
Pucca	=	Permanent, good quality structures.
Rabi	=	Winter season or dry season.
Thana	=	Political sub-division of a sub-division: police station or revenue unit.
Sub-Division	=	Political division of a district.

CHAPTER I

INTRODUCTION

Section 1: Authority

This report on the Rural Irrigation Works Study was prepared for the Ministry of Local Government, Rural Development and Cooperatives (MRD) of the Government of Bangladesh, under the terms of an agreement, dated January 28, 1979, between MRD and the joint venture firms, Engineering Consultants Inc.(ECI) and Planners, Engineers & Consultants (PEC).

Section 2: Project Description and Objectives

A. Project Objective

The objective of the Rural Irrigation Works Program is to increase agricultural production through the provision of flood protection, improved drainage, irrigation water, or a combination of these engineering schemes. The two-phase Study for which the Consultant was engaged was intended to prepare for implementation the proposed three-year AID-financed project for constructing and effectively operating small-scale irrigation systems through the Government of Bangladesh's Rural Works Program.

B. Phase I

Prior to the initiation of Phase I, MRD requested that the Deputy Commissioner of each of the six districts selected for the Study submit a list of top-priority irrigation sites which would be appropriate for the proposed types of irrigation systems. Phase I consisted of using a survey/evaluation questionnaire developed by the Consultant to rank 90 sub-projects by applying a set of criteria

outlined in the contract. The 30 highest-ranked sub-projects were then to be recommended for design and construction.

Phase I also included the Consultant's evaluation of the methodology used to rank the 90 sub-projects and, if necessary, recommendations for alternative methods of ranking the Program's second- and third-year ranking and selections.

B. Phase II

Phase II consisted of the preparation of design criteria and total input requirements which could serve as the basis for final design of all sub-projects to be constructed over the three-year Program. Together, the Consultant and MRD prepared an evaluation of and recommendations for the institutional requirements for all stages of the Project, including arrangements at all institutional levels from the irrigation systems themselves through that of the central Government.

A major portion of the Phase II responsibilities consisted of the preparation of designs for each of the 30 sub-projects, locations and specifications for wells and pumps, and complete designs for channels, appurtenant structures, and dikes or small dams. In addition to serving as functional designs for the construction of the sub-projects in the Program's first year, these designs were intended to serve as models for the second and third years' sub-projects.

Phase II also included the preparation of an operation and maintenance manual, a design manual, an economic evaluation of a sample of sub-projects, and an assessment of the sub-projects' socio-economic impact on the affected populations.

Section 3: General Information

Bangladesh, located at the intersection of meridian 90E and the Tropic of Cancer, has an area of 55,598 square miles and a population of approximately 86 million. Of the 15 largest countries of the world, Bangladesh is ranked last in surface area, eighth in population, and first in population density. Bangladesh is essentially a

rural country with 91 percent of its inhabitants residing in rural areas. The country is a huge delta formed by three major river systems--the Ganges, the Brahmaputra, and the Meghna--of which the first two are among the world's largest rivers. The terrain is extremely flat and is interlaced with an intricate system of rivers and tidal channels which divide the land into numerous separate areas. These channels carry flood water from the main rivers and act as conveyance channels for rainfall runoff and tidewater to the Bay of Bengal. Because of the land's flatness and the region's heavy rainfall, surface drainage systems are not well defined. There are many streams, but they consistently divert their flows from one area to another and continually change courses. Many of the resulting separate land areas have saucer-like shapes with higher elevations on the natural banks adjacent to the river where the sediment deposited by bank overflow is heaviest.

The general slope of the terrain decreases from north to south with elevations in the northwest region as high as 300 feet. In the northeast and southeast regions, however, there are hills ranging up to about 3000 feet elevation.

Being under the influence of the Himalayan, Assam, and Burmese ranges on the north and northeast and of the Bay of Bengal on the south, the climate of Bangladesh is of tropical and monsoonal. There are three markedly distinguishable seasons: The period March through May is the warm season with the highest temperatures, occasionally reaching 110° F, and the lowest humidity. About 15 percent of the annual rainfall occurs in this season, towards the end of which violent thunderstorms and strong winds are common. June through September, and at times until October, constitutes the monsoon season during which 80 percent of the annual rainfall occurs. Temperatures are in the 90° F range and the atmosphere has extremely high humidity. Toward the latter part of the monsoon season, cyclonic storms often occur. The winter season is from October or November through February. During this period, temperatures are below 90° F and, at places, the night temperature may drop to as low as the 38° to 42° F range. Rainfall in the country ranges from about 50 inches in the west-central region to over 200 inches in the southeast region. The

annual average rainfall of 90 inches is unevenly distributed, and the annual evaporation ranges between 40 and 56 inches. There is no apparent geographical pattern for the distribution of humidity, wind, or temperature.

Section 4: Agricultural Setting

Agricultural development in Bangladesh is constrained by the scarcity of cultivable land, climatic hazards, and the lack of irrigation facilities. In many areas of the country, crop production is affected by one or a combination of the following problems: early floods, intrusion of saline water, poor drainage in the monsoon season, droughts, or lack of irrigation in the dry season.

Approximately 22.5 million acres in Bangladesh are now being cultivated for one season or another with cropping intensities that are often far below those in other countries. No significant areas of virgin land are available for cultivation; therefore, the increased production that is needed to meet expected population increases and to achieve food self-sufficiency must come from land that is already cultivated. Of the total acres now cultivated, approximately 60% is cultivated for one crop, 34% for two crops, and only 6% for three crops. This gives a total cropping intensity of about 140%.

The chief means of increasing crop acreage is by providing irrigation, especially during the dry season (November-March) during which there is little cultivation of wheat, pulses or oil seeds and during which cultivation of rice is impossible without irrigation. Approximately 11 million acres can be cultivated for an additional crop if irrigation facilities are provided; part of this land is now cultivated with available moisture in the soil, but with very poor yields. Furthermore, approximately two-thirds of the country are also vulnerable to flooding: about 15 thousand square miles are flooded each year. Although the floods benefit some areas where people have adapted their lives and farming habits to take advantage of the floods, there is still very heavy damage to crops and property,

annually estimated at $40 million. Fourteen million of the 15 million acres subjected to floods are now being cultivated. Because farmers must accept the risks of occasional higher or earlier than normal floods or the risks of drought, they are reluctant to use fertilizer and grow mainly traditional varieties of rice which have low yields.

Cropping patterns vary in relation to climate, elevation of the land, and annual flooding patterns. Rice is the major crop and is grown on about 80 percent of the cultivated agricultural land. Jute occupies 6 percent. Wheat, pulses, oil seeds, sugarcane, and vegetables are grown on the remaining 14 percent. The 3 main paddy crops grown are:

Aus, rice varieties sown/planted in March/April and harvested in July/August;

Aman, rice varieties sown/planted in March to June/July and harvested in November/December; and

Boro, rice varieties sown/planted during November/December and harvested during the April to June period.

Both aus and aman varieties may be grown by broadcasting or by transplanting. The transplanted crop gives the higher yield. The most common pattern is aus and aman followed by a dry season crop such as boro rice, wheat, vegetables, pulses or oil seeds where irrigation or residual moisture makes it possible.

CHAPTER II

SURVEY/EVALUATION QUESTIONNAIRE AND SUB-PROJECT SELECTION

Section 1: Introduction

One of the main objectives of this study, as stated in the contract, was to develop "a set of selection criteria for order-of-priority ranking of...sub-project proposals under the Rural Works Program." The Consultant was to develop a survey/evaluation questionnaire so that a set of criteria as outlined in the contract were applied and utilized to rank 90 previously selected sub-projects, of which 30 would be selected for final engineering design. The questionnaire was designed to serve as the priority ranking instrument to be used by MRD in the selection of future sub-projects.

A. Initial Sub-Project Selection

Initially, about 400 small-scale irrigation sub-projects were submitted by six District Commissioners' offices to MRD. They represented the Chittagong, Dacca, Khulna, Rajshahi, Rangpur, and Tangail Districts. This study's first task was the selection of the 90 most promising and technically feasible sub-projects. To involve the beneficiaries in the selection process and to expedite the execution of the study, a procedure for narrowing the 400 to fewer sub-projects was recommended to MRD in the letter 1232/2, DA2/79, January 30, 1979, which is presented in Annex A at the end of this chapter.

B. Further Screening of Sub-Projects

Based upon these recommendations, a format letter was prepared and submitted to MRD and then forwarded to the six District Commissioners. This format letter was an attachment to the letter 1232/2, DA2/79, January 30, 1979. The format letter is also presented in Annex A at the end of this chapter.

After receiving the letter with the recommended selection criteria, MRD personnel selected 90 sub-projects from the six Districts. These 90 were then submitted to the Consultant for priority ranking.

Section 2: Development of Survey/Evaluation Questionnaire

A. Preliminary Questionnaire

A survey/evaluation questionnaire was developed by the Consultant in conformance with Article 3.2 of the contract. The questionnaire is intended to assist MRD personnel in making complete evaluations of proposed small irrigation systems by briefly visiting the sub-project areas. The point rating obtained from the questionnaire should provide a relatively accurate measure of their suitability for design and construction, and it should be the only basis for ranking sub-projects. Significantly, economic justifiability was not considered to be a primary factor in the development of the survey/evaluation questionnaire. The economic justifiability of individual systems is evaluated in Chapter V of this study.

The Consultant was to follow evaluation criteria, detailed in the contract (Article 3.2) and presented in Table II-1, which only indirectly referred to the economics of sub-projects. These criteria were designed specifically to accomplish the objectives of this study and to fulfill the institutional responsibilities and functions of MRD.

To accomplish the priority ranking of sub-projects, a preliminary survey/evaluation questionnaire was prepared and a schedule was developed for visiting each of the 90 sub-projects. A copy of the schedule was sent to the Assistant Commissioner of each Thana in which there was a sub-project, to the Deputy Commissioner of each district, to each Sub-Divisional Officer, and to each Executive Engineer. The schedule included the date of each visit, the time a meeting was to be held to discuss the sub-project and complete the questionnaire, the time when the sub-project site was to be visited, and the town where

the consultant team would need accomodations. A letter accompanied the schedule that explained the purpose of the visit, requested that the Executive Engineer arranged accomodations, and asked that the following people be present at the sub-project meeting:

Chairman Thana Development Committee;
Secretary Thana Development Committee;
Chairman Union Parishad;
Assistant Commissioner;
Thana Irrigation Officer, BADC;
Thana Agricultural Officer;
Thana Extension Officer;
Thana Project Officer, IRDP;
Thana Co-operative Officer;
Thana Irrigation Program Overseer; and
Union Agricultural Assistant.

Each of the 90 sub-projects was visited by a two- or three-man team assigned by the Consultant. Team members included engineers, economists, and agriculturalists. The questionnaire was completed by the local representatives listed above and under the supervision of the Consultants' team.

To facilitate the development of the questionnaire, the criteria (Table II-1) were divided into three categories: Socio-Economic (Criteria 1, 2, and 7), Agroclimatic (Criteria 3, 5, and 9), and Technical (Criteria 4, 6, and 8). From these criteria, a total of 33 questions were developed for the evaluation of sub-projects. The 90 sub-projects submitted to the Consultant by MRD were visited and the questionnaire was completed. A numeric ranking of all sub-projects within each District was obtained. The results obtained from the questionnaire were submitted to MRD and USAID, were included in the Phase I Report, and are presented in Tables II-3 through II-8.

The planned ranking procedure was found to be deficient after the sub-projects in the Districts of Dacca and Tangail had been visited and while visits were in progress at the sub-projects in the District of Khulna. It was found that in many cases the local people had not received appropriate assistance from engineers or other trained people

in developing technical plans for their sub-projects. Consequently, some sub-projects were obviously not technically or economically feasible, were too complex for development under the Rural Irrigation Works Study, or were not suitable design models as intended to improve MRD's capability to design irrigation systems. In cases such as this, the number of points given to a sub-project by the questionnaire was meaningless because the questionnaire was designed to aid in ranking only sub-projects that were deemed suitable for development under this study.

Section 3: Questionnaire Refinement

A. Screening Questions

To solve these deficiencies, several actions were taken. The first added a set of screening questions to the survey/evaluation questionnaire to provide a means of eliminating from consideration those sub-projects not suitable for development or not within the study's scope and the Consultant's time constraints.

1. Does an organized water users' group function in an effective manner? Yes ___, No ___.

   This question is intended to eliminate sub-projects for which a water users' group does not operate efficiently or does not exist. To determine whether a water users' group functions efficiently, various factors are analyzed, such as irrigated area per cu. sec. of pumping capacity, the farmers' opinions of managing committee members, the farmers' willingness to pay irrigation charges, and the number of members in the group. Since these sub-projects designed and developed are to serve as model sub-projects for MRD and for future development, it was thought desirable to have a water users' group already in operation and efficiently functioning at each site.

2. <u>Is an adequate water supply available for irrigation of the sub-project area during dry season</u>? Yes ___, No ___.

This question was intended to screen out sub-projects for which the water supply was insufficient. To answer this question properly, detailed hydrological data is needed; however, an interviewer can eliminate sub-projects where the water supply is obviously inadequate. Two kinds of such sub-projects were prevalent during the study:

(a) The first consisted of those where the people wanted to re-excavate canals and build cross dams to store monsoon runoff for irrigation. Such projects are not economically feasible because the amount of water that can be stored in a canal is insignificant.

(b) The second consisted of those where a perennial stream was to be the water source. In this case, the interviewer was instructed to estimate the flow in the stream. If it was dry during their visit, it was obviously not a perennial source and further investigation would be required to determine its dependability. An estimate of the flow in a stream could be used to determine whether it was adequate to serve the proposed command area.

The prevalence of such circumstances points out the need for screening by MRD when applications for sub-project development are first submitted for consideration. The engineer in charge should make sure that the sub-project is technically feasible and that the information furnished is correct.

3. Is the area to be irrigated equal to at least 50 acres per cu sec of pumping capacity? Yes ___, No ___.

This question is directed toward sub-projects with a DTW, STW, or LLP already in operation. A minimum area to irrigated of 50 acres per cu. sec. of pumping capacity was established to screen out sub-projects for which there was not enough crop land to make efficient use of existing pumps. During visits to sub-projects the Consultant observed that several sub-projects originally submitted to MRD had pumps for which not enough crop land was available for irrigation, thus making the pump operating process inefficient and, therefore, not economical.

4. Are farmers willing to accept the construction of facilities other than those previously proposed to MRD? Yes ___, No___.

During the initial stages of conducting the questionnaire, the Consultant observed that the proposed irrigation, drainage, and flood-control facilities would not be the best feasible solution to an existing problem. Instead, alternatives were conceived at the same time of the visits, or the Consultant believed that a better solution could be found once the surveying work was completed. The construction and implementation of the best alternative is dependent upon the farmers' willingness to cooperate and accept that alternative.

5. Does this sub-project require the acquisition of new pumps?
Yes ___, No ___.

This question was included in view of the institutional responsibilities and functions of MRD. Because pumps in Bangladesh are rented on a yearly basis to sub-project areas by BADC and because the provision of pumps is not a component of this study, the necessary acquisition of pumps eliminated a sub-project from consideration.

6. Is this sub-project too large and complex to be designed, constructed, and operated with MRD capabilities?
Yes ___, No ___.

Complex and large water management schemes should be administered by BWDB in accordance with government policy because their design, construction, and operation would require services beyond those provided by MRD. Design of such projects by the Consultant would be very time consuming and would reduce the amount of time that could be spent on small projects that would meet the objectives of providing worthwhile examples to MRD engineers for future reference.

7. Would the proposed system adversely affect neighboring croplands or have any negative environmental effects?
Yes ___, No ___.

A precise answer to this question's first part may be difficult to substantiate during a short visit, but some information about possible consequences can be obtained from executive engineers and Thana officials. The second part of this question is also difficult to substantiate on a short visit; however, an answer can be obtained by interviewing

farmers and government officials familiar with the sub-project area. Before completing this question, interviews with several people in the area should be held. The interviewer must contact different groups of people to obtain several opinions. This question is included in the questionnaire to eliminate sub-projects that, if developed, could harm the environment or deteriorate farming conditions in adjacent lands.

8. Can the water intended for a proposed area be used to irrigate crop land closer to its source or does the water have any better alternative use? Yes ___, No ___.

This question is intended to eliminate sub-projects for which an inefficient allocation of irrigation water is being proposed. This can be determined either from a visit to the sub-project area or from a comprehensive map showing the sub-project area, neighboring lands, and sources of water. The Consultant believes that some of the sub-projects proposed to MRD do not satisfy this condition and that the same source of water could be more efficiently used in the irrigation of other crop lands.

If any one of questions 4, 6, 7 or 8 were answered "Yes" or if any one of questions 1, 2, 3, or 5 were answered "No" the survey/evaluation questionnaire was completed, but the sub-project was not considered for design and development by the Consultant.

B. Study Team Composition

The second action taken to screen out unsuitable sub-projects consisted of making every effort to have at least one senior professional on each study team. Even though this was done, evaluating the sub-projects was sometimes difficult because of the short time available to visit the sub-project sites and because of the lack of mapping and other information.

C. Criteria

Having gained experience in conducting the questionnaire in the six Districts and considering its future use by MRD, several changes were made. The major change relates to the criteria used. Of the originally proposed nine criteria (Table II-1), one was eliminated and another included in the screening questionnaire.

Criterion No. 6, "Representative Example Characteristics for Future Sub-Project Design", was eliminated because it had been included only for use by the Consultant in this study. Obviously, future applications of the questionnaire by MRD should ignore this criterion.

Criterion No. 9, "Lack of Negative Impact Upon the Environment", was transferred from the survey/evaluation questionnaire to the screening questions. During visits to sub-projects, the Consultant observed that people interviewed did not generally understand the question and, in most cases, answered "Yes". By transferring it to the screening questions, the interviewer, with the help of local people's opinions and his knowledge of the area, could obtain a more accurate answer.

Table II-2 presents the criteria used in developing the survey/evaluation questionnaire, which is recommended for MRD sub-project ranking. The maximum rating an individual sub-project can obtain is 100. The respective points assigned to each criterion are also in Table II-2. An explanation and justification for the inclusion of the recommended criteria follows:

1. Socio-Economic Criteria

1.1 Probability of Proposed System Providing Substantial Benefits to Poorer Landowners, Tenants, and Landless Laborers. (22 points)

One of the main policy objectives of the Rural Works Program is to channel benefits to the poorest strata of the rural population. To increase chances of the selection of sub-projects located in relatively poorer areas, this criterion was given a weight of 22 out of the total 100 points. In answering this criterion's questions, special attention should be given to determining the average farm size. Supporting literature (Januzzi, 1977) and the results obtained during the Consultant's visits to sub-project areas indicate that farmers tend to report a larger than actual farm size, believing that to claim ownership over a larger tract of land might help them obtain actual title in the near future. Also, farmers tend to combine tracts of land owned by brothers or close relatives into a single farm.

1.2 Existence of or Intent to Create a Local Institution Capable of Effective Operation, Maintenance, and Repair of Proposed Structures. (12 Points)

To guarantee the proper and continued operation of an irrigation, drainage, or flood-control system, the organization of a water users' group is a necessity. Sub-projects with an effective water users' group or a cooperative already in operation should be given priority over sub-projects where only initial steps to form one have been taken. Sub-projects where farmers are not organized in any manner and do not have intentions to do so should not be considered for selection.

The successful operation of a proposed system is not achieved without adequate financial support. Because the government cannot subsidize operation of all projects in the country, it is expected that farmers pay for operation, maintenance, and repair of structures. For this reason, a question addressing this issue has been included in the questionnaire. Furthermore, to ease the financial burden incurred by MRD, or the financing institution in the construction of proposed facilities, it is recommended that farmers provide voluntary labor.

1.3 Easily Solved Land Acquisition Difficulties. (12 Points)
To facilitate and expedite construction of proposed facilities, farmers should be willing to make available the land needed for right-of-way. This can be accomplished by the farmers donating the land for the development of the sub-project or by their selling it to the community. When necessary, people should be willing to accept relocation of their households.

2. Agro-Climatic Criteria

2.1 Potential for Increased Agricultural Production. (14 Points)
Bangladesh being a country with chronic food deficits, increased food production and productivity are highly desirable. Sub-project development is expected to provide means to farmers to increase their crop yields during kharif (wet) and rabi (dry) seasons by providing irrigation water when needed. Development of a sub-project will also make it possible to bring into production lands that are fallow during certain parts of the year, either because they do not have enough water for crop production or because they are flooded. Sub-project areas with low crop intensities (130 or less) have a substantial potential for higher cropping intensities through improvement or construction of new facilities. Such sub-projects are desirable from the social and economic points of view.

2.2 Availability of Agricultural Inputs. (12 Points)

To guarantee better yields and increased total production in a given sub-project area, an adequate and reliable supply of agricultural inputs is indispensable. These include the supply of quality seeds, pesticides, fertilizer, labor, and credit. The Government of Bangladesh, through several of its institutions, has programs for production and distribution of agricultural inputs. Because these programs seem to have a greater impact in some areas of the country, selection and development of sub-projects in those areas appear to guarantee a successful choice.

3. Technical Criteria

3.1 Likelihood of Effective Operation of System. (12 Points)

The farmers' willingness and enthusiasm for sub-project development is necessary for securing its effective operation. To judge their interest in developing their facilities, the evaluation should rank their crops and existing facilities as specified in the questionnaire. Also necessary is a reliable supply of physical inputs (spare parts, oil, fuel, etc.) to guarantee proper functioning of mechanical equipment.

3.2 Construction and Development. (16 Points)

The abundance of unskilled labor in Bangladesh suggests that the construction of a sub-project should involve as much labor as possible. The use of heavy, sophisticated machinery should be avoided where it can be replaced by less costly labor. And because the local availability of foreign currency is limited, it is imperative that materials and equipment used in development of facilities be obtained locally.

Section 4: Recommended Survey/Evaluation Questionnaire

A sample survey/evaluation questionnaire, which was proposed by the Consultant to MRD, is presented in Annex B at the end of this chapter. It includes the screening questions and a list of persons that should be present at the meetings. All questions are clearly stated to solicit "Yes" or "No" answers or simple numeric rankings. Weights of individual questions were established by the Consultant, based upon experience obtained during Phases I and II of this study. It is recommended that before the questionnaire is used again, it be translated into Bengali.

Section 5: Results of Sub-Project Ranking

A. Introduction

This section presents the results of the ranking of 90 sub-projects obtained through use of the survey/evaluation questionnaire. Sub-projects were ranked within each district. Those that did not satisfy screening questions were ranked below all those that did satisfy all the screening questions. Although these sub-projects were considered by the Consultant to be beyond the scope of this study or beyond the scope of MRD institutional responsibilities and were not recommended for design and development, they were ranked according to their questionnaire scores.

The following paragraphs contain a brief summary of the Consultant's recommendations made about sub-projects in each district when submitted to MRD and USAID for review and approval. The Consultant believes that the sub-projects recommended for design and development are within the scope of the "Rural Irrigation Works" and provide enough material for fulfillment of the objectives of the study.

B. Ranking of Sub-Projects, Chittagong District

Table II-3 shows the ranking of the 12 sub-projects in Chittagong District submitted to the Consultant by MRD.

Sub-projects 1 through 5 were recommended for selection. Sub-projects ranked 6 through 12 were not recommended for the following reasons:

Sub-Project 6 was not recommended because the Consultant believes that DTWs are a more efficient solution to the irrigation problem. Farmers in this sub-project area appear to want the construction of a dam and a sluice gate although during the Consultant's visit to this sub-project it was not possible to determine exactly what they do want. In any case, the sub-project appeared to be too complex to be designed within the scope of this Study.

Sub-Project 7 was eliminated because the available crop land is inadequate to make efficient use of available water. The Consultant also believes that this sub-project can be designed and developed with MRD's available staff.

Sub-Project 8 was eliminated because of the lack of a KSS or an operating water users' group. Furthermore, prior to development, the existing water users' groups that presently irrigate land between the water source and the proposed project area should be coordinated in order to make optimum use of any new facilities.

Sub-Project 9 is considered by the Consultant to be too complex and beyond the scope of the Study. It includes the design and construction of two dams for which field investigations are needed. Moreover, farmers in the area are not willing to accept construction of facilities other than those submitted previously to MRD.

Sub-Project 10 was eliminated because of the lack of available irrigation water in the proposed area. Farmers in the area want the construction of a dam and a sluice gate and the re-excavation of a canal for storing water. The Consultant believes that the area can be properly and more economically irrigated with shallow tube wells.

Sub-Projects 11 and 12 were eliminated because a water users' group does not exist and because the available water is inadequate for irrigation of the proposed areas. The Consultant believes that for the limited available water the constructon of sluice gates is unwarranted. Should detailed investigations show that the sluice gates are feasible, this very simple design work can be carried out by MRD with its present capabilities.

The Consultant's recommendations, notes, and completed questionnaires for each sub-project were submitted to MRD and USAID for review and approval. Their final decision was to select sub-projects 2, 3, 5, and 11, namely:

Sub-project 2: Re-excavation of Khan Mohan Khal, Patia Thana.

Sub-project 3: Nabajugh Tebhage Kamer DTW Pucca Drain, Hathazari Thana.

Sub-project 5: Re-excavation of Faranga Sublong Khal, Satkania Thana.

Sub-project 11: Pucca Sluice Gate on Bepula Chara, Hathazari Thana.

C. Ranking of Sub-Projects, Dacca District

Table II-4 presents the ranking of Dacca sub-projects.

Sub-projects 1 through 9 were recommended for selection by the Consultant. Sub-projects ranked 10 through 17 were not recommended for reasons summarized below.

Sub-Project 10 was not recommended because the Consultant believes its implementation would do little to increase the design expertise of MRD engineers and could be accomplished during a subsequent stage of this project by MRD engineers.

Sub-Project 11 was not recommended because of its size and complexity. This sub-project includes irrigation of an area of 20,000 acres and, therefore, includes work beyond the scope of this Study.

Sub-Projects 12, 13, and 15 were eliminated because a KSS does not exist and no water users' group is effectively functioning.

Sub-Project 14 was not recommended because it is quite large and because it is a part of a larger project (Dacca South-West) and, therefore, is under the jurisdiction of another government institution.

Sub-Project 16 was eliminated because farmers are not willing to donate land for construction of irrigation structures. Moreover, farmers have not formed a water users' group.

Sub-Project 17 was eliminated because farmers are not interested in its development. They did not attend a pre-scheduled meeting and information could not be collected about this sub-project.

The Consultant's recommendations, notes, and completed questionnaires for each sub-project were submitted to MRD and USAID for review and approval. Their final decision was to select sub-projects 4, 7, 9, 11, and 12, namely:

Sub-project 4: Pucca Drain for Kawanara Irrigation Project, Saturia Thana.

Sub-project 7: Rajghat DTW Pucca Drain, Savar Thana.

Sub-project 9: Embankment of Saldah River, Sreepur Thana.

Sub-project 11: Aricha-Ichamati Irrigation Project, Shivalaya, Parts I, II, III and IV, Thana.

Sub-project 12: High Irrigation Pucca Drain, Palash Thana.

D. Ranking of Sub-Projects, Khulna District

Table II-5 presents the ranking of sub-projects from the Khulna District.

Sub-projects 1 through 3 were recommended for selection by the Consultant. Sub-projects 4 through 18 were not recommended for several reasons, as summarized below:

Sub-Projects 4 and 7 were not recommended. The Consultant believes that the development of the irrigation system as proposed by MRD is technically and economically inefficient because other crop areas closer to the source of water can be irrigated

with the same water supply.

Sub-Projects 5, 6, and 17 were not recommended for selection because further study of sub-project areas is needed before a decision can be made. Sub-projects 5 and 17 do not appear to be economically or technically feasible as proposed by MRD. Design distribution systems for larger areas rather than for small individual units with parallel irrigation canal systems would provide a better solution. Sub-project 6 would be served better by DTWs than by the proposed canal re-excavation.

Sub-Projects 8, 9, and 10 were eliminated because a KSS does not exist and because no water users' group is functioning efficiently. The Consultant also believes that prior to design of irrigation structures for these sub-projects, field studies are needed to analyze different alternatives and to determine the technical feasibility of the sub-projects as proposed.

Sub-Projects 11, 12, 17, and 18, which were proposed for canal re-excavation to provide storage of irrigation water, were eliminated because the Consultant believes that DTWs may be a better technical and economic solution to the irrigation problem. This cannot be precisely determined until more detailed studies, including field investigations, are conducted.

Sub-Projects 13, 14, 15, and 16 were eliminated for several reasons, the principal one being the uncertain supply of irrigation water. To design and develop any of these sub-projects, further analysis is needed to guarantee efficient operation of the irrigation system.

The Consultant's recommendations, notes, and completed questionnaires for each sub-project were submitted for review and approval by MRD and USAID, who then selected sub-projects 1, 3, 6, 9, 14, and 18, namely:

Sub-Project 1: Construction of Sluice Gate over Sharaskati Khal, Kalaroa Thana.

Sub-Project 3: Extension of Kismat Pucca Drain to Railway Line, Sadar Thana.

Sub-Project 6: Re-excavation of Chowdhury's canal from Basuri to Nalua River, Mollahat Thana.

Sub-Project 9: Reconstruction of Fatepur-Baitpur Embankment, Excavation of Khal and Construction of Two Sluice Gates, Bagerhat Thana.

Sub-Project 14: Sluice Gate at Parshikhali Khal, Fakirhat Thana.

Sub-Project 18: Re-excavation of Nalburia Dhansagar Khal, Sarankhola Thana.

E. Ranking of Sub-Projects, Rajshahi District

Table II-6 presents the ranking of sub-projects in the Rajshahi District.

Sub-projects 1 through 6 were recommended for selection. Sub-projects 7 through 15 were not recommended for the reasons discussed below:

Sub-Projects 7 and 8 were eliminated because no water users' group was effectively operating.

Sub-Project 9 was eliminated because an efficient water users' group did not exist. The Consultant also believes that this sub-project can be designed and developed by MRD's staff engineers.

Sub-Project 10 was eliminated because an efficient and effective water users' group does not exist and because the water supply is of questionable adequacy. Moreover, during the Consultant's visit to the sub-project area, it was difficult to determine exactly what the farmers wanted. The Consultant's perception of the sub-project does not agree with the sub-project description submitted by Thana officials to MRD.

Sub-Project 11 was eliminated because the Consultant believes that its implementation would not provide a significant model for MRD engineers, who are capable of designing and developing this sub-project at a later stage of this project.

Sub-Project 12 was eliminated because the proposed storage canal cannot hold enough water for irrigation. If a large dam is built, its construction and operation are beyond MRD's responsibilities.

Sub-Project 13 and 14 were eliminated because no water users' group was efficiently working.

Sub-Project 15 was eliminated because it is technically and economically inefficient as proposed. Crop lands adjacent and closer to the source of water can be irrigated more efficiently and more inexpensively. Furthermore, the water users' group was found to be inactive.

The Consultant's recommendations, notes, and completed questionnaires for each sub-project were submitted for review and approval by MRD and USAID, who selected sub-projects 1, 2, 3, 4, and 7, namely:

Sub-Project 1: Reexcavation of Canal from Beel Kutchua to Beel Pankha under Hatkalupara U.P., Atrai Thana.

Sub-Project 2: Low lift Pump Pucca Drain at Salinafar, Bagatipara Thana.

Sub-Project 3: Pucca canal and Spans Acqueduct in Milky Bidirpur, Nawabganj Thana.

Sub-Project 4: Sluice Gate at Padamari Dama, Gomostapur Thana.

Sub-Project 7: Nawapara Deep Tube Well Pucca Drain (1000 ft), Gurudaspur Thana.

F. Ranking of Sub-Projects, Rangpur District

Table II-7 presents the ranking of 16 sub-projects from the Rangpur District.

Sub-projects 1 through 9 were recommended for selection. Sub-projects 10 through 16 were not recommended for the reasons summarized below:

Sub-project 10 was eliminated because sufficient water cannot be stored in the canal to irrigate the sub-project crop lands. Moreover, initial cost estimates indicate that shallow tube wells would be more economical.

Sub-projects 11 and 12 were eliminated because they are too large and complex; therefore, they are considered to be beyond the scope of the Study.

Sub-projects 13 and 14 were eliminated because no effective, active water users' group exists. The Consultant also believes that water to be stored in the canals is adequate to irrigate only a very small tract of land.

Sub-project 15 was eliminated because the available water is inadequate to irrigate an economically large tract of land.

Sub-project 16 was eliminated because it would require the acquisition of a relatively large pump station.

The Consultant's recommendations, notes, and completed questionnaires for each sub-project were submitted for review and approval by MRD and USAID, who selected sub-projects 1, 2, 3, 4, 7, and 8, namely:

Sub-Project 1: Mouza Gobral Deep Tube Well Pucca Drain, Jaldhaka Thana

Sub-Project 2: Uttam Deep Tube Well Pucca Drain, Kotwali Thana

Sub-Project 3: Hatia Deep Tube Well Pucca Drain, Ulipur Thana

Sub-Project 4: Sluice Gate at Malibari U.P., Gaibanda Thana

Sub-Project 7: Patilvasar Nala Sluice Gate, Badarganj Thana

Sub-Project 8: Sluice Gate on Berubari Embankment at Nabularadara, Nageswari Thana

G. Ranking of Sub-Projects, Tangail District

Table II-8 presents the ranking of the 12 sub-projects in the Tangail District.

Sub-projects 1 through 9 were recommended for selection.

Sub-projects 10, 11, and 12 were not recommended for the following reasons:

Sub-projects 10 and 11 were not recommended because the Consultant believes that their development does not require its technical assistance. They can be designed and developed by MRD, at some later stage, with their present technical resources.

Sub-project 12 was eliminated because available crop land is inadequate for effective use of the pump.

The Consultant's recommendations, notes, and completed questionnaires for each sub-project were submitted for review and approval by MRD and USAID, who selected sub-projects 4, 5, 6, and 8, namely:

Sub-Project 4: Construction of Dubail-Basail DTW Drain, Basail Thana.

Sub-Project 5: Reexcavation of Godtala Mir-Kumilli Khal, Tangail Thana.

Sub-Project 6: Construction of Lowhati North DTW Pucca Drain, Nagarpur Thana.

Sub-Project 8: Construction of Sluice Gate over Deojan Khal, Patjrao Thana.

Section 6: Summary of Sub-Project Ranking

Table II-9 lists the 30 sub-projects selected and approved by MRD and USAID. Work at these sub-projects was performed according to the terms specified in the contract. Sub-projects are numbered from 1 to 30. These numbers are used extensively throughout this report to refer to specific sub-projects.

Figure II-1 shows the location of selected sub-projects in each district.

TABLE II-1

SPECIFIED CRITERIA, WEIGHT FACTORS, SCALES, AND MAXIMUM RATING

Criteria	Weight Factor	Scale	Maximum Rating
1. Probability of Irrigation System Providing Substantial Benefits to Poorer Landowners, Tenants, and Landless Laborers.	2.2	1-10	22
2. Existence of or Statement of Intent to Create a Local Institution Capable of Effective Construction, Operation, and Maintenance of the Irrigation System.	1.2	1-10	12
3. Potential for Increased Agricultural Production if Irrigation System is Constructed.	1.0	1-10	10
4. Likelihood of Fulfillment of Requirements for Low-Lift Pumps, Pipes, Manual Water Lifting Devices, etc., for Effective Use of Proposed System.	1.0	1-10	10
5. Availability of Agricultural Inputs (Seed, Fertilizer, Pesticides, Credit) in the Sub-Project Area.	1.0	1-10	10

(Continued)

TABLE II-1

(Continued)

Criteria	Weight Factor	Scale	Maximum Rating
6. Representative Example Characteristics for Future Sub-Project Design.	1.0	1-10	10
7. Easily Solved Land Acquisition Difficulties.	1.0	1-10	10
8. Approximate Cost of the Sub-Project	0.8	1-10	8
9. Lack of Negative Impact upon the Environment.	0.8	1-10	8
Maximum Possible Rating for All Criteria			100

TABLE II-2

RECOMMENDED CRITERIA FOR RANKING OF SUB-PROJECTS

Criteria	Scale Points
1. Socio-economic Criteria:	
1.1 Probability of Proposed System Providing Substantial Benefits to Poorer Landowners, Tenants, and Landless Laborers;	22
1.2 Existence of or Statement of Intent to Create a Local Institution Capable of Effective Operation, Maintenance and Repair of Proposed Structures; and	12
1.3 Easily Solved Land-Acquisition Difficulties	12
2. Agricultural Criteria:	
2.1 Potential for Increased Agricultural Production; and	14
2.2 Availability of Agricultural Inputs	12
3. Technical Criteria:	
3.1 Likelihood of Effective Operation of System; and	12
3.2 Construction of Sub-Project	16
Maximum Rating	100

TABLE II-3

RANKING FROM SURVEY/EVALUATION QUESTIONNAIRE OF CHITTAGONG DISTRICT SUB-PROJECTS SUBMITTED BY MRD

Rank	Sub-Project Name	Thana	Total Score
1	Re-excavation of Mohalia Khal	Satkania	98.0
2	Re-excavation of Khan Mohan Khal	Patia	96.4
3	Nabajugh Tebhage Kamer DTW Pucca Drain	Hathazari	86.3
4	Re-excavation of Karim Sikder Para Khal	Cox's Bazar	83.6
5	Re-excavation of Faranga Sublong Khal	Satkania	63.0
6	Mudhir Chara Khal Cross Dan and Excavation of Channel At Dissujahati	Maiscal	87.4
7	Chirengha Circular Embankment	Chakaria	86.8
8	Pucca Drain from Sanga River to Subujgram	Chandanaish	81.6
9	Construction of Dam on Sonaichari Chara	Mirsarai	77.0
10	North Mitachari Char Dam, Sluice Gate, and Re-excavation of Canal	Ramu	74.3
11	Pucca Sluice Gate on Bepula Chara	Hathazari	72.8
12	West Tala Nagar Sluice Gate	Sitakundu	64.1

TABLE II-4

RANKING FROM SURVEY/EVALUATION QUESTIONNAIRE OF DACCA DISTRICT SUB-PROJECTS SUBMITTED BY MRD

Rank	Sub-Project Name	Thana	Total Score
1	Mayda Palash DTW Pucca Drain	Palash	87.5
2	Pucca Drain for Dawtia DTW	Dhamrai	86.6
3	Parajikanda LIP Irrigation Canal	Bandar	86.0
4	Pucca Drain for Kawanara Irrigation Project	Saturia	85.6
5	Pucca Drain at Kaliakair DTW	Kaliakair	84.6
6	Tengra East DTW Drain	Sreepur	79.1
7	Rajghat DTW Pucca Drain	Savar	73.1
8	Northeast Shideshiput Tipe Scheme	Munshiganj	70.2
9	Embankment of Saldah River	Sreepur	55.2
10	Gazaria DTW Drain	Sreepur	92.0
11	Aricha-Ichamati Irrigation Project Parts I, II, III, and IV	Shivalaya	89.6
12	High Irrigation Pucca Drain	Palash	87.6
13	Kewa West DTW Drain	Sreepur	84.0
14	Re-excavation of Ichamati River	Harirampur	81.4
15	Ghasipukurpar TIP Scheme	Munshiganj	76.8
16	Over Head Earthen Drain for Nammar DTW	Dhamrai	60.2
17	Katabari DTW Pucca Drain	Dhamrai	0

TABLE II-5

RANKING FROM SURVEY/EVALUATION QUESTIONNAIRE OF KHULNA DISTRICT SUB-PROJECTS SUBMITTED BY MRD

Rank	Sub-Project Name	Thana	Total Score
1	Construction of Sluice Gate over Sharaskati Khal	Kalaroa	90.6
2	Construction of Pucca Drain for Patali DTW	Kalaroa	84.6
3	Extension of Kismat Pucca Drain to Railway Line	Sadar	78.0
4	Re-excavation of Laudove Khal from Kalikabat to Laudovo Trimohini	Dacope	91.4
5	Construction of Pucca Drain of Sultanpur	Kalaroa	89.0
6	Re-excavation of Chowdhury's Canal from Basuri to Nalua River	Mollahat	88.5
7	Re-excavation of Kalinagar Khal from Kalinagar Bazar to Kamargoda Nabi	Dacope	87.5
8	Paleghat Majhidanga Harikhali Embankment and Re-excavation of Khal	Bagerhat	87.1
9	Reconstruction of Fatepur-Baitpur Embankment, Excavation of Khal and Construction of Two Sluice Gates	Bagerhat	85.7
10	Re-excavation of Chulkati Margangi Khal	Bagerhat	84.6
11	Re-excavation of Pathamara Namar Khal	Morrelgonj	84.2
12	Re-excavation of Sanakandar Khal	Kachua	83.2
13	Re-excavation of Karishagar Magra Khal	Bagerhat	80.2
14	Sluice Gate at Parshikhali Khal	Fakirhat	78.7
15	Sluice Gate at Gojari Khal	Fakirhat	78.7
16	Re-excavation of Malikhura Khal	Satkhira	77.7
17	Construction of Pucca Drain from Kapatakhi River to Dhandia	Kalaroa	76.1
18	Re-excavation of Nalburia Dhansagar Khal	Sarankhola	75.6

TABLE II-6

RANKING FROM SURVEY/EVALUATION QUESTIONNAIRE OF RAJSHAHI DISTRICT SUB-PROJECTS SUBMITTED BY MRD

Rank	Sub-Project Name	Thana	Total Score
1	Re-excavation of canal from Beel Katchun to Beel Paukha under Hatkalupara U.P.	Atrai	92.4
2	Low Lift Pump Pucca Drain at Salinafar	Bagatipara	88.8
3	Pucca Canal and Spans Acqueduct in Milky Bidirpur	Nawabganj	85.7
4	Sluice Gate at Pabdamari Dama	Gomostapur	84.8
5	Re-excavation of Canal from Fahanahad Borobilla to Baranai River	Mohonpur	79.5
6	Excavation of the Chautahar Bagram Canal	Badalgachi	70.7
7	Nawapara DTW Pucca Drain	Gurudaspur	80.3
8	Nawapara Multipurpose Society DTW Pucca Drain	Gurudaspur	79.3
9	Re-excavation of Canal from Goalgram to Sankarpur Khari	Patuitola	79.2
10	Re-excavation of Canal from Piarpur to Shibe River	Mohanpur	79.1
11	Re-excavation of Canal from Sankarpur Shibanadi to Sankarpur Beel	Manda	78.9
12	Sluice Gate at Mohanandi Khali on Shalbagan Nawhate Khari	Paba	78.4
13	Re-excavation of Nalkhola Khal from Narad River to Paighat Beel	Natore	72.3
14	Samaskhali DTW Pucca Drain	Natore	72.3
15	Pagla Baluari Pucca Canal	Shibganj	67.8

TABLE II-7

RANKING FROM SURVEY/EVALUATION QUESTIONNAIRE OF RANGPUR DISTRICT SUB-PROJECTS SUBMITTED BY MRD

Rank	Sub-Project Name	Thana	Total Score
1	Mouza Gobral DTW Pucca Drain	Jaldhaka	92.6
2	Uttam DTW Pucca Drain	Kotwali	88.8
3	Hatia DTW Pucca Drain	Ulipur	88.8
4	Sluice Gate at Malibari U.P.	Gaibanda	88.0
5	Dakhin Bishnapur DTW Pucca Drain	Badarganj	86.4
6	Bridge-cum-regulator at Nawdanga	Fulbari	86.3
7	Patlivasar Nala Sluice Gate	Badarganj	84.0
8	Sluice Gate on Berubara Embankment at Nakulardara	Nageswari	84.0
9	Regulator over Mara-Dudkumar	Nageswari	83.0
10	Sluice Gate and Reexcavation of Akhira River	Pirganj	93.0
11	Sluice Gate on Ghagoa Kata River	Pirgacha	92.4
12	Bridge-cum-regulator for Gidari U.P.	Gaibanda	86.2
13	Sluice Gate on Paksilar Bander	Kaliganj	73.9
14	Water Control Structure Bridge-cum-regulator at Shishandaha	Palashbari	73.4
15	Bridge-cum-regulator on Canal of Sarghat Chara	Bhurungamari	57.2
16	Pucca Canal in Paikamchara U.P.	Bhurungamari	51.6

TABLE II-8

RANKING FROM SURVEY/EVALUATION QUESTIONNAIRE OF TANGAIL DISTRICT SUB-PROJECTS SUBMITTED BY MRD

Rank	Sub-Project Name	Thana	Total Score
1	Construction of Pucca Drain at Bhaura Madhayapara DTW	Mirzapur	86.0
2	Construction of Mominpur DTW Drain	Bhuapur	85.6
3	Construction of Baheratail DTW Drain	Shakipur	83.2
4	Construction of Dubail-Basail DTW Drain	Basail	82.8
5	Re-excavation of Godtala Mir-Kumilli Khal	Tangail	82.0
6	Construction of Lowhati North DTW Pucca Drain	Nagarpur	81.8
7	Construction of Paktipara DTW Drain	Madhupur	73.8
8	Construction of Sluice Gate at Deojan Khal	Pathrail	73.6
9	Construction of Pucca Drain for Kaliagram East DTW	Gathail	72.6
10	Re-excavation of Canal from Asgara to Shibpur Bairan River	Gopalpur	91.0
11	Re-excavation of Canal from Khanpara to Badaliata	Gopalpur	91.0
12	Construction of Ellenga DTW Drain	Kalihati	82.4

TABLE II-9

LIST OF SUB-PROJECTS SELECTED FOR DESIGN AND DEVELOPMENT BY MRD AND APPROVED BY USAID

Sub-Project Number	District	Thana	Sub-Project Name
1	Chittagong	Patia	Re-excavation of Khan Mohana Khal
2	Chittagong	Hathazari	Nabajugh Tebhage Khamer DTW Pucca Drain
3	Chittagong	Satkania	Re-excavation of Faranga Sublong Khal
4	Chittagong	Hathazari	Pucca Sluice Gate on Bepula Chara
5	Dacca	Saturia	Pucca Drain for Kawanara Irrigation Project
6	Dacca	Savar	Rajghat DTW Pucca Drain
7	Dacca	Sreepur	Embankment of Saldah River
8	Dacca	Shivalaya	Aricha-Ichhamati Irrigation Project. Parts I, II, III, and IV.
9	Dacca	Palash	High Irrigation Pucca Drain
10	Khulna	Kalaroa	Construction of Sluice Gate over Sharaskati Khal
11	Khulna	Sadar	Extension of Kismat Pucca Drain to Railway Line
12	Khulna	Mollahat	Re-excavation of Chawdhury's Canal from Basuri to Nalua River
13	Khulna	Bagerhat	Reconstruction of Fatepur-Baitpur Embankment, Excavation of Khal and Construction of Two Sluice Gates
14	Khulna	Fakirhat	Sluice Gate at Parshikhali Khal
15	Khulna	Sarankhola	Re-excavation of Nalburia Dhanasagar Khal

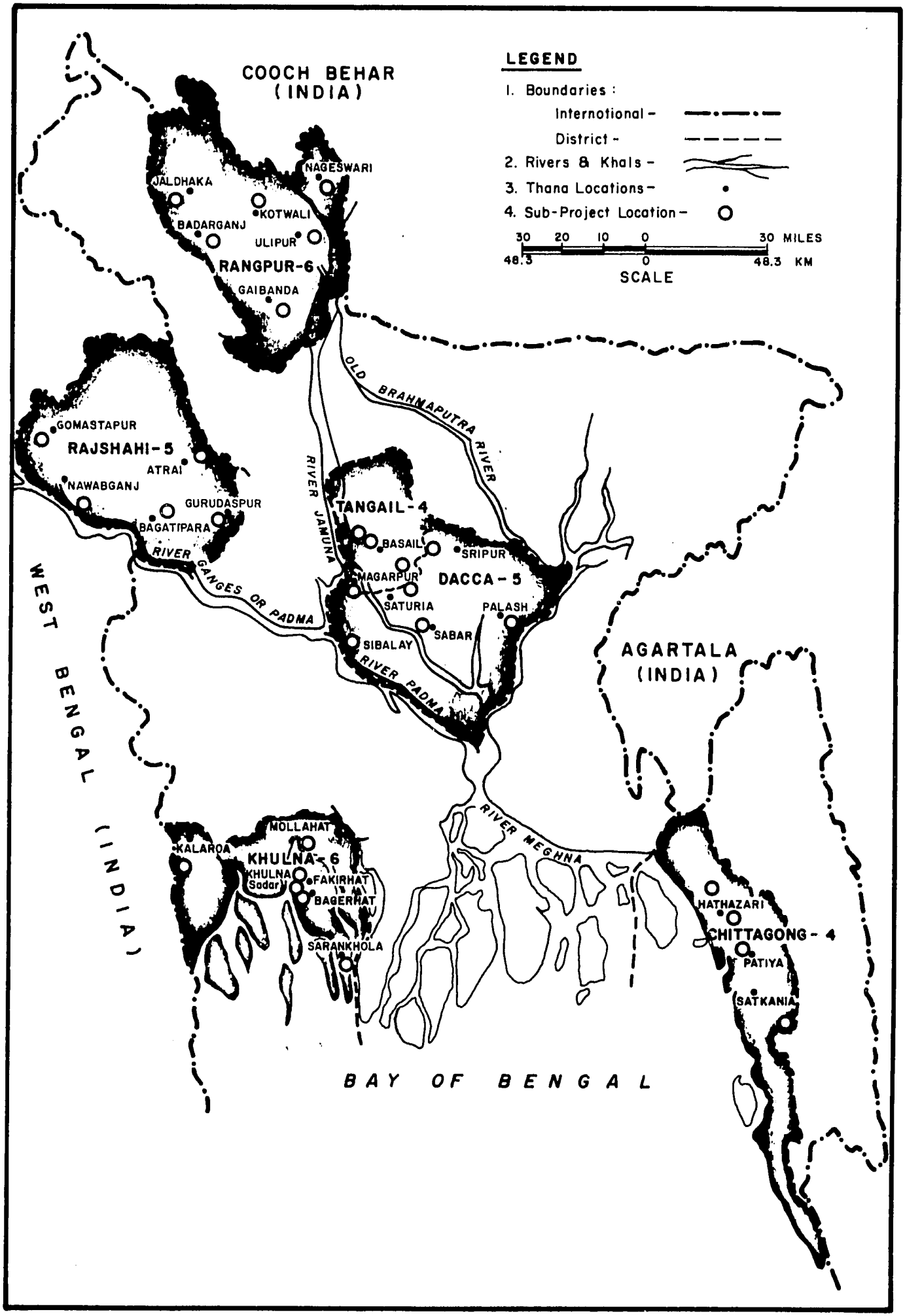
(Continued)

TABLE II-9

(Continued)

Sub-Project Number	District	Thana	Sub-Project Name
16	Rajshahi	Atrai	Re-excavation of Canal from Beel Katchua to Beel Pankha under Hatkalupara U.P.
17	Rajshahi	Bagatipara	Low Lift Pump Pucca Drain at Salinafar
18	Rajshahi	Nawabganj	Pucca Canal and Spans/Acqueduct in Milky Bidirpur
19	Rajshahi	Gomostapur	Sluice Gate at Pabdamari Dama
20	Rajshahi	Gurudaspur	Nawapara Multipurpose Society DTW Pucca Drain
21	Rangpur	Jaldhaka	Mouza Gobral DTW Pucca Drain
22	Rangpur	Kotwali	Uttam Deep Tube Well Pucca Drain
23	Rangpur	Ulipur	Hatia Deep Tube Well Pucca Drain
24	Rangpur	Gaibanda	Sluice Gate at Malibari U.P.
25	Rangpur	Badarganj	Patilvasar Nala Sluice Gate
26	Rangpur	Nageswari	Sluice Gate on Berubari Embankment at Nabulardara
27	Tangail	Basail	Construction of Dubail-Basail DTW Drain
28	Tangail	Tangail	Re-excavation of Godtala Mir Kumilli Khal
29	Tangail	Nagarpur	Construction of Lowhati North DTW Pucca Drain
30	Tangail	Pathrail	Construction of Sluice Gate at Deojan Kahl

FIGURE II - 1


LEGEND
1. Boundaries :
International -
District -
2. Rivers & Khals -
3. Thana Locations -
4. Sub-Project Location -
30 20 10 0 30 MILES
48.3 0 48.3 KM
SCALE
COOCH BEHAR (INDIA)
NAGESWARI
JALDHAKA
KOTWALI
BADARGANJ
ULIPUR
RANGPUR-6
GAIBANDA
OLD BRAHMAPUTRA RIVER
GOMASTAPUR
RAJSHAHI-5
ATRAI
NAWABGANJ
GURUDASPUR
BAGATIPARA
RIVER GANGES OR PADMA
RIVER JAMUNA
TANGAIL-4
BASAIL
SRIPUR
MAGARPUR
DACCA-5
SATURIA
PALASH
SABAR
SIBALAY
RIVER PADMA
WEST BENGAL (INDIA)
AGARTALA (INDIA)
RIVER MEGHNA
MOLLAHAT
KALAROA
KHULNA-6
KHULNA Sadar
FAKIRHAT
BAGERHAT
SARANKHOLA
HATHAZARI
CHITTAGONG-4
PATIYA
SATKANIA
BAY OF BENGAL

CHAPTER II

ANNEX A

CHAPTER II

ANNEX A

The following is the text of a letter sent to MRD by the Consultant, dated January 30, 1979 (file 1232/2, DA 2/79):

1. Notify the six District Commissioners by radio that MRD will send them, by February 4, 1979, a procedure by which they are to select a given number of sub-projects from the list of sub-projects already submitted.
2. Request the District Commissioners to arrange a meeting at a suitable time and place prior to February 10, 1979, between the user's representative, the union officials, and the Thana officials corresponding to the sub-projects already submitted to MRD. MRD should clearly indicate which officials should be present to ensure that the user's interests are properly considered and that the necessary TIP forms can be expeditiously completed for the selected sub-projects immediately after the selection process has been completed.
3. Issue the selection guidelines so that they arrive at the various District Commissioners' offices no later than February 4, 1979.
4. Instruct the District Commissioners to submit the people's selection on a standard form provided, no later than February 15, 1979.
5. Instruct the district Commissioners to complete the TIP form for the selected sub-projects and submit them to MRD no later than February 28, 1979.

To determine the number of sub-projects to be selected from each District, two different approaches were used. The results of these two approaches and the recommendations made to MRD appear in Tables II A-1 through II A-4.

Attached to the above letter was the following format letter, which specifies the procedure for the selection of sub-projects:

To: District Commissioner of _____ District

From: Ministry of Local Government, Rural Development and Co-operatives

Subject: Procedure for selection of _____ sub-projects from those submitted to MRD prior to January 25, 1979.

Under the Rural Irrigation Works Study, a total of ___ sub-projects are to be selected from those already submitted by your District to MRD prior to January 25, 1979. This selection process is to be carried out as follows:

1. It is important that selection of the ___ sub-projects be undertaken by the beneficiaries of the sub-projects to the greatest extent possible. You should, therefore, arrange for selection to be made at a suitable meeting at which at least representatives from the water users' group, Union, and Thana officers are present.
2. The criteria to be used in the selection of the ___ sub-projects are as follows:
   a. Each sub-project must be a complete small irrigation scheme, in which all related infrastructure elements required for its efficient operation are included.
   b. The total cost of the sub-project must be between Tk 20,000 and Tk 300,000.
   c. The landowners affected by the sub-project must be willing to donate whatever land is required for construction of facilities.
   d. There must be an existing water users' group covering the entire sub-project area.
   e. The water users' group, the Union, the Thana, or a combination of these organizations must be willing to operate and maintain the sub-project.

f. The main source of water must remain unsilted for not less than five years if the sub-project entails provision, use or re-excavation of waterways. If a sub-project involves a tube well, it must already be installed in the area.

g. If the sub-project is to receive its water supply from BWDB project, then BWDB must agree to the sub-project operating off their system.

h. The sub-project must be labor intensive.

3. The final selection of sub-projects is to contain the following numbers of sub-projects in the given size categories:

- approximately ____ (2/3) of the ____ sub-projects should irrigate a total area of less than 200 acres.
- approximately ____ (1/6) of the ____ sub-projects should irrigate a total of 200 to 500 acres.
- approximately ____ (1/6) of the ____ sub-projects should irrigate a total of 500 to 1000 acres.

4. After selection of the ____ sub-projects, Table II A-5 is to be prepared and returned to MRD.

TABLE II A-1

APPROACH I

CRITERIA AND WEIGHTED RATING FOR SELECTION
OF NUMBER OF SUB-PROJECTS FROM EACH DISTRICT

Criteria	District	Rating (1-10)	Weight	Weighted Rating
1. Degree of Development	Chittagong	3 (least)	5	15
	Dacca	6	5	30
	Khulna	7	5	35
	Tangail	8	5	40
	Rajshahi	9	5	45
	Rangpur	10	5	50
2. Existing Area of Boro Crop	Chittagong	5 (greatest)	20	100
	Dacca	6	20	120
	Tangail	8	20	160
	Khulna	9	20	180
	Rangpur	10	20	200
	Rajshahi	10	20	200
3. Dry Season Unemployment	Dacca	10 (greatest)	25	250
	Tangail	9	25	225
	Chittagong	6	25	150
	Khulna	6	25	150
	Rangpur	6	25	150
	Rajshahi	6	25	150

(Continued)

TABLE II A-1

(Continued)

	Criteria	District	Rating (1-10)	Weight	Weighted Rating
4.	Food Deficit	Rangpur	3 (least)	30	90
		Rajshahi	4	30	120
		Khulna	4	30	120
		Chittagong	5	30	150
		Dacca	9	30	270
		Tangail	10	30	300
5.	Existing Cultivable Area	Tangail	3 (least)	20	60
		Chittagong	5	20	100
		Dacca	6	20	120
		Rangpur	7	20	140
		Rajshahi	7	20	140
		Khulna	10	20	200

TABLE II A-2

SUMMARY OF APPROACH I

TOTAL WEIGHTED POINT AND NUMBER OF SUB-PROJECTS
RECOMMENDED FOR SELECTION

District	Total Weighted Points	Number of Sub-Projects
Chittagong	515	11
Dacca	790	18
Khulna	685	15
Rajshahi	655	15
Rangpur	630	14
Tangail	785	17

TABLE II A-3

APPROACH II

CRITERIA AND NUMBER OF SUB-PROJECTS
RECOMMENDED FOR SELECTION

District	Population/ % of total	Area (square miles/ % of total)	2/3 Pop % + 1/3 area	Number of sub-projects
Chittagong	4,324,000	2786		
	15.9%	14.7%	15.4%	14
Dacca	7,607,000	2880		
	27.9%	15.2%	23.6%	21
Khulna	3,552,000	4630		
	13.0%	24.4%	16.9%	15
Rajshahi	4,266,000	3653		
	15.7%	19.3%	16.9%	15
Rangpur	5,428,000	3701		
	19.9%	19.5%	19.8%	18
Tangail	2,072,000	1309		
	7.6%	6.9%	7.4%	7

TABLE II A-4

APPROACHES I AND II

FINAL RECOMMENDATION OF NUMBER
OF SUB-PROJECTS FOR SELECTION

District	Number of sub-projects
Chittagong	12
Dacca	20
Khulna	15
Rajshahi	15
Rangpur	16
Tangail	12
Total	90

TABLE II A-5

GENERAL INFORMATION ABOUT SUB-PROJECTS

Description	Sub-Project Number					
	1	2	3	4	5	6
1. Location						
- District						
- Sub-Division						
- Thana						
- Union						
- Village						
2. Date Previously Submitted to MRD.						
3. Estimated Total Cost.						
4. Brief Description of Sub-project.						
5. Area of New Irrigation System (acres).						
6. Area of Existing Irrigation System (acres).						
7. Number of Low-Income Beneficiaries.						
8. Approximate Person-months Required for Construction of Sub-project.						

CHAPTER II

ANNEX B

Survey/Evaluation Questionnaire

CHAPTER II, ANNEX B

MINISTRY OF LOCAL GOVERNMENT

RURAL DEVELOPMENT AND COOPERATIVES

SURVEY/EVALUATION QUESTIONNAIRE

Thana Meeting, Dated: _____

PRESENT	NAME
People's Representative	
Chairman Thana Development Committee	_____
Secretary Thana Development Committee	_____
Chairman Union Parishad	_____
Government Representatives	
Assistant Commissioner/Thana Circle Officer (Development)	_____
Thana Irrigation Officer, BADC	_____
Thana Agricultural Officer	_____
Thana Extension Officer	_____
Thana Project Officer, IRDP	_____
Thana Co-operative Officer	_____
Thana Irrigation Program Overseer	_____
Union Agricultural Assistant	_____

Item Description	Sub-Project Details
Project Name	
District	
Sub-Division	
Thana	
Union	
Village	
Name of Team Leader	
Total Proposed Project Area (acres)	
Area of Existing Irrigation System (acres)	

SCREENING QUESTIONS

The following questions will be asked before the "Survey/Evaluation Questionnaire" is completed:

1. Does an organized water users' group exist? If not, are farmers intending to form one? Yes _____ No _____

2. Is adequate water supply available for irrigation of sub-project area during dry season? Yes _____ No _____
   (If sub-project is mainly a drainage sub-project or a flood protection sub-project, do not answer this question.)

3. Is area to be irrigated equal to at least 50 acres per cusec of pumping capacity? Yes _____ No _____
   (If no pumps are involved in sub-project, do not answer this question.)

   Are farmers willing to accept construction of facilities (such as reservoirs and property-crossing ditches) other than those submitted previously to MRD? Yes _____ No _____

5. Does this sub-project require the acquisition of new pumps? Yes _____ No _____

6. Is this sub-project too large and complex to be designed, constructed, and cperated with MRD capabilities? Yes _____ No _____

7. Will the proposed system adversely affect neighboring crop lands or have any negative environmental effects? Yes _____ No _____

8. Can the water intended to irrigate the proposed area be used to irrigate crop lands closer to the source of water or be used for a better alternative use? Yes _____ No _____

If questions 4, 6, 7, or 8 have a positive answer, or if questions 1, 2, 3, or 5 have a negative answer, the survey/evaluation questionnaire will be completed, but the sub-project will not be considered for design and development by the MRD.

1. Socio-Economic Criteria

1.1 Probability of Irrigation System Providing Substantial Benefits to Poorer Land Owners, Tenants, and Landless Laborers.

Scale Points

1.1.1 Is the average farm size in the sub-project area between: (Check one.)

Less than 3 bighas? --------- 5 Points

3 - 6 bighas? ---------- 3 Points

6 - 9 bighas? ---------- 1 Point

More than 9 bighas? --------- 0 Points _____

1.1.2 Size in bighas of 5 largest farms in sub-project area: _____

Total area of 5 largest farms: _____

Is this total area equal to or greater than 25% of the proposed sub-project area?

Yes _____ 0 Points, No _____ 4 Points _____

1.1.3 Percentage of farmers in sub-project area which own 5 bighas or less of crop land. (Check one.)

0 - 20% ---------- 0 Points

20 - 40% ---------- 1 Point

40 - 60% ---------- 3 Points

More than 60% -------- 5 Points _____

1.1.4 Is there severe unemployment of landless laborers during rabi season?

Yes _____ 5 Points, No _____ 0 Points _____

1.1.5 Are there any farms on the proposed irrigated area with crop land equal to or in excess of 10% of the total proposed sub-project area? (i.e. a farm of 10 bighas in a 100-bighas project area.)

Yes _____ 0 Points, No _____ 3 Points _____

Total Score _____

Maximum Score 22.0

1.2 Existence of or Statement of Intent to Create a Local Institution Capable of Effective Construction, Operation, Maintenance, and Repair of Proposed Structures

Scale Points

1.2.1 Does a cooperative society registered under the KSS & TCCA exist?

Yes _____ 2 Points, No _____ 0 Points _____

1.2.2 Does a water users' group exist?

Yes _____ 3 Points, No _____ 0 Points _____

If not, have steps been taken to form one?

Yes _____ 1 Point, No _____ 0 Points _____

1.2.3 Have they worked as a group on any operation and maintenance program of an irrigation or drainage system before?

Yes _____ 1 Point, No _____ 0 Points _____

1.2.4 Are potential water users willing to provide voluntary labor (no pay) in the construction of proposed facilities?

Yes _____ 2 Points, No _____ 0 Points _____

1.2.5 Are water users willing to pay water charges in amount enough to cover operation, maintenance, and repair costs of proposed system?

Yes _____ 4 Points, No _____ 0 Points _____

Total Score _____

Maximum Score 12.0

1.3 Easily Solved Land Acquisition Difficulties

		Scale Points
1.3.1	Are the farmers willing to donate land for development of sub-project? Yes _____ 6 Points, No _____ 0 Points	_____
1.3.2	Are new land irrigation facilities displacing people's households? Yes _____ 0 Points, No _____ 3 Points	_____
1.3.3	Have they donated land for any community development project before? Yes _____ 3 Points, No _____ 0 Points	_____
	Total Score	_____
	Maximum Score 12.0	

2. Agro-Climatic Criteria

2.1 Potential for Increased Agricultural Production

		Scale Points
2.1.1	Do you expect increased crop yields during Kharif season with sub-project development? Yes _____ 2 Points, No _____ 0 Points	_____
2.1.2	Do you expect increased crop yields during Rabi season with sub-project development? Yes _____ 2 Points, No _____ 0 Points	_____
2.1.3	In relation to actual crop intensity, will sub-project development increase crop intensity by: Check one 0 - 50% ---------- 0 Points 50 - 100% ---------- 4 Points 100 - 150% ---------- 6 Points More than 150% -------- 8 Points	_____
	Total Score	_____
	Maximum Score 14.0	

2.2 Availability of Agricultural Inputs

		Scale Points
2.2.1	Reliability of supplies	
	HYV seeds: Good ----- 2 Points	
	Fair ----- 1 Point	
	Bad ----- 0 Points	_____
	Pesticide: Good ----- 1 Point	
	Fair ----- 1/2 Point	
	Bad ----- 0 Points	_____
	Fertilizer: Good ----- 1 Point	
	Fair ----- 1/2 Point	
	Bad ----- 0 Points	_____
2.2.2	Are inputs (fertilizer, seeds, and insecticides) obtained at official prices?	
	Yes _____ 2 Points, No _____ 0 Points	_____
2.2.3	Source of credit to small farmers:	
	Cooperative Societies: ----- 2 Points	
	Local Agricultural bank: ----- 2 Points	
	Others: ----- 0 Points	_____
	(If there is more than one source, indicate only the principal one.)	
2.2.4	Is farm labor readily available during Kharif season?	
	Yes _____ 2 Points, No _____ 0 Points	_____
2.2.5	Is farm labor readily available during Rabi season?	
	Yes _____ 2 Points, No _____ 0 Points	_____
	Total Score	_____
	Maximum Score 12.0	

3. Technical Criteria

3.1 Likelihood of Effective Operation of System

Scale Points

3.1.1 How do irrigated crops in the area look?

Good -------- 2 Points

Bad -------- 0 Points _____

(If no irrigation available, enter 2 points.)

3.1.2 Is the supply of mechanical equipment, fuel, oil, and trained mechanics readily available?

Yes _____ 2 Points, No _____ 0 Points _____

(Enter 2 points if no mechanical equipment is included in the sub-project.)

3.1.3 Is the supply of trained labor for maintenance and repair of proposed structures easily available?

Yes _____ 2 Points, No _____ 0 Points _____

(Enter 2 points if there are no structures in the sub-project.)

3.1.4 Are farmers willing and enthusiastic about project development?

Yes _____ 4 Points, No _____ 0 Points _____

3.1.5 How are existing irrigation, drainage, and/or flood protection facilities maintained?

Good -------- 2 Points

Bad -------- 0 Points _____

Total Score _____

Maximum Score 12.0

3.2 Construction and Development

Scale Points

3.2.1 Approximately what percentage of the total construction cost of sub-project is attributed to unskilled labor?

Less than 25% ---------- 0 Points

26% to 50% ---------- 2 Points

51% to 75% ---------- 7 Points

More than 75% ---------- 12 Points _____

3.2.2 Are materials needed for construction of proposed structures locally available?

Yes _____ 4 Points, No _____ 0 Points _____

Total Score _____

Maximum Score 16.0

SIGNATURES

Assistant Commissioner of Thana _____

Chairman of Union Parishad _____

Union Agricultural Assistant _____

Chairman of Thana Development Committee _____

MRD Representative _____

CHAPTER III
AGRICULTURE

Section 1: General Description

Agriculture is a mainstay of the social and economic life of Bangladesh. Nearly 90 percent of the country's population is engaged in agriculture; of the labor force, 75 percent is employed in agricultural activities; and agriculture contributes 56 percent of the gross national product (Oswal, 1979).

Rice is the major food crop and is grown on about 80 percent of the total cropped land. However, at present the country is producing only 11.8 million tons of clean rice annually for its 86 million people. This results in a food deficit of nearly 2 million tons, which is currently being provided through imports (BRRI, 1978).

There are numerous constraints to agricultural production. Of the land suitable for cultivation, 95 percent is under agricultural production, thus severely limiting the development of new agricultural lands. Nearly half of the households have one acre or less of land; with continued population growth, the farm size in the future will become even smaller. Crop yields and cropping intensities are among the lowest in the world. Production is frequently reduced due to climatic extremes, which range from flooding to drought. The use of inputs -- such as fertilizer, improved seeds, and insecticides -- is much lower than required for sustained high levels of production. This may be caused by the farmers' economic condition, by the unavailability of credit, and by the uncertainty of required supplies. At present, one-third of the cultivated land is double-cropped, and only 6 percent is triple-cropped.

However, opportunities are available to improve the future situation. These include expanding irrigated agriculture, developing appropriate crop and water management programs, improving cropping patterns and intensities, strengthening the extension service, establishing reliable sources of inputs, and making available credit with reasonable pricing through a fair marketing system.

The expansion of irrigated agriculture has the potential to increase both crop yields and cropping intensities by making water available during the dry season. The assurance of irrigation water would also provide an incentive for the farmer to increase the level of inputs used. If this incentive could then be supported with improved crop and water management programs, with assured sources of material supplies and credit, and with a strong marketing system, the agricultural production could show a dramatic improvement. It is equally essential that these support items also be extended to the non-irrigated sector, since only about 13 percent of the cultivated lands are currently under irrigation.

Section 2: Crop Calendars

Bangladesh has two main growing seasons. The kharif season, sometimes referred to as the summer or wet season, spans the months of April through September. The rabi season, sometimes referred to as the winter or dry season, is from October through March.

Generally, there are specific crops suitable for each of these major seasons. There are, however, some instances where certain crops may be sown in one season and harvested in another. In developing cropping patterns for a sub-project, a crop calendar should be prepared for each proposed crop. The crop calendar presents the total period of time required for the crop from seeding to harvest. From these crop calendars it is possible to determine which crops can best be combined in a one year growing period. Working out a suitable crop calendar is a first step in developing sub-project cropping patterns. Additional factors are discussed in the section on Cropping Patterns.

Figure III-1 presents the crop calendars for major crops grown in Bangladesh.

Section 3: Cropping Patterns

This section outlines a procedure for evaluating and improving cropping patterns for an existing or proposed sub-project. The basis for this discussion is a paper entitled "How to Improve Cropping Patterns", August 1978, by Hugh Brammer, FAO Project Manager, Soil Survey Interpretation Division, Department of Soil Survey, Dacca.

A. Factors Influencing Cropping Patterns

Crop suitability and cropping patterns are influenced both by physical and socio-economic factors. Physical factors include land, soil, and climatic conditions can be classified according to types of land, floods, drainage, soil permeability, soil moisture holding capacity, and soil properties.

1. Land types are based upon the land position as related to the depth of flooding during the rainy season. Brammer defines five land types: highland, medium highland, medium lowland, lowland, and bottomland.

a) Highland is normally above flood level. During years of very high flood, fields may be flooded for a short period of time.

b) Medium Highland is normally shallowly flooded to a maximum depth of less than 3 feet. If the soils are suitable, this land type may be used for aus or transplanted aman.

c) Medium Lowland is normally moderately deeply flooded to a maximum depth of 3 to 5 feet. This is too deep for growing ordinary transplanted aman varieties. It is possible to grow mixed aus and broadcast aman if the soils are suitable.

d) Lowland is normally flooded to a depth greater than 5 feet. Usually, this land type is used for growing boro during the winter season and for broadcast aman during the summer. The flood level is too great for ordinary aus and transplanted aman varieties.

e) Bottomland is usually in a depression, where flooding is greatest, and remains wet for most or all of the dry season. Boro and transplanted deepwater aman varieties are the usual crop grown in these areas.

2. Flood types assist in determining whether or not it is safe to grow boro, aus or broadcast aman. Three types of flooding are defined by Brammer: early flooding, normal flooding, and flash-flooding.

a) Early flooded land may be flooded during early heavy rainfalls prior to the onset of monsoon rains. Lands in this category are not well suited to aus, aman, or boro because flood damage is likely to occur once in every two-to-three years.

b) Normally flooded land are normally not flooded before June or July. Damage seldom occurs more than once in three-to-five years when the rains may begin very early, resulting in high river levels. In most cases, boro, aus, broadcast aman, and jute are not severely damaged by flooding.

c) Flash-flooded land generally consists of lands located near the foothills, near rivers flowing from the hills, in valleys within the hill acreas, or in the Madhupur and Barind tracts and result from unusually heavy rainfall. These floods can occur at any time and may cause damage to boro, aus, broadcast aman, transplanted aman, and early winter crops.

3. Drainage types are based upon the times at which floodwaters normally drain off. This timing determines when the rabi (winter) crops can be grown. Brammer defines three drainage classes: early draining, normal draining, and late draining.

a) Early draining land is normally free of floodwater by September or October, thus allowing early rabi crops to be grown where soils are suitable. These crops could include early vegetables, tobacco, sweet potatoes, and mustard.

b) Normally draining land normally becomes free of floodwater sometime during the period between the end of October and mid-December. In areas with suitable soils, middle rabi crops can be grown; these include wheat, barley, potatoes, lentil, gram, oilseeds, and spices.

c) Late draining land normally remains wet after mid-December. In areas where the land drains by the end of January, late rabi crops such as sesame, kaon, sorghum, chili, cowpea, khira, and melon may be grown. Boro may also be grown, where soils are suitable, both with and without irrigation, depending upon when the soils dry out.

4. Soil permeability indicates the rate at which water passes through the soil. It significantly influences the types of crops suitable for certain areas. Permeability is related directly to soil texture, which is determined by the amounts of sand, silt, and clay and the size and number of pores in the soil. Three types of soil permeability can be identified: permeable, moderately permeable, and impermeable.

a) Permeable soils do not hold water on the surface more than a few hours after a heavy rain or a heavy irrigation. Normally, these soils are not suitable for boro or transplanted aman unless the area is naturally flooded or wet throughout the growing season.

b) Moderately permeable soils usually retain water on the surface for two-to-three days after a heavy irrigation or rain. This may make these areas unsuitable for crops, such as wheat, maize, and vegetables, that cannot tolerate wet conditions during their seedling stage. Normally, these soils are unsuitable for boro or transplanted rice. In areas of high rainfall, it may be possible to grow transplanted aman on medium highland sites.

c) Impermeable soils will normally retain water on the surface for one week or more following heavy rainfall or irrigation. Most floodplain clay soils are naturally impermeable. The puddling process used in preparing land for transplanted rice changes the naturally permeable silt loam and clay loam soils to impermeable soils suitable for rice cultivation. It should be noted that this puddling process may make naturally permeable soils unsuitable for dry land rabi crops unless the topsoil is thoroughly broken up before seeding.

5. The moisture-holding capacity of a soil determines how well the soil holds moisture for the plant's use. The moisture-holding capacity is directly related to soil texture and soil porosity. Organic matter content also affects this capacity. Brammer classifies soil moisture-holding capacities as good, moderate, or poor.

a) Good moisture-holding capacity is usually characteristic of deep, loamy or have a water table relatively close to the surface during the dry season. These soils will normally hold sufficient water after the rainy season to grow a dryland rabi crop (such as wheat, pulses, or oilseeds) without irrigation or to receive sown aus, jute, or broadcast aman in February and March without waiting for the first rain showers to occur.

b) Moderate moisture-holding capacity is characteristic of deep sandy loams, moderately deep silt loams, clays, or clay loams. These soils normally hold sufficient water after the rainy season to grow an early rabi crop (such as mustard) or a quick-maturing middle rabi crop (such as wheat, pulses, or oilseeds) without irrigation; however, yields may be low without favorable winter rains or irrigation.

c) Poor moisture-holding capacity is characteristic of various soils: loose sands; heavy clays that quickly dry and crack; some areas that have been puddled for transplanted aman, resulting in a strong ploughpan or a compacted layer; red and brown soils in the Madhupur and Barind tracts; and most hill soils. These soils do not hold sufficient moisture for rabi

crops unless irrigation is available or unless very favorable winter rains occur. Highland and medium highland areas suffer from drought during the rainy season if there is a one-to-two week period without rainfall. Frequent irrigation is required for sandy and shallow, loamy soils.

6. Several soil properties significantly influence cropping patterns and management practices. Properties listed by Brammer include: subsoil texture; organic matter content; chemical properties, such as salinity; soil parent material; soil moisture properties determined by flooding, drainage, permeability and moisture-holding capacity; and soil disturbance resulting from man's activities.

Several sources of information are available to determine the soil properties of a specific site. Very important to these determinations are field observations and questioning of farmers regarding existing cropping patterns, crop rotation, crop conditions, flooding, and drainage characteristics. Field observations should consider the texture of the subsoil and substratum, particularly where there appear to be changes in land and drainage type. Also important to these determinations are reviews of the District reconnaissance soil survey reports prepared by the Soil Survey Department of Bangladesh, which provides essential information on soil associations and land use. By combining all of these sources of information, general soil types can be defined and their influence on cropping patterns and management practices determined.

B. Main Existing Cropping Patterns

Brammer (1978) outlines nine traditional cropping patterns used by farmers in Bangladesh: aus-rabi crops, aus-transplanted aman-fallow, transplanted aman-fallow, mixed aus and broadcast aman-rabi crops, broadcast aman-fallow, boro-fallow, boro-transplanted aman, jhum cultivation, and perennial crops.

1. Aus-rabi cropping constitutes the main pattern practiced on permeable highland and medium highland soils, particularly in the central and western districts. These areas are usually located on higher floodplain ridges, on raised soil platforms, or on the red soils of the Madhupur and Barind tracts. Perhaps ten-to-thirty percent of the aus acreage may be planted to jute, particularly on loamy soils in medium highland areas. Mesta and kharif groundnuts may replace small portions of the aus acreage on soils having a poor moisture-holding capacity. Rabi crops are generally determined by soil moisture-holding capacity. Soils having a moderate-to-good moisture-holding capacity are suitable for wheat, barley, mustard, lentils, gram, sweet potatoes, rabi groundnuts, and vegetables. Soils having a poor moisture-holding capacity are best suited for early rabi crops, such as mustard.

2. Aus-transplanted aman-fallow constitutes a major cropping pattern practiced on moderately impermeable or impermeable soils in highland and medium highland positions on the Teesta floodplain, on higher portions of the Brahmaputra floodplain, in Bhola, in northeastern parts of the Barisal mainland, on some grey soils of the Madhupur and Barind tracts, and on some foothill land. The amount of aus acreage being transplanted rather than broadcasted, and the use of high yielding varieties are increasing. Portions of the aus acreage may be replaced by jute, especially on the Teesta and Brahmaputra floodplains. Most of the transplanted aman varieties following aus or jute are local or locally improved varieties; however, where aus and jute can be sown early, HYV transplanted aman can be grown. In areas where the topsoil has been puddled for the transplanted aman crop, the planting of a rabi crop may be limited and in some cases may result in the lands staying fallow during the winter.

3. Transplanted aman-fallow constitutes a pattern practiced mainly on impermeable loams and clays in highland and medium highland positions. It is practiced mainly in the Rajshahi District, along coastal areas in Khulna Division, on the Noakhali

charland, in northern Dinajpur, and in western portions of Jessore. This practice of single-cropping may result from low rainfall, but it is more often due to larger land owners' satisfaction with one crop; however, the amount of double-cropping does appear to be increasing in all of these areas.

4. Mixed aus and broadcast aman-rabi cropping occurs on medium lowlands of the Brahmaputra, the Jamuna, the Ganges, and the old Meghna floodplains in the Districts of Bogra, Pabna, Rajshahi, Faridpur, Dacca, Tangail, Mymensingh, and Comilla. The soils are usually moderately permeable and have a good moisture storage capacity, and the lands normally drain by October or November. This is the major triple-cropping area found in the country. Mixed aus and aman constitute the double-cropping and are followed by a rabi crop. Therefore, the land is used throughout the year. Jute may be substituted for mixed rice in areas, such as the main river channels, where there is a greater risk of early or high floods. Many different rabi crops are found in this pattern. Some farmers broadcast mustard, mashkalai, and lentil in the aman crop two-to-three weeks before harvest. In some areas, such as the western portion of Comilla District, the early rabi crop may be followed by a late rabi crop (such as sesame, kaon, or chili). In other cases, farmers plough the land after aman is harvested and then sow wheat, barley, potatoes, mustard, gram, lentil, onions, or spices.

5. Broadcast aman-fallow constitutes the main cropping pattern practiced in the lowland areas of the Brahmaputra, the Jamuna, the Ganges, and the Meghna floodplains in the Pabna, Rajshahi, Faridpur, portions of Jessore, northern Barisal, Dacca, Tangail, Mymensingh, Kishorganj, Comilla, and Sylhet Districts. Normally, flooding is too deep in July and August to mix aus with the aman crop, and much of the land is too wet in December and January for a rabi crop. Jute is sometimes substituted for the aman where the topsoils are loamy. In years of low flood levels, it is possible to broadcast khesari and mustard in the standing aman

crop prior to its harvest.

6. Boro-fallow constitutes the usual cropping pattern in lowland and bottomland areas where the soil is wet most or all of the dry season or where irrigation is available. These lands are common in all of the major floodplains, in Noakhali north of the char areas, in deep valleys of the Madhupur tract, and in some hill areas. Some farmers, especially in the Dacca and Comilla Districts, follow the boro crop with a transplanted deep-water aman crop.

7. Boro-transplanted aman constitutes the main rotation practiced on impermeable highland and medium highland areas where irrigation is available. Typical areas for this pattern are the Brahmaputra, the Teesta, and the Ganges floodplains; parts of the tidal clay areas in the Khulna Division; and the gray soil areas of the Madhupur and Barind tracts.

8. Jhum cultivation is used in the Chittagong Hill Tracts. It involves clearing and burning the natural vegetation during the dry season and then sowing a mixture of summer crops (such as aus-type rice, sesame, beans, gourds, and hill cotton). After one or two years, the land is abandoned to remain idle for several years.

9. Perennial crops include tree crops (such as mango) or field crops occupying the land most or all of the year (such as sugarcane, ginger, and pineapple). This type of cropping is practiced on the permeable highland soils: on the high floodplain ridges in the western portion of the Ganges floodplain, in parts of Rangpur and Dinajpur, on the deep red soils of the Madhupur and Barind tracts, on the hill soils, and in homestead areas. At times, farmers practice this cropping on lands normally used for aus-rabi crop rotation. Sometimes intercropping of perennial crops with quick maturing field crops occurs.

C. Recommended Cropping Patterns With Irrigation

When irrigation water becomes available to the farmers, such as through DTW's and LLP's, their traditional cropping patterns must be examined and carefully modified where appropriate. Table III-1 outlines improvements that could be made to each of the nine traditional croppings patterns upon introduction of available irrigation water (Brammer, 1978).

The following information on four of the recommended irrigated cropping patterns should be considered when determining the most appropriate cropping system for an irrigation sub-project:

1. Aus (HYV)/Jute - T. aman (HYV) - Rabi crops (wheat/mustard/potatoes): Wheat and similar rabi crops are most ideally suited for rotations not having transplanted rice. In cases where transplanted rice is a part of the rotation, as it is in this cropping pattern, certain techniques should be used to obtain maximum crop production. Wheat and other rabi crops that are to be grown on naturally impermeable soils or on puddled lands should be sown on ridges or raised beds to prevent water logging damage (Brammer, 1978). Also necessary, is the careful control of water in order to prevent over-irrigation, which results in damage to the seedlings. It is important to ensure that any plough pan created for the transplanted rice be broken up to allow penetration of both roots and irrigation water. This means that the fields must be re-puddled for subsequent transplanted rice crops. These operations increase the labor required for land preparation for both types of crops.

2. Boro (HYV): When boro (HYV) is introduced under irrigated conditions to replace the traditional mixed aus and broadcast aman-rabi crop pattern, it is important to determine which cropping pattern gives the farmer the greatest financial return for each specific sub-project area. The mixed aus and broadcast aman-rabi crop pattern is the major triple-crop pattern practiced in Bangladesh and it seems likely that, in some applications, the single boro crop has given lower financial returns than the

triple-crop system (Hobbs, Clay, and Hogue, 1979).

3. Boro (HYV)-Transplanted deep water aman: Some farmers are experimenting with transplanting deep water aman following the boro crop. The yields of transplanted aman are somewhat reduced, but the farmer still receives the boro crop, plus the "bonus" aman production (Hobbs, Clay, and Hogue, 1979). This practice needs further experimentation before its widespread use is recommended.

4. Boro (HYV) - Transplanted aus (HYV/LIV) - Transplanted aman (LIV): This triple-rice-crop pattern is possible using an early maturing boro (HYV), harvested by April or May, followed by a quickly maturing transplanted aus (HYV/LIV/LOCAL) harvested in August, and followed by transplanted aman (LIV or Local). However, this cropping pattern requires a high degree of management, proper irrigation, and high levels of fertilizer and labor (Brammer, 1978). The BRRI reports two problems with triple-cropping of rice in some areas: First, soils kept in a continuously wet condition may have increasing amounts of iron, which can be harmful to the rice plants. Second, continuously flooded, heavy silt and clay soils may lose their capability to support the weight of animals and people and must be periodically allowed to fallow and dry. Due to high input requirements and other problems experienced by BRRI, extensive triple-cropping of rice is not recommended without careful consideration and experimentation to determine which parts of the country are suitable for this intensive system.

D. Procedure for Evaluating and Recommending Improved Cropping Patterns

The following procedure is suggested for use in evaluating and recommending improved cropping patterns for existing and proposed irrigation sites. These steps should be followed for each specific sub-project and must be accomplished through interviews with farmers,

village, and project leaders; through on-site inspections; through crop-cut surveys; and through farm management studies.

1. Determine and evaluate existing cropping patternss, including:

   a) cropping patterns presently used;

   b) the extent of each crop and time grown;

   c) the amount and kind of intercropping and mixed cropping;

   d) cropping intensities;

   e) crop inputs and yields;

   f) productivity of total system;

   g) the gross and net returns from entire systems; and

   h) the crop production problems encountered by farmers.

2. Collect and evaluate socio-economic information, including:

   a) farm sizes;

   b) land tenure system;

   c) family sizes;

   d) the labor situation;

   e) the availability of credit;

   f) the input supply system;

   g) marketing arrangements; and

   h) the farmers' other socio-economic problems.

3. Collect information on soil and water resources and climate:

   a) Prior to field observations, review available literature on soil and water resources and climate and discuss this literature with the appropriate Government agencies. For example, in collecting information on soil resources, review the District reconnaissance soil survey reports prepared by the Soil Survey Department of Bangladesh:

   a-1) Review general district geology, soils, and land use;

a-2) Locate sub-project on the soil and land-use association maps;

a-3) Review the soil and land-use association in which the sub-project is located to determine soil series and appropriate land use;

a-4) Review the soil series description, noting soil texture, drainage, permeability, moisture holding, chemical properties, relief, flooding, etc;

b) Supplement the literature with field observations and survey questions regarding physical resources.

4. Determine the land types as defined in "Factors Influencing Cropping Patterns", from field observations and interviews.

a) These land types should then be plotted onto a detailed map having a scale such as that used on the mouza maps.

b) Each land type should be denoted by color on the map. For example: Highland, red; Medium Highland, brown; etc.

5. Determine the flood types, as defined in "Factors Influencing Cropping Patterns" from field observations and interviews. Delineate the different flood types on the map.

6. Determine the drainage types, as defined in "Factors Influencing Cropping Patterns", from field observations and interviews. Delineate the different drainage types on the map.

7. Determine the soil permeability types, as defined in "Factors Influencing Cropping Patterns", from field observations and interviews. Delineate the different permeability types on the map.

8. Examine the soils in those areas having different land and drainage types and in those areas exhibiting significant relief changes.

a) Especially important are the subsoil and substratum textures and the soil structure. To determine these, holes must be dug three-to-four feet deep and the soil examined.

b) Subsoil and substratum textures are generally determined in the field by dividing them into four broad, textural classes: sand, loam, clayey loam, or clay. The following criteria are used for classification (Brammer, 1970):

b-1) Sand: This includes sand, loamy sand, and loose sandy loams that, when moist, can be squeezed into a cone or rolled into a ball but cannot be rolled into a cylinder.

b-2) Loam: This includes loam, silt loam, and sandy loam that, when moist, can easily be rolled into a cylinder but cannot then be bent into a ring.

b-3) Clayey Loam: This includes clay loam, silty clay loam, and sandy clay loam that, when moist, can easily be rolled into a cylinder and then bent into a ring. It is also characterized by the fact that a small fragment can be squeezed out to form a "tongue", although it breaks easily.

b-4) Clay: This includes clay, silty clay, and sandy clay that, when moist, can easily be made into a ring. It is also characterized by the fact that a small piece can be squeezed into a strong "tongue".

c) Delineate the soil texture classes on the map.

9. Determine the soil moisture-holding capacities, as defined in "Factors Influencing Cropping Patterns," from field observations and interviews.

a) The soil textural and structural characteristics of the soil (determined in Step 8) are the main determinants of that soil's moisture-holding capacity.

b) Observation of the types and condition of crops growing in an area provides other important information.

c) Areas having different moisture-holding characteristics should be denoted on the map.

10. Recommend cropping patterns for the irrigated sub-projects.

a) Evaluate the existing cropping patterns, the socio-economic situation, physical resources, land types, flood types, drainage types, soil permeability, soil types, and moisture-holding capacities (determined in Steps 1 through 9).

b) Using Table 3-1 as a guide and by inserting the information gained from Steps 1 through 9, determine the most appropriate irrigated cropping pattern for each sub-project.

E. Conclusion

Cropping patterns used by farmers in Bangladesh are generally well suited to the land and soil on which they are used. However, the conditions affecting cropping patterns continuously change due to the complex interrelationship of numerous factors: the beginning of the rains, the depth and duration of floodwaters, current crop prices, seeds and other input availability, labor requirements, and other such influences.

The availability of irrigation water eliminates one of the uncertainties in crop production and allows the farmers to intensify cropping. The reliability of available water also provides an incentive to increase the level of inputs because the risk factor is lessened.

Adapting cropping patterns to specific irrigation sub-projects, based upon the procedure outlined in this section, is only the first step toward increased crop production. The second step, equally essential, is improved management: Cropping patterns must be continually evaluated at each site and an appropriate management program adopted for each. The third critical step is the extension of this information to the farmers. Finally, if the farmers are to accept the

concept of increased crop intensities and improved management, they must be assured of a supply of the required inputs of water, seed fertilizer, insecticides, and credit and assured of a secure market for their increased production. All of these elements must work together consistently before the farmers are willing and able to increase crop intensity and to increase the level of inputs required for higher crop yields.

For DTW and LLP sub-projects in the Rural Irrigation Works Study, which require the design of brick-lined channel distribution systems, the procedure outlined in this section was used to determine the recommended cropping patterns. In an effort to bring more acres of land under irrigation, MRD policy dictates that future cropping patterns maximize the use of crops that require less irrigation water, such as wheat, where the land and soil types are suitable. New crops and practices should be introduced gradually and cautiously. For example, an individual farmer presently irrigating boro has difficulty understanding why he should switch to wheat, which has a lower net return per acre than boro. He also has difficulty accepting responsibility for increasing the total grain production of the country because he is mainly concerned with producing enough food for himself and his family.

Because farmers make the final cropping selection, early discussions, usually at the final design stage, must be held with the user group. The farmers must understand the selection of the command area, the location of the distribution channels and turnouts, and the recommended cropping patterns. They must also realize that growing boro on all of the irrigated acreage will reduce the size of the command area. For certain sub-projects it may be more successful to propose cropping pattern changes gradually over a two-to-three year period.

Section 4: Supply of Agricultural Inputs

A. Fertilizer

The major chemical fertilizers used in Bangladesh are Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), and Hyper Phosphate (HP). There is a strong farmer demand for these fertilizers. The amounts used are generally below the recommended levels, perhaps because of the farmers' financial constraints or the paucity of the fertilizers. Nevertheless, the consumption of fertilizer is increasing annually.

Currently, Bangladesh imports over one-half the fertilizer it uses, but the Government has implemented programs to increase local production.

BADC has the responsibility for distributing fertilizer to the thana level where cooperatives and private individuals then sell it to the farmers.

B. Seeds

The production and distribution of improved seeds are the responsibilities of BADC. Currently, seeds for paddy, wheat, potatoes, vegetables, and oilseeds are being distributed to the Districts.

C. Insecticides and Pesticides

BADC is responsible for procuring these chemicals. PPD, which has recently been created, is responsible for the storage and distribution of insecticides and pesticides and for the training of farmers in their use. PPD is also responsible for all aerial treatment. In general, the use of insecticides and pesticides by farmers is not extensive, a fact which may be attributed in part to the need for additional training in the selection, application, handling and storage of these chemicals.

Section 5: Credit

As in the past, the farmers' major source of credit continues to be private lenders (such as shop keepers, traders, large land owners, and relatives). Interest rates vary but are generally very high.

In general, institutional credit is not widely available to the farmer; however Government, through several organization, is attempting to make more institutional credit available. The BKB has several schemes for advancing loans to farmers for purchasing seeds, fertilizers, insecticides, and cattle, for paying water charges in areas having deep tube-wells, and for purchasing shallow tube-wells. Other sources include the cooperative bank and the Bangladesh Jatiya Sambaya Bank, as well as commercial banks.

Section 6: Marketing

The marketing system in rural Bangladesh is largely traditional. Most growers dispose of sizable portions of their crops before or immediately after harvest. This practice can be attributed largely to their need for cash, their inability to hold grain in storage, their crop loan obligations, and the tenure crop division arrangements (otherwise known as share croppir,). Such farmers often must buy grain later in the year at a higher price for family comsumption. In some cases, farmers sell their crops in order to get back their mortgaged lands.

Traders and private individuals buy and sell grain at daily and weekly local markets. These markets normally start business in early afternoon and continue until 8 P.M. People within a radius of five-to-ten miles come to the bigger weekly markets to buy and sell goods. Smaller daily markets are also held briefly in the morning. These mostly cater to daily needs for fish, vegetables, beel leaf, and other small items. These markets open at 7 A.M. and close at 10 A.M. Generally, one such market serves three or four villages.

Farmers' cooperatives, encouraged by the Government, also operate in some places. They market paddy and mill rice but their success has been limited so far.

The Government has opened 585 food grain procurement centers throughout the country in places near to the growers to minimize transportation costs. In cases where the centers are located far from the growers, the Government paid transportation costs. However, these have often been resented by farmers because procurement prices have been below the market price. Farmers prefer to sell their produce in the open market, but the inadequacy of centers has compelled growers to sell their produce to the middlemen and 'fariahs' at relatively low prices. The procurement program has remained small, handling an average of only 3 percent of national production.

Section 7: Agricultural Extension

The Directorate of Extension and Management (DEM), under the Ministry of Agriculture, has major agricultural extension responsibility in Bangladesh. The organization has components at the Directorate, Regional, District, Sub-Division, Thana, and Union levels.

Each extension agent at the Union level serves the farmers in 10 to 12 villages, totaling 1,000 to 1,200 farm families. Extension activities at the Union level involve rendering technical advice to the farmers concerning the use and usage rates of fertilizers, the use of new crops and improved seeds, the use of improved cultural practices, and the establishment of insect and pest control programs.

The Thana Agricultural Officer represents the extension service on the Thana Committees, which deal with pump irrigation projects and with the estimation of fertilizer and pesticide requirements. The Thana Officer also assists the Union agents in both technical and supervisory capacities.

To further expedite extension services, a number of other Directorates and Boards have implemented extension programs in their respective fields. Examples include Jute Production, Plant Protection, Seed Certificate Agency, Horticulture Development Board, Cotton Development Board, Tobacco Development Board, and the Bangladesh Water Development Board.

The extension programs' ineffectiveness has prompted the Government to experiment with reorganization of the extension service to include more training for the agents and more frequent visits to the farmers by the extension agents, generally referred to as the Training and Visit system (see Institutional Requirements).

To improve extension techniques, the Agricultural Information Service, formed under the Secretary of Agriculture, uses printed material and audio-visual aids--including radio and television--to more effectively educate farmers in the needed technical information.

Section 8: Research

The Bangladesh Agricultural Research Institute was recently reorganized to become the major agricultural research unit of the Government. It has eight major programs that are implemented through 21 research sub-stations, four regional research stations, six special crops research stations, and nine district testing stations.

Numerous other organizations are involved in research work throughout the country. The Bangladesh Rice Research Institute has introduced new rice varieties, such as IR-20, IR-8, IR-5, BR-3, Mala, and Chandina. The Institute is also developing crop and water management programs and is attempting to improve cropping systems. The Soil Survey Department of Bangladesh is providing valuable soil and land use information, particularly in developing areas. The Rapid Soil Fertility Scheme has developed essential information on fertilizer use and requirements. Other contributing organizations include the Bangladesh Jute Research Institute, Dacca; the Sugarcane Research Institute, Ishurdi; Agricultural University, Mymensingh; the Agricul-

tural Institute; Dacca University; and the Bangladesh Atomic Energy Commission.

The Bangladesh Agricultural Research Council (BARC) has been established to strengthen and to coordinate all agricultural research activities. However, many of the research organizations, with the exception of the Bangladesh Rice Research Institute, are having severe problems with funding, logistics, and staffing and with adapting research to the current needs of the country. The coordination and support of agricultural research must continue to be emphasized.

TABLE III-1

EXISTING MAIN CROPPING PATTERNS AND POSSIBLE IMPROVED CROPPING PATTERNS WITH IRRIGATION

Existing Cropping Patterns and Subtypes	Land Characteristcs	Recommended Cropping Patterns with Irrigation
1. Aus - Rabi crops Jute - Rabi crops Mesta - Rabi crops Groundnuts - Rabi crops	Land: highland, medium highland Flooding: normal Drainage: early and normal Permeability: Permeable, moderately permeable Moisture holding: good, moderate, some poor	T. aus (HYV) - Wheat (HYV)/tobacco/potato/cotton/soybean/vegetables Sugarcane (highland soils)
2. Aus - T. aman - Fallow Jute - T. aman - Fallow Aus/jute - T. aman Rabi crops (minor)	Land: highland, medium highland Flooding: normal some flash flood Drainage: normal and late Permeability: impermeable, some moderately permeable Moisture holding: mainly poor (good on Teesta silt soils)	Boro (HYV) - T. aman[1] T. aus (HYV) - T. aman[1] - Wheat[2] (HYV)/mustard/potato

(continued)

TABLE III-1

(continued)

Existing Cropping Patterns and Subtypes	Land Characteristics	Recommended Cropping Patterns with Irrigation
3. T. aman - Fallow T. aman - Rabi crop (mainly pulses)	Land: highland, medium highland, (part saline) Flooding: normal Drainage: normal and late Permeability: impermeable Moisture holding: mainly poor	Boro (HYV) - T. aman[1] T. aus (HYV) - T. aman[1] - Wheat[2] (HYV)/ mustard/potato
4. Mixed aus and b. aman - Rabi crop Aus and b. aman - Fallow Jute - Rabi crops Jute and b. aman - Rabi crops/Fallow	Land: medium lowland Flooding: normal Drainage: normal, some late Permeability: mainly moderate, some permeable and impermeable Moist holding: good or moderate	Boro (HYV)[3] Boro (HYV, quick maturing) - T. deep water aman[4]

(continued)

TABLE III-1

(continued)

Existing Cropping Patterns and Subtypes	Land Characteristics	Recommended Cropping Patterns with Irrigation
5. B. aman - Fallow B. aman - Rabi crops Jute - Rabi crops Aus - Fallow	Land: mainly lowland Flooding: normal, some early and flash flooding Drainage: mainly late, some normal Permeability: mainly poor, some moderate Moisture holding: mainly poor or moderate	Boro (HYV) Boro (HYV, quick maturing) - T. deep water aman[5]
6. Boro - Fallow	Land: lowland, medium low land, bottom land Flooding: early, normal Drainage: mainly late Permeability: impermeable Moisture holding: poor (for dryland crops)	Boro (HYV, quick maturing) - T. deep water aman[5]

(continued)

TABLE III-1

(continued)

Existing Cropping Patterns and Subtypes	Land Characteristics	Recommended Cropping Patterns with Irrigation
7. Boro - T. aman	Land: medium highland, highland Flooding: normal, some flash flooding Drainage: normal or late Permeability: impermeable Moisture holding: moderate or poor (for dryland crops)	Boro (HYV) - T. aman (HYV) Boro(HYV, quick-maturing) - T. aus (HYV/LIV, quick-maturing) - T. aman (LIV)
8. Jhum cultivation	Land: highland (mainly sloping) Flooding: none Drainage: well drained Permeability: mainly permeable Moisture holding: mainly poor, some moderate	Usually not irrigated with the exception of tea

(continued)

TABLE III-1

(continued)

Existing Cropping Patterns and Subtypes	Land Characteristics	Recommended Cropping Patterns with Irrigation
9. Perennial crops Sugarcane Ginger, turmeric Pineapple Fruit trees	Land: highland Flooding: none Drainage: well drained Permeability: mainly permeable Moisture holding: moderate or good, (some poor for fruit trees)	Intercrop with quick-maturing rabi crop, such as vegetables, potato, mustard, spices, etc.

[1] HYV where water depth is suitable.

[2] Sow rabi crops on ridges or beds.

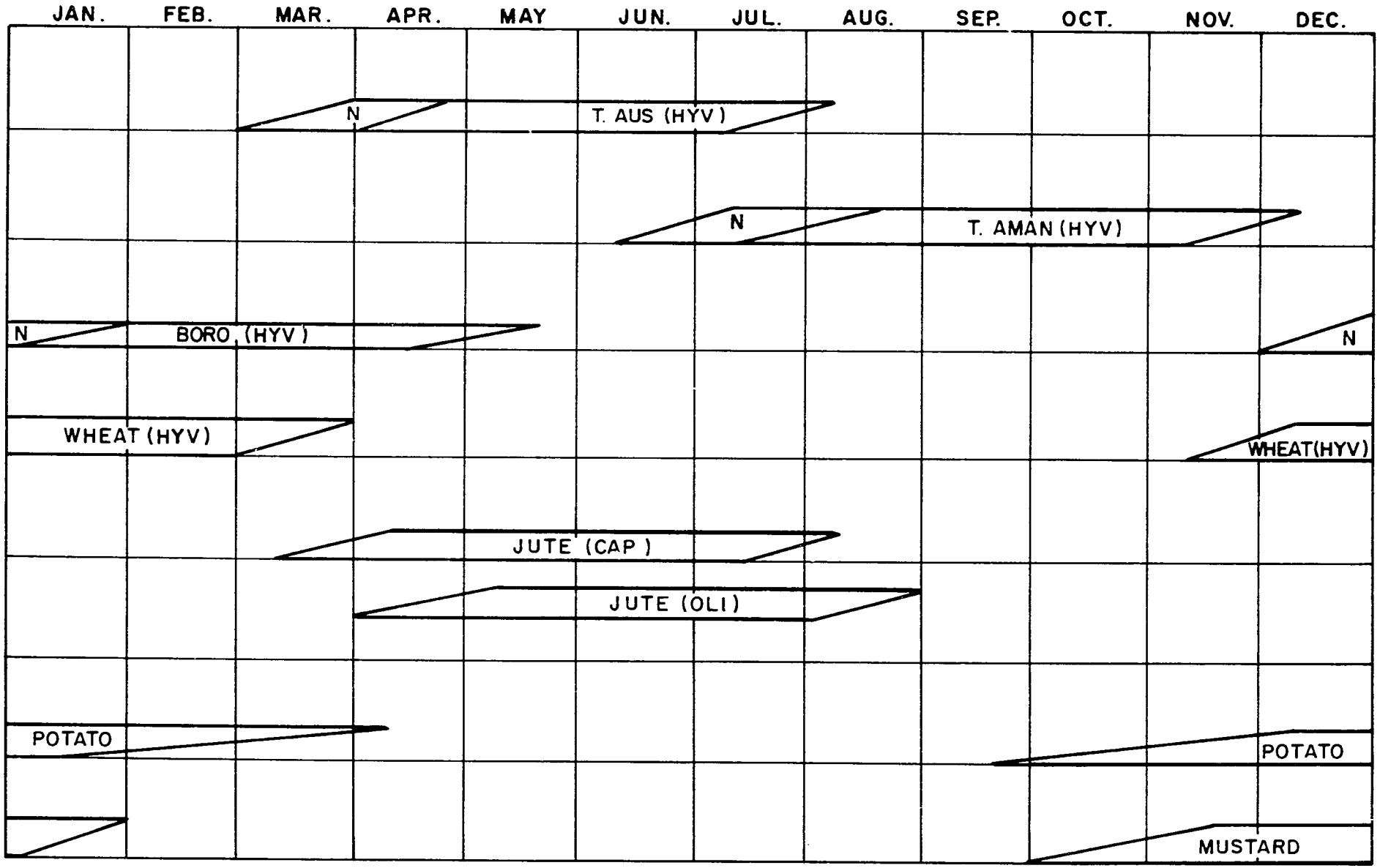
[3] Should investigate if this is as profitable as the triple-crop pattern it replaces.

[4] Except on early flooded land.

[5] Where possible.

Source: Brammer (1978). How to Improve Cropping Patterns. Soil Survey Interpretation Division. Department of Soil Survey, Dacca, Bangladesh.

FIGURE III-1 CROP CALENDAR FOR MAJOR CROPS GROWN IN BANGLADESH



N = NURSERY