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ORIGINAL

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

FEB 2 1975

Mr. J. B. Knapp
Executive Vice President
International Bank for Reconstruction
and Development
Washington, D.C. 20433

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Subject: Grant No. AID/otr-G-1366
PIO/1 930-11-995-054-73-3058019

Dear Mr. Knapp:

Pursuant to the authority contained in the Foreign Assistance Act of 1961, as amended, the Agency for International Development (hereinafter referred to as "AID" or "Grantor") hereby grants to the International Bank for Reconstruction and Development (hereinafter referred to as "IBRD" or "Grantee") the sum of $400,000 in support of the Study of Substitution of Labor for Equipment in Civil Construction" as more fully described in the attachment to this Grant entitled "Purpose and Implementation of Grant" and your proposal entitled "Substitution of Labor for Equipment in Civil Construction" and dated October 17, 1973.

This Grant is effective as of the date of this letter and is applicable to commitments made by the Grantee in furtherance of program objectives during the period March 1, 1975 through June 30, 1977.

The Grant is made to the IBRD on condition that the funds will be administered essentially as described in your proposal and in accordance with the terms and conditions as set forth in Attachment A entitled "Purpose and Implementation of Grant", Attachment B entitled "Standard Provisions" and Attachment C entitled "Payment Provisions", all of which have been agreed to by your organization.

Please sign the original and seven (7) copies of this letter to acknowledge your acceptance of the conditions under which these funds have been granted.

FUNDS OBLIGATED

Approp. No. 11X1023
Allot. No. 402-30-099-00-20-51
Obl. No. 3058019 2590
[illegible] 400,000.00
Proj. No. 930-11-995-054-73

By [illegible] 2/28/75

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Please return the original and six (6) copies of this Grant to the Office of Contract Management.

Sincerely yours,

L. E. Stanfield
Grant Officer
Chief, OTR Branch
Central Operations Division
Office of Contract Management

Attachments:

A. Purpose and Implementation of Grant
B. Standard Provisions
C. Payment Provisions

ACCEPTED:
INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

BY: _____

TITLE: Senior Vice President, Operations

DATE: April 18, 1975

ATTACHMENT A TO
GRANT NO. AID/otr-G-1366

PURPOSE AND IMPLEMENTATION OF GRANT

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A. Purpose

The purpose of this Grant is to provide support for the Grantee's research project on substitution of labor for equipment in civil construction.

B. Activities

The Grantee began this project in 1969 and has completed Phases I and II. Phase I focused on a survey of existing literature and problem formulation for road construction. Phase II concentrated on direct field observations of ongoing construction activities with different capital-labor mixes at a variety of sites and related sub-studies.

Phase III activities of the research project will place major emphases on the development and demonstration of more efficient labor-intensive and intermediate civil construction technologies appropriate to labor abundant capital scarce economies. This phase of the project will extend over a period of four years and will be financed by a consortium of donors: IBRD, Canada, Denmark, Federal Republic of Germany, Finland, Japan, Norway, Sweden, United Kingdom, and the United States.

Phase III will consist of a series of experimental studies and demonstration projects carried out in, at least, three countries. The areas covered by the studies will be as follows:

1. Labor Productivity: Commencing at the labor intensive end of the spectrum the project will explore increments in labor productivity associated with:

a. Improved organization and management, including scheduling and sequencing of activities in a project; the application of time and motion techniques to individual tasks; and costs of recruitment, mobilization, organization and supervision of large labor forces.

b. Improved tools and machinery, from simple hand tools and hand wheeled conveyers to small-scale power machinery adapted for use by unskilled labor, with a view of obtaining higher productivities of labor and increased efficiency of equipment.

c. Improved nutritional standards of labor, including a limited diet intervention program on pilot construction projects in India.

2. Labor Markets: The labor market for unskilled labor and lower level supervisory staff will be investigated to determine seasonal and geographic variations in demand and supply, wages and other emoluments, costs of recruitment, the extent of unionization and the objectives and attitudes of such unions. Wage differentials for different categories of skill, and between migratory and local laborers, will be quantified. The effect of employing large labor forces on the supply price of labor at the project level and the macro-level will be analyzed.

3. Studies of Alternative Policy Instruments available to international development agencies and Lesser Developed Countries government construction agencies to insure the choice of appropriate technology will be studied in the context of specific cases. These include shadow pricing schemes (in design, tendering and execution phases), tax and subsidy schemes, force account construction, and further Research and Development activities.

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C. Implementation

The Grantee will be responsible for the implementation and management of activities under Phase III.

The labor productivity experimental studies and demonstration projects will be undertaken in stages and will be extended successively to three or more countries. A small central team (servicing the three countries) will lead the research, conducting brief exploratory studies, training a counterpart team and initiating longer term studies in each country. These longer term studies would consist primarily of one to two-year demonstration projects conducted by the counterpart teams with continuing support from the central team.

Labor Productivity studies have been started in the first country, India, and in the second country, Indonesia. At least one other country to be included in the project will be chosen from outside the Asian region.

AID may select a designated official to visit project sites and review project progress at least once per annum. The time of each visit will be established by prior mutual agreement with IBRD.

The funds provided under this Grant shall be used toward the support of salaries, wages, fees, and stipends costs attributed to this Grant.

D. Reporting

The Grantee will furnish the following reports to the Project Monitor, PPC/PDA/DA, Agency for International Development, Washington, D.C. 20523 as follows:

1. Quarterly Report

Within thirty days after the end of each quarter, a brief statement of project activities.

2. Annual Report

Within thirty days after the end of each year, in three copies, an annual substantive and financial report of all project activities including project progress. The financial report will include all uses and sources of funds.

3. Final Reports

The Grantee will furnish AID 200 copies of the final report on the different subtopics of the projects as they become available and will have finalized all reports within one year of the completion of the project.

E. There is attached to and hereby made a part of this Attachment A "Purpose and Implementation of Grant", the proposal of the International Bank for Reconstruction and Development dated October 31, 1973, entitled "Substitution of Labor for Equipment in Civil Construction - A Study Proposal".

October 17, 1973

INTERNATIONAL BANK FOR RECONSTRUCTION AND DEVELOPMENT

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Substitution of Labor for Equipment in Civil Construction

A Study Proposal

I. Introduction

1. Increasing attention has been paid in recent years to the question of appropriate technology for construction and manufacturing in developing countries. The principal issue of concern is to find suitable technologies which would utilize to the maximum extent the abundant surplus of labor available in many of these countries. The World Bank has sought to examine this problem in a study of the substitutability of labor and equipment in civil construction. Two phases of the study have been completed. This proposal summarizes the results of the effort thus far and outlines future work that is to be carried in the final phase of the study. Since most of the research funds available to the Bank in this field have been fully used up in the first two phases, active collaboration and participation of other bilateral and multilateral aid agencies is being sought in continuing this work.

2. The study is attempting to establish the technical feasibility of alternative civil construction technologies utilizing different combinations of labor and equipment and in turn to relate these technically feasible solutions to relative factor scarcities so that the economically optimum technology can be determined in any given case. The cost of delays in project execution are included and practical problems in the organization and management of construction projects are being examined. The interrelationships between choice of technology and project design are also being investigated. The study emphasizes the development of efficient technologies which not only yield greater employment but also higher labor productivities.

II. Background

3. Phase I of the study focused on a survey of existing literature and problem formulation for road construction.1/ Its findings were that the substitution of labor for equipment is technically feasible for a wide range of construction activities for roads of various qualities. However, economic feasibility depends on relative factor prices and factor productivities under different conditions. Unfortunately, engineering data normally available are inappropriately structured or too poorly defined with respect to specific environmental conditions to permit a quantitative analysis of the

1/ C. C. Harral, et. al., "Study of the Substitution of Labor and Equipment in Civil Construction, Phase I: Final Report," (IBRD, Multilith October 1972).

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substitution possibilities. Specific environmental parameters are critically important, including the physical environment, the size or scale of the project and the time available to complete it, work incentives, organization and management, and health and nutritional standards of the labor force.

4. The Phase II study therefore has focused on direct field observations of ongoing construction activities to obtain the production relationship between varying inputs of capital (equipment) and labor and the output of different tasks of civil construction. Observations have been taken at several road, dam and irrigation canal construction sites in India, Indonesia and Nepal. The outputs of each activity; the inputs of labor, equipment and material; and the associated environmental parameters have been carefully recorded. Analysis of these data have been completed and a report is currently being prepared.1/ In Indonesia, a substudy is being conducted to determine the effect of health and nutritional standards on productive potential of the labor force.2/

5. Findings to date of the Phase II study are:

(a) Techniques currently in use in civil construction are either highly labor-intensive or highly equipment-intensive; no significant "intermediate" techniques have been observed in the present study. Where attempts have been made to combine traditional labor-intensive methods with modern equipment operations, e.g. hand-loading of trucks, the resulting "mixed" method obtains such inefficient use of the equipment that it in fact requires more capital than a fully equipment-intensive operation and is highly inefficient.

(b) Traditional labor-intensive techniques currently in use are not economically competitive with modern capital-intensive techniques, even in labor abundant economies when labor is "shadow priced" at a fraction of market wages. This is because (i) existing labor-intensive techniques are employed in an atmosphere where primary emphasis is on employment creation rather than efficient use of labor, and (ii) existing methods are primitive and do not employ elemental mechanics effectively, if at all. These factors result in extremely low labor productivities.

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1/ The report is expected in late 1973.

2/ Preliminary results are given in D. Karyadi and S. Basta, "[illegible] Indonesia Construction [illegible]," [illegible] Staff Working Paper No. 152 ([illegible]).

(c) Management and supervision of large labor forces requires special skills, experience and organization, quite different from equipment-intensive operations. Labor-intensive methods should not be attempted without careful advance planning, organization and training, particularly in regions where these methods have not been commonly practiced.

(d) Even in labor abundant countries there are frequently shortages of labor at different times and places; indeed, the social cost ("shadow value") of labor fluctuates widely with season and location. Unless construction authorities are prepared to pay higher wages during peak periods (e.g. the harvesting season), projects may suffer costly interruptions. "Shadow value" correction of market prices becomes a complicated proposition, and application of a single norm could lead to harmful results.

(e) Health and nutrition standards have a significant impact on productivity of the labor force. Anemia, induced by a combination of parasitic infestation and iron deficiency, has been shown to be widespread, often in severe stages among construction workers in at least one country. Experiments suggest that programs of improved nutrition can have a significant impact on labor productivity in these cases.

III. Future Work

6. The conclusions of our Phase II study clearly indicate that labor-intensive construction techniques traditionally practiced in many developing countries are not economically competitive with equipment-intensive technology under most conceivable factor prices and environmental conditions. Yet, there is a pressing problem faced by most developing countries of creating productive employment opportunities for large segments of unemployed and underemployed population. In the next phase of this study (Phase III), major emphasis is to be placed on development and demonstration of more efficient labor-intensive and intermediate civil construction technologies appropriate to labor abundant, capital scarce economies. The labor market, which to a large extent will determine the economic viability of labor-intensive intermediate technologies will be investigated. Government policy instruments to achieve the socially optimum choice of technology will be studied.

7. Labor Productivity Studies: Commencing at the labor-intensive end of the spectrum, the study will explore increments in labor productivity associated with:

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(a) Improved organization and management at the project and subproject level. Scheduling and sequencing of activities in a project will be analyzed and work sampling and time and motion techniques will be applied to individual tasks. The cost of recruitment, mobilization, organization and supervision of large labor forces will also be examined.

(b) Employment of improved tools and machinery, from simple hand tools and hand wheelbarrows, conveyers to small-scale power machinery adapted to use by unskilled labor, with a view to obtaining higher productivities of labor and increased efficiency of equipment. Machinery, and techniques in use in construction prior to development of large-scale power machinery, will be reviewed as well as currently available technology, and research and development of new "intermediate" technology will be undertaken as necessary.

(c) Improved nutritional standards of labor. It is proposed that a limited diet intervention program be undertaken by reducing or eliminating deficiency of a set of nutrients and observing its effect on labor productivity.

8. Labor Market Studies: Effect of choice of technology on supply conditions of labor requires further investigation. In particular, the effect of employing large labor forces on the supply price of labor at the project level and the macro level will be analyzed. The labor market for unskilled labor and lower level supervisory staff will be investigated to determine, separately for migratory and local workers, seasonal and geographic variations in demand and supply, wages and other emoluments, costs of recruitment, the extent of unionization and the objectives and attitudes of such unions. Wage differentials for different categories of skill, and between migratory and local laborers, will be quantified.

9. Alternative policy instruments available to international development agencies and LDC government construction agencies to insure the choice of appropriate technology will be studied in the context of specific cases. These include shadow pricing schemes (in design, tendering and execution phases), tax and subsidy schemes, force account construction, and further R & D activities.

10. Implementation: Success of any new intermediate technology will depend on its acceptance by the local engineers and planners. In this study emphasis will be given to carefully planned demonstration of the technology developed on one or more ongoing projects. It is recognized that many proposals which have been made in the past to employ labor-intensive construction technology in developing countries have been proposed on an ad hoc basis

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without careful planning and analysis. This approach may lead to higher project costs, unanticipated delays and other management problems and therefore, has the danger of reinforcing ingrained bias of many planners and engineers against labor-intensive technology. Demonstration projects undertaken in this study will be carefully monitored so that it would be possible to compare their performance with both capital-intensive and traditional labor-intensive construction methods.

11. It is expected that the study will develop more efficient technology and organization procedures for civil construction suited to labor abundant economies. The results of the study will be disseminated widely to the public works departments, private contractors and research institutions and management consulting organizations. In conjunction with the demonstration projects, several workshops and training courses will be organized for the benefit of local engineers and planners. It is anticipated that after completion of the study, further research and development will be carried out by local research institutions. An attempt will be made to encourage equipment manufacturers in the developed as well as the developing world to undertake research and development activities on construction machinery appropriate to labor abundant economies.

IV. Work Program and Budget

12. The Phase III study will be undertaken in stages and will be extended successively to three or more countries. A small central team of experts will lead the research, conducting brief exploratory studies, training a counterpart team and initiating longer term studies in each country. These longer term studies would consist primarily of one to two year demonstration projects conducted by the counterpart teams with continuing suport from the central team.

13. The central team will consist of a team leader and three specialists, all full time, who will have such short term expert assistance as necessary. The central team will train and lead local counterpart teams in four areas:

(a) productivity measurements;
(b) organization and management studies;
(c) hardware development and testing;
(d) health and nutrition studies (to determine effect on labor productivity).

Ultimately, a fifth counterpart team in each country may be developed to study the adaptation of project design to accommodate labor-intensive and intermediate technologies, but this function will initially be handled by the central team itself.

14. Attachment I depicts the work program over the entire four year period. Phase III-A, commenced in India in collaboration with the Director

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General of Border Roads in October 1973, encompasses six months of exploratory studies at ongoing construction projects in northern India aimed at improving the productivity of traditional labor-intensive methods and laying the basis for further research and demonstration projects. The sequencing and scheduling of construction activities will be analyzed, major construction tasks will be subjected to time and motion studies, and small experiments with simple tools and equipment will be conducted. Comparative data on labor productivities and costs by different methods will be collected. Major objectives of this phase of the research are to determine the extent to which the costs of predominantly labor-intensive methods can be lowered through better management, and to measure the marginal product of small increments of capital. The most promising techniques will be selected for further testing and development in small demonstration projects.

15. During Phase III-B two or three typical projects scheduled for construction in 1974-75 will be undertaken as demonstration projects, including one road construction, one irrigation canal, and if resources permit, at least one confined site at an earthfill dam construction. Each of the projects will be "paired" with two comparable projects being constructed respectively by equipment-intensive and traditional labor-intensive methods. Care will be exercised in the selection and execution of the projects to ensure that conditions are as comparable as possible. The design (but not design standard) of the project will be adapted to accommodate the method of construction being tested, e.g. macadam materials and design may be substituted for equivalent density graded "crusher run" pavements. Construction is expected to require one to two years for each project. The central study team would initiate the study during the period February-April 1974, and would return at intervals to give further guidance to the study. The local team, where necessary assisted by one or two expert construction engineers, would be responsible for the execution of the experiment.

16. Budget requirements for Phase III encompassing field research and demonstration projects are shown in Attachment 2. When undertaken in three countries, the total cost is estimated at $2.47 million, or approximately $825,000 per country. $1.9 million (77 percent) represents foreign exchange costs and $575,000 (23 percent) local costs. These estimates do not include normal construction costs of projects being studied, which would be incurred in any case. Moreover, they include a relatively small allowance for procurement and development of experimental hardware, on the assumption that much of this could be provided from the normal costs of construction. In addition the Bank is budgeting 20 man months per year for participation in and supervision of the study.

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WORK PROGRAM - PHASE III

STUDY OF THE SUBSTITUTION OF LABOR FOR EQUIPMENT IN CIVIL CONSTRUCTION

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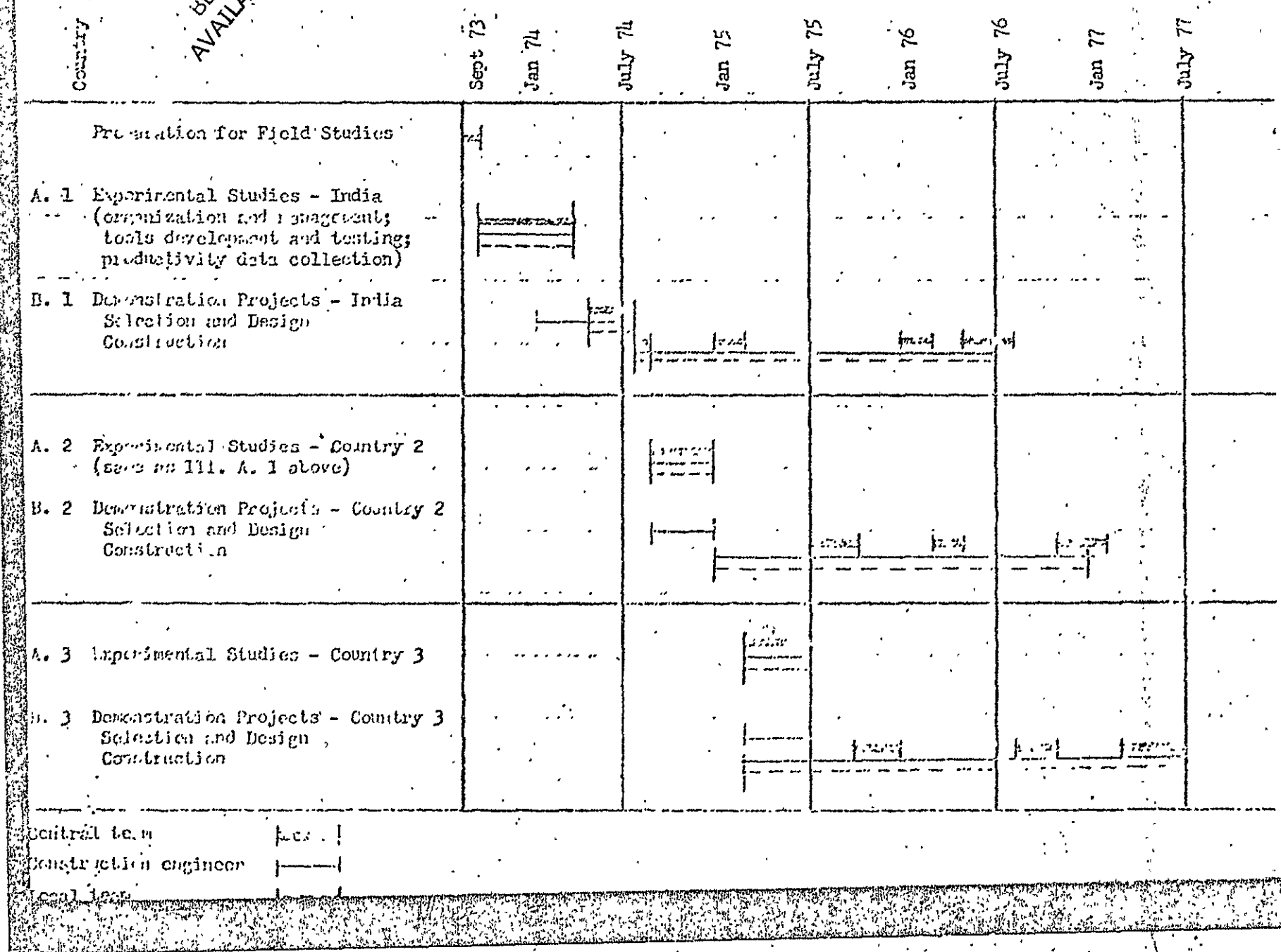

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Budget: Phase III Study in Three Countries 1/

(Thousands of U.S. dollars)

	FY 74	FY 75	FY 76	FY 77	Total
A. Productivity Data Collection (incl. counterpart team in support of B.C.D. below)	95	160	195	165	615
B. Organization and Management Studies	65	85	105	90	345
C. Equipment Development and Testing	115	180	220	195	710
D. Demonstration Projects (design adaptation & supervision of construction)	60	170	270	145	645
E. Health and Nutrition Studies	10	15	-	-	25
F. Labor Market Studies	35	40	55	-	130
Total	380	650	845	595	2,470 2/
Bank Staff (man months)	20	20	20	20	80

1/ Some costs are fixed, so that total costs would not change proportionately if the study is undertaken in less than or more than three countries, or if some parts of the study were omitted.

2/ This excludes Phase I and Phase II studies which have involved 71 man months of IRRI staff time and $275,000 in external costs.