PD-ABE-220

FINAL EVALUATION REPORT

INDO/U.S. AGRICULTURAL RESEARCH PROJECT

PROJECT NUMBER 386-0470

IQC Contract No. PDC-1406-I-00-0034-00
Delivery Order No. 12

Prepared for : USAID/India

Prepared by:

Dr. Peter H. Van Schaik, Team Leader
Dr. Keith R. Allred
Dr. J.S. Kanwar
Dr. C. Krishna Rao

International Resources Group Ltd.
1400 I Street, N.W., Suite 700
Washington,D.C. 20005

May 1992

INTERNATIONAL RESOURCES GROUP, LTD.

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1. PREFACE

After forty plus years of involvement in the development of the agricultural research system in India the Agricultural Research Project (ARP) can be considered the cap on this endeavor for USAID. And just as a flag is raised when the roof is capped on a new building so can the GOI/ICAR and USAID raise a proud flag.

The ARP's purpose was to build institutional research capacity through facility and staff development by ICAR and through U.S. consultant services, training of Indian scientists in the U.S. and bringing in U.S. scientific equipment by USAID. All this has been accomplished. Eight sub-projects have been completed and six pre-projects have been given a good start. The ICAR has more then exceeded its committed contribution of $8 million in Rupee equivalent, considering the number of facilities constructed and the number of staff positions filled. The GOI has also shown its commitment to the continuity of the research by including all Project components in its Eighth Five-Year Plan beginning in 1992.

The evaluation team commends the GOI and USAID for their participation and support in the design, implementation, and execution of this impressive Agricultural Research Project.

The evaluation team acknowledges the assistance and cooperation of the many people in ICAR, USAID, and Winrock who helped make this task a pleasant one.

P.v.S.
K.A.
J.S.K.
S.K.R.

May, 1992

LIST OF ACRONYMS

ACE	Agricultural Commercialization Enterprise
ADG	Assistant Director General
AGRC	Animal Genetic Resources Conservation
AICRP	All India Coordinated Research Project
APAU	Andhra Pradesh Agricultural University
ARP	Agricultural Research Project
AGROFOR	Agro-Forestry
AGROMET	Agro-Meteorological Research to Enhance Crop Production
BAU	Birsa Agricultural University, Kanki
BCKU	Bidhan Chandar Krishi Vishwa Vidayala, West Bengal
BP	Blood Protista
CBAW	Conversion of Biodegradable Animal Waste
CFTRI	Central Food Technology Research Institute
CIAE	Central Institute of Agricultural Engineering
CIPHET	Central Institute for Post Harvest Engineering Technology
CIRB	Central Institute of Research on Buffaloes
CIRG	Central Institute of Research on Goats
CIHNP	Central Institute of Horticulture for Northern Plains
CRIDA	Central Research Institute for Dryland Agriculture
CTD	Centre for Technology Development
DARE	Department of Agricultural Research and Education
DBT	Department of Biotechnology
DDG	Deputy Director General
DEA	Department of Economic Affairs
DG	Director General
ETT	Embryo Transfer Technology
FAO	Food and Agricultural Organization of the United Nations
FEMTC	Farm Equipment Manufacturing Technology Centers
FERRO	Far Eastern Regional Research Office, USDA
FFT	Forestry Faculty Training
GAU	Gujarat Agricultural University, Anand
GBPUAT	G.P. Pant University of Agriculture and Technology
GOI	Government of India
HAU	Haryana Agricultural University

IARI	Indian Agricultural Research Institute
IBRD	International Bank for Reconstruction and Development (World Bank)
ICAR	Indian Council of Agricultural Research
IIHR	Indian Institute for Horticulture Research
IPM	Integrated Pest Management
IVRI	Indian Veterinary Research Institute
JNKVV	Jawaharlal Nehru Krishi Vishwa Vidyalaya (Madhya Pradesh Agricultural University)
LOP	Life of Project
MPKV	Mahatma Phule Krishi Vishwa Vidayala, Maharashtra
MSS	Management Support Services
NAARM	National Academy for Agricultural Research Management
NADU	Nerander Development Agricultural University, Faizabad
NARP	National Agricultural Research Project
NDDB	National Dairy Development Board
NDRI	National Dairy Research Institute
NRCC	National Research Center for Citrus
OFWM	On-Farm Water Management
PACT	Program for Advancement of Commercial Technology
PAMC	Project Administration and Monitoring Committee
PASA	Participating Agency Service Agreement
PAU	Punjab Agricultural University
PCGH	Protected Cultivation and Green Houses
PGR	Plant Genetic Resources
PHT	Post Harvest Technology
PHT-FV	Post Harvest Technology - Fruits and Vegetables
PIL	Project Implementation Letter
PIU	Project Implementation Unit
RAU	Rajendra Agricultural University
SAU	State Agricultural University
SPU	Soybean Processing and Utilization
TAG	Technical Advisory Group
TC	Tissue Culture
TNAU	Tamil Nadu Agricultural University

UAS	University of Agricultural Sciences, Bangalore
UNDP	United Nations Development Program
U.S.	United States
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

PROJECT IDENTIFICATION DATA

1. **Country:** INDIA

2. **Project Title:** Indo-U.S. Agricultural Research Project

3. **Project Number:** 386-0470

4. **Project Dates:** June 30, 1983 to June 30, 1992

5. **Project Funding:**

a.	USAID Bilateral Funding (grant)	U.S.$ 20 Million
b.	Host-Country Counterpart Funds	U.S.$ 8 Million
	Total	U.S.$ 28 Million

6. **Mode of Implementation**: Host country with management support services provided by USAID contractor Winrock International.

7. **Project Designer**: The Government of India (the Indian Council for Agricultural Research) and USAID/INDIA.

8. **Responsible Mission Officials**:

   a. Mission Director: Walter G. Bollinger
      Deputy Director : Steven Mintz

   b. Project Officers: R.E. Flashpohler,
      NRM Office Director

      Surjan Singh,
      NRM Project Officer

9. **Previous Evaluation**: Interim Evaluation, June 1988
   Chemonics International Consulting Division

1. EXECUTIVE SUMMARY

1.1 Project

The Indian Agriculture Research Project (ARP) terminates June 30, 1992. This completes nine years of rather successful activities associated with staff development, technology transfer, institutional building and overall improved agricultural research capability. This final evaluation, involving each of the sub-projects and pre-projects active during the program, was conducted in April-May, 1992 at the request of USAID/India.

Initially the ARP was approved for a seven year period, 1983-90, but was subsequently extended two additional years. Total project support of $28 million was provided over the life of the project. Of this amount the Government of India (GOI), through the Indian Council Of Agricultural Research (ICAR), contributed $8 million in Rupee equivalent and the U.S. Government, through USAID, contributed $20 million in grant funds.

1.2 Project Purpose

The overall project goal was to increase agricultural productivity, production, employment and income. The general purpose was to strengthen the capability of the Indian agricultural research system to conduct research on priority problems in certain key functional scientific areas. This was to be accomplished by building institutional research capacity through collaborative assistance with designated U.S. Land Grant Universities, the U.S. Department of Agriculture and other agricultural organizations, and by assisting in the development and transfer of agricultural technology through collaborative research between Indian and U.S. research scientists with cooperation and support from their respective participating institutions.

The ARP Project Paper placed emphasis on addressing two priority problem areas at the outset: 1) soybean processing and utilization, and 2) post harvest technology development in processing and utilization of perishable fruits and vegetable crops. Provision was made to also consider collaboration on additional sub-projects.

From a rather extensive list of priority agricultural projects proposed by ICAR a total of fifteen were identified to receive financial support: eight as sub-projects and seven as pre-projects. Approval of each of these projects to be funded was provided on the basis of being reviewed and recommended by the Indo-U.S. Subcommission on Agriculture. This Subcommission meets annually as a body and serves as a forum in determining issues of mutual interest between the two countries regarding agricultural research, education and development. In this function it has filled a significant role in the programs of the ARP project.

1.3 Evaluation Purpose

The main purpose of this final project evaluation as outlined to the review team was to assess: a) research capabilities, b) research accomplishments, c) technology transfer, d) commercialization potential, and e) continuity, sustainability and future direction of the research beyond USAID involvement. The charge also included making specific recommendations for GOI/ICAR to ensure continuity and sustainability of research activities and transfer and commercialization of technologies in priority areas to achieve the stated goal of increasing agricultural productivity, employment and income. (see Attachment 4.2 for the complete Scope of Work).

1.4 Evaluation Methodology

The evaluation was carried out by a joint U.S./India team of four scientists (see Attachment 4.5) with extensive experience in agricultural research and project evaluation, much of it in India.

The review team chose not to follow a formal methodology but rather an informal approach of documentation reviews and personal interviews. An Issues and Questions memorandum was developed and sent to all project research locations asking for a brief note on five main issues of the evaluation. A copy is included in Attachment 4.4. The responses were used in discussions and personal interviews, and have formed the basis for many of the team's findings and conclusions.

1.5 Findings and Conclusions

The overall goal of the project, to contribute to an increase in agricultural productivity, production, employment and income was obviously unrealistic and impossible to attain during the ARP's life span. The project's purpose, to strengthen the capacity of the Indian agricultural research system in selected key areas has been reached. There is no question that the INDO/U.S. Agricultural Research Project has made a significant contribution to the research capability of all sub-projects and pre-projects in which it has invested. The team found universal agreement that the training and technical exchange opportunities, the assistance provided by U.S. consultants in planning and implementation, and the provision of previously unavailable equipment, have provided the stimulus and means for productive research.

The review team was favorably impressed that the following components of the ARP were especially beneficial in developing and strengthening the individual sub-projects: 1) International training of Indian scientists, 2) Input of U.S. consultants, 3) Procurement and installation of modern equipment, and 4) The GOI contribution of staff, land and facilities. The main benefit to the pre-projects has been the provision of funds for planning, project design, limited consultation and equipment.

Tremendous strides have been made in the training and updating of Indian scientists in the various agricultural fields associated with the ARP sub-projects. Considering all programs combined more than 300 scientists have spent anywhere from two weeks to 18 months at training locations in the United States. This amounts to 1600 man-months of specialized training wherein these scientists have benefited from direct contact with programs of other professional scientists at locations where teaching and research activities are being conducted in scientific disciplines directly associated with their own areas of interest.

Few of the accomplishments could have been attained without the willing cooperation of the U.S. consultants who came to India to share their knowledge and expertise in their various fields of agricultural science. A total of 51 came during the nine-year life span of the

ARP. This accounted for 115 man-months of consultation, training and direct contacts. While here, these scientists interacted with hundreds of agricultural professionals including teachers and researchers. They taught courses and seminars and demonstrated the proper use of modern equipment while serving as mentors to their Indian colleagues.

As a direct result of the ARP considerable state-of-the-art laboratory and field equipment was imported from the United States and elsewhere to provide Indian research scientists the opportunity to conduct agricultural research at the cutting edge of their scientific specialties. Essentially all of the equipment purchases that were planned under the sub-projects were placed. The equipment was ordered, shipped, most had been received and installed in existing laboratories and is operating.

The research results, research products and, beyond that, possible commercialization of any developed products vary greatly from program to program. In seven pre-projects the ARP contribution was limited in funds and time and only some training, consultation and equipment could be provided. On the other hand the pre-project on plant germplasm has led to a major stand-alone project in support of India's plant germplasm conservation and exploration activities benefitting worldwide efforts in this field. The Forestry Faculty Training sub-project trained a record number of scientists in a short time to establish forestry research and education capability at 14 agricultural universities. The sub-projects with accomplishments of greatest commercial potential are Soybean Processing and Utilization with several processes and products developed; Post-Harvest Technology, with several promising techniques and products; Blood Protista, with one commercially produced vaccine; and the Conversion of Biodegradable Animal Wastes for animal feed with processes for recovering animal feed ingredients from slaughterhouses, as well as poultry and fisheries operations.

The success of ARP is to a considerable extent due to the fact that all projects were in areas of research in which the ICAR has had considerable ongoing activities. Many of these priority projects formed an important part of the coordinated all India network of research. This also provides the basis for the general confidence expressed for the future. The GOI Eighth Five-Year Plan contains funding for all ARP programs and sustainability appears to be assured for the immediate future.

The GOI is to be commended on their overall interest in this broad ARP. In addition to providing the manpower that made these sub-projects possible, the GOI has lived up to its commitment to provide up-to-date facilities to house the ongoing programs. This was evident as the team made site visits and saw the facilities made available for the research. In some instances the buildings were remodeled for the needed purposes while others were new and recently occupied.

1.6 Principal Recommendations

At this point in time without any anticipated prospect for USAID extension or continuation in any ARP related projects, the team found it difficult to formulate many specific recommendations.

During the team's visits, interviews and discussions one theme was constantly heard. In addition to expressions of success, appreciation and confidence in the future of the research programs, concern was repeatedly voiced about the total cessation of U.S. support.

Repeated pleas were made for some form of limited but continued U.S. involvement, particularly in the areas of consultants' participation in program planning and review and the availability of some foreign exchange for purchase of urgently needed repair parts for imported equipment.

The review team came to the conclusion that the concerns for the future lie not so much in India's agricultural research capability but in its ability to translate research results into useful, adoptable practices, processes and products. Ultimately India's growth will depend on the development of its rural areas. Improved farming and marketing systems are the key to this process. The review offers the following recommendations:

- The review team urges USAID explore means to reconsider its decision to terminate all financial assistance to ARP beyond the current agreement.

- The review team recommends that USAID explore means to establish projects for the commercialization of promising process and products developed from ARP sub-projects.

- The review team urges ICAR to build on the momentum established through the ARP and honor its commitment to continuing the projects through funding provided in the Eighth Five-Year Plan.

- The review team strongly recommends that for long-term needs ICAR find a mechanism to provide foreign exchange for the purchase of repair parts and maintenance of imported scientific equipment.

- The review team recommends that ICAR explore any available means to expedite the transfer and adoption of improved technologies both within the public domain and from the public sector to private enterprise.

- The review team recommends that USAID and ICAR encourage Indian and U.S. scientists to continue professional exchanges.

- The review team recommends that USAID and ICAR maintain a regular liaison to monitor research progress, discuss scientist exchanges, use U.S. consultants in workshops, symposia, and project reviews in India, and generally assist in the continued development of agricultural research in India.

2. BACKGROUND

2.1 Genesis of the Project

Given its importance in India's economy, the agricultural sector must provide not only for the improvement in per capita food supplies, but also for a major impetus to overall employment generation and income growth. Thus far, the GOI has been able to set ambitious but feasible production growth rates. The GOI strategy for food production and rural employment combines efforts to consolidate and spread the agricultural production gains of the Green Revolution with targeted rural development programs aimed at raising household incomes above the poverty line. However, to sustain its agricultural growth, the GOI must continue to strengthen its agricultural research for technology generation and transfer. It is in this area that this project had its focus in collaboration with U.S. institutions and scientists.

The Indo/U.S. Subcommission on Agriculture serves as an official forum for the development and enhancement of bilateral programs between the two countries concerning agricultural research, education and development. The Subcommission has identified priority areas of mutual interest from among those presented by the Indian Council of Agricultural Research (ICAR) from its priority areas which are also included in its components of the country's five-year plans.

The implementation of the Indo/U.S. Agriculture Research Project was initiated in June 1983. The original project was for a period of seven years which was extended to nine years until June 30, 1992.

The overall project has served as an umbrella under which a series of sub-projects were developed. Selected priority areas, identified by the Indo/U.S. Subcommission on Agriculture, served as the basis for sub-project selection by mutual agreement between the GOI and USAID.

2.2 Current Status of the Project

Following the selection and approval of recommended sub-projects the ICAR and USAID jointly identified appropriate project design teams, including U.S. consultants to provide technical expertise, and prepare budgets and time frames for the various developmental activities. Each sub-project was to have an expected life span of up to five-years. A complete list of all sub- and pre-projects acted on during the life of ARP is shown in Figure 1.

Two sub-projects, Soybean Processing and Utilization (SPU) and Post Harvest Technology of Fruits and Vegetables (PHT), were implemented January 1, 1985 and completed activities March 31, 1991. Six additional sub-projects were developed in time to have full five-year life spans and end before the final termination of the total Project on June 30, 1992.

Seven sub-project proposals did not reach full implementation. One of these, Plant Genetic Resources (PGR) was approved as a pre-project with limited resources and then transferred outside the ARP in 1990 as a stand-alone project with considerably greater scope and USAID funding. Also in 1990, six others were funded equally ($150.000 each) to accomplish limited activities of design, bring in U.S. consultants, provide for training of Indian scientists in the U.S. and purchase some equipment for the Indian research institutes. This action was taken because limited funds were available but not enough time was left in the life of the ARP to permit implementation of a sub-project. It was considered that this action would at least meet one purpose of the ARP, that of enhancing the future research capability of associated institutions in those priority areas.

Two sub-projects deal with program management. One, the Project Implementation Unit (PIU), functions within ICAR. It is responsible for handling all technical and administrative needs of the ARP and its sub-projects within India. The Interim Evaluation in 1988 which criticized the PIU for not adequately meeting the required needs of ARP, led to organizational changes and significant improvement of PIU functions.

Figure 1. ARP Sub-Project and Pre-Project Financial Support During Life of Each Project

No.	Title of Project	Starting Date	Ending Date	USAID Funds	G.O.I. Contribution	Total $
	Sub-Project					
1.	SPU	20-11-84	31-03-91	1,743,075	559,000	2,302,075
2.	PHT	25-01-85	31-03-91	2,970,748	1,767,550	4,736,298
3.	CBAW	21-01-87	31-03-92	1,104,441	1,443,000	2,547,441
4.	IBP	26-11-86	31-03-92	1,315,485	1,052,000	2,367,485
5.	ETT	09-01-87	31-03-92	1,141,070	1,072,000	2,213,070
6.	FFT	28-04-86	30-09-90	3,181,387	-	3,181,387
7.	AGROFOR	28-06-88	30-06-92	2,044,403	1,358,000	3,402,403
8.	AGROMET	26-07-88	30-06-92	1,554,985	538,500	2,093,485
	Pre-Project					
9.	PGR	01-07-87	30-06-90	200,000	-	200,000
10.	FEMTC	21-03-90	30-06-92	150,000	-	150,000
11.	OFWM	21-03-90	30-06-92	150,000	-	150,000
12.	PCGH	21-03-90	30-06-92	150,000	-	150,000
13.	TCHC	21-03-90	30-06-92	150,000	-	150,000
14.	IPM	21-03-90	30-06-92	150,000	-	150,000
15.	AGRC	21-03-90	30-06-92	150,000	-	150,000
	Program Management					
16.	PIU	16-03-85	30-06-92	947,318	333,000	1,280,318
17.	MSS	30-09-85	30-6-92	2,522,367	-	2,522,367
	TOTAL :	–		**19,625,279**	**8,121,050**	**27,746,329**
	OTHER :			**374,721**	**-**	**374,721**
ARP	**GRAND TOTAL**	**30-06-83**	**30-06-92**	**20,000,000**	**8,121,050**	**28,121,050**

In the original ARP Project Paper, USAID was to administer and manage all business and financial aspects of the sub-project activities outside India. This included, among other things, arrangements for U.S. consultants and procurement of the large volume of U.S. equipment for Indian research institutes. When it became apparent that USAID would be unable to properly and timely meet these needs it was agreed to use an outside contractor to provide management support services. Winrock International (WI) received a contract to provide these services in 1985. From all records and reports this has been a good move. WI has received high marks for an efficient operation and providing expeditious liaison and services between sources in the U.S. and requirements in India.

On the whole the progress in all areas of ARP activities has been significant. Because of the wide range of sub-projects and pre-projects, some having completed the full LOP, and others having only received limited time and resources for start-up activities, it is difficult to make a concise assessment of progress. In a few sub-projects, notably PHT and SPU, the main purposes of the program may have been reached, namely, improved research infrastructure, improved research capability and accomplishments, technology transfer and even some commercial utilization. In one other, FFT, the required training was done in record time but there are some serious questions about the sustainability of some of the Forestry Departments in the State Agricultural Universities. In other sub-projects, IBP, ETT, CBAW, AGROMET and AGROFOR, the research capability level of Indian institutions and scientists has certainly been improved and scientific information output has been enhanced considerably. But because of various factors, including economics, sophistication of agricultural production and service components, it is doubtful that any technology transfer or commercialization can be expected in the foreseeable future.

For the seven pre-projects which were approved with very short LOP's, the goals of providing training and equipment to improve the research capability in those subjects matter areas have certainly been met.

The progress as well as the sustainability of the research and technology transfer of the various project components will be discussed in more detail in a later section of the report.

The main purpose of this evaluation was to provide an end-of-project assessment of the degree of success obtained in reaching the project's long-term goals, objectives and purposes. In the Scope of Work (see Attachment 4.3) several issues and questions were raised for the evaluation team to address. Thus this evaluation was to assess the research capabilities in terms of facilities, staff, training and equipment, research accomplishments, technology transfer (realized or potential), commercialization of any developed or potential products, and discuss the prospect for continuity and sustainability of the work after termination of U.S. assistance.

In contrast to the extensive review schedule of the interim evaluation team in 1988 the final evaluation team had no opportunity to review project activities at various U.S. institutions which participated in both the U.S. and India in project design, training and equipment selection and procurement. No time was spent in Washington D.C. to review project documentation or discuss project issues with appropriate agencies such as AID/W, USDA and Winrock International.

The team began its task upon arrival in India. It did not follow a formal evaluation procedure but used an informal approach. The main elements of the evaluation methodology were:

- Project document reviews
- Personal interviews and discussions
- Travel and site visits
- Use of responses to the Issues and Questions memorandum as a basis for specific sub-project evaluations.

The evaluation was conducted by a joint U.S./India team of four scientists under a contract with International Resources Group, Ltd., Washington D.C. Attachment 4.5 provides background information on each team member. Attachment 4.6 provides a listing of places and persons visited in the course of this evaluation.

3. EVALUATION OUTCOMES

3.1 Findings

3.1.1 **Overall Impact**

The long-term goal of the Agricultural Research Project was to increase agricultural productivity, production, employment and income in the Indian economy. To expect this goal to be reached in nine years with a U.S. contribution of $20 million and a GOI contribution of $8 million was unrealistic at best. It would be analogous to contributing building cement for a foundation and expecting a multi-story building as a result. A more realistic purpose to achieve within the life of the project (LOP) was to build institutional research capacity and assist in technology development and transfer through collaborative research between Indian and U.S. scientists with cooperation and support from their respective institutions. In reaching this purpose, the Project has been an unqualified success. In all 15 sub- and pre-projects, in varying degrees, this purpose has been reached. The impact on the research establishment has been significant and the GOI's own commitment, through planned funding in the Eighth Five-Year Plan for the Project's components, ensures the best intention for continuity beyond USAID's involvement.

Many specific findings, observations and conclusions (which may have not been included in the general and overall evaluation of the ARP) are included in the detailed write-up prepared for each sub-project in Attachment 4.1. The reader interested in specific sub-project details is encouraged to refer to this section of the report.

3.1.2 **Research Capability**

Facilities and Staffing

Research capability is undoubtedly the area in which the greatest visible improvements have been made. The ICAR has contributed significantly to facilities and staffing. A new laboratory building has been constructed for Soybean Processing and Utilization (SPU), Bhopal. Post Harvest Technology of Fruits and Vegetables (PHT) has new buildings at IARI, New Delhi and IIHR, Bangalore, a remodeled facility at NRCC, Nagpur and is housed in temporary quarters at CIHNP, Lucknow. The Embryo Transfer Technology (ETT) program has a new, well equipped facility at NDRI, Karnal as well as at IVRI, Izatnagar. A new laboratory building was constructed for the Coordinating Unit of IBP at the SAU, Hisar.

The Agroforestry (AGROFOR) and Agrometeorology (AGROMET) programs are located in facilities constructed in recent years, not as a direct result of the ARP but certainly strengthened by its implementation and the availability of additional sanctioned staff and equipment.

Plant Genetic Resources (PGR), a pre-project under the ARP until 1990, with new and additional resources from both GOI and USAID, will have a new building at IARI, New Delhi.

Modern facilities for collection, inventory, storage and maintenance and worldwide distribution of large plant material collections will be included.

In staffing, the ICAR approved a total of 423 positions, including 199 scientists and 224 technicians. Although not all positions were filled and some variations existed among projects and locations, it does not appear that any critical positions were left vacant.

3.1.3 **Training**

Training of Indian scientists was a major component of the ARP. The team found universal agreement of its success. The two components of the training were visits by U.S. consultants to India and travel and training of Indian scientists in the U.S. As of May 31, 1992 more than 115 U.S. and 1600 Indian man-months have been expended on training activities. The latter was exclusively for training in the U.S. ranging in length from 2 weeks to 18 months. U.S. consultants, in addition to participating in developing project designs and plans, have conducted numerous training sessions, seminars and workshops. The training component of the ARP has therefore had a significant multiplier effect in increasing the technical capacity of India's agricultural research system.

A rather unique aspect of the training component has been the in-country use of trained personnel, both Indian and American. Examples were given where Indian scientists, upon returning home from their training experience, were asked to organize and conduct a short course to which 15-20 local scientists would be invited to participate. A training manual would be developed for use and subject matter covered would be a condensation of the course material the trainee had received while studying abroad. When possible these training sessions would be correlated with the visits of U.S. consultants so they could attend and provide additional input. In this manner not just one person benefitted from the program but 15-20 or more received the short-course version of the material covered during the U.S. training experience.

One disappointment to the team was the apparent lack of a means to maintain contact with U.S. consultants on the part of the Indian scientists. It would appear they could continue to benefit considerably from the knowledge and expertise of the consultants through direct correspondence, the exchange of information, exchange of scientific papers and sharing of research reports.

3.1.4 **Equipment**

Importation of previously unavailable items of research equipment has been a major component of the ARP. All sub- and pre-projects have benefitted to varying degrees from this activity. The identification of equipment items was included in each sub- and pre-project's design. Some delays were experienced at various stages of the long and complex delivery chain but by March 31, 1992 over $5 million in equipment had been installed and made operational. Equipment items have ranged from relatively simple standard measuring devices used in forestry field research to fully automated, computer monitored weather stations and highly sophisticated analytical laboratory equipment. The ability to include a major equipment component has contributed significantly to research capabilities and accomplishments of various scientists and institutions.

3.1.5 Research Accomplishments

Research accomplishments have been many and varied. As expected they have varied as a result of many factors, among them status of previous ongoing research and levels of infrastructure and staffing involved.

Of the 15 research oriented sub- and pre-projects, seven were identified as pre-projects only (see Figure 1). One of these, PGR, was discontinued as an ARP component in 1990 and set up as a stand-alone USAID project in India with major infrastructure contributions from the GOI. The other six pre-projects (FEMTC, OFWM, PCGH, TC, IPM, AGRC) were purposely approved in 1990 for two years only with the understanding that activities would be limited to project planning, project design and some training and equipment procurement. The results from these pre-projects were therefore only in the area of improving the research capability and the formulation of comprehensive project designs and research plans by joint India-U.S. teams. This has been accomplished. No research output or accomplishments specifically attributable to the ARP were expected or have occurred.

The sub-project on Forestry Faculty Training (FFT) did not have a research accomplishment objective. Seventy-two Indian scientists were trained in the U.S. to return to staff forestry faculties and develop curricula at the State Agricultural Universities.

The Agroforestry (AGROFOR) and Agrometeorology (AGROMET) sub-projects have established multiple research locations, an extensive network of programs and are beginning to generate considerable research data. It will be some time however before these data will translate into recommendations and programs usable in production agriculture. Discussions are taking place in AGROMET workshops to use data such as temperature, relative humidity, wind direction and speed, both as occurring and forecast, in relation to planting dates, occurrence of insects and diseases, mid-term corrections in crop season, response farming and other useful information via radio for farmers' use.

In the three livestock related sub-projects, ETT, IBP, and CBAW, research accomplishments are tangible and potentially useful. The ETT has provided some notable results in producing offspring from superior parents under controlled conditions of research laboratories and research farm herds. Successful embryo transfers have been made and pregnancies and births have resulted in cattle, buffaloes and goats. For the foreseeable future, the practical application of this work will be limited to controlled situations of Government livestock farms and improved herds. The next phase of this sub-project can make valuable contributions to the generation of large numbers of highly pedigreed Males and Proven Sires. These are urgently needed to bring about genetic improvement of the large population of cattle, buffaloes and goats, which at present largely multiply through uncontrolled propagation.

The IBP sub-project has been mainly concerned with three major animal diseases transmitted by ticks. These diseases are particularly serious in crossbred herds using exotic breeds. This research has resulted in an effective vaccine against Theileriosis, the most serious of the diseases. Three more vaccines are in final stages of testing. In addition, simple and easy to use diagnostic kits have been developed.

The sub-project on Conversion of Biodegradable Animal Waste for feed (CBAW) has developed some techniques and processes particularly useful for commercial enterprises. There are reports of widespread use of processing wastes from aquaculture operations in South India for animal feed. Also commercial poultry producers are showing considerable interest in reducing feed costs by recycling poultry litter and droppings. Another potential application is the use of ensiled slaughterhouse waste in providing maintenance feed requirements for animals being held and awaiting slaughter.

Considering that very little post harvest related research had been carried out in India prior to 1985, the PHT sub-project has produced some notable accomplishments. Emphasis of the research is on: pre-harvest handling; marketing; packaging and transportation; storage; and processing of fruits and vegetables. The detailed final report of this sub-project which terminated its USAID assisted phase on March 31, 1991 lists a series of project accomplishments. Studies at Bangalore, Lucknow and Nagpur showed that losses in fruits and vegetables ranged from 5-40 percent during handling, marketing and transportation. Highest losses were found in mangoes, oranges and onions. Spraying with fungicides before harvest can reduce post harvest decay in mangoes and Nagpur mandarins. A zero-energy cool chamber, built with locally available materials, was developed at IARI, New Delhi. It is effective for storage of citrus, potatoes, tomatoes and onions and has found acceptance in rural areas. Other studies have dealt with standardizing maturity indices for tropical fruits, the effects of packaging, curing, storing, and transportation, different methods of fruit and vegetable preservation and utilization of processing wastes.

The Soybean Processing and Utilization (SPU) sub-project was implemented after several years of significant research and development work on soybean production in India. Soybean acreage increased rapidly but utilization was limited to commercial extraction of the oil and use of the meal as exportable livestock feed. Using soybean's high quality protein, oil, carbohydrates and mineral content for the development of soybean food items for direct use in Indian diets was the main objective of the SPU sub-project. During its 6-year life span, several accomplishments have been recorded. The most notable as described in the Final Report of the Indo-U.S. sub-project on Soybean Processing and Utilization (June 1991) and in Soybean Food Options and Technology (May 1992) are fullfat soyflour, soy-fortified biscuits and soypaneer (tofu). These are the furthest advanced among eleven products and processes developed by this research. This sub-project also developed a total of seventeen items of soybean processing equipment which can be locally fabricated for home, farm or small industry use.

3.1.6 **Technology Transfer and Commercialization**

As with research accomplishments, the transfer of the developed technologies varied greatly from sub-project to sub-project. It depended on the time the sub-project was working, on the level of research activity previously in existence, on the complexity of the problem and on the many factors involved in the actual transfer of the developed process or product to its user. In an economy which is in its beginning stages of technical development, the technology transfer process can be difficult and slow even for products and processes which have obvious advantages and benefits. It is fair to say that at this early stage of technology development, actual transfer and commercialization of any product is more hope than reality.

Several sub-projects have produced processes and products which, with the right incentives and follow-up R & D will be used and commercialized.

The IBP sub-project has developed a vaccine against the livestock disease Theileriosis. This vaccine is produced commercially by Indian Immunologicals, a subsidiary of the National Dairy Development Board (NDDB).

The SPU sub-project has developed several items of equipment, product development processes and food products. It also has pursued further R & D activities towards having this technology transferred to appropriate users. A small pilot plant operation produces actual products on a limited scale. This sub-project appears to have the greatest promise for the appearance of commercial food products in the market place. There is, however, an apparent reluctance on the part of entrepreneurs to invest venture capital in these new products. The SPU staff at CIAE, Bhopal has plans to establish a pilot plant to develop a package of production technologies for each product. This would be used to demonstrate the economics and technological feasibility to users, entrepreneurs, lending agencies, etc. At present entrepreneurs are relying on the production from this sub-project's experimental pilot plant for saleable products, a practice which of course should not continue. Thus far, no commercial production of soybean products has been undertaken even though market and consumer acceptance surveys have been positive. This sub-project could benefit from follow-up assistance in the areas of private enterprise and commercialization development.

The PHT sub-project has developed a number of methods to reduce the losses and improve the quality and quantity of fruits and vegetables reaching the market place. These include pre-harvest techniques, harvesting methods, improved packaging, handling, and transportation of perishable commodities. A major obstacle to the acceptance and adoption of these improvements lies in the lack of organizational structure in the sector of the economy which produces and handles these products. Production acreages of individual farm holdings are very small and farmers are not organized in cooperative or marketing organizations. Crops are often sold under contract long before harvest or at harvest from the field. From there to market they are handled by contractors and merchants. The process is primitive, inefficient and causes very high losses (estimated at up to 40%). Perishable crops such as banana, mango, citrus and tomato are harvested green and immature which reduces post-harvest losses but does little to enhance market quality. There are few incentives to adopt improved practices as most of these add to production or marketing costs without adding to income or profit. As a result of this situation, it is anticipated that little technology transfer on a significant scale will take place, at least until the other links in the long chain of production, handling and marketing are strengthened. In the area of exportable fruits and vegetables and in the processing industry (e.g., tomatoes), this is beginning to occur.

None of the other sub-projects nor any of the seven pre-projects have produced any transferable research results. The sub-projects have developed research programs and activities but data are still preliminary and not sufficiently conclusive for use and adoption. In the case of the seven pre-projects, the purpose was to establish or improve research capability with training, equipment and consultants. During their two-year life span no research was planned or expected to produce results or accomplishments.

3.1.7 **Sustainability**

The sustainability and continuity of all research programs appear quite well ensured since all subject areas have been identified by the Indo-U.S. Subcommission and by ICAR as high priority. Without exception all sub-projects are covered in the Eighth Five-Year Plan with all staff positions retained and adequately funded. In several instances funding is in the Plan for new or additional research facilities. The Five-Year Plan also contains resources for research programs in the six subject matter areas for which USAID could only provide limited pre-project funding. It is anticipated that the initial resources including those used for U.S. consultants to assist in drawing up detailed plans and project designs will lead to additional outside funding assistance. For some for which additional funds may not become available, resources may be more limited and restrict the anticipated research accomplishments. The Eighth Five-Year Plan is quite ambitious and only time will tell if the GOI will be able to meet its commitments. It is beyond the scope of this review to speculate on the validity of the GOI's budgetary processes. It is enough to note with considerable satisfaction that the Five-Year Plan has been approved and that ARP programs are fully covered for sustained continuity.

3.2 Conclusions

3.2.1 **Mid-course Considerations**

In 1988 an interim evaluation was conducted by an outside team. Although in the life span of the ARP this was a mid-term evaluation, it was closer to the early stages of implementation for most ARP sub-projects. The evaluation team was critical of many of the delays in program development, selection of U.S. consultants, getting Indian scientists off for training in the U.S. and having equipment procured and installed. It made a number of recommendations regarding the effectiveness of the Project Implementation Unit (PIU), the review and fund allocation process for sub-projects and the use of U.S. consultants.

Immediately after this interim review, USAID and ICAR staff prepared an Action Plan to incorporate recommended actions deemed acceptable and advisable.

There is ample evidence that delays and problems experienced in the early stages of the ARP have since been overcome. Before June 30, 1992 all U.S. consultants have been in India, all Indian scientists scheduled for training in the U.S. have returned and all planned equipment items will have been delivered and installed. Procedural changes including the level of authority of the PIU Coordinator have been implemented. Timely and appropriate reviews of budgets have permitted reallocation of funds including the funding in 1990 of six additional pre-projects.

Many specific findings, observations and conclusions are included in the detailed write up prepared for each sub-project in Attachments 4.1.1 to 4.1.17 which may not have been included in the general and overall evaluation in this report. The reader interested in specific sub-project details is encouraged to refer to these sections of the report.

3.2.2 **Financial**

No effort was made by the review team to conduct an analysis and evaluation of the financial management of the Project for the following reasons:

1. The Scope of Work did not indicate a requirement of this activity.
2. The team had no specific expertise in financial analysis.
3. The team was repeatedly told that financial adjustments and reallocations had been made (e.g. $900,000 to 6 additional pre-projects in 1990).

In discussions and interviews the team found no evidence of problems in financial management. To the contrary there was ample evidence of sound judgement and proper decision making in allocating funds and reallocating excess or unneeded funds to higher priority uses.

In early 1992, within only a few months prior to the termination of the ARP, the ICAR requested approval and funding for an additional six pre-projects utilizing funds unused or uncommitted in some of the other sub-projects. Wisely, USAID did not honor the request but instead urged ICAR to expedite the use of funds already approved for visits of U.S. consultants, travel for Indian scientists, and equipment procurement for the sub- and pre-projects.

3.2.3 **Design and Implementation**

The basic concept of the Agricultural Research Project (ARP) as an umbrella under which a number of sub-projects could be developed appears to have been successful. All sub- and pre-projects were selected by mutual agreement between GOI/ICAR and USAID from subject areas that had previously been identified as high priority areas within the Indian system. Such positive pre-planning undoubtedly contributed to the successful implementation of the program. Another factor was the selection of projects in researchable subject matter areas in which some preliminary work had been done and which were supported by All-India Coordinated Research Projects (AICRP). These positive preconditions plus the joint teamwork between U.S. and Indian scientists in designing the implementation plans, selecting scientists for training and identifying modern equipment needs, have all contributed to the overall accomplishments.

Research, in order to be successful in most agricultural fields, should be planned for long-term. Often too many variables and unknowns are encountered while researching a problem to expect solutions in a relatively short period of five or six years. A ten to twenty-year period is a more realistic target. Often research objectives and operating procedures need to be modified as research data become available. So it is with the ARP and its associated sub-projects. The first set of goals have been reached. A desired level of research capability has been established at the targeted institutes and universities. The necessary infrastructure of facilities and the budget for recurring operational expenses are in place. In addition the quality of research capability has been enhanced by bringing in expert consultants to assist in designing research projects, by training staff both in India and in the U.S., and by installing sophisticated research equipment in the laboratories and the field.

Progress has been most notable in staff training. All training was intended to be of an intensive nature, of rather short duration and geared to the specific scientist's needs. Except for AGROFOR, advanced degree training was not an integral part of the plan. More than 300 Indian scientists have benefitted from this training experience. The review team found rather universal praise for its value. Also, there was praise for the quality and kinds of laboratory and field equipment selected. Except for some earlier problems related to procurement and shipping, which caused serious delays early in the life of ARP, it appears the budgeted equipment will be fully operational at the designated research institutes and universities.

For the sub-projects that completed their intended full life span the research has already produced meaningful results. This is particularly true for SPU, PHT, IBP and CBAW. In these sub-projects some improved techniques, processes and products have been developed which, in the right economic environment and with the proper incentives, could reach the stage of commercialization. In India, however, commercialization of new agricultural processes and products appears to be a slow and difficult process. Agriculture, although it forms the base for the Indian economy, is practiced at a very low technological level. The farmer produces the product, a middleman moves it to market and the consumer purchases it. Almost all research and development associated with this system is accomplished in the public sector and there are few incentives for adopting new technologies by either the farmer, the middleman or the merchant.

3.2.4 Continuity and Sustainability

There is no evidence that the Project has made any significant contribution to the goal of increasing agricultural productivity, employment and income. As stated previously, that goal appeared to be somewhat unrealistic based on the limited period under which the project was to be supported.

It does appear that the end-of-project output as stated in the Project Paper, has been achieved to varying degrees for the sub-projects. There were no output expectations for the pre-projects since they were provided only a limited budget for planning and in some instances for an element of training and equipment purchases.

From the Indian perspective the ARP has provided a good beginning for research activities in several selected subject matter areas. GOI/ICAR has committed itself to continued support by including all components of the Project in the new Five-Year Plan. Funds for facilities, all staff positions and operational costs have been included.

The USAID assisted component is terminating and no commitments for further participation have been made beyond June 30, 1992. USAID, however, should have an interest in seeing that the overall program is continued and sustained. A strong case can be made to urge USAID not to walk away from its significant investment in India's agricultural research system without some continued level of transitional involvement. As the interim review noted, the Project has served to re-establish cooperation in agricultural research on a firm footing between India and the United States. This is an important accomplishment that should be nurtured and built upon.

The continuation of many collaborative aspects of the ARP can be assisted through personal and professional interactions between Indian and U.S. scientists. Many productive contacts and relationships have been established as a result of U.S. consultants coming to India and Indian scientists studying at universities in the U.S. Such voluntary unstructured interactions would foster professional collaboration and benefit scientists in both countries.

USAID has recently embarked in a participatory role with several private enterprise programs in India. The Center for Technology Development (CTD) in Bangalore, consists of a private group of retired administrators, scientists and businessmen interested in the development of agricultural products for domestic consumption and for export. They have an ambitious project underway to develop post harvest facilities at IIHR in Bangalore for fruit and vegetable processing, packaging and product development. USAID is providing funds for training and equipment purchase in support of this center. The CTD intends to transform research findings into commercial products through technology transfer. This activity of developing technology transfer through industrialization is an important next phase in the process of moving research results to commercial reality. The Soybean Processing and Utilization program at CIAE, Bhopal could benefit from similar program involvements.

3.3 Recommendations

3.3.1 USAID

- The review team urges that USAID reconsider its decision to terminate all financial assistance to ARP beyond the current contract. In order to help maintain the momentum generated through this collaborative research project and help provide for its sustainability USAID could establish a limited fund for a 3 to 5-year transition period to:

  1. continue the use of U.S. consultants for project review and program planning,
  2. purchase needed spare parts and help maintain the scientific equipment, and
  3. foster professional ties and interactions between research scientists in the two countries.

  It would be desirable to provide a contact person (possibly part-time) to maintain liaison with ICAR, to monitor and evaluate research accomplishments, to screen and route requests for scientist exchanges, and service requests for meeting equipment needs.

- The review team recommends that USAID explore means to establish projects for the commercialization of promising processes and products developed from ARP sub-projects, particularly soybean processing and utilization and post harvest technology related to the processing of fruits and vegetables.

3.3.2 GOI/ICAR

- The review team urges ICAR to build on the momentum established through the ARP. It must honor its commitment to continuing the sub-projects through funding provided in the Eighth Five-Year Plan. It is also urged to recognize the long-term needs of research and development programs and make appropriate commitments for facilities, staff, equipment and recurring costs to ensure progress in these meaningful programs.

- The team recommends that for the continuity and long-term sustainability of the Agroforestry program, ICAR should explore with appropriate officials in the Forestry Department the establishment of official policies and implement measures regarding employment opportunities for all candidates having the required educational qualifications.

- The review team strongly recommends that ICAR find a mechanism to provide foreign exchange for the purchase of repair parts and the maintenance of the imported scientific equipment.

- The review team recommends that ICAR explore any available means to expedite the transfer and adoption of improved technologies both within the public domain and from the public sector to private enterprise.

3.3.3 USAID and GOI/ICAR

- The review team recommends that USAID and ICAR through direct communication and policy statements, encourage Indian scientists as well as U.S. scientists who have served as consultants in India or hosted Indian scientists in the U.S. to continue professional exchanges on a personal nonstructural basis through correspondence, exchange of research ideas and the review of prepared manuscripts.

- The review team recommends that USAID and ICAR maintain a regular liaison to monitor research progress, discuss scientist exchanges, use U.S. consultants in workshops, symposia, and project reviews in India, and generally assist in the development of agricultural research in India.

4. ATTACHMENTS

ATTACHMENT 4.1

STATUS OF SUB- AND PRE-PROJECTS

ATTACHMENT 4.1.1

SOYBEAN PROCESSING AND UTILIZATION (SPU)

BUDGET	USAID GOI	U.S.$ 1,743,075 U.S.$ 559,000
IMPLEMENTATION DATE	April 01, 1985	
COMPLETION DATE	March 31, 1991	

PARTICIPATING INSTITUTIONS

Direct Participants (India)

1. CIAE, Bhopal
2. GBPUAT, Pantnagar

Collaborating Institutions

a) U.S. Institutions

1. University of Illinois, Urbana, Champaign, Illinois
2. Michigan State University, St. Joseph
3. Iowa State University, Ames, Iowa
4. Kansas State University, Manhattan, Kansas
5. Colorado State University, Fort Collins
6. U.S. Department of Agriculture, Northern Regional Research Laboratory, Peoria, Illinois.
7. American Institute of Baking.

b) **Indian Institutions**

1. National Research Center Soybean, Indore.
2. All India Coordinated Research Project on Soybean.

CONSULTANTS Nine Consultants, 3-6 weeks, 1983-90

BACKGROUND

Introduction of soybean cultivation on a large scale in the plains of India, initiated in the late sixties, owes its origin to the University of Illinois collaboration with the G.B. Pant University of Agriculture and Technology (GBPAUT), Pantnagar, and Jawaharlal Krishi Nehru Vishwa Vidyalaya (JKNVV), Jabalpur, under the auspices of USAID.

USAID made a substantial contribution to soybean cultivation as well as processing and utilization research in India.

Soybean cultivation spread very fast in Madhya Pradesh because it provided an additional crop for rainfed farming. Madhya Pradesh accounts for 80 % followed by Uttar Pradesh (18%) of over two million hectares under soybeans. The acreage is increasing rapidly. India is presently fifth in world soybean production.

Soybeans are utilized primarily for oil and soybean cake is exported as cattle feed. Sipso, a soybean drink, Nutri nuggets, Nutrela and other products are in the market as a result of soybean utilization research but they account for only a small, but potentially increasingly important source of high quality nutrition in India.

PROJECT DESIGN

The Project was designed by Dr. A. Siegel, University of Illinois, assisted by Dr. A. Alam and Dr. T.P. Ojha of the Central Institute of Agricultural Engineering (CIAE), Bhopal. The scientific talent from India represented only one discipline - Agricultural Engineering, drawn from only one institution, CIAE, which limited project design and location selection. However, this limitation does not appear to have had any major negative impact on the implementation and success of the project.

Two centers were selected for SPU activities. This allowed for concentration of appropriate technology development with limited resources, and avoided dilution of resources and duplication of efforts. The centers were :

1. The Central Institute of Agricultural Engineering (CIAE) in Bhopal (M.P.).

2. G.B.Pant University of Agriculture and Technology (GBPAUT), Pantnagar (U.P.)

CIAE was to undertake the soybean processing research program while GBPAUT was supported to provide graduate training. A Coordinating Committee consisting of six administrators and scientists under ICAR was established to monitor and evaluate project activities.

OBJECTIVES

The basic objectives of the SPU sub-project were to maximize the use of soybeans as a food source and to improve soybean processing and utilization. Research activities therefore were geared to the development of simple and adaptable soybean processes and equipment and subsequent technology transfer to the rural population at the home, village and small industry level.

Problems associated with processing and utilization of soybeans adaptable to home and village levels were attributable to:

(a) an unpalatable off-flavor (beany flavor);
(b) presence of trypsin inhibitors in unprocessed soybeans;
(c) flatulence factors (formation of gastrointestinal gas) in soybeans;
(d) poor cooking quality of soybeans associated with hardness and consequent increased cooking time;
(e) lack of simple processing methods for soybeans at the home and village level;
(f) unavailability of low-cost equipment for processing soybeans at the home and village level;
(g) lack of pilot plant facilities for promoting soybean processing at the small industry level, and
(h) lack of information on proper packaging and storage methods for soybean products.

Components of the Sub-project

The sub-project aimed at solving these problems by means of the following components:

1. Development of processes and equipment for full-fat soybean flour applicable to home, village and small industry levels.
2. Development of processes and equipment to obtain Dal from soybeans applicable to home, village and small industry levels.
3. Development of low-cost extrusion cooking processes and equipment for soybean flour and other soy products applicable to small industry levels.
4. Development of processes and equipment for preparing low-fat soybean flour applicable to village and small industry levels.
5. Development of processes and equipment for soy flour- supplemented baked foods applicable to the small industry level.
6. Development of processes and equipment for a fermented and coagulated soy-based product applicable to home, village and small industry levels.
7. Establishment of appropriate systems/technologies for handling, storage and packaging of whole soybeans and soy products.
8. Supportive training programs in oilseeds processing and utilization.
9. Establishment of pilot plants and demonstration units.
10. Establishment of soybean processing plants by entrepreneurs.

IMPLEMENTATION

The sub-project was sanctioned by the ICAR in 1984 but budget provisions and approvals for staff and other expenditures did not take effect until April 1985. This delay initially caused some difficulties in the early implementation activities including timely recruitment of staff.

Facilities

The ICAR has provided Rs.3.5 million for construction of facilities for SPU at CIAE in Bhopal. A 1450 square meter building has been completed which includes offices, laboratories, and a pilot plant. Plans are being developed for additional pilot processing facilities to simulate actual complete manufacturing lines for different products.

Staffing

The sub-project had 60 sanctioned positions, of which 49 were filled as of March 31, 1991. Scientific positions included 15 at CIAE and six at GBPAUT out of which 11 and six were filled respectively. Considering the difficult and lengthy process involved and the scarcity of well qualified candidates this is a satisfactory record. There was no evidence that recruitment problems were encountered for a multi-disciplined group of scientists at a basically single disciplined (engineering) institution at CIAE.

Equipment

Indian made equipment was built and/or procured at CIAE worth Rs.2,189,140 and for GBPAUT worth Rs.243,912. This includes an impressive array of relatively simple but effective equipment for dehulling, blanching, flaking, extruding and wet grinding.

U.S. equipment totaling 22 items worth almost $500,000 including $22,000 of spare parts was imported. An exception to the US-made rule was allowed to import a Japanese made Takai tofu system.

Training

Training activities under the SPU project fell under four types : U.S. consultants coming to India, Indian Scientist going to the U.S. for short-term training and study tours, graduate degree training of Indian students at GBPUAT, and training of Indian consumers, housewives, entrepreneurs, etc. in the production and use of processes and products.

U.S. Consultants

In addition to Dr. A. Siegel from the University of Illinois who assisted in the project design, eight U.S. consultants have spent time in India to participate in various aspects of the project (Table 1).

Table 1 — **U.S. Scientists to India**

Name	Field
Dr. G.C. Shove	Soybean Storage
Dr. Mark Love	Quality Standards for Soyfoods
Dr. L.S. Wei	Production and Quality Evaluation
Dr. R.E. Triblehorn	Low Cost Extrusion Technology
Dr. C.E. Walker	Soybean Milling Technology
Dr. G.S. Ranhotra	Soybean Storage
Dr. T.P. Shukla	Research on Soyfortified Foods
Dr. S.A. Demos	Soya Products
Dr. H.E. Kauffman	Technical Assessment

Indian Scientists to U.S.

A significant number of scientists from both of the SPU centers benefitted from study tours and short-term training in the U.S. (Table 2).

Table 2 — **Indian Scientists to U.S.**

Name	Field
Dr. A. Alam	Management Team
Dr. Nawab Ali	"
Dr. B.P.N. Singh	"
Dr. P.S. Bhatnagar	"
Dr. R.T. Patel	Soybean Processing and Utilization
Dr. D.S. Singh	Coagtd. and Fermn. Products
Jaswant Singh	"
Dr. A.P. Gandhi	Soybean Processing and Utilization
Dr. S.D. Kulkarni	Soy Based Baking
B.S. Bisht	Entrepreneurship Development
Y.C. Agrawal	Oil Extraction
B.K. Mittal	Coagtd. and Fermn. Products
S.K. Mittal	Soy Isolates and Conc.
K.C. Joshi	Soybean Processing
P.C. Bargale	"
I.K. Sinha	"
Nawab Ali	Study Tour
V.K. Tanwar	Soybean Processing
Gurmukh Singh	"
R.N. Tripathi	"
H.C. Kashyap	"
P.A. Unde	"
Y. Ojha	"
H.N. Tripathi	"
K. Jha	"
Nawab Ali	"
A.P. Gandhi	"

Degree training in India

The GBPUAT at Pantnagar provided postgraduate degree programs for four Ph.D. and 22 M.S. level students with supporting research in soybean processing and utilization.

Other training

Based on limited public relations activities a few demonstrations have been held for inquiring individuals and groups. Some 150 inquiries are reported to have been received from potential entrepreneurs interested in soy based cottage and small scale food industries. This type of activity will need to be a major component of future SPU activities.

ASSESSMENT

There is ample evidence that the SPU sub-project has been successful. All objectives set for this project regarding facilities, staffing and training, other physical resource development and research accomplishments have been met. A six-year period (1985-91) is too short to obtain a fully accomplished research program, transfer developed technologies or begin the process of commercialization of products and processes. But significant strides have been made as detailed below.

Research Capability

Research capability at CIAE has been significantly enhanced by the construction of facilities specifically for soybean processing, by staff additions in several disciplines, by participation of U.S. consultants in various aspects of the project, by training both in India and the U.S.A of Indian personnel and by the acquisition of U.S. as well as Indian laboratory and processing equipment. All this together has had a significant effect on the advancement of soybean technology in India. The evaluation team visited CIAE in Bhopal and was impressed by the progressive and strong leadership provided by the Institute's Director and the SPU Project Director as well as the enthusiasm shown by personnel in the laboratories.

Research Accomplishments

Research accomplishments have included the development of 11 products and processes including full-fat soyflour, soypaneer (tofu), soysplits, soyflakes, soysnacks, soybadi, partially defatted soyflour, soy-fortified biscuits, temper soy-yoghurt, and soy-ice cream. Of these, pilot plant production levels and techno-economic feasibility analyses have been accomplished for full fat soyflour, soypaneer, and soy-fortified biscuits.

Cottage level soybean processing equipment has been designed and built at CIAE including a dehuller, blancher, dryer, grinding mill, flaker, forming extruder, and paneer press.

These processes, products and tools are described in detail in the Final Report of the Indo-U.S. Sub-Project on Soybean Processing and Utilization. Also in an impressive list of 80 publications from CIAE, Bhopal and 39 publications from GBPUAT, Pantnagar.

Commercialization

Commercialization has not been fully realized nor should it be expected. However the status of full fat soyflour, soypaneer, and soy-fortified biscuits is such that commercial production could be initiated upon development of production facilities and venture capital. The Madhya Pradesh Agro Industries Development Corporation is considering the SPU technology for large scale production of SOYBIX soy-fortified biscuits. The Corporation is also preparing to establish a soybean processing complex in collaboration with Modern Foods of India, Ltd. with technical input from CIAE/SPU.

A discussion by team members with a Mr. Kawalkar, a private potential entrepreneur in Bhopal brought out the following :

- a very positive response to market surveys of various soy products.
- a strong desire to market and sell.
- a hesitancy to commit venture capital for building a production line but rather a dependency on the CIAE/SPU pilot plant to provide the products on an indefinite basis for "test" marketing and sales. Obviously further R & D work is needed to provide production line technology, economic feasibility data, and convincing financial information before significant commercialization of these products can be expected to occur.

Future

The future for soybean processing and utilization activities is quite bright. Soybean production is continuing to increase and the realization is taking hold that, in addition to oil and meal for export, a significant contribution can be made to improved human nutrition in India through the use of a number of home and industrial products from soybeans.

The research program appears to be well established and sustainable. The research capability is in place with facilities, staffing and equipment. The Eighth Five-Year Plan is reported to have a sufficient commitment of resources for continuity including a proposed production line pilot plant at CIAE, Bhopal. The Madhya Pradesh Government is fully supportive of the growing soybean industry, as evidenced by appearances of the Chief Minister and Minister of Agriculture on a video recording. In discussions with the team, the possibility of U.S. assistance in development of joint venture commercialization was brought up. A recent announcement was made that a U.S. trade and investment mission will visit India to explore the possibility of joint ventures in such areas as oilseeds, fruits and vegetable processing.

FINDINGS, RECOMMENDATIONS

Findings

There is little doubt that the soybean processing and utilization sub-project of ARP has been very successful. The sub-project was started at a timely stage of soybean development in India and the project plan was formulated by a group of knowledgeable people including consultants from leading U.S. institutions. Although the interim evaluation in 1988 raised some criticism about the limited number of research locations and the selection of an agricultural engineering center (CIAE, Bhopal) as the main center, this does not appear to have been an impediment to the success of the project. To the contrary, each of the two locations, CIAE, Bhopal and GBPUAT, Pantnagar, have made their respective contributions. The SPU was started by the ICAR with financial assistance from USAID in 1985 for the development of simple processes, processing equipment and utilization of soybeans as food at home and village levels and for the establishment of small scale food product industries to produce and market soy based foods. Most of these objectives have been met.

The SPU has established a well equipped research laboratory and facilities for the production of several soy products, a number of scientists have benefitted from training in advanced processing technologies and used this training to develop several simple processes and needed equipment for soybean products.

The project is now at the take-off stage. Although some eleven products have been developed as well as 17 items of processing equipment, none of these are as yet in commercial production or marketing channels. Three products, full fat soyflour, soypaneer (tofu) and soy-fortified biscuits have been test marketed on a limited scale but thus far production is limited to that from the SPU pilot plant. A major hurdle appears to be the lack of commercial credit and commitment of venture capital by potential entrepreneurs. The CIAE/SPU has requested additional funds in the Eighth Five-Year Plan to establish a full production line pilot plant for each product to aid in solving this aspect of the commercialization process.

There is apparently consideration being given within ICAR to incorporate the SPU project as a regional station of the Central Institute for Post Harvest Engineering Technology (CIPHET) in Ludhiana. CIPHET, established within only the past five-years, has not been fully staffed and does not appear to be, as yet, in a position to provide the leadership and coordination to SPU as is now occurring at CIAE.

Recommendations

USAID

1. Although USAID's direct involvement and financial support has terminated there continues to be a need for a limited involvement in the continuing process of soybean utilization. It is in the U.S. interest to be involved in R & D activities of mutual interest, to continue a limited exchange of scientists and consultants and to provide some means to assure that U.S. provided equipment remains operational.

   It is, therefore, recommended that some mechanism be found to have within USAID/India, a limited fund to provide on an 'as needed' basis, and with careful screening of true needs, (1) some exchanges of scientists for workshops, consultancies, etc. and (2) importation of replacement parts for essential equipment.

2. The SPU project has benefitted from USAID financial assistance in developing a considerable research capability resulting in significant accomplishments in processes and products. The next phase of R & D lies in the areas of commercialization, test marketing, merchandizing and production. This phase appears to have the interest and support of both GOI (State and Central) and private entrepreneurs. USAID involvement in this phase would be of considerable benefit. USAID has increasing interest and activity in post production agriculture technology development, notably through participation in such projects as ACE, PACT, and CTD. The review team recommends that USAID explore with interested Indian institutions and commercial enterprises and possibly U.S. commercial interests an involvement in furthering the commercialization of appropriate technology of soybean processes and products.

GOI

1. In view of the considerable success of the SPU project and the near realization of commercial success in producing and marketing several soybean products, the GOI/ICAR is urged to fully support the funding needs of CIAE/SPU in the Eighth Five-Year Plan. Included in this are facilities for a full production pilot plant to demonstrate much needed information on production processes, equipment, financing needs, packaging requirements, etc for each product.

2. An excellent coordination of activities between CIAE and SPU has been developed in Bhopal. Since CIAE activities involve many post harvest equipment aspects and a considerable degree of interaction exists, it is recommended that any decision to merge SPU under the direction of CIPHET, Ludhiana be delayed for some time. A change in supervision and leadership would be quite disruptive to SPU activities and progress at this time.

ATTACHMENT 4.1.2

POST HARVEST TECHNOLOGY FOR FRUITS AND VEGETABLES (PHT-FV)

BUDGET — USAID U.S.$ 2,970,748; GOI U.S.$ 1,767,550

IMPLEMENTATION DATE — January 01, 1985

COMPLETION DATE — March 31, 1991

PARTICIPATING INSTITUTIONS

(a) **Direct Participants**

i. Indian Agricultural Research Institute, New Delhi, (IARI)
ii. Indian Institute of Horticultural Research, Bangalore, (IIHR)
iii. Central Institute of Horticulture for Northern Plains, Lucknow, (CIHNP)
iv. National Research Center for Citrus, Nagpur, (NRCC)

(b) **Collaborating Participants**

a. Indian Institutions

i. All India Coordinated research project on post harvest technology of horticultural Crops (AICRP-PHT)
ii. Central Food Technology Research Institute Mysore (CFTRI)
iii. National Agricultural Cooperative Marketing Federation of India (NAFED)
iv. Associated Agricultural Development Foundation
v. National Horticulture Board
vi. Modern Food Preservers Association
vii. State Agricultural Universities (SAUs)

b. U.S. Institutions

i. Post Harvest Institute for Perishables, University of Idaho, Moscow, Idaho, U.S.
ii. United States Department of Agriculture (USDA)
iii. Universities in the U.S.A - Arkansas, California, Cornell, Florida, Georgia, Hawaii, Michigan, Ohio, Oregon and Purdue.

CONSULTANTS

Twelve U.S. Scientists visited India for total period of 13.5 months. Most of them came up to December 1990. Dr. Ron Buescher who has been the lead consultant from the beginning of the project came in the last quarter about the time of completion of the project and prepared the Technical assessment report.

BACKGROUND

In India horticultural crops particularly fruits and vegetables, form a significant part of the agriculture produce. Apart from providing nutrition they are the source of cash income to producer who grow them as part of farming systems, as intercrops and sole crops. They are all considered cash crops forming an important marketable export commodity. They suffer tremendous losses both in quality and quantity due to poor management at pre-harvest, post-harvest and, storage stages and in the marketing processes. The losses are estimated up to 40%. Realizing the importance of the pre-harvest and post-harvest management technology, for improving quality and quantity of fruits and vegetables, an Indo-U.S. collaborative research sub-project called Post Harvest Technology (PHT) covering the seven most important commodities - four fruits (mango, citrus, guava, banana) and three vegetables (onion, potatoes, tomatoes) was initiated in October 1985 under the main umbrella of the U.S.-aided Agricultural Research Project, and completed on March 31, 1991 after a one-year extension.

DESIGN PLANS AND LOCATIONS

The project was included in the seventh five-year plan of the GOI for implementation at IARI, New Delhi; IIHR, Bangalore; NRCC, Nagpur and CIHNP, Lucknow. The coordinator of this sub-project was located at IARI, New Delhi and it formed an integral part of All India Coordinated Research Project on Fruits and Vegetables. GOI/ICAR provided infrastructural facilities staff and operational budget for the project and USAID provided consultants, imported equipment and training to Indian scientists, plus some local cost financing, as agreed upon with the GOI.

OBJECTIVES

The primary objective of this research project was to strengthen four Indian institutes of horticultural research to undertake research activities on post harvest technology of mango, banana, citrus guava, onion, potatoes and tomatoes and to reduce losses of these perishable crops during harvesting, handling, transport, storage, marketing and processing.

To accomplish this objective, U.S. assistance was targeted to strengthen the capability of participating Indian lead centers of horticultural research through training of scientists in U.S. institutions, provision for local and imported modern equipment for research and arranging visits of U.S. scientists for consultation and interactions in India. The project also included development of new laboratory buildings by ICAR wherever essential. The strategy of research focussed attention on the following five thrust areas of research for development of an integrated post harvest technology :

1. Pre-harvest factors and harvesting techniques.
2. Handling Marketing packaging and transportation.
3. Storage.
4. Processing and
5. Utilization of commercially unacceptable produce and processing waste.

LINKAGE TO HIGHER GOALS

The PHT also had the following higher goals in view :

1. Stimulation of post harvest research and technological development throughout India.
2. Improvement in food supplies, nutritional status, employment and income of Indian population.
3. Marketing of perishable and preserved foods which meet international export quality standards.
4. Facilitation of the development of private sector businesses involved with fruits and vegetables handling, marketing and processing.
5. Stimulation of Indo-U.S. scientific and business collaboration.

The accomplishment of these higher goals seems to be more idealistic than real within such a short time frame in an area where India was just in the initial stages of development of an organized fruits and vegetables industry to meet local and export needs.

FACILITIES

Under this sub-project, the PHT laboratories have been established in each of the cooperating institutes. The PHT laboratory at IIHR Bangalore is well set and equipment has been installed and put to use for research. The institute also has plans for getting the support of another U.S.-aided project called Center of Technology Development (CTD) for creating complementary facilities for fruit processing. This will certainly enhance its capability for commercialization of technology being developed under the program.

The PHT laboratory at IARI, New Delhi is still under construction and the scientists hope that it will be completed in a few months but not before June 1992.

The PHT research facility at CIHNP, Lucknow continues to be located in a private building which was reported to be unsatisfactory and inadequate by the consultant, Dr. Ron Buescher. The team understands that ICAR has commissioned construction of a laboratory building for CIHNP, Lucknow at the Research Station and the PHT research will also be shifted there as soon as the construction is complete.

The NRCC, Nagpur, though the youngest center for PHT research is found to be carrying out its research work successfully from the temporary laboratory remodelled for the purpose. We also understand that the permanent laboratory building is also under construction and the PHT research will be located in this building. Thus by June 1992, except IIHR, Bangalore all the other three centers will continue to use the temporary building facilities for the PHT research. Not- withstanding this handicap, the new equipment provided in all the centers is being put to maximum use.

STAFF

ICAR has provided the following staff at the operating research center exclusively for PHT research :

	Scientists	Technicians	Administrative Staff	Support Staff
IARI New Delhi	9	5	3	5
IIHR Bangalore	11	10	3	3
CIHNP Lucknow	8	8	2	1
NRCC Nagpur	6	6	2	-

Further strengthening in the Eighth Five-year Plan is also contemplated. In fact at IIHR, Bangalore the PHT research unit has been accepted for upgradation to the level of a department of the institute. According to the final report of the PHT sub-project there are 34 positions of scientists 29 of technicians 10 of administrative and 9 of support staff. Most of the positions are filled.

TRAINING

Twenty-nine Indian Scientists, generally in groups of two each, and four technicians from the four lead Institutes included in the post harvest technology project received training in U.S. for four months each, except the last group which visited for 0.5 months only. The technicians received two months training. In addition, a team of three scientists/managers visited U.S. institutions for 0.75 months.

The training of technicians was a good innovation and has strengthened the foundation of research in PHT.

Although training programs were planned to be predominantly conducted during spring to fall months to coincide with most post harvest processing activities in the U.S., most of the programs were carried out during fall to spring months. This shift in scheduling was primarily caused by the delays in obtaining the clearance approvals for the Indian scientists to travel to U.S. However, it is satisfying to note that not withstanding this limitation the training program was satisfactory.

The principal objective of the project to strengthen the capability of the research staff of post harvest technology has been accomplished, but it is too early to judge the contribution of this trained manpower as the equipment has been only recently received and installed and most of the researches have been done with minimum use of this equipment. The training is only a means to an end and the result will depend on the use that these scientists make of it in their future research. However there is no doubt that the necessary potential for doing relevant research has been created and it is for the ICAR to exploit this potential.

RESEARCH EQUIPMENT

Equipment costing about U.S.$1,521,200 was received by the participating Indian Institutes. Most of it has been installed and put to use. In some institutes such as IIHR Bangalore it has been installed in the laboratory building specially developed for the purpose and in others like IARI it has yet to be installed in the laboratory which is under construction and is likely to be completed within a few months. In CIHNP Lucknow, it is housed in a rented building and in NRCC Nagpur in a specially remodelled building. The team understands that at Nagpur as well as at Lucknow, the PHT units will be finally moved to permanent laboratory buildings of both these institutes which are under construction. Notwithstanding these differences, all the equipment is in use in all the participating institutes.

About half of the items were delivered and installed in the last six months before the project ended. This has affected their use and impact on quality of research. The delays in procurement also affected the in-country training of scientists and technicians and utilization of the services of the consultants. The Indian scientists are now getting acquainted with its use for the research activities, but it is too early to assess its impact on research output both in terms of quality and transferability. There is an apprehension that lack of availability of spare parts and repair facilities in India, after the termination of the project will affect the future usefulness of the equipment. The team endorses the recommendations of Dr. Ron Buescher, the lead consultant of this project that USAID may consider follow up support for technical assistance for repairs and spares and services of an instrumentation engineer after the termination of the project. The team understands that some of the equipments received early in this project has been useful to other scientists of the centers even outside this program. This should be encouraged more in the future also as it is the facility for upgrading research activities.

CONSULTANTS

Technical assistance has been provided by 12 consultants for the total period of 13.25 months in India. Two consultants advised on research in post harvest loss assessment. Two in PHT physiology, one in PHT pathology, one each in microbiology storage and handling, and flavor analysis. These consultants participated in workshops, presented short seminars and advised on research plans and programs on the thrust areas of the project. The technical assistance has been appropriate and beneficial for the scientists and PHT research program. However, less than anticipated utilization of U.S. scientists has occurred due to delays encountered in obtaining the research equipment.

Now that the required equipment has been received and installed in all the four centers and the project has also completed even the extended period of one year, it does not lessen the need for some follow-up specially for servicing the equipment.

RESEARCH ACCOMPLISHMENTS

Research under the sub-project was initiated after it was approved. It was sharply focussed on the five thrust areas and on the commodities selected for each center according to its capability and priorities. NRCC focussed attention on citrus and bananas, CIHNP on mangoes, guava and potatoes, IIHR on banana, mangoes, onions and tomatoes and IARI covered all except guava. All the centers accepted responsibilities for research in all the 5 thrust area except IARI which excluded the assessment of losses from its thrust areas of research.

MECHANISM OF RESEARCH PROGRAM EVALUATION

The annual progress report of the project is discussed in the annual workshop of the All India Coordinated Research Project of ICAR on Post Harvest Technology of Horticultural crops which is the umbrella project covering the range of environments for PHT research in India. This provides an excellent forum for exchange of information and planning relevant research programs. A voluminous final report of the PHT research for the period of October 1985 - March 1991 has been prepared by ICAR. It is an exhaustive account of inputs and outputs of research under this sub-project. In the quarterly meetings held by ICAR under the chairmanship of the Deputy Director General/Assistant Director General Horticulture, the program implementation progress is reviewed regularly. Although the participating centers strictly followed the main objectives, there were major changes in the type and quality of data after the scientists received the training and the equipments.

Most of the results reported were obtained without relying on imported equipments or new facilities for all areas of research but there is an indicated trend of improvement in quality and productivity of research directed with the assistance received under this sub-project. With the installation of new equipments greater potential has been created for more sophisticated research.

ACHIEVEMENTS

The salient achievements are summarized below:

1. Pre harvest application of gibberellic acid and calcium salts are found to retard ripening of mangoes, oranges, and guava.
2. Sprouting inhibitors of onions and potatoes have been identified but the commercial application needs testing.
3. Effect of maturity stage and specific gravity of fruits at the time of harvest on post harvest losses of several crops has been studied and the method using specific gravity criteria for separating spongy ALPHONSO mango from non spongy ALPHONSO has been developed.
4. Assessment of losses and techniques for reducing them in the wholesale and retail markets have been studied.
5. Pre-harvest spray of TOPSIN.M or BAVISTIN was found to be effective in controlling post harvest diseases in mangoes and Nagpur mandarin.
6. A mango harvester having a fruit conveying nylon chute has been developed.
7. A ventilated corrugated fiber board (CFB) box with ventilated partitions was developed for packaging and transportation of mangoes.
8. Wrapping MH films in mangoes was found to delay ripening and increase shelf life. Similarly film wrapping coupled with ethylene absorbent increased the shelf life of bananas. But the use of these techniques for commercial scale application remains to be developed.
9. Precooling was found to increase the shelf life of mangoes and reduce spongy tissues in ALPHONSO variety of mangoes.
10. Post harvest CIPC treatment was found to significantly inhibit sprouting of potatoes and MT spray of onions during storage.
11. The development of a zero energy cool chamber was found to be most effective in enhancing shelf life of fresh and processed fruits and vegetables and suited for adoption in rural areas.
12. Application of stay-fresh storage wax 6% and Bovistin (2000 ppm) was found to increase shelf life of mandarin oranges.
13. Methods have been developed for manufacture of alcohol and vinegar by fermentation of mango waste and preparation of jelly grade pectin from citrus and mango peels.

14. Standardization of manufacture of carbonated fruit-based drinks has been done and the process is ready for commercial exploitation.

ASSESSMENT

Many of the techniques and concepts of post harvest technology are still confined to the researcher's laboratories and need to be evaluated on an operational scale either through on-farm research or pilot scale research in collaboration with traders, manufacturers and processors of vegetables and fruits. The interaction of scientists with fruit and vegetable growers, marketeers, processors, traders and exporters is needed. In case of manufacturing techniques, the question of comparative advantage of ICAR horticultural research centers with the Central Food Technology Research Institute, Mysore (CFTRI) also needs to be considered. ICAR institutions seem to have greater comparative advantage in developing technology for preventing pre-harvest and post- harvest losses and reducing losses in handling, storage and marketing. This should continue to be the priority area of its research agenda. On the other hand, CFTRI has a comparative advantage in processing research and ICAR institutes should work cooperatively with it.

Before the initiation of this project, most of the research on PHT in ICAR/SAUs system was directed towards processing and product demonstration. Establishing objectives that emphasize pre-harvest and
post-harvest research to retard deterioration of fresh produce has been the main contribution of this project and continuation of this thrust in research in the future is most appropriate for the ICAR/SAU system.

The technology should be directed towards processing and development of value-added products, generating employment, improving returns to the producers and improving quality and quantity of fruits and vegetables available to the consumers. This will also help India in increasing exportable fruits and vegetables (both fresh and value added products). Thus, this sub-project has laid the foundation of research for reaching the goals of modernizing the fruit and vegetable industry in India.

TECHNOLOGY TRANSFER

Research on the thrust areas of PHT has no doubt resulted in a number of findings of practical significance, but the economics of the techniques and cost benefit relations have not been adequately studied. In many cases, the techniques have yet to be evaluated at the farm level or on an operational scale.

According to the research scientists, the most important recommendations ready to be transferred to users are:

1. Three sprays of Topsin.M (0.1%) at an interval of 15 days before harvest for controlling post harvest diseases of mangoes and Nagpur mandarin.

2. Harvesting of mangoes along with the stalks using improved harvester at the maturity stage when ALPHONSO and Piri varieties attain a specific gravity of 1.00 to 1.02 and Dushehri less than 1.0. for reducing post harvest losses.
3. The corrugated fibre board (CFB) box with ventilated partition is recommended for packaging and transportation of mangoes. The film wrapping of mangoes and bananas is recommended for delaying ripening and increasing their shelf life.
4. Precooling of mangoes to 12-15 °C and treatment with 500 ppm Bavistin or hot water treatment with .1% Bavistin is recommended for controlling storage and spoilage loses
5. The zero energy chamber is recommended for storage of potatoes, citrus, mangoes and bananas. It is also an appropriate technology for small farmers in rural areas.
6. Carbonation of lime drinks is suitable for commercialization.
7. Pectin extraction from mango peel and mandarin orange peel is suitable for jelly preparation and needs to be exploited commercially.
8. Production of alcohol from mango waste and vinegar from mango peel is feasible, however, their commercial exploitation needs to be studied.

The IARI New Delhi center claims to have transferred successfully the zero energy cool chamber system of storage of fruits and vegetables to users. The IIHR Bangalore claims that the hot water treatment method of mangoes has found acceptance with many users. Similar claims are made by NRCC Nagpur about the efficiency of pre-harvest and post harvest sprays of fungicides in reducing losses and improving shelf life of Nagpur mandarin, but we have no way to assess the impact of these techniques on commercialization of the commodities.

COMMERCIALIZATION

Most of the techniques developed by this sub project relate to reducing the losses in quality, increasing shelf life and minimizing incidental diseases in transport of mangoes, bananas and Nagpur mandarin. Some relate to reducing sprouting of onion and potatoes. While educating the farmers or growers of these perishable commodities can create awareness of the problems and of the remedial measures, the desired results cannot be achieved unless the contractors who are responsible for harvesting, transportation, marketing and storage are educated and motivated to adopt these practices. Ignorance as well as greed motivates them to harvest immature fruits and ripen them artificially to avoid the cost of proper packaging, unmindful of the loss and adverse effect on quality. The techniques found useful in laboratory scale experiments need to be demonstrated on a commercial scale and its cost benefit relationship highlighted. The technology has yet to go to the stage when it could be adopted on a commercial scale.

For processing techniques for best utilization of waste products of fruits and vegetables, pilot plant scale evaluation is needed to convince the entrepreneurs. It is hoped that in the future, these aspects will receive due attention. Thus R & D for this intermediate stage is needed before the post harvest technology can be commercialized. The USAID Project of Center for Technology Development (CTD) at Bangalore, if properly tied up with the post harvest technology Research at IIHR, Bangalore has the potential of becoming a bridge between the laboratory research and the next stage of Commercialization. Likewise, in case of PHT research on Nagpur mandarin, the Agricultural Commercialization and Enterprise Project (ACE) assisted by USAID in Maharashtra could lead to exploitation of technology developed by this center for commercial use. However, all depends on the effective linkages which research projects develop with ACE and similar other developmental projects.

FUTURE OUTLOOK

Sustainability of Research

The question of sustainablity after the close of this sub-project in March 1991 is a matter of concern, but all the evidence available shows that the research is continuing with the same vigor and enthusiasm as in the past. Moreover its continuation in the future is also assured by its inclusion as a high priority program in the Eighth Five-Year Plan of the Government of India. The GOI also considers it a key to the development of export potential of fruits and vegetables, which is the cherished goal of the country in the future. Moreover, it is necessary to reduce the huge losses both in quantity and quality which occur due to neglect of post harvest practices causing great financial losses to the nation and affects its national nutritional security. The training of scientists and provision of necessary equipment installed very recently has created a favorable environment for the sustainabilty of the relevant research.

The trained manpower, if effectively motivated and supported, can lead to the goal of commercialization of post harvest technology application and acceptance of the challenge of the second generation problems.

However, one area of concern relates to the availability of spares and repairs of the equipments imported from U.S. The team recommends that USAID consider developing a mechanism of providing critical assistance for servicing the equipment and prevent training assistance going to waste due to small failures and non-availability of spares which are inevitable. Some arrangements for follow-up action with the suppliers of the equipment are also suggested.

It is also necessary to ensure that the interaction with the U.S. lead scientist in PHT research is continued, joint research programs developed and scientist to scientist interaction and technical exchange of information encouraged. This will certainly help in creating a multiplier effect on the payoff from investment in this sub-project.

FINDINGS AND RECOMMENDATIONS

The PHT sub-project ended in March 1991 and achieved the target goals of building up competence for research in post harvest technology in the participating institutes through training of scientists, provision of equipment, arranging consultancies and facilitating exchange of information through workshops, seminars, and interaction with the leaders in selected areas of research. It is noteworthy that almost all the scientists engaged in PHT research in the four participating institute, viz., IARI, New Delhi; IIHR, Bangalore; CIHNP, Lucknow and NRCC Nagpur, have received training in U.S. Universities and institutions specializing in the relevant researches. They are trained and equipped to do meaningful researches. The thrust areas of research of high priority are relevant and appropriate. It is hoped that with modern equipment which has been provided to all of them equally, it will be possible to do more sophisticated and problem- oriented research.

Before the initiation of this project, there was no critical mass of well-trained scientists in PHT nor there were exclusive laboratories and modern equipment for relevant researches. Today, all the four participating institutes have the necessary equipments. The laboratory facilities have also been created though there are still some concerns about the laboratory facilities at some of the PHT centers. Nevertheless, the work at all the centers is in progress and its quality and orientation will improve with time and with greater use of modern equipments.

The additional payoff from this project has come from its synergistic effect on the All India Coordinated research project of fruits and vegetables. The awareness of the harvest losses of both quality and quantity of fruits and vegetables and promising technology evolved for reducing these losses have created a favorable climate for enthusiastic support to sustain PHT research in India.

RECOMMENDATIONS

Government of India

The team is pleased to know that the GOI has accepted the pivotal role which PHT will play in development of fruits and vegetables industry, but it wishes to stress the need for greater investment and more critical research specially the adaptive research - on farm research and pilot scale operational research in collaboration with the growers of fruits and vegetables, traders and processors. Need is felt for developing linkages with the industry and taking advantages of emerging technologies in the developed countries. Linkages with other USAID projects on PHT of fruits and vegetables, such as Agricultural Commercialization and Enterprize project (ACE) and CTD, Bangalore and in CFTRI, Mysore should be developed.

USAID

Though the continuity of the project by GOI is assured, the serviceability of the equipment supplied by the U.S.A is not assured. The team suggests that it will be of mutual benefit if USAID develops a mechanism of necessary support of servicing and supplying of spares.

The payoff from the concluding project will be enhanced if the collaboration in joint research between Indian scientists and U.S. scientists in areas of mutual interest is encouraged, exchange visits, exchange of information and participation in workshops facilitated. The U.S., because of its vast experience, expertise and improved technologies in PHT, should consider continuing to play its catalytic role through interactions even after the conclusion of this project. This is due to its having the potential of encouraging exports of acceptable quality of fruits and vegetables to achieve the long-term goals of food security, nutritional security and generating more employment in India.

To sum up, this sub project has accomplished the short-term targeted goal of creating, strengthening and stimulating PHT research in fruits and vegetables. But the long-term goals for generating greater employment, potential income and nutritional security through this research is rather far away. However, the fact remains that this sub-project has provided the means and the first step towards reaching the goal.

ATTACHMENT 4.1.3

CONVERSION OF BIODEGRADABLE ANIMAL WASTE FOR LIVESTOCK FEED (CBAW)

BUDGET USAID U.S.$ 1,104,441
GOI U.S.$ 1,443,000

IMPLEMENTATION DATE April 01, 1987

COMPLETION DATE March 31, 1992

PARTICIPATING INSTITUTIONS

U.S.

1. Purdue University, Lafayette
2. University of Illinois, Urbana.
3. Auburn University, Auburn.
4. Virginia Polytechnic and State University, Blacksburg

The following Indian Institutions participated:

1. Coordinating Unit, New Delhi
2. Central Toxicological Laboratory, Haryana Agricultural University, (HAU) Hisar
3. Bombay Veterinary College, (BVC), Bombay
4. Haryana Agricultural University (HAU), Hisar
5. Kerala Agricultural University, (KAU), Trichur
6. Punjab Agricultural University (PAU), Ludhiana

CONSULTANTS Lead Consultant - Dr. J.P. Fontenot
Virginia Polytechnic and State University, Blacksburg.

BACKGROUND

India suffers from chronic shortages of concentrate feed and roughage which has adversely affected livestock production programs. With the recent measures the Government has taken to augment livestock production by induction of exotic inheritance the need for self-sufficiency in the nutrient requirements of the livestock population cannot be over-emphasized.

The purpose of this sub-project was to strengthen the capability of Indian scientists to conduct research on processing of biodegradable animal wastes to livestock feed. Research in this area would aim at increasing the quantity and quality of feeds available to meet the nutrient requirements of livestock in India. Specific objectives of this sub-project were:

1. To screen microorganisms that have potential to convert animal waste into practical livestock rations.
2. To evaluate the nutritive value of fermented feeds for farm animals and to determine means and economics of including these new feeds into practical livestock rations.
3. To transfer viable technology of processing feeds from farm animal wastes to villagers and industry.

DESIGN, PLANS, LOCATIONS ETC.

The components of this sub-project were assigned to five participating centers. There is also an "ICAR Coordinating Unit" which is responsible for coordination, monitoring and evaluation of the work of all participating centers. The research work is distributed among the several centers as follows :

Center 1	-	Haryana Agricultural University (HAU), Hisar. Toxic products from biodegradable wastes.
Center 2	-	Bombay Veterinary College (BVC), Bombay. Slaughter house waste.
Center 3	-	Haryana Agricultural University (HAU), Hisar. Wastes from large animals.
Center 4	-	Kerala Agricultural University (KAU), Trichur. Biodegradation of fish and other aquatic animal wastes.
Center 5	-	Punjab Agricultural University (PAU), Ludhiana. Biodegradation of poultry wastes.

OBJECTIVES

The basic objective of this sub-project is to increase the quantity and quality of feeds from nonconventional resources to meet the growing nutritional requirements of Indian livestock. Large quantities of farmyard wastes, slaughter house wastes and agro-industrial wastes are currently unutilized. Research work is directed to the development of simple microbial techniques, processing and equipment to convert current waste materials into economic feeds for providing improved and nutritive rations to animals. The sub-project also envisages dissemination of proven technologies to the small farmers and also to the livestock feed industry.

IMPLEMENTATION

All the centers participating in this sub-project have experienced scientific staff, ample laboratory space, requisite equipment and other facilities for undertaking the research assigned to them. The Coordinator of this sub-project is a scientist with vast experience in this field.

The sub-project has covered new areas hitherto unexplored and adopted new techniques to enhance the availability of more animal feeds and roughage of higher nutritive value through the utilization of unconventional feed materials. The processing techniques adopted are also simple, economical and such that progressive farmers with large poultry farms and small dairy units can easily implement these technologies and profit from them. However, in the initial stages, extensive extension work has to be undertaken with practical demonstrations to convince the farmers. Some of the farmers are already following some of these technologies like utilization of poultry litter and cage droppings and aquatic waste which are processed more easily. The livestock feed manufacturers are also showing keen interest in this new area with great promise for the future. However, the nature of work involved is such that dynamic extension work, very effective field demonstrations and much persuasion are needed to make these new technologies popular. There can be no doubt, whatsoever, about the practical success of these technologies in view of the worsening feed and fodder situation in the country and their rising costs.

TECHNICAL ASSESSMENT

The sub-project was divided into several components which were implemented at the various participating centers.

Center 1: Haryana Agricultural University - Central Toxicological Laboratory, Hisar.

Component: Toxic products in feeds from Biodegradable wastes

The objective of this component is to provide the service of testing for toxic compounds that may occur in feeds based on waste products, to provide in-country training in this subject matter area and to provide special chemical analysis needed.

There have been delays in setting up the toxicological laboratory and getting operational. The laboratory was moved from NDRI, Karnal to HAU, Hisar after the first year of activity under the sub-project. Samples of milk from the university herd were analyzed for pesticides and some feed samples for aflatoxin residues.

Center 2: Bombay Veterinary College (BVC), Bombay

Component: Slaughter House Wastes

The objectives of this component are to provide complete analysis of intestinal and ruminal contents collected at slaughter houses, to develop technologies for utilization of rumen and intestinal contents, to utilize blood by making meal for non-ruminants, screen intestinal contents for organisms that can convert waste into proteins that are useful as feeds etc. The following research programs were followed at this center:

1. Chemical composition of blood and rumen contents was undertaken. The work included rumen contents before and after squeezing rumen contents of different species like cattle, sheep and goats in different seasons.
2. Use of non-toxic, non-pathogenic fungal isolates for protein synthesis from rumen contents.
3. Ensiling of rumen contents and straw with different levels of straw and molasses at different moisture levels.
4. Urea and molasses treatment of rumen contents.

There is considerable variation in the chemical composition of the biodegradable animal wastes. For example, crude protein varies from 8.4% for cattle rumen contents to 87.3% for blood on dry matter basis. Dry matter was lower in rumen contents than for any of the other wastes. The crude protein content varied from 14.4 to 18.4%. Experiments have been conducted on various aspects of ensiling slaughter house waste and paddy straw. Use of blood and rumen contents in ensiled mixtures resulted in silage of higher nutritive value than rumen contents only-crude protein content and digestibility were higher for silages containing blood. Addition of molasses to squeezed rumen contents treated with urea increased digestibility of crude fibre. The increases were larger when molasses was added after ensiling was completed. When rumen contents were ensiled with 40 to 70% paddy straw, digestibility increased with increased proportion of blood in the mixture in situ. Digestibility of dry matter, crude protein and crude fibre was increased by treatment with 5.3% urea.

Center 3: Haryana Agricultural University (HAU), Hisar

Component: Wastes from large animals

The technical program covered the items listed below:

1. Chemical composition of dung and urine from different classes of cattle and buffaloes.
2. Chemical composition and ensiling of bedding consisting of bovine waste and wheat or paddy straw.
3. Ensiling of bedding with different levels of green forage and molasses.
4. Preservation of cattle waste by sun drying and urea treatment.
5. Effect of urea treatment and molasses addition on ensiling characteristics, nutritional value and microbial destruction in cattle waste and straw mixtures.

The crude protein of cattle and buffalo dung was 14.2%. Adding green oat forage to ensiled wheat or paddy straw cattle waste bedding increased digestibility. Adding molasses increased digestibility only if green oat forage is not added. Digestibility of dry matter and crude protein were higher for a ration containing urea treated wheat straw cattle waste bedding compared to sundried bedding.

Center 4: Kerala Agricultural University (KAU), Trichur

Component: Biodegradation of fish and other aquatic animal wastes

Work has been done on the following aspects:

1. Chemical composition of prawn processing waste.
2. Ensiling of prawn waste.
3. Ensiling of crab processing waste, with wheat bran and maize forage.
4. Preservation of crab waste and ensiling with straw.

Progress for the first three years was limited. The prawn waste contained 41.8% crude protein and 29.0% on dry matter basis. Addition of tapioca flour and coconut cake enhanced the nutritional value of ensiled prawn waste and rice bran and paddy straw.

Center 5: Punjab Agricultural University (PAU), Ludhiana

Component: Biodegradation of poultry wastes

Work at this Center covered the following aspects:

1. Deep stacking of a combination of wheat straw and poultry droppings.
2. Chemical and microbiological changes in poultry litter with saw dust and rice hulls as bedding.
3. Fungal biodegradation of poultry droppings.
4. Changes in chemical composition of litter with time.
5. Isolation and characterization of fungal species isolated from poultry droppings.
6. Protein synthesis by fungi.
7. Deep stacking of poultry litter alone and use of litter as livestock feed.
8. Evaluation of deep litter stacked and ensiled poultry litter as livestock feed.

Poultry litter which had accumulated for eleven months contained 14.7% crude protein on dry matter basis. Poultry droppings contained 24.4% crude protein on dry matter basis. Feeding of fungal fermented droppings to chicks resulted in higher efficiency of protein utilization compared to untreated droppings. In broiler growth studies, inclusion of fungal treated poultry droppings in the diets resulted in higher weight gains compared to untreated droppings.

There have been no animal health problems associated with feeding processed animal wastes. Health problems from feeding poultry litter have not been reported. Rumen contents and paddy straw treated with 5.3% urea on dry matter basis and ensiled were free from coliform and spores forming bacteria after six days. Ensiled prawn waste, rice bran and tapioca flour (45:45:10) mixture was found to be free from pathogenic bacteria. Samples of silage from cattle waste, straw, green oat forage and molasses contained 30 to 65 ppb aflatoxin BI. There has been no evidence of problems of residues of heavy metals, mycotoxins, pesticides and medicinal drugs.

All the centers participating in this sub-project have adequate trained staff to cope with the work on hand. Several of them have received higher training in advanced laboratories in the U.S. which has enhanced their research capability considerably. These centers are all fully equipped and have no problems in this regard. All of them also have adequate laboratory space.

Research Accomplishments

Several technologies for rendering biodegradable farm and animal wastes and byproducts of agro-industries as useful ingredients of livestock feed have been developed. Poultry wastes from layers can be fed to any class of farm animals. If layers are on litter this could be processed by deep stacking. This litter could be ensiled with high moisture ingredients like maize or oat forage. The dry matter content of the combination should not exceed 50% for good ensiling. If layers are in cages the waste could be dried or ensiled. Sun or heat drying is also satisfactory. The waste can also be ensiled with straw.

Cattle waste was ensiled with straw or other crop residues with the addition of 10% molasses. The level of waste should be 50 to 60% and the dry matter content 40 to 50%. Since this silage is low in energy value it should be fed as a maintenance ration or to animals at low levels of production. This waste is best suited to feed ruminants. Rumen contents with or without blood can be ensiled with dry ingredients like crop residues. Addition of molasses may help in ensiling. The dry matter should not exceed 50%. Since silage is low in energy value, it should be fed as maintenance ration or to animals with low production, primarily to ruminants. Prawn waste can be combined with rice bran or straw in 1:1 ratio with 10% tapioca and fed to ruminants.

Technology transfer

The raw materials involved and the technologies are such that the transfer of these innovative technologies to end users is bound to be slow but sure. Some progress has already been made in technology transfer. Farmers in Kerala are already reported to be making use of fish and prawn processing wastes for feeding dairy cattle. Poultry litter from birds raised in cages is also being sundried and recycled to poultry to some extent. Deep litter from poultry farms is also finding limited application in ruminant feeding. With the passage of time most of these technologies are bound to be adopted by most of the organized dairy and poultry farmers while some of them will be adopted by the livestock feed manufacturing industry.

Commercialization

The livestock feed manufacturing industry has shown keen interest in the researches and the new technologies generated. This industry is very progressive and has so far made the best use of new technologies involving unconventional feed ingredients. However, more extensive research work involving more animals of different classes over longer periods has to be undertaken to make these new technologies fool-proof.

Future

With the chronic shortages of animal feeds and fodders, their high prices and the worsening situation in India the scope for the success of the practically oriented new technologies is very bright. Feed costs make up from 50 to 70% of the cost of livestock products. The programs implemented in this sub-project are designed to produce wealth from waste. The current achievements cover a wide basically academic area to fill up gaps in the existing knowledge. The programs have reached a take-off stage with the demonstration of farmers' willingness to adopt these technologies. However, much more work needs to be done to dispel some doubts and infuse confidence in the minds of the farmers and the industry about the safety of these technologies.

FINDINGS AND RECOMMENDATIONS

The most important need for stepping up animal production in India is an adequate availability of feed and fodder of good quality. The current picture in this regard is far from satisfactory. Viewed against this background both from the immediate as well as long-term points of view the technologies generated in this sub-project have great practical value. Substantial achievements have been made in this sub-project of which both USAID and GOI can be proud. However, much more work remains to be done for at least five more years to provide reliability and credibility to these technologies.

USAID

The training of senior Indian scientists in laboratories in the U.S. in advanced technologies coupled with the support from sophisticated equipment strengthened by the very keen interest taken by the lead consultant have been the key factors contributing to the success of this sub-project. These activities have to continue for at least five more years to complete the unfinished work. During this period the involvement of the U.S. Consultants in workshops and in other ways will greatly help in speeding up the whole program.

GOI

The sub-project has competent and experienced staff at all centers which also have adequate laboratory space and equipment. The programs undertaken in the sub-project are vital to India's efforts to step up meat and milk production. The results of these investigations have only shown the trend and need five more years to complete the unfinished work and produce viable technologies. It is, therefore, essential that GOI extends continued financial support to these programs on a priority basis. Adequate funds should also be made available for import of spares for the sophisticated equipment.

ATTACHMENT 4.1.4

INTRACELLULAR BLOOD PROTISTA WITH PARTICULAR REFERENCE TO IMMUNO-PROPHYLAXIS AND CONTROL (IBP)

BUDGET	USAID	U.S.$ 1,315,485
	GOI	U.S.$ 1,052,000

IMPLEMENTATION DATE April 01, 1987

COMPLETION DATE March 31, 1992

PARTICIPATING INSTITUTIONS

U.S.

1. Kansas State University, Manhattan
2. University of Illinois, Urbana
3. Colorado State University, Fort Collins

The participating institutions in India are:

1. Indian Veterinary Research Institute (IVRI), Izatnagar.
2. National Dairy Development Board (NDDB), Anand.
3. Haryana Agricultural University (HAU), Hisar.
4. Punjab Agricultural University (PAU), Ludhiana.
5. Tamil Nadu Agricultural University (TNAU), Coimbatore.
6. Rajendra Agricultural University, (RAU), Patna.

LEAD CONSULTANT Dr. M. Ristic, University of Illinois.

BACKGROUND

The purpose of this sub-project was to strengthen the capabilities of Indian scientists to conduct research on arthropod-borne blood diseases by utilizing modern immuno-chemical, cultural and biotechnological procedures.

The research to be done is aimed at three haemotropic diseases which cause acute damage to high producing Bos Taurus cattle and their cross-bred progeny with local zebu. The effects are so acute that a serious limitation is placed on the usefulness of these highly productive crossbreds and thus hamper India's efforts to step up milk production. The diseases are Theileriosis, Babesiosis and Anaplasmosis which are spread by ticks. Fortunately, a recent research breakthrough in the U.S. has resulted in the development of a highly effective vaccine for Babesiosis and Anaplasmosis. No such vaccine has been available for Theileriosis although many of the research techniques used in the successful research on the other two diseases could be applied in Theileria research.

DESIGN, PLANS, LOCATIONS ETC.

In order of importance the haemotropic diseases are - Theileriosis (T.annulata), Babesiosis (B.bigamina) and Anaplasmosis (A.marginale). Research activities are directed to discover and produce suitable vaccines for these diseases. Essential components of this program are:

1. To adapt to Indian conditions the use of sheep-adapted attenuated Anaplasma marginale vaccine produced in U.S.
2. To adapt the use of the micro aeroplirlus stationary phase cultivation method for propagation of Babesia for vaccine production.
3. To develop Immuno-prophylactic procedures against Theileriosis by utilizing various cell culture immunogens of Theileria.
4. To find out antigenic relationship and cross-protection between different strains of the parasite.
5. To field test promising candidate drugs for treatment and control of the infection.
6. To conduct epidemiological studies.
7. To carry out training program.

OBJECTIVES

With a view to increasing the availability of meat and milk to its fast expanding human population, the Govt. of India embarked on an ambitious program of crossing its local zebu cattle with bulls of approved dairy breeds of the West. These exotic breeds as well as their crossbred progeny are highly susceptible to tick-borne haemotropic diseases. This infection causes high mortality and high morbidity manifested by reduced milk yield, retarded growth rate and increased susceptibility to intercurrent infections. Apart from cattle these diseases are also found in sheep, goats and horses. Research activities are now geared-up to the development of an effective vaccine for prevention and control of the three major diseases transmitted by ticks.

IMPLEMENTATION

The four participating centers located at IVRI, NDDB, PAU and HAU have excellent laboratory facilities, well-experienced and well-trained staff, good equipment and adequate animal facilities. Some of these centers have been working particularly on Theileria for nearly a decade prior to commencement of this sub-project. A Central Laboratory building has been constructed at HAU which has excellent built-in facilities. A van has also been provided for this center for field work.

Six Indian scientists were trained in the U.S. for 20 weeks and 8 scientists were on a three-week study tour of research laboratories in the U.S. Five U.S. consultants visited India during the project period. Dr. Ristic, the Chief Consultant, visited India five times.

TECHNICAL ASSESSMENT

There are several research components of the sub-project but three most important ones are:

1. Adapt to India the babesia vaccine derived through the U.S. breakthrough.
2. Adapt to India the anaplasma vaccine based on U.S. technology.
3. Develop an immuno prophylactic procedure against theileriosis by using various cell culture immunogens of theileria.

Major research effort will be on Theileria where it is a matter of developing a vaccine.

A. Theileria Vaccine

Major research accomplishments have been achieved in the development of control measures against theileriosis. Four centers, i.e., NDDB, IVRI, PAU and HAU have been able to develop effective vaccines. NDDB has also started marketing their vaccine all over the country commercially. The use of this vaccine is recommended for calves of two months age and above. It is reported to confer protection to challenge infection after about six weeks following vaccination. However, the consensus of opinion among scientists from all the centers is that mortality and morbidity is the highest among very young calves. They, therefore, feel that a suitable vaccine has to be developed to protect very young calves which are a few days old. The scientists of IVRI, PAU and HAU have developed a vaccine which promises to be effective in young calves below two months of age. Research is underway to determine the appropriate age for vaccination, time required for development of immunity after vaccination, degree of protection conferred, etc. These centers are working on three different isolates common in their respective zones.

B. Babesia Vaccine

Research with B.bigemina exoantigen system for immunization is under way. The lyophilized spent culture medium collected during in vitro cultivation in an indigenously developed system of an Indian isolate of B.bigemina which presumably contains soluble glycoproteins released by the parasite in the medium is being investigated.

In a controlled experiment, three susceptible crossbred calves were vaccinated with exoantigens derived from cultures of Mexican B.bigemina and then challenged with an Indian strain of the organism along with three unvaccinated susceptible crossbred calves. From the clinical point of view all the three vaccinated calves fully resisted the challenge while the three control animals developed typical clinical symptoms of acute babesiosis and died. This is a very meaningful result from two points of view. Firstly, it documents that the vaccine technology developed in the U.S. is applicable to Indian livestock and secondly, it substantiates the general scientific concept that B.bigemina antigens are identical in all parts of the world.

C. Anaplasma Vaccine

Work was initiated at HAU on attenuated modified live anaplasmosis vaccine developed at the University of Illinois. The effort is aimed at the development of a similar sheep- adapted strain using Indian virulent A. marginale. For this purpose, 500 ml of citrated blood from a calf having anaplasma infection was collected and inoculated in two calves with spleen in situ. One of these calves was later splenectomized and the infection flared up in this calf. 40 ml of blood from this calf was collected and exposed to gamma irradiation at 70 Krads and then injected into two splenectomized sheep at 20 ml each. None of the sheep revealed any anaplasma in their peripheral blood circulation.

D. Chemotherapy

More than 600 clinical theileriosis cases were treated successfully with a single I/M injection of buparvacuone at 2.5 mg/kg body weight. Long acting oxytetracycline has been found to be effective in the treatment of anaplasmosis. Supportive therapy hastens the recovery process. The recovered animals remain pre-immune. Stress factors contribute to recrudescence of infection in pre-immune animals.

E. Serodiagnostic methods

The application of the vaccines is ultimately associated with the availability of serodiagnostic tests useful for epidemiological studies and follow-up of immune responses to each of the vaccines. To this effect, tests like DOT ELISA and Indirect Fluorescent Antibody tests useful for the three diseases are being used in the field. Another test, Capillary Tube Agglutination test is being used as a field screening test for anaplasmosis and babesiosis.

The four major centers at IVRI, NDDB, PAU and HAU have attained a high degree of competence and are all fully geared up for faster progress in research on the three haemoprotist mentioned. They have already demonstrated their

research capability by producing effective vaccine against Theileriosis. Vaccines against the other two diseases are also in an advanced stage of production.

These four centers have ample laboratory space, adequate experienced staff, good equipment and farm facilities and are in a position to pursue the research programs they are already involved in. Several scientists have received advanced training in the U.S. and their interaction with the U.S. consultants has been highly beneficial. Dr. Ristic, an outstanding scientist from the U.S., has made repeated visits to India and has been a great driving force.

Sufficient research capability has been built up during the project period to enable these scientists to continue their research endeavors without any difficulty.

Research Accomplishments

A major breakthrough has been achieved in this sub-project by the production of an effective vaccine against Theileriosis which is one of the most dreaded diseases of crossbred cattle and their calves in India. An effective vaccine has also been produced against Babesia which has yielded promising results in the laboratory. Considerable progress has also been achieved in producing a live attenuated vaccine against Anaplasmosis. Very effective serodiagnostic tests have been found to facilitate epidemiological studies against all the three diseases. Effective chemotherapy has also been found for Theileriosis and Anaplasmosis.

Technology Transfer

In collaboration with USAID, two workshops were organized at IVRI for the benefit of Indian scientists engaged in this sub-project. One workshop of 12 weeks duration was organized by Dr. Renu Lal of the U.S. on "Hybridoma and Related Immunology Techniques". Dr. Altaf Lal, of the U.S. organized the second workshop of eight weeks duration on "Genetic Engineering of Protozoan Diseases".

Research work on Haemoprotists is of a highly sophisticated nature and there is no need to train field workers in this area.

Commercialization

The vaccine produced by NDDB is already commercialized and is received well all over the country. The other three vaccines under field trial are also likely to be commercialized when released. There is a very large market for Theileria vaccine in India if a low-cost, highly effective vaccine is available.

Future

The future of this sub-project is bright since it has an impact on dairy development in the country and all-out efforts are currently being made to step up milk production in India. While the work relating to vaccine production against Theileria has been successful and similar work for Babesiosis and Anaplasmosis is in an advanced stage, there are several other areas of advanced research in related areas which require some attention.

To sustain the high level of competence and to cope with the latest advances it is highly desirable to send a few highly selected senior scientists to U.S. for further training in specific areas for a short period. It is equally important that a few consultants visit India annually to participate in the annual workshops.

Necessary financial support should be forthcoming from the Government of India on a priority basis for the completion of the unfinished work.

FINDINGS AND RECOMMENDATIONS

USAID

Support from USAID came to this sub-project at a crucial time when the basic work relating to life cycle and other matters relating to Theileriosis were completed by Indian scientists. The scientists were fully equipped with the requisite knowledge to proceed with efforts for vaccine production. The high quality U.S. consultants who repeatedly came to India were a driving force for the success of this sub-project. The battle against haemoprotists will now take us to control of the ticks which are the vectors. In this context, the future participation of USAID in providing limited training facilities in the U.S. to Indian scientists and the participation of consultants from the U.S. in the annual workshops will be a great asset.

GOI

The evolution of effective vaccines against Theileriosis and the advances made in the production of suitable vaccines against Babesiosis and Anaplasmosis will assure cattle health and promote animal production in India without serious obstacles. The battle against the three haemoprotista is far from won. We have to move further to consolidate the gains made. This needs the continuance of these research programs to complete the unfinished work. This, therefore, requires the financial support of GOI on priority basis. Adequate finances have also to be provided for import of essential spares.

ATTACHMENT 4.1.5

EMBRYO TRANSFER TECHNOLOGY AND BIO-ENGINEERING IN LIVESTOCK SPECIES AND THEIR PATHOLOGICAL IMPLICATIONS (ETT)

BUDGET	USAID	U.S.$ 1,141,070
	GOI	U.S.$ 1,072,000

IMPLEMENTATION DATE January 09, 1987

COMPLETION DATE March 31, 1992

PARTICIPATING INSTITUTIONS

U.S.

1. Colorado State University, Fort Collins.
2. University of Georgia, Athens
3. Embryo Tech. Inc., California.
4. University of Wisconsin, Madison.
5. Louisiana State University, Baton Rouge.
6. Utah State University, Logan.
7. USDA Laboratory, Clay Center.

The participating centers in India are:

1. Indian Veterinary Research Institute (IVRI), Izatnagar.
2. National Dairy Research Institute (NDRI), Karnal.
3. Central Institute for Research on Buffaloes (CIRB), Hisar.
4. Haryana Agricultural University (HAU), Hisar.
5. Central Institute for Research on Goats (CIRG), Makhdoom.
6. G.B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar.
7. Andhra Pradesh Agricultural University (APAU), Tirupathi.

CONSULTANTS Dr. D.S. Dhindsa was the lead consultant.

BACKGROUND

The purpose of this sub-project is to strengthen the research capability of Indian scientists to do embryo research in Indian livestock with special reference to cattle, buffaloes and goats.

The major advantages of this technology pertains to the generation of a large number of superior, highly pedigreed males required for the genetic improvement of livestock in a short period of time by exploiting superior dams and sires. Through this technique a large number of proven sires can be produced in a short span of time at much less cost than through conventional procedures. With the ambitious livestock development programs launched by GOI to step up availability of meat and milk to the fast expanding human population, the need for high pedigreed males for breeding needs no special emphasis. This technology can also be of immense benefit for preserving some of the fast disappearing breeds of economic importance.

DESIGN, PLANS, LOCATIONS, ETC.

The areas identified in the sub-project include:

a) Superovulation and synchronization of oestrus in donor and recipient animals.
b) Collection of ova and embryos for implementation of basic research for in vitro fertilization, embryo culture, cryopreservation, sexing, cloning, genetic engineering, embryo-environment interaction and embryo uterine secretory interactions.
c) Transfer of viable technology for field application.

Essential components of the program are :

1. Studies on superovulation and synchronization of oestrus in donor and recipient animals with emphasis on dairy animals in different regions of the country.

2. Superovulatory responses and endocrine profiles in animals subjected to different synchronization treatments for assessing individual breed responses and optimization of synchronization drug schedule.
3. Studies on embryo collection techniques and cultivation of embryos.
4. Cryopreservation of embryos.
5. Factors affecting ova production and evaluation of ova/embryos.
6. Development of methodologies for sexing and cloning of embryos.
7. Development of methodologies for genetic engineering aspects of embryo transfer through utilization of embryos from large and small animals.

OBJECTIVES

To meet the animal protein requirements of the fast growing population in India there is an urgent need for the genetic improvement of Indian livestock for meat and milk production. This is possible through the large scale use of males with proven merit. Research activities are directed to the generation of a greater number of offspring from genetically superior males and females in a much shorter period. Through ETT, it is possible to produce a large number of progeny-tested males within a short period and at much less cost than through conventional procedures.

IMPLEMENTATION

IVRI, NDRI and CIRG have excellent facilities in term of good laboratories, equipment, trained staff and adequate elite cattle, buffaloes and goats, to undertake the technical program as envisaged in the sub-project. These three are old organizations with considerable infrastructure and are also funded by other organizations like the Department of Biotechnology. CIRB is a relatively young institution and has the barest minimum of staff, equipment and laboratory space but has excellent farm facilities. HAU has a truncated unit divided between the College of Veterinary Science and College of Animal Science in spite of the recommendation of the consultant to merge the two. The facilities here are at the minimum for coping with the work envisaged. Farm facilities are very unsatisfactory. APAU unit has the minimum necessary infrastructure to carry on ETT and related works but has the serious handicap of working with a breed of cattle reported to be non-responsive to superovulation.

Success

Centers like IVRI, NDRI, CIRG, AND CIRB have achieved considerable success in the basic objectives of this sub-project. They have succeeded in establishing suitable protocols for superovulation, were able to synchronize oestrus in donor and recipient females and were able to retrieve the embryos and transfer them to recipient females etc. However, the overall success rate whether in superovulation, retrieval of embryos or impregnation is far below that achieved in advanced countries. The basic reasons for this are the differences in hormonal profiles in the zebu compared to the exotic breeds and their biological responses. The difficulties are all the more in buffaloes. It will take some more time and experience to reach higher levels of performance. This requires concentrated efforts without diverting attention to more sophisticated areas before basic issues are solved.

Difficulties

Some centers had expressed problems about late receipt of equipment, resulting in delay in implementation of the program and also delay in training of scientists. However, the four major centers did not have any serious problems in this regard, having had access to support from other quarters.

TECHNICAL ASSESSMENT

The sub-project covers an area relatively new to India with far-reaching implications for livestock development through adoption of a technology that has proven its worth in advanced countries. It aims at rapid multiplication of superior germplasm that is currently available in limited numbers to have an additive effect on highly productive female stock and particularly step up production of genetically superior pedigreed male stock to accelerate livestock improvement. The current availability of such superior males is very low.

For producing this large number of highly pedigreed sires and proven sires we have to resort to the technique of superovulation and Embryo transfer. The time taken and cost involved in producing Proven Sires by conventional methods is enormous when compared to the achievements through Embryo Transfer Technology. This program, therefore, forms a strong and stable foundation for the future livestock development strategy in India.

There are seven participating centers in this sub-project and one ICAR Coordinating Unit to monitor progress at these centers. Each of these centers has undertaken research towards a number of objectives in an area of major focus and others in minor focus. The objectives are of a long-range nature and can be expected to go beyond the life of the sub-project. These include:

a) Superovulation and oestrous synchronization in donor and recipient females.
b) Research on embryo culture, cryopreservation, in vitro fertilization, sexing, cloning, genetic engineering etc.
c) Transfer of the technology for field application.

1. Indian Veterinary Research Institute (IVRI), Izatnagar

This center has excellent laboratory facilities, well trained staff, good equipment and a large herd of elite cattle and buffaloes to facilitate ETT and related work. ET has resulted in about 25 to 30% pregnancies in cattle which is low. The number of embryos transferred in buffaloes is small and no pregnancy has been achieved so far. More difficulties are encountered in superovulation and synchronization of oestrus in buffaloes than in cattle. This center is enthusiastic about initiating more sophisticated research on in vitro fertilization, sexing, cloning splitting of embryos and genetic engineering, etc.

The pregnancy rates are low compared to those in advanced countries. It is, therefore, desirable to concentrate on greater success in superovulatory response and higher pregnancy rates with transferred embryos. Other areas of advanced research can be taken up after achieving success in the fundamental approaches to ETT, the basic objective of this sub-project.

This center is currently being funded by Department of Biotechnology and UNDP for ETT and related programs.

2. National Dairy Research Institute (NDRI), Karnal

This center has well trained staff, good and well- equipped laboratory facilities and adequate farm animal support. This is a small but enthusiastic group working under good leadership. A spacious Central Embryo Transfer Laboratory is in an advanced stage of completion and is ready to be commissioned in the next few months. The superovulatory response in cows is very good. In Karan Swiss, Karan Fries and Sahiwal cows an average of 5.5 embryos were collected per animal of which on the average 3 were transferable. As many as 10 calves from a single elite Karan Fries donor were born in one year. More than 4 calves were produced in one year from other elite cows with this technology. A total of 193 embryos were transferred in cattle resulting in 46 pregnancies. A total of 43 calves have been born here. 35 embryos have been frozen and two pregnancies have been achieved. This center has been able to obtain more than 1,300 cattle and buffalo embryos of which nearly 70% were from cattle. About 50% of these were of transferable quality. In cattle, an embryo recovery rate of 67.6% was established. The possibility of utilizing elite cattle donors even when they cannot be superovulated has also been established.

Currently, this center is placing more emphasis on buffaloes. So far, of the 70 embryos transferred, 12 animals were diagnosed as pregnant and 7 calves were born. One calf was born from frozen embryos. On the average 2.7 embryos were harvested per buffalo of which 1.3 were transferable. Through the process of embryo collection from naturally cycling animals, the problem of poor superovulatory response from these elite females was overcome. A recovery rate of 60% of embryos was established of which 67% were of transferable quality.

Dissection of embryos has been successfully done at this center and pregnancies achieved through bisected embryos. The first set of twins produced at this center from bisected embryo is a great achievement. The birth of the first test tube buffalo calf through in vitro fertilization is yet another achievement of this center. The scientists at this center have been doing work pertaining to oocyte collection, their maturation and in vitro fertilization utilizing material collected from slaughter houses. It has excellent laboratory facilities for hormonal assay and considerable work was done on the protein and steroid hormones in various species during oestrous cycle, pregnancy and anoestrous period. A simple test has been developed for detection of pregnancy in buffaloes after two months based on progesterone content in milk. This center was also funded by the Department of Biotechnology. This is the best among all in this sub-project.

3. Central Institute for Research on Buffaloes (CIRB), Hisar

This center has a small but efficient staff under good leadership with minimum essential laboratory facilities to undertake superovulation, embryo retrieval and their transfer. Excellent farm facilities are available with a large herd of high-producing Murrah buffaloes housed and maintained under excellent conditions. Various hormones are being tried for superovulatory response in buffaloes. It is desirable to follow the protocol finalized at NDRI in this regard.

Fifty-five fertilized embryos were recovered from 29 buffaloes with a maximum of 7 from one animal. Thirty-three embryos of transferable quality were transferred into 31 synchronized recipients. Of these, 7 were confirmed pregnant. In view of the poor embryo recovery rate and the poor quality of embryos, no trials with frozen embryos were made. In all, 7 buffalo calves were born through ETT at this center. One pregnancy through the transfer of embryo from a single naturally cycling donor was recorded. Cryopreservation of embryos is being practiced here.

4. Haryana Agricultural University (HAU), Hisar

Two independent units are working here: one unit is located in the College of Veterinary Science and the other in the College of Animal Science. The staff, laboratory and equipment facilities are just sufficient to undertake ETT and related work. However, animal facilities are very poor and will not permit large-scale trials on ETT which is unfortunate. Two trials on superovulation and embryo retrieval were made with poor results in buffaloes. A total of 50 embryos were collected in 1989 but none of them could be transferred due to non-availability of recipients. Considerable work on hormone profiles in different species of farm animals during oestrous cycle and pregnancy has been carried out.

The availability of superior female stock in adequate numbers is an essential prerequisite for practicing ETT. It is also equally important to merge the two units into a single viable unit to achieve success in this field. The protocols evolved at NDRI for superovulation can be adopted here. Finally, with two major units functioning in Haryana State one at NDRI and the other at CIRB, the continuance of this truncated unit appears redundant.

5. G.B. Pant University of Agriculture and Technology (GBPUAT), Pantnagar

On the recommendation of the consultant to close this center in view of the poor response, it has been closed.

6. A.P. Agricultural University (APAU), Tirupathi

This center has done some work on surgical recovery and transfer of embryos in cattle with some success. Work has not progressed at this center as envisaged. The superovulatory response of Ongole cows is reported to be poor. The animal facility at this center is poor and even if transferred to Guntur where there is a large Ongole herd as recommended by the consultant, the success of this unit is doubtful. Guntur is a progressive area which has already adopted a crossbreeding program and is not likely to accept Ongole embryos. The staff, equipment and laboratory facilities are just adequate to cope with the work on hand. No harm will result if this center is closed.

7. Central Institute for Research on Goats (CIRG), Makhdoom

This center has good laboratory facilities, equipment and a good team of scientists working under good leadership. It is also funded by the Department of Biotechnology. There is a large flock of goats of different breeds of high quality. Much of the equipment that is in use has been designed at this center and is being fabricated locally. Protocols for superovulation and techniques for non-surgical recovery of and transfer of embryos have been perfected here.

The main thrust at this center is to multiply the fast dwindling number of superior Jumnapari goats which is the best breed in the country. Through ETT it is proposed to multiply superior high pedigree males by using genetically superior dams and sires. The ovulation rate is 13 per doe and embryo recovery rate is 7.46 per doe. 50 fresh embryos have been transferred to recipient does and 30% pregnancies have been achieved. The activities of this center cover a wide range from freezing of oocytes to embryo freezing and in vitro fertilization of oocytes, etc.

Research capability

While advanced centers like IVRI, NDRI, CIRG and CIRB have demonstrated a great deal of research capability due to their excellent resource base, all the other centers barring GBPUAT demonstrated great zeal in research and competitive spirit. During the period of the sub-project, the advanced training received by Indian scientists in advanced laboratories in the U.S. and their interaction with the U.S. consultants who have been periodically visiting India, the research capability of scientists has been greatly enhanced. With this background given enough support and encouragement, the research programs can go on unabated in future.

Facilities

The four major centers mentioned earlier have all the basic facilities for continuing the program in an uninterrupted manner. Staff, laboratory and animal facilities are available to the desired extent. There is also adequate equipment to cope with the work on hand.

Staffing, Training etc.

The requisite trained staff is available at all the four centers. The core group has already received training in the U.S. and can keep the programs on the move without any difficulty.

Equipment

In view of a sizeable grant from the Department of Biotechnology the IVRI has undoubtedly the best equipment. This is followed by NDRI which also has good equipment. The CIRG has adequate equipment for the ongoing program. CIRB has the required essential equipment for ETT work.

Research accomplishments

The sub-project deals with an advanced area in Animal Science relating to intricate aspects of reproductive physiology in farm animals. The Western countries have been working in this area for over four decades and have now perfected the technologies and collected the basis data on hormonal profiles etc. This technology of the West has to be suitably modified according to the hormonal profiles and physiological reactions of the farm animals in India. Notwithstanding this serious lacuna Indian scientists have made significant achievements in meeting the objectives of the sub-project. They have been successful in formulating protocols for superovulation in cows, buffaloes and goats, embryos could be recovered and transferred to recipient females and oestrus could be synchronized in donor and recipient females. While the pregnancy levels are far below the accepted norms of advanced countries, with further experience the percentage of success in pregnancy rates is bound to improve.

The technical program for this sub-project covers a very extensive area which cannot be completed in five-years and necessarily has to go on if all the objectives are to be achieved. However, the most important component of this sub-project is ETT and related aspects which impinges on the future livestock development in India. It is, therefore, essential to concentrate on achieving higher levels of perfection to achieve greater success in all vital areas of ETT which can take the pregnancy rates to Western standards and render ETT economically feasible in India. The other sophisticated aspects of the sub-project can wait for some more time.

Technology transfer

The work undertaken in this sub-project is such that it cannot be passed on to the farmers. ETT has to be passed on to Veterinarians working in Govt. Livestock Farms where this can be implemented to produce the required highly pedigreed males and proven sires. Both at IVRI and NDRI, training programs have been conducted.

Commercialization

ETT work has to continue for at least five more years before one can talk of the commercialization of this program. At the present moment, ETT has to be considered as a very essential and economic tool for producing the large number of highly pedigreed males for bringing about rapid genetic improvement of Indian livestock. This is also a powerful tool for producing Proven Sires so badly needed in the country.

Future

This is a program that is vital to the interests of the nation both from the immediate as well as long-term perspectives. While some measure of success has been achieved in ETT, the most important component of the sub-project, more fundamental work relating to reproduction in farm animals has to be undertaken. Scientists should in the first instance concentrate on achieving a greater measure of success in all areas related to ETT to bring the level of success on par with advanced countries.

With the present level of achievement the ETT work should now go on to the States where the State Animal Husbandry Departments have to take up the production of genetically superior males adopting ETT. This must also be followed by producing Progeny/Tested bulls without further loss of time.

While the sophisticated aspects relating to embryos can wait for some more time it is important at this point to mention that IVRI and NDRI are already involved in some of these aspects and have the requisite equipment and the expertise. These institutes are supported in these objectives and funded by Department of Biotechnology. They have to give the highest priority to ETT and make it relevant economically and practically feasible in the country.

It is desirable to depute a few senior scientists to the U.S. to visit some advanced laboratories for short periods. It is equally important that some Consultants from the U.S. attend the annual workshops conducted in India and interact with local scientists.

FINDINGS AND RECOMMENDATIONS

USAID

With the valuable support from USAID and other agencies like the Department of Biotechnology, India has reached a very advanced stage in Animal Science research not attained in many other developing countries. USAID has made significant contributions in terms of advanced training and provision of Consultants apart from the supply of sophisticated equipment. The continuance of training facilities in a limited way and participation of U.S. consultants in the future will enable this sub-project to consolidate the gains made and reach higher levels of competence.

GOI

At this time when India is making all-out efforts to meet the demands for increasing supplies of meat and milk to meet the requirements of its population, ETT has come as a powerful tool for livestock improvement through the generation of a large number of high pedigree males and Proven Sires to improve the quality of Indian livestock. The program has to go on to perfect the technologies formulated and to move to more sophisticated areas. Requisite funds have to be provided for this program.

ATTACHMENT 4.1.6

FORESTRY FACULTY TRAINING

BUDGET	USAID	U.S.$ 3,181,387
IMPLEMENTATION DATE	28 April 1986	
COMPLETION DATE	30 September 1990	
PARTICIPATING INSTITUTIONS	Indian faculty members from 15 State Agricultural Universities throughout the country received training in one of 14 cooperating U.S. Universities.	

State Agricultural Universities	U.S. Universities
Assam Agricultural University	Auburn University
Birsa Agricultural University	Florida State University
C.S. Azad Univ. of Agri. & Tech.	Michigan State University
G.B. Pant Univ. of Agri. & Tech.	Mississippi State University
Haryana Agricultural University	North Carolina State University
J.N.K.V.V. University	Ohio State University
Kerala Agricultural University	Oregon State University
Konkan Agricultural University	Purdue University
Orissa Univ. of Agri. & Tech.	Texas A & M University
Punjab Agricultural University	Univ. of California, Berkeley
Punjabrao Krishi Vidyalaya	University of Idaho
S.K. Univ. of Agri. Science	University of Minnesota
Tamil Nadu Agricultural Univ.	Utah State University
Univ. of Agri. Science (Dharwar)	Virginia Polytechnic Institute
Y.S. Parmar Univ. of Hort. & For.	

CONSULTANTS

An evaluation of the program was conducted in April-June 1988 by Ms. Sarah T. Warren, Program Associate, Renewable Resource Management, Winrock International.

Two U.S. Consultants, Dr. Douglas P. Richards of Mississippi State University and Dr. R.G. Newton of Texas A & M University visited India in November 1990 to conduct a technical assessment of the Forestry Faculty Training sub-project.

BACKGROUND

The Forestry Faculty Training sub-project was developed as a means of addressing the need for additional fuel, building materials and other forest products resulting from the increased demands for these materials due to a growing human population. Also there were the environmental and ecological concerns associated with the rapid depletion of the nation's natural resources that needed to be considered. The establishment of the forestry departments at the State Agricultural Universities, therefore, became a high priority item. At the time this project was conceived there were only a few trained foresters in the country. Therefore, faculty members in Agronomy, Horticulture, Soil Science, Entomology and Plant Pathology were encouraged to transfer to the new forestry departments. Associated with this transfer was the opportunity of going to a U.S. University for a 12-month period of intensive training in a scientific discipline associated with forestry.

DESIGN

The program purpose was to accelerate the development of forestry education in India and to facilitate the adoption and assimilation of the new departments within the university system. The SAUs, under the direction of ICAR were expected to institute forestry departments, develop a curriculum and initiate a training program for the faculty.

The plan was to train a cadre of young professional foresters at some of the well recognized Departments of Forestry at Universities in the United States. Upon completion of a one-year training course, they would return to their State Universities in India and form the nucleus of the newly organized forestry departments. They would then develop a forestry curriculum, teach courses in forestry science and train newly recruited students at the B.Sc. level. Following that would come the capability to educate M.Sc. and Ph.D. graduates to fill faculty and advanced research roles in the public and private sectors.

OBJECTIVES

The following objectives were provided for the training of forestry faculty and the development of forestry departments:

1. To provide individual faculty members from the State Agricultural Universities of India an introduction to the integration and management of forestry education, research, and technology transfer.
2. To develop and strengthen the individual's academic and technical capabilities to facilitate their performance as forest educators and scientists.
3. To maintain long-term professional development of the individuals.

IMPLEMENTATION

Starting in August 1986 and continuing through September 1990, training programs were established for a total of 72 Forestry Faculty members from 15 Indian State Universities in cooperation with 14 U.S. Universities having well recognized Departments of Forestry. Each scientist received training for a twelve-month period involving courses for credit, theory and hands-on experience dealing with field and laboratory techniques, computer programming and use, participation in departmental faculty meetings, workshops, seminars, visits to other institutions and participation in professional society meetings. These experiences provided the SAU faculty members the opportunity to become completely immersed in the day-to-day workings of an active forestry department in a sister institution in the U.S. They were able to acquire a first hand knowledge regarding teaching methodologies and modern research techniques.

The period of training for faculty members from each of the different State Agricultural Universities is provided in Table 3. The majority of the institutions sent either five or six faculty members for this training experience. Three Institutes sent fewer than five with only one scientist being sent from an institution that later did not establish a forestry department at the school.

Table 3. Faculty Members Trained in Forestry from Indian State Agricultural Universities

State Agricultural University	Location	Number of Faculty Trained				
		1986-87	1987-88	1988-89	1989-90	Total
Assam Agricultural University	Jorhat	-	2	1	-	3
Birsa Agricultural University	Ranchi	1	2	1	1	5
* C.S. Azad University	Kanpur	-	1	-	-	1
G.B. Plant University	Pantnagar	2	2	1	1	6
Haryana Agricultural University	Hisar	-	3	1	2	6
J.N.K.V.V. University	Jabalpur	-	3	1	2	6
Kerala Agricultural University	Mannuthy	1	3	1	1	6
Konkan Agricultural University	Dapoli	2	2	1	1	6
Orissa Agricultural University	Bhubaneswar	-	-	-	2	2
Punjab Agricultural University	Ludhiana	2	2	1	-	5
P. Rao Krishi Veidyalaya	Akola	2	-	1	2	5
S.K. University of Ag Science	Srinagar	2	2	1	-	5
Tamil Nadu Agricultural University	Coimbatore	2	3	1	-	6
University of Agricultural Science	Dharwad	2	3	-	-	5
Y.S. Parmar University	Solan	2	2	-	1	5
TOTAL		18	30	11	13	72

* Only one faculty member was trained and no forestry department was established.

The SAU members selected their training experience from among eight separate disciplines at the University where they were assigned (Table 4). Nearly one-third (24) chose to concentrate their studies on tree genetics and species improvement. The second largest group (23) chose nursery technology while the remaining group (25) divided their interests among the other six disciplines which included : seed technology, tree crop culture, forest soils, tree physiology, forest pathology and forest entomology. All have completed their training abroad, have returned and assumed their faculty roles in their forestry departments and are active in fulfilling their teaching and research responsibilities at their respective State Universities.

Table 4. U.S. Universities and Forestry Disciplines Used in the Training of Indian Faculty Members

U.S. University	Seed Tech.	Nurs. Tech.	Tree Crop Cult.	Tree Genet.	Forest Soils	Tree Physi.	Forest Patho.	Forest Ento.	Total
Auburn			1		1		1		3
Berkley				2					2
Florida		7		3			1		11
Idaho		4	1						5
Michigan		1	2	3	1		1		8
Minnesota		2							2
Mississippi	5	2		5	1			1	14
North Carolina				2					2
Ohio				2					2
Oregon		2	3					1	6
Prudue						2			2
Texas A&M		2		5		1			8
Utah		2							2
VPI		1		2			2		5
TOTAL	5	23	7	24	3	3	5	2	72

ASSESSMENT

In keeping with the GOI plans to organize, staff and develop functional Departments of Forestry at selected State Universities and with the goal to establish forest species on thousands of hectares throughout the land and protect the nation's natural resources, the Forestry Faculty Training sub-project was implemented as part of the Agricultural Research Program.

Through this approach Departments of Forestry have been established at 14 State Universities : Assam Agricultural University (Jorhat), Birsa Agricultural University (Ranchi), G.B. Pant University of Agriculture and Technology (Pantnagar), Haryana Agricultural University (Hisar), J.N.K.V.V. (Jabalpur), Kerala Agricultural University (Mannuthy), Konkan Agricultural University (Dapoli), Orissa University of Agricultural and Technology (Bhubneshwar), Punjab Agricultural University (Ludhiana), Punjabrao Krishi Vidhalaya (Akola), S.K. University of

Agricultural Science (Srinagar), Tamil Nadu Agricultural University (Coimbatore), University of Agricultural Science (Dharwad) and Y.S. Parmar University of Horticulture and Forestry (Solan).

A total of 72 young scientists were selected and sent to Universities in the United States for 12 months of specialized training in Departments of Forestry. There they immersed themselves in departmental activities, obtained first hand experience in the classroom, field and laboratory, participated in workshops and seminars, and attended professional scientific meetings. All of them successfully completed their course of training in one of eight identified forestry disciplines. They returned home to their newly organized Departments of Forestry in their respective State Universities. They have assumed their professional roles of teaching and agroforestry research.

This cadre of young professional foresters now provide a solid base on which to build the forestry/agroforestry industry of India. They are equipped to train both undergraduate and graduate students in the field and the classroom. They provide a base from which sound research programs can be developed. Agroforestry plantings for fuel, fodder and timber can become an integral part of small farming operations throughout the country.

FINDINGS

It can be concluded that the FFT project was successful in accomplishing the goal and purpose for which it was initially established. A total of 72 scientists were recruited for the forestry program. They each received one year of training at recognized forestry departments in the U.S. and returned to become forestry faculty members in their state agricultural universities. They have assumed their professional roles of teaching forestry courses and in conducting agroforestry research.

This faculty training was to be followed up by a classroom instruction program leading to the awarding of B.Sc., M.Sc. and eventually Ph.D. degrees in forestry. Students were recruited and several completed their educational training. Now, however, there appear to be some unanswered questions regarding the sustainability of the forestry educational program in its present form. The reasons given are the lack of employment opportunities in government and the private sector. Student enrollment is on the decline and some SAUs have even closed down their undergraduate teaching programs and have restricted enrollment in their postgraduate studies. For some unexplained reason there appears to be a feeling of discriminatory treatment being given against graduates in agroforestry coming out of the State Agricultural Universities for positions in the Forestry Department and other related agencies. For the continuity and long-term sustainability of the Agroforestry and Forestry Faculty Training programs, ICAR should explore with appropriate officials in the Forestry Department the establishment of official policies and implement measures regarding equal employment opportunities for all candidates having the required educational qualifications.

There may be hope for these programs in the future. Like the benefits received from the Green Revolution wherein India had State Agricultural Universities and Agricultural Research Institutes in place when they were needed to take advantage of improved varieties of wheat, corn and rice, it now has the manpower base in place to take advantage of the worldwide movement to plant trees and clean up the environment. In years to come this present investment in trained manpower could very well result in a long-term payout.

ATTACHMENT 4.1.7

AGROFORESTRY RESEARCH (AGROFOR)

BUDGET	USAID	U.S.$ 2,044,403
	GOI	U.S.$ 1,358,000
IMPLEMENTATION DATE	June 28, 1988	
COMPLETION DATE	June 30, 1992	

PARTICIPATING INSTITUTIONS

1. **Direct Participants (India)**

Three-tier system of 32 research stations including :

i) one National Research Center for Coordination of basic research on Agroforestry at Jhansi (U.P)

ii) Six Regional Research Centers of Agricultural universities at Faizabad, Dantiwada, Dharwad, Ranchi, Srinagar and North East Hill Research Station, Shillong

iii) 25 Centers in other states (18 agricultural universities and 7 ICAR research centers)

2. **Collaborating Institutions**

(a) U.S. Institutions

i) Mississippi State University, Mississippi

ii) North Carolina State University, Raleigh, NC

iii) Oregon State University, Cornwalis, Oregon

iv) University of Florida Gainsville, Florida

v) University of Idaho Moscow, Idaho

vi) U.S. Forest Service, Southern Forest Experiment Station at the University of Mississippi

vii) Yale University, New Haven, Connecticut

(b) International Institutions

i) International Crops Research Institute for Semi-Arid Tropics (ICRISAT), Patancheru (A.P.), India

ii) International Center for Research in Agroforestry (ICRAF) Nairobi, Kenya

(c) Indian Institutions/Organizations

i) National Wasteland Development Board

ii) Indian Council of Forestry Research and Education, Dehra Dun (U.P.)

iii) Department of Environment and National Resource, New Delhi

CONSULTANTS

Twenty U.S. scientists (including two visits of three scientists) came as consultants for short periods at different times to organize and guide the workshops for in-country training of Indian scientists engaged in agroforestry research and advise on research programs. The mechanism of training developed by them was excellent. Every workshop involved 2-3 U.S. consultants and two Indian scientists trained in U.S. in the relevant area and 25-30 trainees from the participant centers in India. Every workshop was a follow-up workshop to the training in the U.S. and thus created the multiplier effect in training of a large number of Indian scientists using Indian and U.S. expertise.

TRAINING

The training involved four types of training program.

i) Short-term training in the U.S.

Short-term training in the U.S. for five months each for 12 Indian scientists and nine months for one scientist was provided. None of the scientist from NRC Agrofor Jhansi could be included in the programs because of the late establishment of the center.

ii) Long-term training in the U.S.

Long-term training of 18 months each in the U.S. leading to the Ph.D. degree program for nine Indian scientists was provided and all the trainees were from ICAR Institutes except the NRC, Agrofor Jhansi.

iii) In-country training

In-country training of groups of 20-25 Indian scientists each in seven workshops trained about 200 scientists.

iv) Short visit of the management team

Management team consisting of Director, NRC Jhansi and a Vice-Chancellor of an agricultural university who is also a leader in the area of integrated pest management (IPM) relevant to this project had a two-week visit to the U.S.

The training mechanism developed in this sub-project produced the maximum multiplier effect. It is also interesting to observe that the training leading to the Ph.D was given to scientists from five Institutes of ICAR and a maximum number of three scientists included in this category was from North-East Hill Region, where slash and burn (*jhumming*) is most common and improved agroforestry is badly needed. However, none of the scientists from NRC Agrofor Jhansi could be trained, as this center was established rather late. Only two scientists from this Center could be trained through in-country training.

BACKGROUND

The rapidly disappearing forests and increasing gap between supply and demand for fuel, fibre, forage and timber both for human and animals created great concern for developing tree-based agriculture and led to development of an all India coordinated research project on agroforestry (AICRPA) by the Indian Council of Agricultural Research in 1983. Agroforestry was considered specially suitable for the purpose as it could be adopted by small as well as large farmers and in rainfed as well as irrigated farming and has potential of providing additional income and protection to the environment.

U.S. assistance provided for building up trained forestry faculty in agricultural universities in India under another sub-project - Faculty Training, stimulated the need for extending assistance for agroforestry research and in 1988 the Indo-U.S. sub- project on agroforestry research came into existence.

DESIGN, PLAN, AND LOCATION

The project includes a three-tier system of research centers and is coordinated by an ADG from ICAR headquarters, New Delhi and linked up with the appropriate basic and strategic research center at NRC Agrofor Jhansi. The second- tier is of six regional research Centers and a third-tier of 25 centers in different agroecological zones.

The broad range of activities concerning this project are:

1) Diagnostic surveys of existing farming systems and appraisal and design of existing agroforestry practices.
2) Correlation, screening, selection and breeding of promising trees and shrubs for fuel fodder and a small center for agroforestry application.
3) Developing cultural/management practices for various agroforestry systems.

Its main aim is to develop appropriate systems for replacing shifting cultivation to provide superior trees shrubs to farmers to fit in the tree crop systems and to develop agronomically efficient, economically viable and environmentally sound practices of agroforestry.

The project has 69 scientists, 112 technicians, 23 administrative and 69 support-staff, and an annual budget of 5.0 million rupees (1991-92) provided by ICAR. This budget is in addition to the budget provided by the participating organization/SAUs.

OBJECTIVES

The main objectives of the sub-project are:

1. Strengthen coordination of agroforestry research in the All India Coordinated Project.
2. Increase the number of scientists with specialized training in agroforestry research through short-term 4-5 month training and long-term training (18 month) leading to the Ph.D degree in the U.S. and in-country training of a few weeks each through training workshops with the help of U.S. scientist/consultants and participation of counterpart Indian resource persons.
3. Quantification of agroforestry systems using modelling.
4. Initiating ecosystem studies of agroforestry system.
5. Initiating tree germplasms collection, screening and propagation program.
6. Developing methodologies and assessments for incorporating economic social and environmental factors into the agroforestry systems.
7. Creation of analytical laboratories for sophisticated soil and plant analysis needed for agroforestry research.

FACILITIES

Necessary laboratory, field facilities and manpower are provided by ICAR and the participating institution. Training of staff was undertaken under this sub-project provided by U.S. assistance. It is creditable for ICAR to create facilities for such a large organization for research in agroforestry from scratch.

EQUIPMENT

For this sub-project, USAID provided to the regional centers six pieces of equipment, such as an electronic analytical balance, a top loading balance, an infra red thermometer, a leaf area meter, soil moisture measuring equipment and a PC computer. In addition, a set of 42 items of common field measuring equipment necessary for forestry research was also provided to each center.

The NRC Agrofor Jhansi was provided with nine items for equipping the analytical laboratory, besides the same items as provided to each regional center. These analytical laboratory items are plant stress meter, photo-synthesis system, steady state parameter, auto kjeldahl analyzer, spectrophotometer, Centrifuge, electronic analytical balance, top loading balance, A.A. Spectrophotometer and a computer.

The other 25 centers are provided with similar kits of field measuring equipment necessary for agroforestry research, as is provided to NRC and regional centers.

Though the equipment was received rather late at NRC Jhansi, it has been installed. The regional centers received their allotment earlier. The field measuring kits were still being distributed at the time of the Review Committee's visit to some centers and are in use at other centers.

STAFF

In the Coordinated project on agroforestry, ICAR has provided 69 scientists out of whom 13 have received short-term training for 4-6 months each in their selected area of specialization in U.S. Institutions. Nine scientists have undergone 18 months training and are completing their Ph.D degree program. In addition, through the mechanism of seven workshops organized in India, groups of 20-25 scientists each have been trained in the following subjects selected for the workshops:

- Tree Crop Technology
- Tree Nursery Technology
- Tree germplasm and species improvement
- Agroforestry modelling
- Tree Crop nutrient cycling studies
- Evaluating agroforestry system

- Ecosystem studies
- Root studies

ASSESSMENT

(a) Research Capability

Twenty-four agroforestry scientists have received special training in U.S. institutions and about 200 have been trained in India. In addition, under the Forestry Faculty Training sub-project, 72 scientists have been trained for one year each. Since they are members of the same faculty in the Universities participating in the agroforestry research, therefore their expertise is also available for contributing to agroforestry research, besides training the students for degree programs in agroforestry. It is sad that from NCR Jhansi, none of the scientists could be trained in U.S. because of the delay in the recruitment of staff. Nevertheless, out of seven scientists in the Center, three had received their education/training abroad through other international assistance programs. The Director, NRC Jhansi visited the U.S. as a member/leader of the management team. In addition two scientists of the Center received in-country training. It may not be out of place to mention that one senior scientist working in an agroforestry unit with special interest in silvipasture research received training for his Ph.D. program through this sub-project. Since both NRC Agrofor and IGFRI are neighbors, sharing common farm facilities, the team would strongly recommend their joint cooperative program.

Agroforestry research in India is also being gradually strengthened by the post graduate students who for their thesis work take up research in this area on various problems and make good contribution through research. Though this sub-project started rather late as far as the training of the staff and provision of minimum laboratory facilities is concerned, the objective has been achieved. Now there is adequate local competence available for producing a multiplier effect. All this trained manpower potential is available for creating an impact in agroforestry development in the country provided their researches are sharply focussed on relevant problems. It is gratifying to note that despite the delays in procurement of equipment and clearance of trainees and consultants and establishment of NRC Agrofor, Jhansi the main objective of strengthening agroforestry research in India has been accomplished. However, it is too early to assess the output of research, as the program is too young and the tree crop based experiments are more complex, requiring a long time to produce acceptable results.

(b) Research Quality

Out of the seven objectives listed under this sub-project, three relate to research agenda and its quality. The diagnosis and assessment of agroforestry systems in vogue has been successfully completed. The program on germplasm collection, evaluation and ecosystems studies have been started. The socio-economic aspects have an important place in a research agenda of agroforestry and relevant studies have been started. However, agroforestry being a new area of research, it is too early to expect any breakthrough. Only time will tell how far the research has provided any acceptable results of practical significance.

Research accomplishments

The important accomplishments are:

- Diagnostic surveys of existing farming systems by all the research centers have provided a valuable list of most important agroforestry systems for every agroecological zone identified constraints and problems affecting productivity.

The preferred agroforestry trees and shrub species have been identified and research programs on selected targeted species planned including:

- Preliminary screening of multipurpose trees (MPT) and shrubs has been done and intensive research on promising species planned. Limitation and potentialities of each MPT species have been identified.
- Provenance trials of selected species have been planned.
- Cultural trials for developing productive and efficient agroforestry systems are in progress.
- A Seed Manual for the use of researchers and extension workers has been prepared.

For rice wheat system, in Indo-gangetic plains poplar-based agroforestry system, for arid and semi arid tracts agro- silvipastoral systems; for sub-humid to humid areas of Himalayan region Grevia Obtiva based agroforestry system and for humid tropical environment of Kerala Casurina and Ailanthus malaborica and Napier grass based silvipastoral system were found to be more promising.

Technology Transfer

Though agroforestry research is still in its infancy, it has aroused considerable interest in development agencies.

An operational research project financed by the National Wasteland Development Board has been established at 16 agroforestry research centers of Agricultural universities in India. This is leading to evaluation of agroforestry technology on farmers' field and training of a large number of farmers and extension workers to accelerate agroforestry development in the country. The team understands that 500 extension workers and 1500 farmers have been trained under this project.

The impact of the agroforestry research project is not confined to universities and research institutions and many non-Governmental agencies (NGO) and private organizations also have started taking interest in agroforestry related activities. Thus, undoubtedly the assistance provided to ICAR all India coordinated research project on agroforestry has proved to be a catalyst for stimulating interest in agroforestry programs in the country. However, it is too early to critically assess the significant contribution to increasing productivity of trees or tree crop based systems at this stage of development of research which has a long gestation period.

It needs critical and vigorous experimentation for development of a system with high productivity, economic viability, environmental suitability and social acceptability.

Commercialization

The shortage of fuel, fodder and environmental concerns have created a favorable climate for agroforestry research and development, specifically for agropastoral, silvipastoral, silvihorticultural systems and farm forestry, because of their commercial attractiveness, but the euphoria of agroforestry systems based on multipurpose trees like leucaena leucocephola has not resulted in expected results. However, the ever increasing demand for trees for use in rural areas and the industry is creating an interest in commercialization of tree crop based systems specially for wastelands and marginal lands.

Future Research Sustainability

The agroforestry research organization of ICAR is probably the biggest in the world as judged by the number of participating centers and organizations and it has been accepted for the Eighth Five-Year Plan even with some commitment for expansion and voluntary collaboration, but there is some concern about further strengthening of quality of research after the termination of the present USAID assistance to it. Since agroforestry not only in India but even in the world is a newly developing area of research, any lack of sustained critical technical input from leading centers of research in forestry science from the U.S. is likely to slow the progress of improvement of quality of research in this field in India. The team suggests that the U.S. scientist leaders in specific areas of specialization in tree crop research should be encouraged to develop collaborative program with Indian scientists and make follow up visits to advise in programs initiated so recently. Such collaboration will be of mutual interest for both the countries.

The review team is also of the opinion that consideration of the following activities would also help to ensure the future sustainability and continuity of the project.

a) Provision of and access to computers and scientific equipment at all sub-project location.
b) Support for participation in professional associations and forestry networks by cooperating Indian and U.S. scientists.
c) Provision of and access to library materials at all sub-project locations.
d) Access to and participation in competitive grant programs to encourage collaboration between scientists. Use of PL 480 funds for this or any other U.S. assistance program may also be appropriate.

The review team is pleased to note that already one research project has been approved for research at NRC Jhansi under PL 480.

It is an exciting time for forestry research in India. The FOREST POLICY of India Act (1988) mandates that future industrial raw material supplies exclusively be provided by private producers rather than public sector agencies. This creates a tremendous opportunity for private individuals and farmers in rural India for taking up agroforestry based farming systems for commercial purposes. But this can only be realized if efficient, profitable agroforestry systems are developed through science based technology. Sustained critical support by USAID will be a catalyst for this purpose. The review team recommends that the possibility of such critical assistance of technical and material inputs should be examined to provide a link with the past and future research in agroforestry.

Technology Transfer and Acceptance

The project being too young does not have many results of practical significance for transfer to farmers. Even in cases of promising technologies, the constraint of availability of seed and plant material for the use of farmers is too serious. Thus at present, major activity in transfer of technology is confined to training in the concept and practice of agroforestry. To create an impact on the production system and acceptance of technology, the development of large scale multiplication of elite tree seed and seedlings deserves high priority.

FINDINGS AND RECOMMENDATIONS

The main objectives of the sub-project on agroforestry were to develop a core of technically well trained research scientists, create a laboratory and field facilities for agroforestry research and assist in developing a relevant research program and tree germplasm collection, evaluation and utilization mechanism.

These limited objectives have been achieved, as through the three-tier system of training a significant number of scientists have been trained and provided with minimum equipment for field research in agroforestry.

USAID/GOI

1. Training in eight workshops held in India, has provided in- depth knowledge of the state of the art relevant to research in agroforestry. The mechanism of training through the system of follow-up training workshops, using 2-3 U.S. Consultants and 2-3 Indian Scientists trained in the U.S. has proven most effective and commends itself for use in future aid programs.

2. The National Research Center in Agroforestry Jhansi has received the necessary equipment for good laboratory research (basic and strategic) in agroforestry. However, it is too early to assess its impact on the quality of research. The Review team suggests that in future the Government of India/ICAR may get a technical assessment made of the quality and productivity of research from this sub-project. USAID may assist by providing one or two Consultants for such critical evaluation.

3. As agroforestry research development is still in its infancy in the world, it is therefore, suggested that India and U.S. may consider encouraging its scientists to develop joint programs and mechanisms for exchange of information.

4. Agroforestry has greater potential for rainfed farming and for marginal and degraded lands, which have otherwise few options, hence the first priority in research should be for development of a viable system for such stressed environments.

ATTACHMENT 4.1.8

AGROMETEOROLOGY RESEARCH (AGROMET)

BUDGET	USAID	U.S.$ 1,554,985
	GOI	U.S.$ 538,500
IMPLEMENTATION DATE	July 26, 1988	
COMPLETION DATE	June 30, 1992	

PARTICIPATING INSTITUTIONS

Direct Participants

1. Coordinating Unit at the Central Research Institute for Dryland Agriculture (CRIDA), Santosh Nagar, Hyderabad
2. CRIDA - All India Coordinating Research Project for Dryland Agriculture (AICRPDA), Hyderabad and Agromet
3. Research Complex, NEH Region, Barapani, Shillong
4. CAZRI - Jodhpur
5. IARI - New Delhi
6. APAU - Anantapur, Hyderabad (A.P.)
7. GAU - Anand, Dantiwada (Gujarat)
8. UAS - Bangalore (Karnataka)
9. NDAU - Faizabad (U.P.)
10. HAU - Hisar (Haryana)
11. JNKVV - Jabalpur (M.P.)
12. BAU - Kanke, Ranchi (Bihar)
13. PAU - Ludhiana (Punjab)
14. BCKV - Mohonpur (West Bengal)
15. TNAU - Kovilpatti, Coimbatore (Kerala)
16. GBPUA&T - Ranichauri, Pantnagar (U.P)
17. MPKV - Sholapur, Rahuri (Maharashtra)

Collaborating Participants

a) U.S. Institutions

1. USDA - Blackland Research Center Temple, Texas
2. Iowa State University, Ames, Iowa
3. Michigan State University, East Lansing, Michigan

4. University of Georgia, Tifton, Georgia
5. University of Nebraska, Lincoln, Nebraska
6. Utah State University, Logan, Utah

b) International Agricultural Research Organizations

1. International Crops Research Institute for Semi Arid Tropics (ICRISAT), Patancheru - 502 324 (A.P)
2. International Center for Research on Agroforestry (ICRAF), Nairobi, Kenya

c) Indian Institutions/Organizations

1. Department of Science and Technology (DST), GOI, New Delhi
2. Indian Meteorological Department, GOI, New Delhi
3. Project and Space Application Center, Ahmadabad

CONSULTANTS

17 U.S. eminent agrometeorologists visited India to provide in-country training through the mechanisms of follow-up. Workshops on the specific subject matter areas were identified for the purpose.

BACKGROUND

Indian Agriculture is considered a gamble in monsoons and most of the challenging task is the management of soil/crop/weather interactions for both irrigated and rainfed farming. The latter is even more important because of the vagaries of monsoon and 70% of the farming areas in the country being dependent on rains only. Understanding of relations of weather to crop production systems, use of inputs in agriculture, understanding of diseases and pests, management of micro-climatic influences and forecasting weather aberrations and planning of strategies for mid-term corrections, management of droughts and response farming have become subjects of high priority research. Realizing the importance of such studies, ICAR launched an all India coordinated research project on agrometeorology in 1983 with CRIDA as the Coordinating Center and 16 centers covering a range of agro-ecological conditions and representing different agricultural universities and states as participating centers.

The sub-project on Agrometeorology was sanctioned in July, 1988 to strengthen the research capability, and determine relevance and excellence and output of research, under the all India coordinated research program on agrometeorology. Its main thrust was on three areas:

1. Infrastructural development by providing computers and modern equipment for agrometeorology research.
2. Training of Indian scientists in the U.S. in specialized areas of research relevant

to agrometeorology.

3. Providing U.S. expert consultancy for improving research and providing training in India.

The sub-project Coordination unit is located at CRIDA with the All India Coordinated Project on agrometeorology operating at 17 centers including the coordinating unit - for its focus of operation.

DESIGN-PLAN AND LOCATIONS

After assessing the needs for training, equipment and research priorities, the time-bound activities were planned and resources committed. CRIDA, being the coordinating Center, was selected for major strengthening of agrometeorology research. The areas of training and experts for training were identified and the program implemented.

Without losing time for the arrival of the equipment and because of the leadership role which International Crop Research Institute for Semi-Arid Tropics, Patancheru, Andhra Pradesh, India (ICRISAT) is playing, it was used as the venue for the first training program. After the arrival of the equipment, the venue of training was shifted to CRIDA and other ICAR centers which were selected as venues for later workshops.

To facilitate the training program, CRIDA was provided with two Computers instead of one. Scientists from 16 centers included in the coordinated program were provided intensive training through the mechanism of workshops. This was found to be most effective mechanism for producing a multiplied effect for strengthening the capability of local scientists.

To accomplish the above mentioned goals, the sub-project identified 5 main objectives for making agrometeorological research in India, efficient, relevant and excellent. These were:

1. Quantification of crop/weather relationships.
2. Development of response farming procedures.
3. Development of expertise for spectral model development and use.
4. Development of competence for agricultural weather advisories.
5. Development of CRIDA and strengthening of research facilities of the cooperating centers of AICRPAM.

IMPLEMENTATION

Staff

Most of the staff provided in the all India coordinated research project on agrometeorology are in position and engaged in research. This staff identified for training was sent in eight groups of two scientists each in different areas of specialization for five months training except the last one which was sent for two months training. To produce a multiple effect, eight training workshops were held in India involving two U.S. scientists, consultants and two Indian scientists trained in the U.S. as resource persons for each workshop. Through these workshops 10-20 scientists were trained in each area of specialization. A management team of three scientists including the coordinator, visited U.S. institutions to prepare the program for training, identify the suitable equipment and to establish contact with the leading scientists in agrometeorology in the U.S. The eight areas of specialization included in the training and follow up workshops were:

- Crop Growth modelling
- Water production functions
- Spatial dynamics of insect pests
- Basic meteorology and instrumentation
- Response farming
- Data base management
- Delineation of agroecological environments
- Crop weather advisories

The training programs were targeted to cover the five objectives of the sub-project to strengthen the capability of CRIDA. Specialized training was also provided to three scientists including the Coordinator. Thus, it is evident that a critical mass of trained scientists has been developed to undertake relevant research in agrometeorology to fulfill the objectives for which the coordinated research project is funded by ICAR.

Facilities and Equipment

Under this sub-project, CRIDA was provided two computers, one line quantum sensor pyrometer, one automatic metdata station, one leaf area meter one soil moisture gauge and one infra-red thermometer. One spectrophotometer was also supplied to CRIDA to equip it as a lead center for better research and training in agrometeorology. All other Centers have been provided a uniform set of six pieces of equipment consisting of the same type of equipment as provided to CRIDA except that they were provided only one computer and no spectrophotometer. Thus, all the 16 centers are equipped with the same instruments to collect the base data required for achieving the objectives of the AICRPAM.

Assessment

The equipment has been installed in all the centers and a critical mass of scientists trained uniformally in handling these instruments, collection of data and its use for drawing valid interpretation created. The team understands that voluminous data is being accumulated, but how far it has been used for interpretation, is hard to assess. The future only will tell how much effective use of this enhanced capability has been made for use of agriculture.

Undoubtedly, the strengthening of research capability and provision of modern equipment has certainly enhanced the ability of AICRPAM to collaborate with international and national research programs and institutes to undertake relevant agrometeorological research of basic and strategic type. It has created a critical mass of scientists and research facilities for simulation model validation and calibration for application to local problems - integrated pest management and development of a data base for response farming.

It has strengthened the competence of CRIDA for study of soil/crop/weather relationships and to develop strategies for mid-term corrections which are so very essential for rainfed farming. It has also created a great potential for training agrometeorologists for research and agrometeorological advisory services in the country. It has developed interest in crop weather modelling as evident from the proposed summer institute for state agricultural universities and ICAR institutes by AICRPAM at CRIDA.

The team understands that the department of Science and Technology (DST) of the Government of India is keenly interested in utilizing the potential created by this sub-project for training a few hundred agrometeorologists by sponsoring a Scientific Engineering Research Council (SERC) school at ICAR centers and state agricultural universities. This has become necessary to develop agrometeorological advisory services in the country by providing well-trained agrometeorologists in about 120 centers already established under a World Bank assisted National Agriculture Research Project (NARP), in different agro-ecological zones of India. The department of Science and Technology has set up a CRAY Super Computer and wishes to use it for agrometeoreological advisory service for forecasting weather 3-10 days in advance. In a country like India where agriculture is affected so much by the vagaries of monsoons, strengthening of agrometeorological research and extension capability is likely to become a great technological asset.

In the words of the quinquennial research team of ICAR which completed its review of this project in March 1992, the project has made a good start and has laid a good foundation for future research in agrometeorology in India with the support of USAID under this sub-project.

Achievement of Research

Agrometeorological research is not only difficult but also is in its infancy in India. The lack of the lack of modern equipment and trained manpower to relate weather data to crop production systems and inadequate collaboration between the biologists, agronomists and agrometerologist for developing response farming strategies makes it all the more a difficult task. Despite the short span of life of this sub-project and many limitations, AICRPAM is reported to have achieved the following results of significance:

1. Analysis of long time daily rainfall data of 26 districts of Andhra Pradesh, 270 locations of Maharashtra and 100 locations of Karnataka has been made available to the scientists, agricultural planners and extension workers for use in their respective states. This has helped them in crop planning strategies and for advisory services.
2. The SORKAM model has been developed and tested for winter sorghum grown under conserved soil moisture conditions at Sholapur (Maharashtra). Likewise, the Peanutgrow model is under test at ICRISAT, Anand and Anantpur and seems to be promising for forecasting the performance of the groundnut crop.

3. Research on modelling the weather effect on late leaf spot disease of groundnut is very promising. The disease incidence becomes very severe with leaf wetness for more than 48 hours and night temperature around 22 °C.
4. Crop weather interaction studies on wheat indicate that yield of the crop declined as the temperature increased from boot stage to milk stage.
5. The studies at Hisar showed that intensity of APHID attack on rape mustard were severe when mean daily temperature was less than 14 °C., humidity more than 70% and cloud cover at six octos.
6. The most outstanding achievement of this sub-project is the training of about 200 scientists for agrometeorological research and the equipping of 16 centers of research in different agro-ecological regions. It has created a potential for useful research. The future will determine how much this potential is exploited.

Technology Transfer

With strengthening of research capability, the agrometeorological research has been put on the right track but at present it does not have many results of practical significance to transfer to the farming community. However, the nucleus created is producing a multiplier effect in developing location specific interpretation of the data being collected by meteorologists, agronomists and the farmers. Three day-advance forecasts of weather and relevant strategies for intervention are at present being broadcast by a number of research centers in state agricultural universities for the benefit of farmers. Efforts are being made to develop capability for 10 days advance forecasts and provide advisory service for crop planning.

The main challenge to this program is to develop advisory models based on the voluminous agronomic data being developed by the all India coordinated program of dryland agriculture.

Commercialization

Agrometeorological advisory service is a public undertaking and a free service. The possibilities of its commercial exploitation are rather remote. However, as commercialization of agriculture specially growing of high value crops like fruits, vegetables and plantation crops such as tea, coffee, spices, sugarcane and cotton with high input, gains momentum and capability of agrometerologists to forecast weather, interpret crop weather relations and incidence of diseases and pests, scheduling of irrigation, and incidence of drought and flood and other climatic hazards to agriculture grow, the possibility of agrometeorology becoming an attractive commercial activity will increase. However, the most important role of it will be to advise the farmer for making best use of the weather and the environment for successful agriculture.

FUTURE

Research Sustainability

While the ARP sub-project on agrometeorology is scheduled to close on June 30, 1992, the activities initiated and stimulated by it will continue. There is strong support for the continuation of this activity in the Eighth Five-Year Plan of the Government of India. Moreover, the keen interest developed by the Department of Science and Technology of the Government of India which has acquired a super computer and sponsored a few programs for forecasting the weather and for assisting in crop planning in many districts has strengthened hope that the research activity will continue with vigor. However, there is concern that this research is still in its in infancy and has yet to produce results of practical significance. If it loses contact with the lead centers of research in the U.S. or other advanced centers in the world, its research productivity and usefulness of the equipment will be hampered. The team, therefore, recommends that U.S. may consider ways and means to maintain contact with CRIDA and the AICRPAM. Scientist to scientist contact should be encouraged and participation of good scientists in workshops, visits and exchange of information facilitated. It hardly needs to be emphasized that the information being developed in India through this project will be of immense value not only to India but for all tropical and subtropical countries including the USA.

FINDINGS AND RECOMMENDATIONS

The sub-project has achieved the goal of strengthening the capability of the Central Research Institute for Dryland Agriculture (CRIDA) and the All India Coordinated Research Project on Agrometeorology. It has provided short-term, on-the-job training in specialized areas of research and created a multiplying effect by in-country training through the mechanism of workshops. It has provided the minimum equipment essential for agricultural research and the training of scientists and technicians in its use. However, it is too early to conclude that the desired goals of research have been achieved.

Recommendation

USAID

1. The team recommends that in a year's time, but not later than December 1993, a critical review of the technical progress of the research project and effective utilization of research equipment and training should be made by an expert team consisting of an eminent meteorologist and an agronomist. USAID may consider providing support for this purpose.
2. A mechanism should be developed to encourage scientist to scientist collaboration in research programs of mutual interest. GOI as well as USAID may examine the possibility of such collaboration as it is of mutual interest.
3. Facilities for Geographic Information Systems (GIS) may be provided by USAID as it will help CRIDA exploit the potential created by this sub-project.

4. The system of training through the mechanism of workshops, supply of equipment and training of resource persons in the U.S. seems to be an efficient system and could be considered for other programs also for producing the multiplier effect.

GOI

1. A system for exchange of technical information should be developed.
2. Possibilities of encouraging Indian scientists and U.S. scientists for repeat visits should be explored.

ATTACHMENT 4.1.9

PLANT GENETIC RESOURCES (PGR)

BUDGET	USAID	U.S.$ 200,000
IMPLEMENTATION DATE	July 01, 1987	
COMPLETION DATE	Jun 30, 1990	

PARTICIPATING INSTITUTES

Indian Institutions

ICAR - Indian Council of Agricultural Research
IARI - Indian Agricultural Research Institute
NBPGR - National Bureau of Plant Genetic Resources

U.S. Institutions

USAID - United States Agency for International Development
USDA/ARS - United States Department of Agriculture / Agricultural Research Service

CONSULTANTS

Several U.S. scientists have visited India as consultants during the three year life-span of this pre-project under the ARP.

In October 1984 a team consisting of Dr. Robert P. Kahn, Dr. Eric E. Roos and Dr. Willis H. Skrdla prepared a comprehensive Sub-project Paper Design Report entitled "Plant Genetic Resources". After review it was considered too large of a program to be a sub-project under the ARP umbrella. The following Spring (May 1987), Drs. Pino, Jones and Mau spent six weeks preparing a project proposal entitled "Project Paper, India, Plant Genetic Resources (PGR) Project".

Between February 1988 and December 1989, a total of eight more U.S. scientists came as consultants for the purpose of providing guidance and recommendations on specific project items such as data documentation, cryopreservation of plant germplasm, plant tissue culture and plant quarantine. They were Dr. Phillip C.

Stanwood, Jimmie Mowder, Dr. O.L. Gamborg, Dr. David Mears, Dr. S.M. Dietz, Dr. Steve Eberhardt and Dr. T.T. Chang. Some came more than once and two had their salary paid through a USDA/PASA.

BACKGROUND

It is a well recognized fact among agricultural scientists and especially among plant breeders that no single country contains all the genetic diversity in plants for use in developing new and improved strains or varieties to help feed a growing world population. However, it is quite readily recognized that India is of particular importance in this regard and is blessed with a wide range of plants from which many of the major food crops have been derived.

Plant diversification exists in India to a large extent because of its wide range of climatic zones, variation in soil types and geographical location. It contains two of the eight naturally occurring centers of origin for important plant species. Thus the extensive plant gene base represented here can be considered one of India's natural resources. Preservation of this wealth of genetic material is possible by collecting both wild and cultivated accessions of existing plant species and storing them in such a way as to retain their viability over many years. They are then available for use in breeding programs throughout the world. Otherwise some could easily be lost because of climatic change, urban invasion, or as a result of other changes in land use management.

The Project Paper written in 1987 provided background material for the consideration of Plant Genetic Resources (PGR) as a sub-project under the ARP umbrella.

DESIGN

The primary purpose was to assist India in developing the physical, administrative, technical and financial resources for NBPGR and associated institutions to develop a national plant germplasm system.

As the project design evolved it became apparent that it would not fit properly under the ARP as a sub-project. Therefore, planning funds were provided at the pre-project stage in order to explore its full potential.

OBJECTIVE

The PGR had as its chief objective to preserve India's rich source of plant genetic materials for use in sustaining advances in agricultural science.

IMPLEMENTATION

Funds allocated for the PGR pre-project played a key role in eventually establishing the direction plant genetic resources would go in India. Three interactive phases were planned through these initial pre-project actions :

- The initiation phase
- The construction phase, and
- The consolidation phase, relating to the fully operating network system.

During the initiation phase, expert U.S. consultants were brought to India to assist in planning the overall project, including specific details relating to equipment purchases, staff training and the correlation of efforts among the related institutions. Top management Indian leaders, plant scientists and computer operators were provided the opportunity to obtain first hand knowledge concerning the layout and operation of a similar organization and facilities in the U.S.

These preliminary activities led to the development of a full-fledged stand-along project. It was removed from the ARP and received USAID direct funding to move forward as planned by those with a vision of its importance for the future.

ASSESSMENT

Planning funds of $200,000 to bring in U.S. consultants and provide the opportunity for Indian scientists to visit plant germplasm computer centers, quarantine quarters and storage facilities in the U.S. were well utilized. Excellent plans for the construction, staffing, equipment purchases including computers for gene tracking and other critical functions were developed for a National Network relating to all aspects of Plant Genetic Resources.

Although the idea originated as a plan to have PGR as a sub-project, it received some planning funds as a pre-project and has now grown to become an exciting stand-alone, full-fledged national agricultural project with many international dimensions associated with it.

FINDINGS

GOI and USAID are to be commended for the initiation of this worthwhile program. By enlarging the scope of PGR and elevating it to the level of a stand-alone project it has the potential to preserve the wide gene base of existing plant materials, not just from India but from other countries of the world as well.

This visionary approach to preserving genetic resources will benefit future generations of mankind.

ATTACHMENT 4.1.10

FARM EQUIPMENT MANUFACTURING TECHNOLOGY CENTER (FEMTC)

BUDGET	**USAID**	Proposed	U.S.$ 563,100
		Actual	U.S.$ 150,000

IMPLEMENTATION DATE March, 1990

COMPLETION DATE June, 1992

PARTICIPATING INSTITUTIONS

1. Central Institute of Agricultural Engineering, Bhopal.
2. Punjab Agricultural University, Ludhiana.
3. Tamil Nadu Agricultural University, Coimbatore.

BACKGROUND

Appropriate agricultural mechanization has played a significant role in developing the agriculture of India. Additional substantial progress must be made in a number of areas if the rate of productivity is to be maintained. There have been several key aspects of mechanization that have made a positive impact on productivity. The use of 10 million pumping sets (electric and diesel) has been important in increasing productivity. As the inputs of irrigation, seed of high yielding varieties and fertilizer have increased productivity, there has also been a resultant increase in the importance of completing key agricultural operations in a timely fashion. Multiple cropping, made possible by improved inputs, is dependent on mechanized harvesting, threshing and tractor plowing to get one crop off the land and the second crop planted in time to realize maximum yields.

Increased productivity of land and labor due to mechanization is accepted by policy makers and realized by farmers in India. Selective mechanization is considered feasible and appropriate for small farm holdings. Efforts to improve the small farm level of mechanization are being concentrated on by government agencies.

Agro-Industrial Corporations were established in almost all the States of India with the aim of catering to the farm equipment needs of small farmers. The Agro-Industrial Corporations abandoned the manufacture and distribution of agricultural machines almost entirely because manufacture of tools and small implements was not commercially profitable due to low price and low profit per unit, disperse demand, complexities of distribution, and resultant high marketing costs.

New tools and implements must be manufactured by enterprises with low investments and in areas where they will be used to simplify distribution and provide effective after sales service. Such enterprises can produce only region- specific tools and equipment in numbers determined through continuous interaction with the farmers.

Specific Program

Establishment of three Farm Equipment Manufacturing Technology Centers with appropriate attention to objectives on manufacturing technology, prototype development, adaptation to mass manufacture, farm testing, technology transfer to manufacturers, and assistance in the form of workshops, demonstrations and public information media.

Coordination Committee

Appropriate representation from ICAR administration, Center Directors, Project Coordinators, engineers, farmers and manufacturing industry.

Collaboration

Numerous national and international institutions, organizations, and centers.

IMPLEMENTATION

A design team from the U.S. composed of Drs. Herrington and Ghran, with Dr. David Mears, USAID/Delhi and a counterpart Indian team prepared the proposal in April 1987. The sub-project proposal with budget details was completed in August 1987. The project was approved in March,1990 for implementation as a pre-project only, with a budget of $150,000.

ASSESSMENT

Since not enough time and insufficient funds were available for implementation of the full sub-project, approval was granted for a short duration pre-project. Sufficient funds were provided to allow for U.S. training of Indian scientists, for an Indian managerial team to visit U.S. sites, and U.S. technical assistance to aid in the project design. The project design was completed and is with ICAR for use in-house activities and for future reference and use.

It is not appropriate at this time to attempt an assessment of the USAID contribution to increasing the research capabilities at any of the participating centers as no research has been initiated which is specifically attributable to this pre-project.

There is reason for confidence that program activities will be sustained in view of the GOI's planned funding in the Eighth Five-Year Plan commencing in 1992. One of the three proposed Centers is to be established at CIAE, Bophal, with funds available for a building and for machine tools necessary for equipment manufacturing. A U.S. consultant has suggested that considerable private enterprise manufacturing ability already exists and that opportunities exist to aid in technology transfer and the privatization of the farm machinery sector. This sector is believed to have considerable capability, but needs assistance and training in improved machine tools, business practices, etc. He suggests that USAID consider this as a possible private enterprise development project with appropriate changes in the FEMTC design to have more direct involvement of the small businessman.

A significant amount of research has already been conducted in India on design and construction of small farm equipment. Particular emphasis has been placed on simplicity of construction design, power requirements, case of operation and other needs of Indian agriculture. CIAE, Bhopal has developed a number of farm tools and equipment for which construction plans are available. The project on the development of farm equipment technology centers hopefully will aid in the distribution of this information.

There is reason for confidence that program activities will be sustained in view of the GOI's planned funding for them in the Eighth Five-Year Plan commencing in 1992.

ATTACHMENT 4.1.11

ON-FARM WATER MANAGEMENT (OFWM)

BUDGET	**USAID** Proposed	U.S.$ 3,903,000
	Actual	U.S.$ 150,000
	ICAR Proposed	U.S.$ 1,688,000 (Rupee equivalent)
IMPLEMENTATION DATE	March, 1990	
COMPLETION DATE	June, 1992	

BACKGROUND

This proposed On-Farm Water Management (OFWM) sub-project will be supported by USAID and ICAR under the Agricultural Research Project. The OFWM sub-project is designed to provide five-years of (Phase I) support to ICAR to strengthen on-going research and implementation efforts in its Coordinated Project for Research on Water Management (CPRWM), with particular emphasis given to on-farm water management. The ICAR Project Directorate for Water Management has given highest priority to strengthening research that focuses on those portions of the irrigation command systems below canal outlets. The primary objective of this sub-project effort is to assist ICAR in improving its institutional capability to expand the relevant research knowledge base and increase the rate of adoption of research based technology and practices, so as to facilitate increases in water savings, crop yields, farmers' income and overall net benefits from irrigation investments over time.

The proposed sub-project focuses on strengthening and complementing ICAR's OFWM research program through ten major activities. These are:

- Work plan formulation, involving initial exchange visits by key ICAR OFWM project administrators/scientists and experienced U.S. OFWM scientists.
- Assisting ICAR in conducting its on-going OFWM research program during the life of the sub-project.
- Providing basic and specialized equipment, and the necessary training to operate it, as needed.
- Providing funds for a package of resources for innovative research projects through a competitive grants program.
- An ICAR visiting scientists to U.S. programs.
- U.S. scientist visits to India.
- Assistance in developing and delivering in-country short courses and workshops.

- A graduate student exchange program.
- Conducting formal, mid-project and near end of Phase I program evaluations.
- Design input for Phase II.

OBJECTIVES

- To improve efficiency of on-farm water management.
- To strengthen basic research for evolving efficient methods/techniques of on-farm water management
- To evaluate socio-economic and environmental aspects of water management
- To disseminate the knowledge gained in research.

Budget Summary (proposed)

	USAID U.S. $
Sub-project to U.S.-Based Project Entity	1,322,000
Scientist Exchange Program Indian Scientist to U.S.	1,344,000
U.S. Scientist to India	1,237,000
Total U.S.	3,903,000

	GOI U.S. $ (Equiv.)
Organization of Symposia	300,000
Equipment	1,388,000
Total GOI	1,688,000

IMPLEMENTATION

A design team composed of Drs. K.Nobe, J. Reuss, and J.M. Reddy came to India for the period January 15 to March 15, 1987. They also attended the AIRCRP Water Management Workshop.

Although a joint U.S. Indian design team finalized a sub-project proposal in 1987, no implementation action was taken until 1990 when approval was granted for a 2-year pre-project, with a budget of $150,000.

An Indian management team visited U.S. sites and at present a finished project design is with ICAR. A 2-member U.S. team spent 3 weeks in early 1992 in India to review water management research at several locations and conduct training workshops with the AICRP on Water Management. Four Indian Scientists have benefitted from short-term U.S. training/study tours.

ASSESSMENT

Because of the limited available time and funds for the remainder of the ARP life span, it appears to have been a wise decision to at least implement the program as a start-up pre-project. This has allowed sufficient time for the Indian management team to conduct a U.S. study tour, for several U.S. consultants to visit India to assist in completing the project design, and for some Indian scientists to benefit from short-term training in the U.S.

No assessment is possible at this time of research capability and output. The inclusion of this work in the Eighth Five-Year Plan provides for anticipated continuity and committed sustainability of the program.

ATTACHMENT 4.1.12

PROTECTED CULTIVATION AND GREEN HOUSES (PCGH)

BUDGET **USAID** U.S.$ 150,000

IMPLEMENTATION DATE March, 1990

COMPLETION DATE June, 1992

BACKGROUND

The National Committee on Plastics in Agriculture, (NCPA) has been formed by the Government of India in order to stimulate research on the appropriate uses of plastics in agriculture within the country and to promote potentially effective applications. This committee has the support of the Department of Chemicals and Petrochemicals, Ministry of Industry and the Indian Council of Agricultural Research, (ICAR). In turn the committee supports and coordinates research and development activities at a number of Plastics Development Centers (PDC's). These centers are located in industrial centers, at ICAR institutes, at State Agricultural Universities, (SAU's) and irrigation research centers. Centers are also being considered at Council for Scientific and Industrial Research, (CSIR) centers and at Defence Agricultural Research Laboratories, (DARL).

The Indo/U.S. Subcommission on agriculture proposed that the topic of plastics in agriculture be supported as a sub-project activity under the Agricultural Research Project, (ARP). The recommendation was for an exchange of visits between Indian scientists working in PDC's and counterpart centers in the U.S., with a focus on research effort. Also recommended was support for study tours of selected manufacturers to the U.S. to study techniques in product development and promotion and develop collaboration with private plastic companies in the U.S. It was pointed out that the appropriate nodal agency for development of these projects from the Indian side would be the NCPA and that collaboration with the National Agricultural Plastics Association, (NAPA) should be sought in developing useful projects.

OBJECTIVES

The objective is to strengthen the ability of selected centers in India to conduct research on protected cultivation and greenhouses. The technical focus is on determining the effects of plastic film mulch, row covers, low tunnels and greenhouses on the microclimate around the plant and the effects of those interventions on the growth and development of the plant. This will lead to the determination of packages of practices for practical management of intensive horticultural production systems.

IMPLEMENTATION

A joint Indo/U.S. team developed the project design document in late 1991. An Indian management team of five persons made a 3-week study tour of U.S. institutions in March, 1992. Upon their return, the project paper was to be amended and revised - according to this team's understanding. Meanwhile four Indian scientists have benefitted from short-term exposure to U.S. greenhouse design and practices.

No assessment of research capability or output is possible at this very preliminary stage of program activity. However, there appear to be opportunities for interaction and cooperation between public and private enterprise in this field. Considerable private enterprise interest and involvement exist for controlled production of fruits, vegetables and flowers (e.g., Indo-American Hybrid Seed Company in Bangalore). An opportunity for USAID may exist to assist in this public-private interaction and in the privatization process in this promising area.

ATTACHMENT 4.1.13

TISSUE CULTURE TO IMPROVE CROP PRODDUCTION (TC)

BUDGET	**USAID**	U.S.$ 150,000
IMPLEMENTATION DATE	March, 1991	
COMPLETION DATE	June, 1992	

BACKGROUND

Plant tissue culture, based on the totipotency of plant cells in culture, has been an established and expanding approach in micropropagation of plants for faster multiplication of improved genotypes. Consequently, India also has established substantial capability in this field but it needs upgrading in order to fully utilize the potential of this technology for enhancing production of selected crops. The proposed project will build upon India's expertise by developing a well coordinated program drawing upon available resources. The Indian Council of Agricultural Research (ICAR) and USAID have agreed to develop a project in the area of plant tissue culture under the Agriculture Research Project (ARP). Funding source for the project so developed could be explored later through some bilateral/multilateral agency.

OBJECTIVES

The specific objective of this project is to upgrade the capability of the Indian agricultural research system in the field of tissue culture to address constraints limiting the production of planting material of important Indian horticultural and plantation crops such as mango, banana, cashew, walnut, tomato, chilly and rose. The project will provide five-years of support to selected research institutions to strengthen their research capability enabling them to conduct research, develop techniques appropriate to the Indian conditions and translate these techniques into useful applications. The objectives and scope of the proposed project will be reviewed and refined by a design team in order to develop a well coordinated and effective program.

IMPLEMENTATION

An Indian Management team of three persons made a 3-week study tour of U.S. institutions in early 1991. This team identified a number of priority research areas applicable to Indian conditions. Following this, a team of two U.S. consultants assisted the Indian management team in designing a project document for tissue culture research in India. This document is presently used as a basis for negotiations for outside support from the World Bank.

Four Indian scientists are presently in the U.S. for 3 months of study and training.

ASSESSMENT

The success of this pre-project is limited to the identification of research priorities and the formulation of a full project design. Continued finding in the GOI Eighth Five-Year Plan and hopefully additional external support could provide the basis for a productive research program on the use of tissue culture for improvement of several major horticultural crops in India.

ATTACHMENT 4.1.14

INTEGRATED PEST MANAGEMENT (IPM)

BUDGET	**USAID**	U.S.$ 150,000
IMPLEMENTATION DATE	March,1990	
COMPLETION DATE	June, 1992	

BACKGROUND

Plant protection is one of the principal factors for achieving high agricultural productivity. The 'over kill' response of farmers and the tendency to use larger quantities of pesticides than really required has resulted in serious environmental concern in India besides spawning such problems as secondary pest outbreaks, pest resurgence and resistance to pesticides. The flora and fauna of the farm lands has also changed, affecting the sustainability of agricultural production. Moreover, extension of irrigation to non-traditional areas, increased cropping intensity, and altered crop sequences have altered the insect pests, diseases and weeds scenarios. To tackle these multifaceted problems, an integrated approach is deemed essential. Consequently, the Indian Council of Agricultural Research (ICAR) and the USAID have agreed to develop a project in the area of Integrated Pest Management (IPM) with a view to develop technologies that would permit adequate control of agricultural pests without resorting to intensive use of toxic chemicals and minimize yield losses.

OBJECTIVES

The specific objective of the project is to upgrade the capability of Indian agricultural research system in terms of research infrastructure, scientific competence of scientists and development of appropriate research programs in the field of integrated pest management research so that it can tackle the major insect/pests and related disease problems of selected crops.

These objectives and scope of the proposed project will be further reviewed and refined by a design team with a view to develop a well-coordinated, feasible and effective program.

IMPLEMENTATION

A management team of three Indian scientists made a 3-week study tour of U.S. institutions in July,1990. They identified priority pest management activities for research in India. Due to delays, some avoidable, some unavoidable (e.g., the Gulf War) a U.S. consultant team did not arrive in India until later in 1991. At that time, a project design was finalized. The IPM group in ICAR did identify a number of Indian scientists for U.S. training and a total of 13 have benefitted from training/study tours ranging from 3 weeks to 3 months in length.

ASSESSMENT

It is safe to say that the USAID contribution to IPM research in India has helped to focus applicable research needs and has contributed to a broadening of Indian scientists by exposing them to activities in IPM in the U.S. Although no specific research has originated as yet from this project, there is an ongoing All India Coordinated Research Project (AICRP) on IPM with a large network of research locations. Also, biological pest control has been a long-term activity in India including the work of the Common-wealth Institute of Biological Control (CIBC), now the National Centre for Integrated Pest Management.

Several factors contribute to confidence that IPM research will continue at a significant level in India. They include continued funding in the GOI's next Eighth Five-Year Plan, the high cost and relatively limited use of chemical pesticides, and the increasing awareness of environmental hazards associated with agricultural chemicals.

ATTACHMENT 4.1.15

ANIMAL GENETIC RESOURCE CONSERVATION (AGRC)

BUDGET	**USAID**	U.S.$ 150,000
IMPLEMENTATION DATE	March, 1991	
COMPLETION DATE	June,1992	

BACKGROUND

India has some of the richest and rarest livestock resources in the world. It also has some of the largest number of breeds of cattle, buffaloes, sheep, goats and poultry in the world. The Red Indian Jungle fowl is reported to be the progenitor of the modern breeds of poultry while the Indian Game birds are said to have contributed to the development of modern broiler breeds. The Indian Runner duck is claimed to have given birth to the modern duck breeds in the world. All these are now on the verge of extinction.

Similarly, other breeds of Indian livestock have also contributed to the rich livestock heritage of the world. Indian breeds of cattle have contributed immensely to the meat industry in the U.S., South America, Australia and elsewhere. Indian breeds of cattle have also contributed significantly to the emergence of new dairy breeds suited to the tropics. The Jumnapari breed of goat has contributed to the development of the Anglonubian. These are just a few examples. Indian breeds of livestock are prized for their resistance to diseases, for their heat tolerance and capacity to survive under harsh environments.

With the extensive crossbreeding based on exotic inheritance that is being followed in India in all species in its efforts to step up meat, milk and egg production, these indigenous breeds which have some good genes for survival are subject to extermination in the future. Under this sub-project, it is proposed to conserve and preserve to the extent possible germplasm of some of the best breeds for use when needed by adopting modern procedures and technologies.

IMPLEMENTATION

Four Indian scientists conducted a management study tour to the U.S.A in early 1991. They identified priority areas for research in India. They prepared an ambitious project design document for animal genetic resource conservation research in India. A team of U.S. specialists followed in 1992 leading to a final project paper documenting a research plan to protect and conserve the basic genetic resources of many of the native breeds of productive livestock species in India.

ASSESSMENT

Unlike the conservation of plant genetic resources the conservation of animal genetic resources is very complicated and expensive. On a worldwide basis, conservation of animal germplasm is far behind that of plant resources. This project on conservation of animal genetic resources may be somewhat premature in India considering the lack of established infrastructure to support it. The Indian National Institute of Animal Genetics and the Bureau of Animal Genetics set up a few years ago are not well organized and will take some more years to become fully functional. On the other hand it is imperative to begin to preserve the valuable resource of indigenous animal germplasm before much of it will be lost.

It is doubtful that this proposal will draw much interest or support from outside sources. However, if internal resources are available in India it would be highly desirable to begin the process of conserving and protecting at least some of the major animal germplasm resources.

ATTACHMENT 4.1.16

PROJECT IMPLEMENTATION UNIT (PIU)

BUDGET	**USAID**	U:S.$ 947,318
	ICAR	U.S.$ 330,000
IMPLEMENTATION DATE	April 01, 1985	
COMPLETION DATE	June 30, 1992	

BACKGROUND

The Project Implementation Unit (PIU) was established at the I.C.A.R. headquarters for handling technical and administrative work connected with the overall Agricultural Research Project. Since each sub-project required considerable attention in preparation, appraisal, implementation, monitoring, evaluation and coordination with several different institutions and departments, it was critical that these duties be carried out judiciously.

Originally, USAID agreed to administer all business and financial aspects involved in operating the sub-project elements scheduled to take place outside India. This was to include arrangements for U.S. consultant services, purchase and shipping of off-shore commodities and supplies and professional training of Indian scientists in the U.S.

RESPONSIBILITIES

The following were outlined as important functions of the PIU:

- Expeditious implementation of the sub-projects already developed.
- Formulation of new sub-projects.
- Coordination in respect of sub-projects monitoring.
- Preparation of sub-project reports.
- Coordination with other governmental agencies/departments.
- Processing of Indian scientists for training abroad.
- Processing of deputation cases connected with the exchange of scientists/specialists.
- Handling of U.S. delegations visiting India, from time to time.
- Coordination work relating to all meetings, symposia, and conferences held in connection with implementation, monitoring of sub-projects and initiation of new project areas.

- Handling importation of specialized equipment, laboratory items/research instruments and materials from time to time, including custom-duty exempting.

IMPLEMENTATION

Early in the life of the ARP it became obvious that the implementation responsibilities of PIU and USAID as originally outlined could more effectively be conducted if certain changes were made. It was agreed that PIU would become more of a coordinating unit that would handle in-country training and procurement. It also assumed the responsibility of scheduling planning meetings involving the various sub-project leaders to be held on a semi-annual basis.

USAID decided to contract a private institution to properly and timely make the necessary arrangements for the increasing number of U.S. consultants coming from the cooperating universities along with the procurement of the large volume of scientific equipment being supplied by U.S. companies for the Indian research institutes and universities under the auspices of the various sub-projects. Thus, in late 1985 USAID signed a Management Support Services (MSS) contract with Winrock International (WI) authorizing them to take over the major responsibilities related to the procurement of professional services, training and equipment in the United States.

ASSESSMENT AND FINDINGS

The PIU has continued to function throughout the life of the ARP but in a somewhat different role than was initially intended. It never was fully staffed to perform it's primary role. After the inception of MSS, it essentially took over the main task of ordering scientific equipment, arranging for U.S. consultant visits to India and providing all the logistics associated with Indian scientists attending training sessions at cooperating universities in the U.S. This shift in out-of-country responsibilities to WI turned out to be a good move. It has effectively and efficiently provided the expeditious liaison and services between sources in the U.S., in meeting the needs of the individual sub-projects, and the research institutions in India.

One key to the effectiveness of the PIU in recent years was the redefinition of its functions to more of a coordinating role. The capability of PIU also improved when the administrative responsibility for coordination of the sub-projects in ICAR was vested in a Deputy Director General instead of an Assistant Director General. The latter, however, continued to work under the direction of the DDG.

The PIU continued to handle in-country training, specialized workshops and equipment purchases. It effectively scheduled the semi-annual conferences and coordinated in-country expenditure of the Rupee budget. It served as a bridge between the sub-project implementing groups, WI and the USAID. A good working relationship between PIU and WI seems to have been developed.

The coordination and the monitoring of all activities associated with each of the sub-projects of the ARP has been successfully accomplished. This has been a monumental task over the nine years of the project. Nevertheless, reports have been provided in a timely manner and the records of all transactions have been kept current.

The system of utilizing Management Services as an intermediary in linking the user agency and the donor agency has proven to be very successful. It has been especially helpful wherein so many sub and pre-projects were lumped under the ARP umbrella. It can be commended for use in future assistance programs as well.

ATTACHMENT 4.2

PROJECT DESIGN SUMMARY

LOGICAL FRAMEWORK

TITLE AND NUMBER	AGRICULTURAL RESEARCH - India (386-0470)
LIFE OF PROJECT	From FY 1983 to FY 1992
TOTAL U.SS. FUNDING	U.S.$ 20 million
DATE PREPARED	May 1992
LOAN	

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS
Program of Sector Goal	**Measures of Goal Achievement**
Increased agricultural productivity	1. Selected crop yields. 2. Expanded, applied knowledge base.
Project Purpose	**Conditions that will indicate purpose has been achieved. End of Project Status**
To strengthen the capacity of the Indian agricultural research system in selected key areas.	1. Technological capacity of collaborating Indian institutions strengthened in selected areas of research and development and is adequate to deal with current and future problems. 2. Improved research organization and management established in selected functional areas. 3. Facilities adequate to conduct necessarty research and development. 4. Certain constraints to food production, preservation and conssumption removed.

Outputs	Magnitude of Outputs
Develop new agricultural technologies in collaboration with U.S. institutions to addresss key constraints to increased agricultural produc-ction and utilization in approximately six selected areas.	1. Research problems identified. research program organized and sub-project approval procedures in place. 2. Three sub-projects with 25 major components in progress. 3. Five research areas defined more generally and four research areas noted. 4. ICAR administrative machinery in place to organize and supervise research sub-projects as implemented.

Inputs	Magnitude of Inputs
1. Participant training (contract). 2. Scientific collaboration (contract). 3. Equipment (contract). 4. Physical facilities. 5. Rupee cost of research.	1. Trained staff in place: Indian scientists trained in the U.S. for six to 12 months each. 2. Physical facilities in place: sq. meters of laboratory, screen houses and office space available to project ha. of experimental fields available to project. 3. Research equipment in place that is appropriate to the research being conducted: laboratories, cold stores warehouses, etc., available to project and property equipped.

Data	Assumption for Achieving Goaal Targets
1. MOA reports. 2. ICAR exists.	1. An appropriate adaptive research system exists. 2. Suitable extension program exists.

Data	Assumption for Achieving Purposes
1. ICAR staffing patterns for projects. 2. ICAR records on building space allocation of 3 sub-projects. 3. ICAR records on assignment of experimental land.	1. ICAR able to get needed new positions approved. 2. ICAR can achieve timely construction of necessary buildings, laboratories, etc. or such facilities available for hire.

4. ICAR records on laboratory and similar space and equipment inventories for these physical facilities.
5. ICAR annual reports to AID.
6. AID monitoring.
7. Contractor reports.

Data

1. ICAR reports to AID.
2. Contractor reports to ICAR
3. Published scientific reports by Indian and U.S. scientists.

Assumption for Achieving Outputs

1. ICAR and GOI make required budget available on a timely basis.
2. AID and U.S. contractor able to deliver collaborating U.S. scientific expertise of high quality.

Data

1. Contractor records.
2. ICAR/AID monitoring.
3. ICAR reports to AID.
4. GOI/ICAR audits.
5. AID audits.

Assumption

1. Inputs by AID and GOI/ICAR provided as scheduled.

ATTACHMENT 4.3

SCOPE OF WORK

for the Final Evaluation of

The Agricultural Research Project (386-0470)

Article I — **Title**

Final Evaluation of the Agricultural Research Project (ARP) (386-0470)

Article II — **Objective**

The contractor shall undertake the final evaluation of the ARP project and submit the report to USAID/India in accordance with the Statement of Work (SOW) and other terms of reference specified here.

Article III — **Statement of Work**

The Statement of Work describes the following:

- i) Project details
- ii) Project purpose and goal
- iii) Project activities
- iv) Progress to-date
- v) Evaluation purpose
- vi) Evaluation issues
- vii) Evaluation methods and procedures

Article IV — **Report**

The contractor will prepare a report which will cover all issues listed in the statement of work (Article III) in the following format required by AID:

- i) Executive Summary
- ii) Project Identification Data Sheet
- iii) Table of Contents
- iv) Body of the Report
- v) Attachments

The executive summary and the body of the report will include the following sections:

i) Description of the project to be evaluated
ii) Purpose of evaluation
iii) Evaluation issues
iv) Evaluation methods and procedures
v) Evaluation team and time table
vi) Evaluation findings (issue-wise)
vii) Recommendations and lessons learned

The contractor will conduct debriefings with the concerned officers from NRM, PDPS and the front office(s) of USAID and the GOI officials on major findings, conclusions, recommendations and lessons learned.

Two copies of a draft report will be submitted to the Chief, PDPS/PPE, USAID/India at least 3 working days prior to the departure of the team. One original and 10 duplicate copies (along with diskette) of the final report will be submitted by the contractor to the Chief, PDPS/PPE within 10 days of the receipt of AID's comments on the draft report.

The evaluation team leader will complete the abstract and narrative sections of the AID Evaluation Summary form and submit the final revised report with the additional time allocated for him in the contract.

Article V **Relationships and Responsibilities**

The evaluation team will be an Indo-U.S. team consisting of senior personnel serving full time during the evaluation exercise. The team will consist of 4 members : two senior U.S. and two senior Indian persons with broad experience in agricultural research and research administration. One senior U.S. scientist/science administrator will serve as team leader.

The team leader, in addition to being a prominent scientist or science administrator must have demonstrated strong writing and organizational skills that will enable him/her to organize the evaluation team effectively and to produce a quality finished product.

He/she should be familiar with USAID evaluation requirements and procedures.

The two senior U.S. scientists/science administrators must be thoroughly familiar with U.S. National Agricultural Research System. They must have international experience in agricultural research preferably in India or at least in South-Southeast Asia. They should be recognized nationally and internationally for their contributions.

The two senior Indian scientists/science administrators should have qualifications and experience comparable to those stated above for the U.S. counterparts as related to their National Agricultural Research System. They should have international expertise in agricultural research preferably one in the area of crop sciences and the other in animal sciences.

The team leader will be responsible for finalizing the report and submitting it in required form and number within 10 days of the receipt of USAID comments.

The evaluation team will receive guidance and support from the Project Officer/Chief, NRM Office on project-related matters and from the Evaluation Officer/Chief, PDPS/PPE office on evaluation-related matters during the period of evaluation.

Article VI **Performance Period**

The evaluation will begin o/a April 06, 1992 for a period of 35 workdays. The contractor will provide a draft report and debriefing for USAID/India and submit the final report within 10 days from the receipt of comments from USAID/India.

The tentative time schedule will be as follows :

Activity		Workdays
Reviewing documents and interaction in U.S.		2
Reviewing documents in Wash/AID/India		3
Briefing with evaluation team		1
Preparing work and travel plan		2
Discussions with AID and GOI officials		2
Site visits to selected institutes		10
Preparing the draft report		6
AID debriefing and comments on draft report		2
Revision of draft		2
	Total :	30

A detailed time schedule will be prepared by the evaluation team in consultation with project and evaluation officers of USAID/India.

In addition to 30 workdays, the team leader will work for 5 more days in U.S.A on finalizing the report in the light of comments received by USAID.

Article VII **Work Days Ordered**

The work days ordered, therefore, would be as follows :

Position		Workdays
i)	For the team leader	35
ii)	For 3 team members (3 x 30)	90
	Total	125

Article VIII **AID Illustrative Budget**

Article IX **Special Provisions**

A. Duty Post: U.S. SITES 2 days
New Delhi & Indian sites 30 days

B. Language requirements and other required qualifications: **None**

C. Access to classified information: The contractor shall not require or have access to any government classified documents.

D. Logistical Support: USAID/India will provide background material to the consultants upon or before arrival in India. The contractor will be responsible for providing the entire secretarial and logistical support.

ATTACHMENT 4.4

EVALUATION METHODOLOGY

The team did not have an opportunity for any review of project documentations, interviews with appropriate officials in Washington D.C., or site visits in the U.S.. During the first week in India the team carried on a thorough review of Project documents, held discussions with USAID staff, Winrock International staff, the Director of FERRO, and appropriate senior officers of ICAR.

An Issues and Questions memorandum (See following page) was sent to all Project research locations asking for a brief Note regarding the five main issues of the evaluation.

Two weeks of travel provided the opportunity to visit several, but unfortunately not all, key research locations. Information from others was obtained from returned questionnaires, reports, and discussions with USAID, ICAR, and Winrock staff.

Each review team member assumed primary responsibility for review of specific sub-projects in his professional areas of expertise. The detailed write-up for each sub-project, included in Attachment 4.1, was prepared by individual team members.

Other parts of the report are the result of joint discussions and deliberation.

A.R.P EVALUATION

QUESTIONS & ISSUES

PLEASE PREPARE A BRIEF NOTE (NO MORE THAN TWO PAGES) REGARDING YOUR ASSESSMENT OF THE ACCOMPLISHMENTS OF YOUR SUB-PROJECT:

I. STRENGTHENING OF THE RESEARCH CAPABILITIES:
  a) Do you consider that you have adequate resources of facilities, staff and equipment to meet the research under your sub-project?

II. RESEARCH ACCOMPLISHMENTS:
  a) Highlight of the results of practical significance

III. TECHNOLOGY TRANSFER:
  a) Application of findings
  b) Useful Products/Outcome
  c) Timing of Application or Use - Now or Future Promise

IV. CONTINUITY AND SUSTAINABILITY:
  a) Can Research be continued at full strength?
  b) Any constraints?

V. RECOMMENDATIONS FOR FUTURE

ATTACHMENT 4.5

EVALUATION TEAM MEMBERS

Dr. Peter H. Van Schaik - Team Leader

Dr. Van Schaik is an agronomist/plant breeder who has extensive experience as a researcher and research administrator both in the United States and in developing countries (including India from 1967-70). He holds a B.S. degree in Agronomy and the Masters and Ph.D. degrees in Plant Breeding. His research has been in agronomy and varietal development of soybeans, cotton, peanuts and dry edible legumes. His administrative experience has been at the Area and Regional levels of USDA. He has held resident assignments in Iran and India, and has served in short-term consultancies in those countries and in Ethiopia, Kenya, Mali and Pakistan. He is the author of numerous technical articles on soybeans, cotton, peanuts and pulses.

Dr. Keith R. Allred

Dr. Allred has over thirty-years experience in teaching and research related to crop production and the administration of these programs in the U.S. and in Latin America. He holds a B.S. degree in Agronomy and a Ph.D. in Crop Physiology. He recently retired as the Head of the Plant Science Department at Utah State University. In that position, he was responsible for coordinating and administering all teaching, research and extension activities throughout the State of Utah as they relate to the areas of agronomy, horticulture and ornamental horticulture. Dr. Allred has served as a resident advisor in Bolivia and as a short-term consultant in Bolivia, Colombia, Mauritania, Somalia, Swaziland, and Trinidad and Tobago.

Dr. J.S. Kanwar

Dr. Kanwar is an internationally known research scientist and research administrator. He holds a B.S. degree in Agronomy/Soils and Masters and Ph.D. degrees in Soil Chemistry. From 1973 to 1988, as Director of Research and Deputy Director, he played a significant role in directing and coordinating research at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India. This research covered sorghum, pearl millet, pigeonpea, chickpea, groundnut, and farming systems to improve the productivity and sustainability of dryland agriculture in the rainfed areas of the semi-arid tropics. He has served as a short-term consultant in numerous Asian countries and in Africa.

Dr. C. Krishna Rao

Dr. Rao has a long and distinguished career as an educator, administrator and researcher in the field of livestock. He holds a B.S. degree in Veterinary Science, a Masters degree in Animal Husbandry, and the Ph.D. degree in Animal Genetics. He began his career as a lecturer in dairy science and is the author of Textbook of Dairy Science. He subsequently served as Director of Animal Husbandry for several state governments and the Government of India. He has chaired numerous research review committees on cattle, sheep, goats, and veterinary research for the Indian Council of Agricultural Research. He is the author of about 40 research publications and has travelled worldwide to participate in national and international conferences related to animal production and research.

ATTACHMENT 4.6

PLACES AND PERSONS VISITED

APRIL 23

Washington, D.C.
International Resources Group
Mr. Robert A. Delemarre

AID/W - R&D/AGR
Dr. Hans P. Peterson
Dr. Tejpal S. Gill
Dr. Robert C. Hedlund

APRIL 27

New Delhi, India
USAID
Dr. B.R. Patil, Evaluation Officer
Dr. Surjan Singh, Project Officer

USDA/FERRO
Dr. James H. Thomas, Director

APRIL 28

Winrock International
Dr. Maharaj Singh, Senior Agril. Scientist
Mr. P.S. Srinivasan, Admin. Specialist
Dr. H. E. Kauffman, India Coordinator-PGR

APRIL 29

Indian Council of Agricultural Research (ICAR)
Dr. Surjan Singh, Program Specialist - USAID
Dr. S.K. Roy, Project Coordinator (PHT)
Dr. G.L. Kaul, ADG (Hort.)
Dr. Ramphal, ADG (Veg. Crops)
Dr. S.C. Chopra, Sr. Sci. (AG&B)
Dr. Kiran Singh, ADG (AN&P)
Dr. J.C. Malhotra, ADG - ICAR
Dr. Maharaj Singh, Winrock International
Mr. P.S. Srinivasan, Winrock International
Dr. M.C. Prasad, ADG (Animal Health) - ICAR
Dr. M.N. Malhotra, Sr. Sci., ICAR HQ
Dr. G. Singh, ADG (Engg.) - ICAR
Mr. B.K. Tyagi, Under Secretary (DARE)
Mr. K.K. Sharma, Desk Officer

APRIL 29 **Indian Agricultural Research Institute (IARI)**
Institute of Post Harvest Technology
Dr. Susanta K. Roy, Principal Investigator
Dr. D.S. Khurdiya, Scientist (SG)
Dr. A.K. Chakrabarti, Principal Scientist
Mrs. V.K. Murthy, Scientist (SG)
Dr. R.K. Pal, Scientist
Dr. B.R. Atteri, Scientist (SG)
Dr. S.B. Maini, Principal Scientist
Dr. (Mrs.) V. Sethi, Scientist (SG)

MAY 1 **USAID, Director's Office**
Mr. S.P. Mintz, Deputy Director
Dr. J. O'Rourke, (PDPS)
Dr. Surjan Singh, Program Specialist (NRM)
Dr. J. Perianayagam, (PDPS/PDI)
Dr. B.R. Patil, (PDPS/PPE)

MAY 4 Karnal, Haryana
National Dairy Research Institute,
Embryo Technology Centre
Sub-project: Embryo Technology Transfer
Dr. M.L. Madan, Project Director
Dr. B.S. Prakash, Senior Scientist
Mr. S.K. Singla, Scientist
Dr. R.S. Manik, Scientist
Dr. M.S. Chauhan, Sr. Technical Officer
National Bureau of Animal Genetic Resources
National Institute of Animal Genetics
Pre-project: Animal Genetic Resource Conservation
Dr. R. Sahai
Dr. A.E. Nivasarhar
Dr. (Mrs.) S. Bhatia
Dr. R.K. Malik

MAY 5 Hisar, Haryana
Haryana Agricultural University
Dr. A.L. Chaudhary, Vice Chancellor
College of Animal Sciences
Sub-project : Conversion of Biodegradable Animal Wastes for **Livestock Feed**
Dr. V. Sagar
Dr. R.P. Singh
Dr. V.K. Paliwal
Dr. K.R. Yadav

Dr. D.C. Sangwar
Dr. M.L. Punj, Project Coordinator

All-India Coordinated Research Project on Intracellular Blood Protista
Sub-project : Intracellular Blood Protista

Dr. Y. Bhattacharyulu, Project Coordinator
Dr. Shruti Dhar, Professor (Epidemiology)
Dr. N.K. Kakker, Assistant Scientist (Immunobiochemistry)
Mrs. Kiran Kapoor, Assistant Scientist (Stats.)
Dr. (Mrs.) Archana Sharma, Sr. Technical Assistant

MAY 6

Haryana Agricultural University
Department of Agricultural Meteorology
Sub-project : Agrometerology

Dr. D.S. Naha

Department of Forestry
Sub-project : Agroforestry

Dr. S.S. Bista - Head of Dept.
Dr. O.P. Toky
Dr. Sunil Puri
Dr. R.R. Singh
Mrs. Bimlendra Kumari

Central Institute for Research Buffalo
Sub-project : Embryo Technology Transfer

Dr. Chopra, Director

MAY 7

Makhdoom (Agra), Uttar Pradesh
Central Institute for Research Goats
Sub-project : Embryo Transfer Technology

Dr. W.K. Bhattacharyya, Director
Dr. Aggarwal
Dr. Nandy

MAY 8

Jhansi, Uttar Pradesh
National Research Centre for Agroforestry
Sub-project : Agroforestry

Dr. R. Deb Roy, Director
Dr. P. Rai, Senior Scientist (Agronomy)
Dr. A.K. Bisaria, Senior Scientist (Plant Pathology)
Dr. Babu Lal, Sr. Scientist (Soil Science)
Dr. Anil Kumar, Scientist (Plant Pathology)

Dr. Ram Newaj, Scientist (Agronomy)
Sh. G.R. Rao, Scientist (Forestry)

Indian Grasslands and Forage Research Institute
Sub-project : Agroforestry

Dr. Panjab Singh, Director IGFRI
Dr. C. Patel, Scientist

MAY 9 — <u>**Bhopal, Madya Pradesh**</u>

Central Institute for Agricultural Engineering
Sub-project : Soybean Processing and Utilization

Dr. NSL Srivastava, Director
Dr. Nawab Ali, Project Director-SPU
Dr. K. Jha, Sr. Scientist-SPU
Mr. B.S. Bisht, Sr. Scientist-SPU
Mr. L. K. Sinha, Scientist
Dr. S. K. Khare, Scientist-SPU
Dr. K.C. Joshi, Scientist-SPU

Potential Entrepreneurs

Mr. K.V.S. Nair, General Manager,
M.P. Agro-Industries Corporation, Bhopal
Mr. Kawalkar, Private Potential Entrepreneur

MAY 11 — <u>**Hyderabad, Andhra Pradesh**</u>

Central Research Institute for Dryland Agriculture
Sub-project : Agrometeorology

Mr. B.V. Ramana Rao, Project Coordinator
Dr. J.C. Katyal, Director, CRIDA
Dr. S.T. Nagaraj, Agrometeorologist
Mr. Md. Osman, Scientist (Agroforestry)
Dr. K. Hubbard, Consultant (Nebraska)
Dr. S. Neyer, Consultant (Nebraska)

Andhra Pradesh Agricultural University
Sub-project : Agroforestry

Dr. Subramanyum, Chief Scientist Horticulture
Dr. Satyanarayan, Scientist Agroforestry
Dr. L.G. Geri Rao, Agronomist
Dr. B. Sreemannarayana, Ass't Chemist

MAY 12 — **International Crops Research Institute for the Semi-Arid Tropics**

Dr. Y.L. Nene, Deputy Director General, Research and Coordination
Dr. S.M. Virmani, Senior Climatologist
Dr. Piara Singh, Soil Scientist

Dr. RamaKrishna, Scientist, Agroforestry
Dr. Flower, Agronomist
Dr. D.R. Butler, Sr. Microclimatologist

MAY 13 **Bangalore, Karnataka**
Indian Institute for Horticultural Research
Dr. R. M. Pande, Director
Post Harvest Technology Division
Sub-project : Post Harvest Technology, fruits and vegetables
Dr. R. M. Pande, Dir. IIHR, PHT Division
Dr. S. Krishnamurthy, Scientist
Mr. I.N. Doreyappa Gowda, (proc.), Scientist
Dr. B.A. Ullasa, (path.), Scientist
Mr. E.R. Suresh, (Micro), Scientist
Mr. S.C. Mandhar, (Engg.), Scientist
Dr. M.S. Ladania, (Procs.), Scientist

MAY 14 **Centre for Technology Development, Bangalore**
Sub-project : Post Harvest Technology, fruits and vegetables
Mr. P.C. Nayak, Director-CTD
Mr. Mani, Member
Mr. M.V. Krishnamurthy, Professor
Mr. S.R. Sampath, Retd. Director
Dr. U.V. Sulladmath, Retd. Professor
Mr. S. Shyam Sunder, Former PCCF-Karnataka
Mr. S.K. Bhat, Chief Executive
Mr. K.S.N. Murthy, Associate Director

MAY 19 **New Delhi, ICAR**
Sub-project : Agroforestry
Dr. S. Chinnamani, ADG

MAY 20 **Sub-project : Post Harvest Technology, fruits and vegetables**
Dr. C. Das, Director-NCCR, Nagpur, Maharashtra

MAY 26 **Indian Council of Agricultural Research (ICAR)**
Project Report Briefing
Dr. Chopra, Director General, ICAR
Dr. I.P. Abrol, DDG (Soils), ICAR
Sh. J.C. Malhotra, ADG (PIU), ICAR

Sh. B.K. Tyagi, Under Secretary (DARE)
Dr. P.N. Bhat, DDG (AS), ICAR
Dr. G. Singh, ADG (Eng),ICAR
Dr. G.L. Kaul, ADG (Hort), ICAR
Dr. Kiran Singh ADG (AN&P), ICAR
Dr. M.C. Prasad, ADG (AH), ICAR
Dr. P.C. Bhatia, ADG (Agronomy), ICAR
Dr. S. Chinnamani, ADG (Agroforestry), ICAR
Dr. S. Nagarajan, ADG (PP), ICAR
Dr. B.R. Sharma, Pri. Sci, ICAR
Dr. T.N. Chaudhary, ADG (IWM), ICAR
Dr. M.N. Malhotra, Pri.Sci. (AH), ICAR
Dr. S.C. Chopra, Pri. Sci. (AG&B), ICAR
Dr. Surjan Singh, Program Specialist, USAID, New Delhi.
Dr. Maharaj Singh, Senior Agricultural Scientist, Winrock International, New Delhi.
Sh. P.G. Srinivasan, Administrative Specialist, Winrock International, New Delhi.

MAY 28 **USAID**
Project Report Briefing

Mr. Walter Bollinger, Director, USAID
Mr. Steven Mintz, Deputy Director
Dr. Timothy M. Mahoney, Director, PDPS
Dr. Jerry Tarter, Deputy Director, PDPS/PDI
Mr. Jon O'Rourke, Deputy Director, PDPS/PPB
Dr. B.R. Patil, PDPS/PPE
Dr. Surjan Singh, NRM
Mr. J. Perianayayam, PDPS/PDI
Mr. C.M. Raman, CO/FRA

ATTACHMENT 4.7

DOCUMENTATION

CENTER FOR TECHNOLOGY DEVELOPMENT

1. Center for Technology Development, A leaflet published by CTD, Post Box No. 1209, CSIC Complex, Indian Institute of Science Bangalore

CENTRAL INSTITUTE FOR AGRICULTURAL ENGINEERING,BHOPAL

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CENTRAL RESEARCH INSTITUTE OF DRYLAND AGRICULTURE (CRIDA, HYDERABAD)

1. A report of the Quinquennial review team of the All-India Coordinated Research Project on Agrometeorology, Dr. S.M. Virmani & Associates, March 1992

INDIAN COUNCIL OF AGRICULTURAL RESEARCH

1. Deputation Report of Management Team of USAID Assisted Sub-project "Embryo Transfer Technology & Bioengineering of Livestock Species and their Patho-Biological Implications", Project 386-0470; Sub-project 6.1987

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5. Study Tour to the U.S. of Management Team of Indo/USAID Sub-project on Post Harvest Technology of Fruits and Vegetables - June 15 - July 18, 1986

6. Establishment of the Project Implementation Unit (PIU) at ICAR Headquarters for Indo-U.S. collaborative Programs in the field of Agricultural Research and Education. March, 1985

7. Intracellular Blood Protista with particular reference to Immuno-Prophylaxis and Control Project No. 386-0470. Sub-project No. 5, April 1986.

8. A Brief Up-to-date Progress Report Of the All-India Coordinated Research Project on Intracellular Blood Protista with Particular Reference to Immunoprophylaxis and Control. Dr. Y. Bhattacharyulu, Project Coordinator, Haryana Agricultural University, Hisar. May, 1992

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U.S. AGENCY FOR INTERNATIONAL DEVELOPMENT

1. Project Paper Agricultural Research - Project No. 386-0470. USAID/New Delhi, June 1983.

2. Project Design Report. SAU Forestry Education Development Collaboration, Strengthening and Excellence. Dr. John Gordan, Dr. Arnett C. Mace, Jr., Dr. Dean Gjerstad, Dr. Charles R. Hatch, USAID/New Delhi, March 1987.

3. Project Paper - India. "Plant Genetic Resources (PGR) Project (386-0513)", January 1988.

4. Sub-project Design Report On-Farm Water Management. Project No. 386-0470. K.C. Nobe, John O. Resus, J. Mohan Reddy. February, 1987.

5. Project Paper - Agricultural Commercialization and Enterprize (ACE), 1991.

6. Project Paper - Program for Advancement of Commercialization Technology (PACT)

7. Report of an Interim Evaluation, Indo-U.S. Agricultural Research Project. June 1988.9.

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TECHNICAL ASSESSMENT

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2. Technical Assessment, Agricultural Research Sub-project, Post Harvest Technology of fruits and Vegetables, R. Buescher, November 1990

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4. Technical Assessment Report, Intracellular Blood Protista with particular reference to Immunoprophylaxin and Control. M. Ristic, November 1990.

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10 Team Report, Project Paper, Plant Genetic Resources, July 1986.

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