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RESEARCH METHODOLOGY AND PROJECT DESIGN FOR EVALUATING THE CONSEQUENCES OF SMALL FARM MECHANIZATION ON PRODUCTION, INCOMES, AND RURAL EMPLOYMENT IN SELECTED COUNTRIES OF ASIA

Contract No. AID/ta-C-1466
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FOREWORD

The United States Agency for International Development has provisionally funded a research study entitled "The Consequences of Small Farm Mechanization on Production, Incomes and Rural Employment in Selected Countries of Asia" (AID/ta-C-1466). The first phase in the implementation of the project was the development of a comprehensive research design for submission and review by the Research Advisory Committee (RAC) prior to field implementation of the project.

A research planning workshop was held at the International Rice Research Institute in Los Baños on October 31 and November 1st to consider the initial proposal and develop a research design and methodology for the study. In addition to the research design, a tentative determination was made of countries to be included in the study, possible survey sites within countries, sample size, survey techniques, alternative modeling formats and the specification and nature of the complimentary case studies required to meet overall project objectives. The research design which evolved at the planning workshop is summarized in the present report.

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INTRODUCTION

Mechanization of small farms in the developing nations has been the center of a continuing controversy for the past two decades. The focal point of these debates centers around three major issues. The first is the impact of mechanization on production. Does mechanization enhance output and in what manner?

A second issue is the effect of mechanization on employment and the level of labor incomes. To what degree is labor displaced by machines and what are the alternative employment opportunities for that labor?

The third issue is the distributional impact of mechanization on rural incomes. Because of the lumpy nature of investments in most agricultural machines, there is a strong presumption that mechanized equipment embodies economics-of-scale in both ownership and operation, particularly in the private market economies found in many developing countries. The above hypothesis strongly implies that benefits from mechanization accrue to larger farmers or to those who command the resources necessary to purchase the equipment. Equity, employment and production are not separable issues in the context of small-farm agriculture. Associated with each of these issues has been the growing presumption that government policies affecting the prices and profitability of mechanized equipment largely determines the pattern, sequence and level of mechanization in the developing nations.

The basic question being addressed in the proposed study is whether "appropriate" small-scale machines, tailored to the income levels and

technical needs of small farmers and manufactured locally have the inherent capacity to raise production without concurrently exacerbating problems of employment and income distribution.

While there is much evidence available pertaining to use of larger equipment, particularly tractors, there has not yet been a major methodologically sound effort to systematically assess the effects of small-scale mechanization on employment, output and incomes. In the sections that follow, the research strategy for the IRRI component of the proposed joint ADC/IRRI project to evaluate the small machinery issue are elaborated.

STUDY OBJECTIVES AND OUTPUT

The research project has two major objectives. The first is to evaluate the effects of small-farm mechanization on small rice based farms in Asia. This objective focuses on use of small equipment of the type being developed at the International Rice Research Institute. Employment, production and income are the pivotal issues in the analysis. The second objective is to develop both the research capacity within countries of the region and the methodologies to rigorously analyze the mechanization issue.

The expected output from the study includes: 1) an improved capacity within countries to conduct research on new technologies, to conduct farm level studies and to analyze policy issues, 2) a set of alternative recommendations regarding the consequences to be expected from use by small farmers of appropriate mechanization practices, 3) an analysis of alter-

native mechanization policies and programs for improving the income and employment opportunities of small farmers, 4) an analysis of resource use patterns under alternative mechanization strategies and economic policies, 5) an analysis of factors affecting the adoption and use of mechanization, 6) regional estimates of the effect of mechanization on farm income, employment and production and, 7) a set of research methodologies for assessing the impact of mechanization on small farms. The purpose, objectives and scope of the study are more fully elaborated in the comprehensive project proposal.

RESEARCH DESIGN AND METHODOLOGY

The proposed study is designed to address the mechanization issue at four levels of generality. The first level is an examination of those factors and policies which have affected the adoption and use of mechanization in particular countries using a historical cross-country framework.

The second level of analysis is to examine the impact of particular policy alternatives on the adoption and use of mechanization and their implications for regional or sectoral level employment, production and incomes.

The third and most important level of generalization in the present study will be a farm-level examination of the consequences of mechanization.

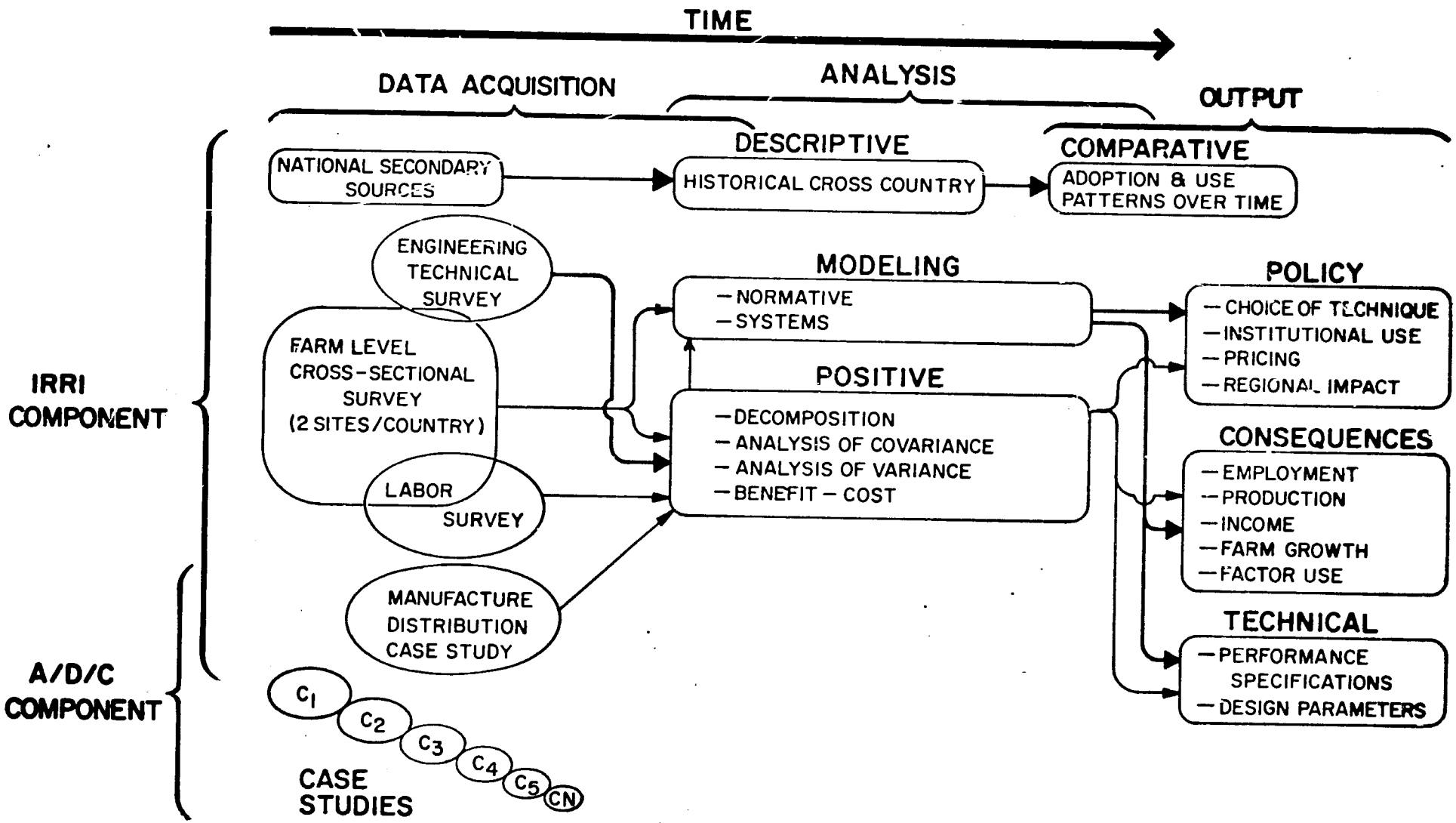
The fourth level will be to carefully evaluate performance at the operation or task level to generate data for particular machines or practices

over a range of environmental-economic conditions. The last will be particularly useful to the engineers in formulating design and cost specifications for improved techniques.

Figure 1 illustrates these components schematically plus the data acquisition, analysis and expected output from each.

Historical Cross-Country Study. The cross-country comparison will attempt to identify, using through a careful review of available studies and statistics o agricultural growth and mechanization, the major causal relationships in the adoption of particular types of equipment, the sequence in which mechanization was used and the time of adoption in relation to wage rates, income levels and degree of industrialization. This work will be undertaken by project staff at IRRI and will be completed within one year following project implementation. Viewed as largely a descriptive study, the cross-country comparison will provide the basis for assembling additional data for more refined comparisons at a later stage in the four-country project.

Case Studies. There are many aspects of the mechanization issue which do not lend themselves to a generalizad research methodology which can be applied at all country locations to be included in the study. Many questions are location or operation specific and can best be addressed through a specialized case study approach. Some case studies will be able to employ data from project farm surveys, others must conduct independent surveys to generate the required input information. In almost all cases, however,



DATA GENERATION, ANALYSIS AND RESULTS FOR MECHANIZATION RESEARCH STUDY

these will be relatively small efforts, capable of being carried out by M.A. level personnel. While it is envisioned that ADC would plan and implement a number of such studies, there will be cases in which the IRRI component of the project will need to utilize a similar approach. An example is an evaluation of the backward linkage and secondary employment effects of indigenous manufacturing/distribution activities in the farm equipment industry. Another possibility is a study of the use of farm machinery under alternative institutional arrangements such as individual, joint, cooperative, private contracting or government tractor pools. Where specific technical questions such as the suitability of particular machines to particular agroclimatic conditions or multicrop utilization must be addressed, the case study approach may be the most appropriate. It is anticipated that the number of such studies will be small and carefully focused. They will be planned on an ad hoc basis in close collaboration with in-country research personnel.

Field Surveys. The basic tool for ascertaining the consequences of mechanization is the farm-level cross-sectional survey. Ideally, such surveys should cover farms with and without mechanization and those who can provide data on the basis of before and after mechanization comparisons. A major defect of almost all previous studies of mechanization has been the failure to use the two-dimensional approach in collecting survey data. The key objection against pure cross-sectional comparison is that mechanized and nonmechanized farms may differ in many respects other than the degree of mechanization. Mechanized farms are usually larger than nonmechanized.

farmers owning machinery are usually better endowed with capital and have better access to credit markets. This is likely to lead to greater use per hectare of irrigation and purchased input such as fertilizer and thus lead to higher observed yields and cropping intensities. There may also be cropping pattern effects. All these effects may lead to higher production, higher yields, higher intensity and higher machine and labor use, even in the absence of mechanization. Most investigators have been consious of these confounding factors and many have attempted to minimize them by judicious choice of sample farms. Through combined use of size-adjusted sampling, before and after recall (in combination with control groups), and statistical testing for significant differences, it is possible to overcome many of these confounding effects. The sampling methodology itself must, however, be carefully controlled to achieve reliable results. A thorough description of the survey procedure is presented in a subsequent section on sampling and data gathering.

Table 1 illustrates the factors considered in selecting countries and stratification variables for the project. The study is confined primarily to small-scale equipment which means the countries to be included must have sufficient numbers of such equipment to make comparisons with traditional technologies statistically meaningful. A second criteria in selecting countries was the policy relevance of the research within the country. A third factor was the availability and capacity of local research institutions to organize and implement the research. While Pakistan and Indonesia do not fully meet the small machine criteria, they do have a

Table 1. Factors in site selection and sample stratification.

Level of Mechanization

Country	Water Lifting	Land Preparation*		Crop establishment	Crop protection	Harvester	Thresher	Level of policy relevance	Research Capacity
		Tractors	Tillers						
Bangladesh	xxx	x	-	-	-	-	-	x	x
Egypt	xxx	xx	-	-	x	-	x	xx	xx
Indonesia	xx	x	x	-	x	-	-	xx	x
Malaysia	xx	xxx	xxx	-	x	-	-	x	xx
Pakistan	xxx	xxx	x	-	x	-	xx	xx	xx
Philippines	xx	xx	xx	-	x	-	xxx	xxx	xxx
Sri Lanka	xx	xx	x	-	x	-	x	x	x
Thailand	xxx	xx	xxx	-	x	-	xx	x	xx

- negligible

x low

xx moderate

xxx high

* major stratifying variable to be small-scale land preparation equipment

strong policy interest in such studies. Indonesia provides the additional feature of providing an in-country comparison between the densely populated areas of Java and the land-abundant outer islands. All countries in the study have both IRRI and ADC representation available for support and logistics purposes. Considerable potential exists for cooperative research involving complementary IRRI disciplines in the areas of cropping systems, water management and economics. Cross-country variation in the research design also captures the effects of alternative government policies.

Land preparation has been selected as the key task upon which to stratify the farm samples. Emphasis is placed on selecting sites within each country where power tillers or similar machines are employed for this task. The coverage will include a major assessment of all crop production activities, including water lifting. The surveys will be confined to areas in which the predominant crop is rice or in which rice weighs heavily in the cropping system. The focus on rice-based cropping systems insures that some portion of the agro-climatic variation in the sample will be controlled.

The exact degree of stratification by farm size, water control systems, degree of mechanized versus non-mechanized farms, etc. will be undertaken in recognition of local needs and the particular equipment to be studied in each country. Where possible, two sites will be selected in each country to permit an assessment of in-country variability which may be an important determinant of mechanization. Using three farm sizes and three levels of mechanization for land preparation, a sample size of approximately 200 observations will be necessary to reliably assess the effects of mechanization.

In addition to the farm management survey, there will also be two supplementary surveys conducted using a subsample from initial survey respondents. The first will be a detailed engineering analysis conducted on an operational basis to (for example) evaluate and measure machine performance rates, determine annual utilization levels, monitor weekly or daily labor and power use requirements to determine peak needs and study machine maintenance schedules.

The second supplementary survey will be a study of labor utilization with primary emphasis on landless laborers and their families. These studies will be designed to assess the degree and nature of alternative employment opportunities available to this labor, to determine the level and proportion of income derived from farming operations which could be mechanized and to quantify the extent of landlessness.

MICROANALYTIC SURVEYS[1/]

A recent study of the survey literature on tractors in South Asia has shown that fairly simple farm level surveys combined with straightforward analytical tools can provide powerful insights into the productivity and income distribution consequences of agricultural machines at micro levels and that these surveys can be structured in such a way that the micro-findings can be meaningfully aggregated to at least regional levels. In addition to such agro-economic surveys, special investigations normally need to proceed in a parallel fashion to investigate issues connected with machinery design, service and repair systems and manufacturing problems.

Minimum Scope of Data Required. A machinery consequences survey proceeds by identifying regions and subregions where technologies have been adopted in sufficient numbers to make an enquiry meaningful. Within this region, cluster sampling techniques are used to identify villages or groups of villages in which the survey will be made. A census of all households is taken in this cluster, which, in addition to names and addresses, provides the information required to draw a stratified random sample from the household list. This information includes main and subsidiary occupations,

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[1/] Acknowledgement is given to Hans P. Binswanger for developing the farm survey methodology and analytical procedures outlined in this section.

landholding size, irrigation levels, education, machine ownership or machine use and any other information which may become an ex ante stratification variable. Such censuses can usually be performed by investigators with the help of local teachers and high school graduates within two or three days for populations of 1000 families. Completeness of the census is essential for any later regional aggregation work.

Stratification is carried out according to mechanization levels and landholding size. If irrigation or other variables vary substantially, and are likely to lead to serious difficulties in interpretation of the results, additional stratifications may need to be introduced. It is essential to include a landless labor sample in the scheme to estimate the incomes earned by these groups from agricultural operations which might be performed mechanically. The added workload to gather data from a landless labor sample is very small because no cultivation schedule has to be obtained from them.

For the random sample, the minimum data base includes the following schedules:

1. Household member schedule

   Containing demographic educational and occupational data (collected only once).

2. Cultivation schedule

   This schedule will have to be collected in several rounds over a year. A high level of reliability of the data can be obtained by having one round per cropping season, although more frequent rounds are desirable. Information is collected and recalled on

a plot basis where plots are continuous pieces of land planted to the same crop. To be useful in answering timeliness questions, the data are collected operation-wise with one line on the schedule for each operation. Operations must be carefully dated so that delays and "turnaround" times can be estimated and labor use can be estimated for peak and off-peak periods. If possible, the schedules should be constructed so that they can:

a) be analyzed by manual methods using a desk calculator,

b) be directly computerized without transfer to coding sheets,

c) contain a set of common core data with the possibility of adding extra data fields and extra codes to collect additional information as required or desired in particular country circumstances

d) be produced in several copies and on sufficiently high quality paper so that they are durable and can be analyzed for specific aspects at different locations and at different times.

The first step in the analysis of the schedules is to prepare a wise summary of the data, which adds up all inputs and outputs for a season by category.[1/] The fieldwise summaries are reasonably easy to computerize whereas computerizing and analyzing the raw data is usually a much more difficult task.

[1/] These summaries are made on the basis of the field and not on a per ha basis because of the need for aggregation at later stages.

3. Animal care and machine service schedule

The basic purpose is the collection of cost and labor requirements for draft animals and the fixed and variable costs and labor requirements for machine service and repair, including frequency, time and labor requirements in repair shops.

4. Asset schedule

This schedule contains an inventory of machines, implements, animals and consumer durables for each farm household. The last item is required for analysis of data by wealth class.

5. Plot inventory and crop rotation history

This schedule is crucial to obtain information describing impact of mechanization on cropping patterns, farm growth and land reclamation. It must be collected for all sample households, including nonmechanized farms and landless laborers since the landless may have become landless only during the past 5 years. Also, unless the nonmechanized farms are included, one cannot sort out the question of whether changes in cropping patterns were caused by the machines or by common responses to changing prices or new varieties, or whether land reclamation occurred only on mechanized or also on nonmechanized farms.

Since much of the information on land transfer or landleasing may be sensitive, this schedule should be collected only after rapport has been established between the investigators and the farmers.[1/] Attempts can be made to trace yields over time, but

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1/ Excellent rapport can be established by paying the respondents at levels substantially above daily wage rates or opportunity cost of interview time.

this information is often inaccurate. Additional information can also be collected on the same schedule such as "when did you first use HYV's or fertilizer or a machine".

6. The supplementary income schedule

This schedule collects data on all wage and nonagricultural incomes. If incomes from animal husbandry are not collected on schedule 3, they should be collected here. Agricultural labor income has to be disaggregated by task. How many hours[1/] of ploughing, planting, weeding, harvesting, threshing and at what wage rate?

Minimum Tabular Analysis of the Cultivation Schedule. Cultivation schedules can be analyzed in many ways but two crucial types of analysis are required:

1. Timeliness and the cost of delays

For each mechanization class, the field is the most important unit of analysis. Crops are grouped by:

date of sowing

delays in sowing

delays in weeding/interculture

delays in harvest

An example of the results from this exercise is shown in the following table.

[1/] In most areas, a labor day has a customary length: 5, 6, 7, 8 hours. The investigator may ask in terms of days, but code in terms of hours for comparability over regions and countries.

Table 2. Extent and cost of delays in operations.

Delay of operation / Degree of mechanization	0 to 2 weeks	2 weeks-4 weeks	4 weeks-6 weeks	more than 6 weeks	No. of observations
	Percent of farms in class				
Bullocks	30	20	20	30	40
Tractor hire	40	30	20	10	55
Tractor owner	60	30	5	5	60
Average yields(quintal)	25	24	22	15	155

Source: A. S. Kahlon, Impact of Mechanization on Punjab Agriculture with Special Reference to Tractorization, Indian Journal of Agricultural Economics, Vol. 31, October-December, 1976.

2. Input-output relationships by farm type/size class.

These input/output tables are basic to further analysis such as decomposition, linear programming, quadratic programming, regional projections, regression analysis, etc. They appear as in Table 2 as follows:

Table 3. Input-output table for mechanization class X, Strata Q.

Input-Output table for Mechanization class X, Strata Q

Crop Class	Crop	Area share W_i	Value share S_i	Yield per ha Y_i	Value per ha y_i	Fertilizer per ha value F_i	Other Inputs (Value) X_1	X_2	X_3	Labor Inputs: Family M L_1	Family F L_2	Family C L_3	Hired M L_4	Hired F L_5	Hired C L_6	Other L_7	Machinery Inputs: Tractor Land Prep. T_1	Tractor Other T_2	Thresher T_3	Bullock B	Other			
Fallow																								
Traditional Unirrigated	Sorghum Cowpea																							
Subtotal				$\Sigma W_i Y_i$	$\Sigma S_i y_i$	$\Sigma W_i F_i$	$\Sigma W_i X_{1i}$	...		$\Sigma W_i L_{1i}$	...	...	...	...	...		$\Sigma W_i T_{1i}$	...	$\Sigma W_i T_{3i}$	$\Sigma W_i B_i$				
Traditional Irrigated	Rice																							
Subtotal																								
HYV Unirrigated	Sorghum Cotton Fodder																							
Subtotal																								
HYV Irrigated	Rice Sugarcane																							
Subtotal																								
Total				$\Sigma W_i Y_i$	$\Sigma S_i y_i$	$\Sigma W_i F_i$	$\Sigma W_i X_{1i}$	...		$\Sigma W_i L_{1i}$	...	...	...	...	...		$\Sigma W_i T_{1i}$	...	$\Sigma W_i T_{3i}$	$\Sigma W_i B_i$				

The individual cells in the input-output tables are all physical quantities or values per ha. The subtotals are values per ha of gross cropped area in a given farm class, because W_i is the share of crop, i is gross cropped area. An exception is $\Sigma_i S_i Y_i$ where S_i is a value aggregate. The tables can be made as complicated as desired. For example, one may partition out only total tractor labor or disaggregate that into field preparation, interculture, transport and harvesting. One can also distinguish owned animal and hired animal hours or can disaggregate labor hours by operation. When disaggregation becomes very specific, it may be necessary to split the tables up into several subtables. In every case, however, all tables should contain empty fields (columns) which allow national cooperators to add their own breakdown based on location or operation specific needs. Note that the input-output table can only be disaggregated to the level of the fieldwise summary discussed earlier. There must be a correspondence between the fieldwise summary and the minimum disaggregation requirements of the input-output table.

DECOMPOSITION AS A MINIMUM ANALYSIS

Recent experience has shown that decomposition of output and labor use differences may be the most powerful analytical tool to be used with mechanization survey data. The precise decomposition required will depend on the local conditions and on the machines now used on mechanized and

nonmechanized farms. Decomposition has powerful advantages over programming, simulation or regression techniques. These stem from its computational simplicity (it can be performed with a calculator) and the ease with which it can be used and understood by people with widely diverse disciplinary backgrounds and levels of training. Is is not, however, competitive with more complex techniques, although these should only be attempted where computer facilities and concentrated analytical manpower make them feasible.[1/]

Output Decomposition into Intensity, Yield and Cropping Pattern Effects. The goal of decomposition is to partition the output differences observed between farms "with and without" certain machines or "before and after" investment in certain machines into an intensity, yield and cropping pattern component. Once this partitioning is done, one can ask much more precisely how each of these effects may have arisen and whether a particular machine has caused the observed effects. Together with information about differences in irrigation, cropping pattern and yield raising investments such as fertilizers, a clear picture of the output effect of a given machine can usually be obtained. An appendix showing a mathematical derivation in a continuous function framework is attached.

[1/] Decomposition has a long history beginning in the work of Minhas. It has usually been used to analyze aggregate data. Raj Krishna, "Measurement of the Direct and Indirect Employment Effects of Agricultural Growth with Technical Change", has more recently used the technique in the context of mechanization over time at regional levels. What is proposed here is to extend the analysis to decomposition across farm types as well.

The Decomposition of Labor Use for a Single Crop. Krishna has shown how to decompose the labor use effect of several types of interacting technologies into the effects of single components.[1/] He also shows how to generalize that approach to many crops and, as a last step, how to integrate the findings with standard interindustry input-output tables to get at the indirect employment effect of agricultural technical changes in other sectors of the economy. This set of methodologies can be used in a stepwise fashion as the project proceeds. The degree of refinement and technical specificity may vary from situation to situation. The minimum analysis which will be common across all countries included in the project is the labor decomposition between different farm types or "before and after" for the two or three dominant crops in a particular country. The principle of labor decomposition is shown below in a simplified example.

Operations can be divided into those where labor input is (a) area dependent or (b) yield dependent. Let us consider only two, namely ploughing as type (a) and threshing as type (b). If all other operations are performed in the same way on two farm types or "before and after", they can simply be neglected. Sufficient variability must exist in the range of techniques found on sample farms to measure the effects. The following notation is used:

t = proportion of area ploughed by power tillers

s = proportion of output threshed by thresher

Note that s and t are equal only in exceptional circumstances.

[1/] Raj Krishna, Measurement of the Direct and Indirect Employment Effects of Agricultural Growth with Technical Change in Employment in Developing Nations, edited by E. O. Edwards, Columbia University Press, New York, 1974.

u_T = labor per ha ploughed by power tillers (operators)

u_B = labor per ha ploughed by buffalo

v_R = labor per ton threshed by thresher

v_H = labor per ton threshed by hand

Y_T = yield per ha on area ploughed by power tillers

Y_B = yield per ha on area ploughed by buffalo

$Y.$ = average yield per hectare

Then $Y. = tY_T + (1 - t)\, Y_B$ (5)

and labor use L for ploughing and threshing is

$$L = tu_T + (1-t)\, u_B + sv_R Y. + (1-s)v_H Y. \quad (6)$$

holding all labor coefficients v and u constant and differentiating (6) and (7) totally in succession and aggregating terms leads to the following equation:

$$\begin{aligned} dL = {} & (u_T - u_B)\, dt && \text{(a)} \\ & + sv_R + (1-s)\, v_H \;\; (Y_T - Y_B)\, dt && \text{(b)} \quad (7) \\ & + (v_R - v_H)\, y.ds && \text{(c)} \end{aligned}$$

Part (a) and (b) together are the effect of increasing the proportion of area under power tillers. Part (a) is the direct labor effect of power tiller ploughing on the power tiller operator and the buffalo driver. Part (b) is the indirect effect of power tiller ploughing on threshing labor which occurs if power tillers increases yields. (In the case of tillers, the yield difference is often zero so this term disappears, but if irrigation were considered, the effect might be large). The (c) term is the thresher effect which traces how much labor is displaced by the thresher.

Equation (7) can be translated into discrete terms by replacing dt and ds by Δt and Δs and by replacing s by $\bar{s} = (s_A + s_B)/2$ in the (b) term. Unlike the output decomposition, transformation into proportional differences is not straightforward but it can be done once all absolute effects are computed numerically.

The example given by Krishna is much more complex and considers two varieties, three irrigation levels and buffalo and mechanically ploughed farms. For the individual country studies, the type of decomposition will depend on local conditions, but the derivations are straightforward. If desired, whole farms can be considered by computing the labor decomposition for all crops, i.e. computing the full set of dL_is, and its components. The total labor effect of all changes are then computed as follows: with L. equal to total labor use on the farm

$$dL. = \sum_i W_i dL_i \qquad (8)$$

For individual components such as the power tiller ploughing effect, similar share weighted sums can be computed as time and resources permit.

It is possible that a computer program could be designed to carry out the individual decompositions after the basic data had been gathered. This approach may prove necessary to adequately address some issues such as the specific interaction effects of selected types of mechanization over a complex cropping pattern. Analysis at this stage of refinement should, however, not take precedence over the first stage labor decomposition carried out by field staff.

Regional Aggregation and Projecting Output and Labor Effects. If clustered stratified random sampling techniques have been used, regional aggregation and projection is straightforward and proceeds directly from the decomposition analysis. Rates of additional machinery investment can be assumed or projected from past data and translated into regional Δt and Δs projections. Normative frameworks such as linear, dynamic or integer programming can also be used since the decomposition analysis presupposes knowledge of all coefficients required for these exercises. Computation of indirect employment effects outside agriculture would presuppose the existence of sufficiently disaggregated input-output tables and of expenditure elasticities of incremental income to permit integration with the farm level analysis.

Aggregation and projection of the farm-level analysis to a regional level will be reasonably uncomplicated if nonfarm effects are not included. Because of the highly specialized nature of the data required to develop a complete equilibrium model at the regional or sectoral level, this will be beyond the scope of the present study. As mentioned previously, there will be a need to undertake case studies to evaluate the indirect income and employment effects for selected types of mechanization, particularly equipment which is manufactured, serviced and distributed by indigenous firms. These studies will, however, be highly specialized and tightly focused efforts not consistent with the input requirements of macro-level aggregation and projection. In those instances where sectoral models already exist or are being developed, an attempt will be made to link the results of the microanalytic surveys with these models to evaluate more

comprehensively the sectoral implications of particular mechanization alternatives. Such models are now operational in the Philippines and Thailand (funded by USAID) and is being constructed in Pakistan (under IBRD funding). The precise methodology for each of these exercises must be handled on an ad hoc basis after close consultation with planners and research collaborators in each of the countries where such efforts are possible.

PROJECT IMPLEMENTATION

The rationale for inclusion of Thailand, Pakistan, Indonesia and the Philippines in the study was outlined previously. Within each country, a minimum of two survey sites will be made based on the primary stratification variables of small-scale mechanization and farm size. Such selections will be made in close consultation with research collaborators in each country to ensure inclusion in the sample survey of all relevant variables.

Selection of research collaborators will be based upon the degree of mutual interest in the research topic, availability to participate actively in the project, intellectual and organizational capacity to guide the project, plus considerations of previous research on mechanization. A tentative listing of possible collaborators has been made, but formulation of working relationships has been held in abeyance pending determination of funding availability for implementation of the project. The

tentative collaborators are as follows:

1. Thailand

Dr. Ammar Siamwalla
Economist, Faculty of Economics
Thammasat University

Dr. Gajendra Singh
Agricultural Engineer & Head
Division of Agricultural Engineering
Asian Institute of Technology
Bangkok, Thailand

Advisory support is available from the ADC Associate-Economist (to be named), the Department of Agricultural Economics, Ministry of Agriculture & Cooperatives, and the Department of Agricultural Engineering, Kasetsart University.

2. Indonesia

Dr. Thomrin Nurdin
Faculty of Agriculture
Andalas University
Padang, West Java

Dr. Nyoman Sutawan
Faculty of Agriculture
Udayana University
Den Pasar, Bali

Dr. Rudy Sinaga
Head, Rural Dynamics Study Group
University of Indonesia
Bogor, Indonesia

Advisory support in Indonesia can be obtained from Dr. William Collier, ADC Associate, Bogor, Indonesia and Mr. Dadang Tarmana of the Directorate of FoodCrops Production, Jakarta.

3. Pakistan

Dr. Javid Hamid
Planning Commission
Islamabad, Pakistan

Dr. Bashir Ahmad
Joint Secretary
Government of the Punjab
Lahore, Pakistan

Advisory support can be obtained from Dr. Richard Goldman, Ford Foundation, Islamabad and Dr. Brian Lockwood, ADC Associate in Lyallpur.

Research personnel to carry out field studies and first stage analytical work will be recruited from local universities and research institutions. Upon implementation of the project, one or two field staff from each country will be assembled at IRRI for approximately two months of training in data gathering, interviewing, questionnaire formulation and data analysis. An experienced field survey administrator will be retained to plan and direct this training exercise.

Project administration will be largely decentralized (as far as possible) to permit in-country collaborators maximum flexibility in implementing and monitoring field surveys and case studies. A workshop to develop a in-country administrative and data gathering procedures will be held at the inception of the study. This workshop will involve the research collaborators in each country, ADC personnel and the project coordinators from IRRI. It is anticipated that an additional associate agricultural economist may be required at IRRI to handle the analytical and field monitoring activities associated with the project.

Timing of project activities will be phased in accordance with the schedule outlined in the comprehensive project proposal. The exact sequences in which each stage of the study is undertaken will necessarily

be conditioned by the rapidity with which local institutional linkages can be developed, project personnel hired and trained and site locations identified and sample populations determined.

COORDINATION BETWEEN ADC AND IRRI

The ADC component of the project will be complimentary in two ways with work to be planned and implemented by IRRI. First, ADC will attempt to identify research topic areas not included in the central research effortdirected by IRRI. These may be country specific topics relating to sociological, institutional or technical issues outside the scope of the main project. Secondly, ADC will attempt, to the degree possible, to focus studies in the areas outside Indonesia, the Philippines, Pakistan and Thailand.

ADC personnel associated with these research projects will be involved in the planning and implementation of joint workshops and conferences dealing with project activities. In addition, it is anticipated that specific ADC personnel will be involved in the development of questionnaires, training programs, and field coordination, particularly in Pakistan, Thailand and Indonesia.

Lastly, there is considerable scope for complimentary work at the graduate level between ADC and IRRI thought linkages at the University of the Philippines and support of field research projects to meet thesis requirements.

Appendix A

DECOMPOSITION ANALYSIS

At the farm level, all changes in cropping patterns, for example, are discrete. The initial presentation, however, will be for the continuous case. The following notation is used:

Y_i = yield of crop i $\qquad$ P_i = price of crop i

$y_i = Y_i P_i$ = values of crop i per ha (yield in money terms). As in the input-output table, HYV and traditional varieties or irrigated and unirrigated plots of the same crop are treated as "different crops".

G = gross cropped area

A = operated area

N = net cropped area

F = fallow land = A - N

(fallow land will be treated as crop number zero)

c = G/A = cropping intensity (alternatively c could be defined as c* = G/N, but the extent of fallow is an important consideration in the mechanization debate in some areas).

A_i = area under crop i

$W_i = A_i/G_i$ = proportion of gross cropped area under crop i

$y. = \Sigma_i W_i y_i$ = value of output per operated area: This is the yardsticks of "productivity" of a farm class in meeting national production goals.

$S_i = W_i y_i / y. =$ value share of crop i in total value

Decomposition proceeds as follows:

$$q = cy. = c\sum_i W_i y_i \qquad (1)$$

Differentiating totally

$$dq = dc\sum_i W_i y_i + c\sum_i W_i dy_i + c\sum_i dW_i y_i \qquad (2)$$

These equations can be converted into rates of change or proportional change by:

- dividing both sides of the equation by q
- dividing and multiplying the second and third right hand side terms of equation (2) by y_i and W_i, respectively.

$$\frac{dq}{q} = \frac{dc\sum W_i y_i}{c\sum W_i y_i} + \frac{c\sum_i W_i y_i dy_i}{c\sum W_i y_i y_i} + \frac{c\sum_i W_i y_i dW_i}{c\sum_i W_i y_i W_i}$$

After cancelling, we obtain the following expression

$$\frac{dq}{q} = \underset{(a)}{\frac{dc}{c}} + \underset{(b)}{\sum_i S_i \frac{dy_i}{y_i}} + \underset{(c)}{\sum_i S_i \frac{dW_i}{W_i}} \qquad (3)$$

The three right hand side terms measure the contribution to the proportional difference in output per ha of operated area of a) intensity, b) yield and c) cropping pattern changes. The yield effect a) is the share weighted sum of the yield differences of individual crops and the cropping pattern effect, b) is the share weighted effect of the cropping pattern differences.

When converting this equation into discrete effects, the following notation is adopted: Let A and B be two different farm types or one farm type "before and after" acquisition of a machine.

Let X_A and X_B the levels of any measured variables in the two farm types and define the proportional differences as:

$$X' = \frac{X_A - X_B}{\bar{X}} = \frac{\Delta X}{\bar{X}}$$

where $\bar{X} = (X_A + X_B)/2$, i.e. the mean of the variable among the two types.[1/] (Note that geometric means could be used instead of arithmetic ones, i.e.

$$\bar{X} = \sqrt{X_A X_B}\ ).$$

Thus equation (3) can be rewritten as follows:

$$q = c' + \sum_i \bar{S}_i y_i + \sum_i \bar{S}_i W_i + R \qquad (4)$$

The R term is a "residual" or "interaction" effect which can be given alternative interpretations. It is usually small and normally is regarded simply as an approximation error arising out of the switch from the continuous to the discrete case. It can be measured and, if it is large relative to other terms, helps provide a check on spurious effects. The output decomposition is computed from and displayed in the following table, which corresponds closely to a comparison of the two input-output tables for the two farm types being compared:

1/ It is important to measure proportional differences with respect to average levels to keep approximation errors (the R term in equation (4)) at a minimum.

Appendix Table A-1

Output Decomposition for Farm Types A and B

Productivity difference: $q' =$ Intensity difference $c' =$ Irrigation difference $I' =$ Education difference $E' =$

Crop class	Crop	Value share $\bar{S}_i$	Area share $\bar{W}_i$	Yield effects $\bar{S}_i y_i'$	C pattern effects $\bar{S}_i W_i'$	Fertilizer diff. F_i	Other input diff. X_1' X_2 X_3'	etc.
Fallow								
Traditional Unirrigated	Sorghum Cowpea							
Subtotal		$\Sigma\bar{S}_i$	$\Sigma\bar{W}_i$	$\Sigma\bar{S}_i y_i'$	$\Sigma\bar{S}_i W_i'$	$\Sigma\bar{W}_i F_i'$ ..	$\Sigma\bar{W}_i X_i'$	.....
HYV Irrigated	Rice Sugarcane							
Subtotal								
Total				$\Sigma\bar{S}_i y_i'$	$\Sigma\bar{S}_i W_i'$	$\Sigma\bar{W}_i F_i'$	$\Sigma\bar{W}_i X_i'$	.....

A decomposition table displayed in this fashion gives very clear indications of the most important source of output differences. If it is intensity, irrigation data can be compared to see whether the irrigation difference is larger or smaller than the intensity differences. Large yield contributions can be compared with fertilizer levels to see whether a machine or the fertilizer was the predominant source of the yield difference. And large cropping pattern effects can be compared with capital and machine input data to see whether the cropping pattern difference was conditional on the machine or not. If a farmer plants more maize after acquiring a maize planter, the machine was causal, but if output on tractor farms is higher because they plant more tobacco, it would be difficult to believe that the tractor was an essential precondition for the shift. To interpret these tables requires common sense and knowledge of the farming situation in the area, but no complicated techniques which are the exclusive preserve of a single discipline.

PROJECT STATEMENT

A. PROJECT SUMMARY

1. Statistics:

Project Title:	Effects of Mechanization Upon Small Grain Farm Production, Income, and Employment
New or Extension:	New
Duration:	Three Years -- September 1, 1977 to August 31, 1977
Total Estimated Cost:	FY 1977 $330.8 FY 1978 $222.9 FY 1979 $216.9 Total $768.6
Principal Investigator:	International Rice Research Institute (IRRI), Agricultural Development Council, Inc., (A/D/C), and subcontractors to be selected by IRRI.
Project Manager:	William C. Merrill Economics and Sector Planning Division TA/AGR/ESP

2. Abstract

Since 1965 AID has promoted the development and use of small scale farm machinery for grain production in Asia. In recent years there has been increased interest in the economic and social effects of such machinery on small farm households. The basic question is, "Does the development and promotion of small scale farm machinery truely benefit small farmers?" This project will not provide the definitive answer to this question but it will begin the process of building an increased awareness in the Asian region of the importance of the question and an increased capacity to carry out research related to the question.

Under this project coordinated case studies of the effects of farm mechanization will be carried out in four Asian countries under the direction of the International Rice Research Institute IRRI and several small independent research activities will be carried out in other Asian countries under the direction of the Agricultural Development Council (A/D/C). The coordinated case studies directed by IRRI are the major component of this project. Under this component it is proposed that a sample of small farms characterized by varying agricultural practices and levels of mechanization be selected and surveyed at various times in the crop production cycle. Farm-level data will be gathered on use and cost of inputs, yields, incomes and other variables required to better understand how the use of small scale farm machinery effects small farmers. Particular attention will be placed on the timing, amount and composition of the labor input vis-a-vis family and hired labor. The data will be analyzed to determine whether significant differences in employment, yields and other relevant variables exist among the various mechanization-technology combinations found in a particular study area. The results from these case studies, will provide micro-level data on input characteristics of several farm operations and insights for analysis of mechanization on other cropping systems in different areas or countries. Since the research project will focus on four countries with differing geographic climatic and socio-economic conditions these externalities will be greater than those from a single country study.

The small, independent research activities directed by A/D/C will provide information on the effects of mechanization which will supplement and complement that developed by the IRRI directed component of the project. The A/D/C directed research will provide scholars not included in the IRRI directed component an opportunity

to carry out small studies on the effects of agricultural mechanization and to exchange ideas, information, and results of their work with IRRI researchers.

The A/D/C component of the project will be managed in such a way as to encourage (1) research on the effects of mechanization in countries not included in the IRRI component and (2) the exchange of information and results of this research with other interested scholars in the Asian area. The exchange of information will take place, in part, through participation in regional seminars on agricultural mechanization. Some of the seminar activities will be funded by this project. Funding for additional seminar and workshop activities will be requested at a later date if necessary but, in general, would be provided by other organizations or through other AID programs.

B. EXPANDED NARRATIVE STATEMENT

1. General Background

Since 1965, the International Rice Research Institute has had a program for the development and extension of small farm machinery which has been funded in part by AID. Total AID funding of these activities to date amounts to approximately $2,200,000. Under the IRRI program prototype models are designed and field tested. Successful models are then made available to local manufacturers. IRRI provides these manufacturers technical assistance and engineering testing services for machinery of IRRI design or modifications of IRRI designs. Most of this work until recently has been conducted in the Philippines. In 1975, however, the IRRI program was broaden to include "industrial outreach" activities in Pakistan and Thailand It is anticipated that similar work will be initiated in Indonesia in the near future..

In the early 1970's AID began to direct greater attention to the impact of its programs on small farmers. As part of this process it became increasingly interested in the effects that programs such as the IRRI small farm machinery program might have on small farmers. A thorough review of the literature on the effects of farm mechanization was undertaken by the Agency in late 1974 and a careful review of the IRRI program was completed in 1975. Following, the 1975 reviews it was decided that, in light of the industrial outreach program, it would be appropriate and timely to initiate more in-depth research on the effects of agricultural mechanization once initiated outside of the Philippines.

Funds were requested for such research in 1976 but staff time did not permit the development of a project proposal or request for such proposal at that time. In early 1977, IRRI submitted an unsolicited proposal to undertake such research in coordination with its industrial outreach project, A/D/C had previously indicated its interest in such research but felt that its style of operation and staff situation would not be consistent with accepting primary responsibility for a large scale, coordinated research effort. This project proposal is a revision of the proposal submitted by IRRI and links that proposal to the approach suggested by the A/D/C for encouraging small research projects on the effects of agricultural mechanization in Asia.

2. Research Purpose and Expected Products

Purpose: This project is designed to achieve two objectives. The first is to provide a better understanding of the effects which farm mechanization has had on small farmers. Emphasis will be given to determining output, income, and employment effects of small scale (IRRI-type) equipment on small grain farms, particularly rice farms. The second objective is to encourage more applied research on the effects of farm mechanization and improve the capacity of Asian scientists and institutions to undertake such research. A large proportion of the total funding for this project is devoted to achieving the second objective. The rational for undertaking IRRI directed research activities in four countries and the proposed A/D/C research grant, in large part, stems from the importance of achieving the second objective. The first objective is a research objective. The second, in large part, an institution (or capacity) building objective.

Expected Products: (1) improved capacity of Asian scientists to use the techniques of agricultural economics and rural sociology to assess new technologies, conduct farm level studies, and to analyze policies; (2) recommendations useful to small grain farmers regarding appropriate mechanization practices based on economic, and technical studies in regions of four Asian countries; (3) analysis of alternative policies and programs for assisting small farmers to improve income and employment opportunities and the extension of this information to relevant government and parastatal agencies; (4) analysis of the optimum resource combinations and the resulting impacts of mechanization on 'typical' farms in four Asian countries; (5) additional knowledge of the factors underlaying the adoption of improved practices,

new technologies and mechanization and projections of adoption rates based on this knowledge; (6) regional estimates of the effects on farm income, employment, and production of adoption of mechanization in grain production and (7) methodologies for assessing the impacts of mechanization on small farms.

Relevant Policy Questions: The information developed by this project will be relevant to program and policy questions such as:

(1) whether or not to include a mechanization component in government agricultural projects,

(2) the use of subsidized small equipment government operated "power/implement" pools for custom-hire work,

(3) the use of subsidized credit for equipment purchase,

(4) removing or improving tariffs on imported machinery, parts, and fuel,

(5) subsidy programs for domestic producers of equipment,

(6) commodity price and input cost subsidies which may alter the relative profitability of small-scale mechanization

(7) land tenure arrangements which may affect size of holdings and thus effect the profitability of mechanization.

It is recognized that the priorities assigned to policy questions of this type will vary between countries. The research designs for the countries may differ somewhat as a result.

3. Relevance and Significance of the Proposed Project

a. The Development Problem

Agricultural mechanization touches on three vital issues which are important not only to AID and the "New Directions" mandate but, to basic development questions: i.e., employment creation, food production and equitable income distributions. For example, employment creation continues to be a most vexing problem for LDCs for it is apparent that employment growth within LDC manufacturing sectors has not been sufficient to absorb the increases in the labor force nor are the prospects for doing so likely to improve in the near future. Therefore the agricultural and rural sectors in LDCs, particularly those with low land/labor ratios, must generate added employment if these increases are to be absorbed in productive activity.

On the other hand, food production and productivity per worker must increase to meet the food demands stemming from population growth and the increasing urban populations. Increases in food production are a vital element of a rural income-generating mechanism that will allow self-sustaining growth. New agritultural technologies, particularly cost decreasing innovations, can be important in this strategy.

In the process of food production, initial factor endowments and the returns to those factors will determine the amount as well as the direction of income flows. It is important to determine the changes in direction and amount of flows due to new technologies and mechanization in particular.

While farm mechanization is viewed as a vital part of agricultural development, the type of mechanization, i.e., size and power and type of machine, may have a profound influence on the demand for labor, output and distribution of income. It has been argued that mechanization will result in increased output and employment by increasing the cultivated area, permitting multiple cropping, and improving cultivation practices and yields, yet, little empirical evidence exists to support this conventional wisdom.

Unfortunately such statements provide little useful information to policy makers since each type of machinery can interact differently with cropping systems and operations, resulting in different and possibly negative employment and output effects.

While the problems of assessing the effects of new technology are not simple, strong interest in these effects is expressed by LDCs and is a necessary input into AID decision making. AID is increasingly concerned about the development and use of appropriate technology given the factor endowments and the needed increases in food output. It is clear that the assessment of the effects of agricultural mechanization can be helpful to many development practioners. The proposed research project will provide information about appropriate technology on farm sizes which make up close to 90% or more of farms in the region, viz., 0-12 hectares.

b. Policy Issues and the Research Focus

By nearly any measure, the amount of useable energy (man, animal, and machine) available for agricultural use in LDCs is low. One of the most important decisions facing a low income country is that of evaluating the most economically and socially desirable process of agricultural mechanization. In evaluating the process, one must consider the type of machine used, the rate of introduction, and the operations affected. For individual countries,

the lack of adequate technical expertise and farm level data makes the formulation of policy and assessment of impacts speculative at best.

Some economists point to the paradox of mechanization in labor abundant economies while other economists and most engineers equate farm mechanization with modernization; and modernization, in turn with high productivity of labor and land. The latter group seems to foster the concept of a mechanization ladder. The first group prescribes a "go slow" policy for mechanization while the second encourages rapid adoption. To some extent these groups may be talking past each other as a result of initial biases, but these divergent prescriptions may also result from different perspectives on the temporal dimensions of mechanization. Over the long run, mechanization appears to be the only viable means of significantly increasing agricultural power. As the availability and quality of land drops per capita, the food energy for men and animals will become increasingly expensive. Thus, mechanization could reduce the demand for animal feeds and increase availability of land for food production. On the other hand most studies have shown that mechanization in its early stages has little effect on crop yields. There appears to be wide agreement that the long term effect of farm machinery on agricultural employment is likely to be substantially greater than the short term changes.

The proposed project will focus on the economic costs and benefits of mechanization on small farms; viz., those associated with short and intermediate term changes in production, income, and employment.

c. Possible Side-effects of the Proposed Research

Environmental aspects of this project have been considered. The project activities are limited to an economic study of the effects of mechanizing small farms. Projects of this type normally do not require the filing of an Environmental Impact Statement (22CFR 216.2(b). This activity is not deemed a major Federal Action (Section 1500.6, CEQ Guidelines) since the project will have no significant effects which adversely affect such aspects of the human environment as air, water, land, flora or socio-economic conditions. Therefore, it is recommended that the Threshold Decision be deemed negative, constituting a Negative Determination since the project will not result in activities affecting environment.

This project will analyze the input requirements particularly the labor used under alternative levels of mechanization. This should permit a clearer understanding of mechanization impacts on population growth, energy requirements and the role of women. For example, if mechanization reduces the drudgery of field work it may increase female labor participation as women assume other jobs. If these jobs are incompatible with the care of children at home there could be implications for fertility. Also, if the skill levels required in agriculture are increased it may motivate farmers to provide more education for their children and increase the cost of children. Therefore, the analysis of family vs. hired labor are or should yield insight into the role of women and population growth implications of mechanization. On the other hand, the analysis of input needs should also provide information on energy requirements of alternatives mechanization levels.

4. Relation to Existing Knowledge

A review of the literature on farm mechanization reveals several complications involved in measuring employment, output and income impacts. First, each individual operation required for crop production can be performed with many alternative techniques. Land preparation, water control, planting, harvesting and threshing are individual operations within the farm production function. Mechanization can impact on all, one or several of these operations. Thus, in the research design proposed, the mechanical changes are disaggregated into specific changes in individual operations.

Secondly, although studies of single mechanization options (tractor hire schemes for example) are relatively easy to carry out, they are of more limited value to policy makers than those concerned with assessing the impact of mechanization options which may affect several production operations. Research in the short and medium term should emphasize the trade-offs inherent in mechanization options. The array of alternatives is wide and an all inclusive sample would be very expensive and difficult to collect. This research project will attempt to investigate only a limited range of mechanization alternatives associated with several farming operations. It is recognized that sorting out the impacts is complicated by the fact that the type of mechanization employed in one operation is seldom independent of that used in other operations. Small power tillers for example, may have little impact on production unless a pumpset is used to increase water availability. Further, it is difficult to sort out the impact of a newly mechanized operation and new technology inputs like fertilizer. Mechanization may enable more precise timing of operations and application of chemical inputs so that double cropping may take place. Thus, the study has to look not only at separate operations and the array of mechanical techniques but

also at the level of technology and the feedbacks between mechanization and other farming practices. The existing literature provides very little insight into the complexities of these relationships.

Existing data available from farm surveys provide limited information for policy analysis of mechanization. Such surveys frequently provide information on size of farms, man/land ratios, implements in use etc., but seldom show changes in output, income distribution and employment associated with changes in inputs including farm machinery. The estimates of employment requirements for particular operations vary widely from country to country. Differences in soil, weather and cultural practices account for some of the variation, but in other cases the differences are hard to explain given similar cultivation practices. Thus the collection of new farm level data is necessary to provide the information needed for this project.

During the past four years, AID has funded five small studies of the effects of new technology on small farmers.

These are:

(1) Antonio Gayoso, The Impact of Changing Technologies Mechanization and Employment: A Preliminary Review Economic Analysis Division, Bureau of Program and Policy Coordination, U.S. Agency for International Development, Washington, D.C., 1974

(2) William C. Merrill, The Impact on Agricultural Mechanization on Employment and Food Production, Occasional Paper No. 1, Economics and Sector Planning Division, Office of Agriculture, Technical Assistance Bureau, U.S. Agency for International Development, Washington, D.C., September 1975

(3) A. L. Becker, W. R. Butcher, C. F. Feise, and C. A. Ulinski, Evaluation of Factors Affecting the Rate of Adoption of IRRI Small Farm Equipment, Department of Agricultural Economics, Washington State University, Pullman, Washington, November, 1975.

(4) John Balis, Appropriate Technology for Agricultural Development, Appropriate Technology Committee, U. S. Agency for International Development, Washington, D. C., June, 1976.

(5) Wayne A. Schutjer and Marlin G. Van Der Veen, Economic Constraints on Agricultural Technology in Developing Nations, Occasional Paper No. 5, Economics and Sector Planning Division, Office of Agriculture Technical Assistance Bureau, U.S. Agency for International Development, Washington, D.C., forthcoming, 1977.

Each of these studies represented three to six man-months of research based on existing literature and data. The conclusions of these studies were quite similar. They confirm:

(1) That little systematic research has been carried out on the impacts of mechanization on small farmers.

(2) That much of the existing research fails to separate out the interactions between mechanization and the adoption of other technologies and practices.

(3) That there is very little evidence to support the contention that mechanization substantially increases yields.

(4) That mechanization which replaces animal power usually reduces rural employment.

(5) That tractorization may result in a gradual increase in the size of land holdings and the displacement of tenants or farm workers

(6) That government policies and programs to promote mechanization through subsidized interest rates, favorable import arrangements, or increased credit availability can cause a significant increase in the rate of mechanization and are likely to benefit large landholders more than others

(7) That the mechanization of agriculture is a continous and inevitable process in economic development but one whose speed and direction can be altered by public policies and programs

(8) That agricultural mechanization should be viewed as a part of modern agricultural production systems.

Combined with new biological and chemical technologies mechanization may enable more precise timing of operations and application of chemical inputs so that the total biological, chemical, and mechanical package results in an increase in output per acre year with little, if any, reduction in total employment

Many of the studies upon which these general conclusions are based are careful analyses of specific types of mechanization in selected types of mechanization in selected regions in most of the countries included in this project. The focus of these studies, however, generally was not on small scale, IRRI-type, farm machinery. A large proportion of the research on this topic has been on medium and larger size tractors, associated equipment, and larger scale modern grain harvesting equipment. These studies will provide background and complementary information for the proposed research. Very little, if any, duplication between the proposed and past research is anticipated. IRRI has, however, carried out several small, case study surveys of the impact of small scale equipment in the Philippines. This work will provide a starting point for the proposed study in the Philippines, and illustrations of the type of information which could be collected relatively quickly in the other countries working with IRRI.

5. Relation to Other AID Projects

There are no AID projects currently underway or proposed on the effects of different types of mechanization on small farms in other areas of the world. The AID Working Group on Appropriate Technology has, however, established a private corporation, Appropriate Technology International, intended to develop and promote appropriate technologies for developing countries. A.T. International may at a later date undertake projects related to the proposed project. TA/AGR/ESP is represented on the AID Working Group on A.T. and, therefore will be able to assure close coordination between the proposed project and any related work sponsored by A.T. International.

The proposed project is directly related to IRRI's industrial outreach program which is funded by AID (AID Contract csd-1208). This project will be managed by IRRI and AID so as to supplement and complement on-going industrial outreach program. It will provide useful information with which to evaluate the industrial outreach program and for re-focusing the program, if necessary, in the future. The IRRI industrial outreach network in Pakistan, Thailand, Indonesia (proposed), and the Philippines will be used to provide information on where IRRI-type equipment is being used and, where appropriate, institutional bases for the research activities.

The A/D/C - Reseach and Training Network (RTN) program will be particularly helpful in the dissemmination of the results of the proposed project, to policy-makers and other researchers.

Current work supported by AID/TA/AGR at Michigan State University, Purdue University, and Cornell University (Poor Rural Households, Technical Change and Income Distribution in LDCs) is related to the proposed project, but differs in the degree of detail being given to the mechanization issue. The Poor Rural Households ... project will not attempt to define specific farm level packages of mechanization and then evaluate their impacts in relation to other tecnnological advancements as does this proposal. Thus, the proposed activity focusses upon the question of the role that adoption of mechanization plays in increasing small farm income, in changing farm labor requirements, and in bringing about change in farm production.

6. Research Project Design and Methodology (IRRI Component)

a. Research Design Summary

The research design for this project will be finalized and approved prior to and during the initial start-up Phase of the project period. Nevertheless, the following discussion outlines what is presently anticipated and serves as the basis for estimating project costs. It is recognized that the needs, capabilities, and interests of each country are likely to differ and must be reflected in the final project design.

b. Preliminary Description and Justification of Project Design

Primary farm survey data supplemented by experiental data derived from agronomic and engineering studies will be utilized in this project. Cross-sectional survey data will be obtained from random samples of farms in selected regions of each of four countries viz., Pakistan, Indonesia, Thailand, and the Philippines. Farmers will be interviewed to determine the nature of their farming operation. Engineering feasibility and cost data will come from IRRI as will agronomic and other production oriented data.

The entire set of information utilized will serve as the basis for describing the production, resource use, costs and income status of typical farms in each region. From these data typical-farm programming models will be constructed and analysis carried out to identify efficient production levels, use of resources, levels of mechanization, labor utilization, costs and returns. Sensitivity analysis will be carried out to determine the impacts at the farm

level of variations in commodity prices resource constraints input prices, and other parameters which may be sensitive to government policies and programs. The effects of alternative levels of mechanization will be shown by comparison between farms where alternative sources of power and implements are the primary difference.

Aggregation of the "typical" results will be carried out to show regional implications of changes in relevant policies and programs. To the extent possible, regional estimates will in turn be aggregated to reveal the general nature of impacts at the national level. Rough estimates of adoption rates for mechanization will be approximated using information derived from the cross-sectoral surveys as well as other sources.

c. Project Activities

Project Phases: This project will be carried out in four phases. Phase I will require approximately four months. (October 1977 - January 1978). During this phase (1) sub-contracts will be negotiated with institutions in Indonesia, Thailand, Pakistan, and the Philippines, and (2) the research design for each country will be finalized and approved. Phase II will entail completion of the field survey questionnaires to be used and the selection of the sample farms for intensive study during Phase II. It is anticipated that Phase II will require approximately six months. Phase III is the data collection phase. It will require approximately one year. Phase IV is the data analysis phase which will end with the preparation of final reports at the end of year three. Workshops will be scheduled at appropriate times during each phase to coordinate the activities in each country and assure the maximum comparability of results.

Phase I October 1, 1977-January 31, 1978

The proposed primary contractor is the International Rice Research Institute (IRRI). During Phase I the research design and methodology for each country will be finalized, and sub-contractors for country studies will be selected.

During early meetings between AID and IRRI staff members the procedures to be followed for reaching project objectives will be finalized. Details to be agreed upon include the different types and levels of mechanization to be examined, the farm size units to be considered, the "mix" of other traditional/modern cultural practices to be included, the basis for stratification of sample data, the probable variation in

sample data, the specific sampling procedures and size required in order for the study to produce statistically reliable results and the methods of analsis to be followed in evaluating the data.

Following agreement on the study design and methodology, IRRI will identify sub-contractors to carry out three studies, one in Pakistan, one in Thailand, one in Indonesia, and will conduct a study themselves in the Philippines. Each sub-contractor will be selected on the basis of capacity to carry out the work and institutional commitment to the research. AID/1A/AGR will have final approval of the sub-contractors. While final selection of sub-contractors has not yet been made IRRI has had preliminary dicussions with several institutions. The following is a synopsis of their findings:

Indonesia - Three institutions offer possibilities to assist with the project. They are the Central Research Institute for Agriculture, the Agriculture Institute (an agricultural university) both at Bogor, and the Institute of Technology, Bondung. The Agricultural Engineering Department, Ministry of Agriculture is also very much interested in mechanizaion studies.

Pakistan - Dr. H. Slamul Haque, Director General of the Agricultural Research Council (ARC) and R. M. Iono Quraisni, Director of Economic Research for ARC are interested in mechanization utilization research. Dr. Quraishi has experience with this type of research at the Sind University and will welcome the opportunity for additional study.

Dr. M. L. Quraeshi, Director Pakistan Institute of Development Economics (PIDE) and members of his staff also indicated an interest in mechanization use studies. Dr. Abdul Salam appeared the most interested in conducting such research. Dr. Quraeshi indicated interest in coordinating a Pakistani effort in this area.

Dr. Amir Khan IRRI/Pakistan talked with Dr. Bashir Ahmed, Joint Chief Economist - Planning and Development Department, Government of the Punjab; and staff of the Economics Department - Layallpur University. Both offices were interested in participating in mechanization use research. All Pakistani contacts indicated facilities for analysis and assessment of data and availability of survey staff. PIDE appeared to be the most capable and interested in coordinating project activity in Pakistan.

Thailand - In Thailand, interest and capability to assist with mechanization use studies were found in the Ministry of Agritulture, Agricultural Economics Division: Kasitsart University Faculty of Economics and Business Administration and at the Asian Institute of Technology (AIT). Dr. Nguen Susurak, Agricultural Marketing Chief and Dr. Nurong Chaprakab, Chief of Planning

Branch are interested staff members in the Ministry of Agriculture. At Kasitsart University, Dr. C. Boonma, Director of Agribusiness and Management Programs also indicated interest. Both the ministry and university voiced preference for a secondary role and not that of coordination. The AIT in addition to having good facilities and capabilities, was interested in contracting to coordinate project activities in Thailand. Also through their graduate training program, they see an opportunity to conduct surveys in neighboring countries with their students who are nationals of those countries.

Dr. Peter Cowell, Agricultural Engineering Chief at AIT is the principal contact for mechanization use studies.

Phase II - February 1, 1978 - July 31, 1978

Phase II begins with the selection of the study region.

Criteria for selection should include:

(a) a high degree of specialization in grain farming;

(b) low variation in those factors which can not be controlled in the model specification such as climate;

(c) widespread use of mechanical, biological, and chemical technologies, and modern practices;

(d) a high level of existing available knowledge, data, or information about farmers and farming in the area in order to facilitate specification of research hypotheses development as well as sampling design and questionnaire construction;

(e) a high degree of cooperativeness of farmers in responding to questions, as exhibited by any previous surveys;

(f) accessibility to facilitate senior staff participation in field work and to facilitate numeration.

Also in Phase II the questionnaire will be developed, translated into the local language and tested. Testing should be carried out on a wide range of farms using different combinations of technology and practices and of different sizes and cropping patterns. After completion of field tests, a workshop will be held in March, 1978 by the research collaborators to construct the final questionnaire and to design sampling procedures for the survey.

Phase III - August 1, 1978 - August 31, 1979

During Phase III basic data will be collected describing farming operations and the economic and institutional environment in which sample farmers exist. As indicated above, these data pertain to farm size, enterprise combinations, access to and use of resources including land, labor, non-farm produced inputs, capital, water, machinery and work animals, cultural practices, input costs and output prices. These data will be used to delineate farming systems prevalent in the regions of interest and the timing and level of inputs utilized. Upon completion of the survey, initial analysis will be undertaken to stratify the sample by farming characteristics. The basis of the stratifications cannot be specified a priori, but it will include relationships such as size of holding, use of mechanical, biological, and chemical technology employed, other cultural practices, and enterprise combinations. Whole-farm calendars of operations and budgets will be the fundamental framework for preparing typical farm accounts. Among the strata will be the traditional farm operation not characterized by mechanization or use of other modern practices.

Following completion of field work the data will be processed for verification and storage for later analysis (i.e. Phase IV). Preliminary examination of the data will be carried out to identify missing segments or gaps, and complementary experimental data added to the data file.

At the end of Phase III a workshop will be carried out in order for the country research teams to share experiences and knowledge gained, and to review programming for Phase IV.

Phase IV - September 1, 1979 - September 30, 1980

Once data has been collected and made ready for analysis Phase IV begins. In this Phase the activities to be carried out involve, first, the design of programming models which adequately characterize typical farming operations within each region studied. It is expected that for each region there will be several typical farming systems, each one reflecting different levels of mechanization and other cultural and resource base differences. For each type of system there will be a economic programming model designed to simulate basic production and resource use behavior of that type of farm. More than likely these models will be based upon linear programming activity analysis, however the "lumpy" nature of mechanization inputs may mean another approach such as integer programming will be a more realistic tool of analysis. In any event, the appropriate modelling technique to be utilized will be decided upon later by the researchers involved in consultation with AID/TA/AGR staff.

Analysis of the impacts of mechanization upon farm production, income,

and resource use, and the interactions which are likely to show up between mechanization and other cultural practices will be carried out by first testing initial solutions of the programming models against actual farm behavior, evaluating solutions to isolate the impacts of interest, and then carrying out parametric studies of the models. The latter activity (i.e., parametric studies) will permit the researcher to evaluate the impacts upon efficient farm operations of alternative policies and programs which affect such things as farm output prices, input costs, input-output technical relationships, and resource constraints.

Finally, attempts will be made to generalize the results of the typical farm studies to their regional and to the extent possible, national implications. Future research needs will be identified, the methodology followed will be evaluated, a final workshop will be carried out and project completion reports will be prepared and distributed.

d. Independent Research Activities: A/D/C Component

The proposed $115,000 research grant to the A/D/C is intended to encourage and facilitate small, independent studies on the effects of agricultural mechanization in Asia. These studies will not be coordinated with those carried out by IRRI but opportunities will be provided for persons working under A/D/C grants to meet with the IRRI directed researchers to compare results and exchange information and data. The A/D/C research grants will be used primarily to fund research by Asian Scholars who are working with A/D/C associates on full time appointments in Asia. The A/D/C will assign one of its associates as the project manager for the A/D/C mechanization research grants component. The project manager responsibilities will be:

(1) to keep other A/D/C associates informed of the research grants program,

(2) to assist in the final selection of small research activities to receive grant support,

(3) to keep in touch with the coordiated research projects directed by IRRI, and

(4) to assure that, where appropriate, researchers funded by A/D/C grants participate in the seminar and worksnop activities carried out under the IRRI directed component of this proposal.

The basic philosophy of the Agricultural Development Council and style of operation in Asia precludes the identification and specification, at this

time, of the research activities to be grant funded. The A/D/C's primary objectives are to facilitate the training of Asian scholars and the exchange of information on the problems of agricultural development. The A/D/C component of this project is designed to be consistent with the broad A/D/C objectives while at the same time encouraging research on the economic and social effects of agricultural mechanization in Asia. The A/D/C, through its associates, will assist in the design and will monitor (or assist in) the implementation of the research. Grants will be made only when there is reasonable assurance that the proposed research is feasible and the work will meet the high professional standards of the A/D/C. The principle criteria specified by AID selection of activities to be grant funded is that the research must be concerned with the economic and/or social effects of small scale mechanization on small grain farmers in Asia.

7. Contribution to Institution Building

Institution building is one of the principal objectives of this project. This will be achieved in two ways under the IRRI directed component. First, by facilitating close working relationships between IRRI personnel and national institutions concerned about the effects of agricultural mechanization. This, in a sense, is building capacity through "on-the-job" training and experience. Second, by hopefully establishing long term professional relationships with scientists in neighboring countries who are undertaking similar work and contributing to international recognition of the interests and capabilities of the institutions selected to participate in the project.

The A/D/C directed research grants will also improve national capacity to undertake research on agricultural mechanization. Again the mechanism is to providing opportunities (1) to undertake research in this area, and (2) to exchange information data, and research results with other Asian scientists through seminar and workshop activities.

To a large extent, this project attempts to build individual and institutional capacity primarily through investments in human capital. Only a small percentage of the funds will be invested in physical capital such as automobiles, calculators, and books.

8. Facilitate Utilization of Research Results

This project has been developed with the assistance of TA/AGR's Food Crop Production Division which manages an AID-funded project carried out by IRRI to develop small scale agricultural machinery (AID Contract csd-1208). That project focuses on engineering/technical constraints and problems in

the design of machine prototypes to be manufactured in the LDCs. This project focuses on the impacts of adopting similar machinery types and other mechanization forms by small farmers and thus will be of direct value to the evaluation and redesign of future IRRI programs to promote agricultural mechanization. In addition, results will be of interest to four audiences: farmers, LDC machinery manufacturers, LDC government policy and program planners, and the international community of development practioners and scholars. The results will be released to farmers and manufacturers through IRRI's Industrial Liason groups. These groups provide technical advisory services to manufacturers of farm machinery and through them to farmers. In addition, IRRI has excellent relationships with the Ministry of Agriculture in each of the countries. Publications summarizing the results of this study will be made available to the Extension Services of these Ministries. Similarly agricultural sector planners will receive publications. IRRI will also publish the results in one of their regular research publication series for distribution to the international community.

9. Researcher Competence and Resources

IRRI has had twelve years of experience in working on agricultural mechanization programs in the Philippines. Since 1970 it has undertaken several small studies on the effects of IRRI designed machines. As part of its industrial outreach program it has established contacts with institutions interested in agricultural mechanization throughout Asia. IRRI has an international reputation for high quality research and the strongest agricultural economics division of any of the international research institutions.

The A/D/C also has an international reputation of excellence in any job which it elects to undertake. Its staff is widely known and respected in Asia and has developed close working relationships with Asian universities and scholars in both government and private institutions. Although the A/D/C staff does not have long term experience in research related to agricultural mechanization, it has had substantial experience in the design and implementation of small research activities.

Both the A/D/C and IRRI have a capacity to rapidly respond to any problems which may arise in carrying out the proposed research. This is in part because both already have staff members in most of the countries involved in this project and, in part, because this project is highly complementary to their existing programs.

Project funding consists of two components:

(1) A research grant of $115,000 (includes 15% for overhead) to the Agricultural Development Council to undertake independent research in selected countries.

(2) A centrally funded research contract between the Agency for International Development (TA/AGR/ESP) and the International Rice Research Institute. Funding of this contract for the three years of operations will be $653,600. Major budgetary items will be for research programs in three countries as shown in the work plan, a project coordination and research program in the Philippines at IRRI and funding for consultants to advise and assist in the planning and implementation of data assembly and in analysis.

Budget Components

Item	Year 1	Year 2 ($000)	Year 3	Total
A. Three Country Projects	$147.9	$132.9	$126.9	$407.7
B. Philippine Project	53.9	64.5	62.5	180.9
C. Consultants*	14.0	25.5	25.5	65.0
Total	$215.8	$222.9	$214.9	$653.6
D. ADC Grant	115.0	--	--	115.0
	$330.8	$222.9	$216.9	$768.6

* Includes salary, per diem and travel

A. IRRI - Individual Country Research Component

Item	Year 1	2 ($000)	3	Total
Salaries 1/	$15.0	$15.0	$15.0	$45.0
Fringe Benefits 2/	5.3	5.3	5.3	15.9
Overhead 3/	3.0	3.0	3.0	9.0
Domestic Travel & Survey Costs	10.0	10.0	10.0	30.0
Vehicle (including Operating Cost) 4/	8.0	2.0	2.0	12.0
Materials & Supplies	3.0	4.0	2.0	9.0
International Travel (workshop & conferences)	4.0	4.0	4.0	12.0
Contingency	1.0	1.0	1.0	3.0
Total	$49.3	$44.3	$42.3	$135.9
For three countries	$147.9	$132.9	$126.9	$407.7

1/ Includes salary supplement for one Senior Research Associate and salaries for four Research Assistants and one Secretary.

2/ Fringe benefits calculated as 35 percent of base salaries.

3/ Overhead for country projects calculated at 15 percent of base salaries.

4/ Locally procured vehicle. Estimated cost is $6,000.

B. IRRI - Philippine Component

Item	Year 1	2 ($000)	3	Total
Salaries 1/	$16.0	$17.0	$17.0	$50.0
Benefits 2/	5.6	6.0	6.0	17.6
Overhead 3/	3.3	3.5	3.5	10.3
Travel and Transportation 4/	15.0	15.0	10.0	40.0
Materials & Supplies 5/	6.0	8.0	10.0	24.0
Workshops & Conferences 6/	8.0	15.0	16.0	39.0
Total	$53.9	$64.5	$62.5	$180.9

1/ Includes salary component for IRRI project manager plus support for three Research Assistants.

2/ Fringe benefits are calculated as 35 percent of project employee salaries.

3/ Overhead is calculated as 15 percent of project salaries and benefits.

4/ Includes domestic travel for country research and international travel for project coordination.

5/ Includes computer analysis of data and publications.

6/ Includes local support costs of workshops and conferences plus travel costs for reseaches not directly associated with the IRRI component

C. **IRRI - Consultants**

Item	Year 1	Year 2 ($000)	Year 3	Total
Consultant's fee	$7.5	$15.0	$15.0	$37.5
Per diem	1.5	3.0	3.0	7.5
Travel	5.0	7.5	7.5	20.0
Total	$14.0	$25.5	$25.5	$65.0

Summary -- Line Item Budget

Item	Year 1	Year 2 ($000)	Year 3	Total
Salaries	$61.0	$62.0	$62.0	$185.0
Consultants	7.5	15.0	15.0	37.5
Fringe Benefits	21.5	21.9	21.9	65.3
Overhead	12.3	12.5	12.5	37.3
Travel & Transportation	63.5	67.5	67.5	193.5
Vehicles*	24.0	6.0	6.0	36.0
Materials & Supplies	15.0	20.0	16.0	51.0
Workshops & Conferences	8.0	15.0	16.0	39.0
Contingency	3.0	3.0	3.0	9.0
Total	$215.8	$22.9	$214.9	$653.6
Grant to Agricultural Development Council				$115.0
Grand Total				768.6

* Included operating expenses for country research projects

It is recognized that some budget adjustments may be required for the IRRI directed component once specific sub-contractors have been identified and scopes of work finalized.

11. Work Plan and Contract Budget

The general work plan for the project is outlined in Section 6 and the estimated project budget presented in Section 10. The proposed project timetable is as follows:

Phase I

(1) July 15, 1977 RAC Approval

(2) September 30, 1977 Contracts signed with IRRI and A/D/C

(3) November 30, 1977 IRRI sub-contractors selected and initial planning workshop held

(4) January 31, 1978 Research design finalized

Phase II

(5) March 31, 1978 Planning workshop held to finalize field survey questionaires and design sampling procedures

(6) September 30, 1978 Field testing of questionaires completed

(7) September 30, 1978 Survey of existing data and studies on agricultural mechanization completed

(8) September 30, 1978 Workshop to compare results of initial field survey work and exchange information on existing research.

Phase III

(9) August 1, 1978 Field data collection initiated

(10) August 31, 1979 Field survey work completed

(11) November 30, 1979 Workshop held to compare initial results of field surveys and coordinate Phase IV activities

(12) January 1, 1980 Field data processed and verified

(13) June 30, 1980 Programming analysis of typical farms completed

(14) July 30, 1980 Final workshop held to compare results of typical farm analyses.

(15) September 30, 1980 Final policy analysis work completed and final reports prepared.

It is recognized that there will be some overlap in the timing of the activities associated with each phase of the research. The four workshops held during each phase of the project are the principal means of coordinating the research activities in the four countries and exchanging results. Nevertheless, it is anticipated that research results will be exchanged throughout the project through publications and travels of individual researchers to other countries. Where appropriate, researchers funded under A/D/C grants will be invited to participate in the workshops and to evaluate research designs and implementation procedures.

It is not possible to make a concise allocation of funds to the two principal project objectives outlined in Section 2. TA/AGR/ESP assigns both objectives approxiamtely equal weight. Nevertheless, most of the funds are allocated to achieving the research objective and the institution building objective is to be achieved as a by-product of the research activities

12. Management Considerations

No unusual management problems are expected to arise in connection with this project. TA/AGR has worked closely with both the A/D/C and IRRI on past projects. Both institutions have shown high technical capacity, efficient administration and excellent cooperation with AID's technical and contract staffs.

It is estimated that the project will require approximately 2 person months per year of TA/AGR/ESP staff time. Consultants will be utilized when necessary for major evaluations of the project.

No person will, on the grounds of sex, race, color or national origin be excluded from participation in, be denied the benefits of, or be subject to discrimination under this project. Women, who are qualified and available, will be employed as research assistants, as consultants and evaluators, and in administrative positions.

13. Internal and External Reviews

The project will be evaluated on a regular schedule of reviews as well as by continuing supervisions by the AID project manager. For the life of the project full-scale evaluations will be scheduled for:

Ten months after project initiation
Twenty-two months after project initiation
Thirty six months after project initiation

The project evaluation team will be composed of:

1-Project Manager, TA/AGR/ESP

2-Representatives of A/D/C and IRRI

3-Dr. William J. Chancellor, Agr. Eng. Dept, University of California, Davis (tentative)

4-Additional Members selected by AID (optional)

14. Proposing Office General Appraisal

TA/AGR/ESP, assigns this project high priority. This is, in part, due to the worldwide importance of the topic and, in part, because of potential effects of the IRRI program to develop and promote small scale farm implements in Asia. Both IRRI and the A/D/C also assign high priority to the proposed research and would like to begin work on the project as early as possible.

TA/AGR/ESP has discussed alternative research designs with several experienced researchers. There is general agreement that the proposed research is feasible but considerable differences in opinion exist as to the specific research design most appropriate to achieve project objectives. The essence of what is being proposed is to first define typical farms using different technology mixes and different types of mechanization in four contries. Then to analyze the effects of mechanization based on in-depth field surveys of the typical farms' operations using for example, linear programming as one of the principal analytical methodologies.

It is recognized that research results with greater statistical reliability could be obtained by utilizing the proposed funds for research in only one or two countries. This approach, however, would limit the achievement of the institutional building capacity objective to fewer contries and would provide less information on differences between countries.

If the entire project could not be funded, TA/AGR/ESP would give highest priority to the IRRI directed component of the project. Further reductions in funding would require reducing the number of countries included in the IRRI component.

Because of the number of host contry institutions that will be involved in implementing this project and the possibilities of raising false expectations TA/AGR/ESP is reluctant to involve these institutions in detailed discussions of the prject's design until RAC has reviewed the project. Never-

theless, TA/AGR/ESP is of the opinion that the final project design can not be finalized until Phase I is completed.

Of the various recommendations which RAC could make on this project, the one preferred by TA/AGR/ESP would be:

(1) RAC provide recommendations for improving the research design.

(2) RAC approve the project subject to (a) a RAC member (or designated consultant) participating in preliminary discussions with IRRI sub-contractors and the finalization of the project design during Phase I of the project, and (b) review of the final research design at the first RAC meeting following completion of Phase I. The RAC participant in Phase I would have authority to recommend (a) termination of the project at the end of Phase I, (b) delay of initiation of Phase II, or (c) initiation of Phase II activities with suggested changes in project design to be reviewed by RAC prior to final approval.

William C. Merrill
Project Manager

Leon F. Hesser
Director, TA/AGR