ASIAN DEVELOPMENT BANK SST:STU 2000-17

SPECIAL EVALUATION STUDY

ON THE

POLICY IMPLEMENTATION AND IMPACT

OF AGRICULTURE

AND NATURAL RESOURCES RESEARCH

December 2000

ABBREVIATIONS

ADB	–	Asian Development Bank
AED	–	Agriculture and Social Sectors Department (East)
ANRR	–	agriculture and natural resources research
AVNET	–	Southeast Asian Vegetable Network
AVRDC	–	Asian Vegetable Research and Development Center
AWD	–	Agriculture and Social Sectors Department (West)
PRC	–	China, People's Republic of
CGIAR	–	Consultative Group on International Agricultural Research
CIAT	–	International Center for Tropical Agriculture
CIFOR	–	Center for International Forestry Research
CIP	–	International Potato Center
CIRDAP	–	Center for Integrated Rural Development for Asia and the Pacific
CLVNET	–	Cambodia, Lao PDR, and Viet Nam Research Network
DMC	–	developing member country
FAO	–	Food and Agriculture Organization
GIFT	–	genetically-improved farmed tilapia
ha	–	hectare
IARC	–	international agricultural research center
IBSRAM	–	International Board for Soil Research and Management
ICARDA	–	International Center for Agricultural Research in the Dry Areas
ICIMOD	–	International Centre for Integrated Mountain Development
ICLARM	–	International Center for Living Aquatic Resources Management
ICRAF	–	International Centre for Research in Agroforestry
ICRISAT	–	International Crops Research Institute for the Semi-Arid Tropics
IDRC	–	International Development Research Centre
IFPRI	–	International Food Policy Research Institute
IIMI	–	International Irrigation Management Institute
ILRI	–	International Livestock Research Institute
IRR	–	internal rate of return
IRRI	–	International Rice Research Institute
ISNAR	–	International Service for National Agricultural Research
IWMI	–	International Water Management Institute
kg	–	kilogram
mt	–	metric ton
MV	–	modern variety
NARS	–	national agricultural research system
NGO	–	nongovernment organization
RETA	–	regional technical assistance
SAVERNET	–	South Asian Vegetable Research Network
SLM	–	sustainable land management
t	–	ton
TA	–	technical assistance

NOTE

In this report, "$" refers to US dollars.

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EXECUTIVE SUMMARY

The Asian Development Bank (ADB) adopted an official policy on agriculture and natural resources research (ANRR) in 1995. This policy focuses on six main agenda items including (i) sustainable and remunerative farming systems for poor farmers, (ii) enhancing the incomes and living standards of rural women, (iii) sustainable management of agricultural and natural resources, (iv) enhancing the productivity of agriculture, (v) enhancing the capacity of national research systems, and (vi) public policy and socioeconomic research. The policy objectives are to be achieved through funding for ANRR channeled through the Consultative Group on International Agricultural Research (CGIAR) to various international agricultural research centers (IARCs) and to national agricultural research systems (NARSs) as well as a limited number of special technical assistance (TA) projects to regional research centers outside the CGIAR system. ADB's agricultural research objectives are to increase food production and food security, and contribute toward poverty reduction. Lending and TA operations are to focus on high-yield technology for less favorable environments and for crops other than wheat and rice, with particular attention paid to rain-fed farming, neglected crops, and integration of crop, livestock, and forestry activities.

This special evaluation study evaluates the appropriateness, effectiveness, and impacts of ADB's policy and support to ANRR in the Asian and Pacific region. The study aims to (i) review and assess ADB's role and contribution to support ANRR, (ii) evaluate the implementation performance of ADB-funded research activities and projects, and (iii) determine the adequacy of ADB-financed ANRR activities in meeting ADB's policy requirements. A sample of ADB-supported projects from four IARCs were selected for formal impact assessment studies. These projects represented a good mix of research activities covering a range of environments, executing agencies, commodities, NARSs, and networking arrangements. A number of NARSs and CGIAR and non-CGIAR centers were visited to enable the study team to undertake a more general assessment of the impacts of ADB's ANRR policy on the welfare of the agricultural producers in the Asian and Pacific region.

ADB provides support to ANRR as part of its strategic framework for poverty reduction. Most developing member countries (DMCs) do not yet have the capacity or resources to undertake needed research without strong international support and partnerships. The products of most research efforts are international public goods with high spillover effects across countries. This leads to underinvestment by the private sector, which is unable to capture most benefits, and by individual countries, which are also unable to capture these spillover effects for its farmers and consumers. To absorb funds needed to reduce the underinvestment, strong public institutions are needed to deliver public goods and services and strong stakeholder participation is needed to guide the resource allocation process. Grants for ANRR have played an important role in meeting ADB's strategic objectives, including economic development and poverty reduction. Since 1975, ADB has provided $67.6 million funding in ANRR TA projects. The original motivation for this support was based on the demand to expand the initial "green revolution" research breakthroughs through support to the IARCs, NARSs, and regional institutions.

ADB's funding for ANRR has been appropriate to the evolving needs of Asian agriculture. Initial investments were for basic infrastructure development such as genebanks, training centers, scientific laboratories, and laboratory equipment, or for founding grants to help construct and equip research centers. These investments are still in place and have played a significant role in the success of these centers in helping increase the productivity of Asian

agriculture, train several generations of Asian scientists, and conserve germplasm and biodiversity.

Since 1996, funding of research projects has followed closely ADB's policy for ANRR. The primary mechanism to achieve maximum impact from limited funds is to support Asian networks as a means of strengthening NARSs while disseminating IARC products to the clients. Many project activities focused on research for less-favored environments. The research agendas of CGIAR and other regional IARCs conform closely to the key research issues of strategic concern of ADB. ADB provides regional technical assistance (RETA) funding once a year covering research projects at several CGIAR centers. Since ADB's policy on ANRR was adopted in 1995, CGIAR centers have received $21.9 million in RETA funds, while non-CGIAR centers have received $3.65 million.

The main recipients of ADB support for ANRR under the CGIAR system are International Rice Research Institute (IRRI), International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), International Water Management Institute, and International Center for Living Aquatic Resources Management (ICLARM). The ADB policy paper also notes that support to the CGIAR system would not exclude other specialized research areas or institutions outside the CGIAR system. Individual TA and loan projects continue to fund other research proposals or programs of interest to ADB and generally follow normal ADB processing procedures. The main recipient outside the CGIAR system is the Asian Vegetable Research and Development Center (AVRDC).

The current policy for ADB funding of ANRR based on the policy agenda items remains relevant and consistent with ADB's new poverty reduction strategy. Benefits of research reach the poor through four main avenues: (i) raising farm income and employment; (ii) lowering food prices in the market; (iii) providing pathways out of poverty by raising incomes thus providing more education for children, better health and other household services, and creating rural and urban employment; and (iv) promoting broad-based economic growth. An environmental consequence of the green revolution technologies is the saving of land not required to produce today's food output at pre-green revolution yield levels. However, not all the agenda items fit into the current policy of supporting ANRR through the IARCs. A broader range of research institutions needs to be considered for ADB support, including NARSs, nongovernment organizations, universities, and specialized research institutes with more expertise in local issues.

The impact assessment indicated that ADB investments in a selected group of projects provided high rates of return, averaging 83 percent for IRRI projects, 45 percent for ICRISAT projects, and 91 percent for AVRDC projects. Research on genetic improvement of fish by ICLARM also showed high rates of return. These returns provide economic benefits to both producers and consumers and justify continuing ADB involvement in ANRR.

A review of project documents indicated that very few formal assessments on the success or failure of TA grants were made in the past. Since the 1995 policy on ANRR, ANRR project assessment has been more formalized. Project completion reports and log frame updates are now standard requirements. Administration of the RETA process has improved and the supervision of individual TA projects is systematic and consistent. The current 19 TA projects under the first four RETAs are in various stages of implementation with elapsed periods ranging from 14 to about 99 percent. The progress of implementation of all the TA projects, except one, has been generally satisfactory. The performance of the studies is being monitored and evaluated by the concerned

ADB staff at three-month intervals. Progress reports have been timely and show generally good performance.

ADB funding for ANRR has improved and stabilized since the policy on ANRR was implemented. However, the amount is small relative to other important donors in this area and rationalization of funding by centers, geographic coverage, and agenda items is needed to make better use of ADB's limited resources for ANRR.

ANRR has played an important role in promoting agricultural and rural development in Asia over the past 30 years. Changes that ANRR set in place have contributed significantly to agricultural productivity increases and a reduction of poverty. ADB investments have paid large dividends, with much of these gains occurring in less-favored environments characterized by a high incidence of poverty. Furthermore, in such environments, investments in ANRR consistently give the highest return. These investments have the greatest impact on farmers' general welfare and poverty reduction.

As ADB is a key development institution in Asia, it has significant potential to expand its role in supporting ANRR in Asia. Additional funding for IARCs would allow ADB to participate in a broader portfolio of research projects to better promote its ANRR policy agenda. This could include (i) practices and policies for more sustainable natural resource management; (ii) socioeconomic research to better understand linkages among ANRR, poverty reduction, income distribution, and impacts of ANRR on the economic and nutritional status of women and children; and (iii) rural investment policies to complement technological progress in agriculture. Projects in ANRR need to be better designed to encourage collaborative effort among IARCs, NARSs, and other DMC research agencies with the capacity to contribute to multidisciplinary field level research in the above area.

Specific recommendations include the following: (i) the ANRR policy agenda should focus on ADB's main thrust of development objectives and closely focus on pro-poor growth, poverty reduction, and environmental protection. To have a sharper focus, this agenda needs refinement and should concentrate on developing sustainable farming systems for poor farmers, ensuring sustainable management of natural resources, enhancing agricultural productivity, and strengthening institutional and technical capacity of NARSs; (ii) ADB should adopt a two-pronged ANRR strategy i.e., TA funding for IARCs focusing on cutting-edge research which would bring about new breakthroughs and a quantum jump in agricultural productivity, as well as a focus on networking with NARSs for effective dissemination of research results. Parallel to it, loan funding should be provided to NARSs, local universities, and interested nongovernment organizations for in situ adaptive research on sustainable farming systems, management of natural resources, variety trials, environmental protection, and socioeconomics, etc.; (iii) ADB should continue the current restrictive funding modality but adopt a cluster TA project-processing approach providing TA funding of about $20 million in real terms once every three years to the IARCs and NARS; (iv) ANRR activities should focus on areas of high poverty incidence and areas with a less-favored agro-ecological environment in DMCs; (v) ADB should strengthen its capacity to supervise, monitor, and evaluate ANRR TA project activities by providing adequate resources for processing and administration functions; and (vi) ADB's agriculture and programs departments should undertake active policy dialogues with DMCs at ADB's annual country programming mission and other policy dialogue missions to ensure that DMC governments give significant emphasis to ANRR and provide adequate staff and financial resources for ANRR activities.

I. INTRODUCTION

A. Background

1. Rural development, improving productivity through advancement of production technologies, and natural resources management are major priorities in the developing member countries (DMCs) of the Asian Development Bank (ADB). During the past three decades, DMCs managed to increase food production to meet the demands of a growing population (DMCs' population in the Asian and Pacific region more than doubled from 1.4 billion in 1950 to 3 billion in 1997). This was made possible by the breakthrough made in the so-called "green revolution." A technological package comprising material components of two high-yielding varieties of cereals (rice and wheat), irrigation, fertilizers, pesticides, extension, and management skills was responsible for much of the significant increase in agricultural productivity. The green revolution embodied a major technological achievement, which resulted, over the period 1962 to 1990, in a 123 percent increase in rice production, and a 338 percent increase in wheat production, in DMCs. The effects of the green revolution have also extended to other crops such as maize, millets, pulses, oilseeds, vegetables, and perennial crops.

2. One significant feature of the green revolution effect was that over the period 1970 to 1995, cereal production in Asia almost doubled.[1] This increase in cereal production was derived mainly from a doubling of yields. The cereal area harvested increased by only 4 percent. This implies that had the cereal yield stagnated at the 1970 level, it would now take twice the crop area to produce the same amount of cereal output to feed the population in Asia. However, as the population increases, the challenges for increasing food production in the Asian and Pacific region during the next three decades are much more difficult.

3. Major problems confronting the development institutions are, among others, (i) the urgent need to increase food production by more than 75 percent to meet the demand of an additional 1.5 billion people by 2025; (ii) the need to develop crop and livestock technologies to improve productivity, particularly in rain-fed areas; (iii) the need to provide food to feed large numbers of poor and undernourished people in the decades to come (estimated at 800 million); (iv) land scarcity meaning that incremental food production must be derived from further increases in yields per unit area; (v) the pressing need to avert the current decline in growth rates of crop yields; and (vi) threats from large-scale deforestation and degradation of land and water resources, limiting potential for increased food production.

4. Agricultural growth is vital to bring about a number of economic transformations, such as an increase in supply of basic foods and raw materials for agro-industry and export, and to release foreign exchange for the importation of strategic industrial and capital goods. It releases labor and capital to the nonfarm sector. The basic point is that agricultural growth must be accelerated in Asia. A key factor to help boost it is public and private investment in agricultural research and extension. These are likely to provide a continuous stream of yield-enhancing technologies for farmers. The impact of the green revolution has diminished, and new scientific breakthroughs, such as may be offered by biotechnology, are now required to raise yields. This is especially important because land and water resources are becoming scarce in the Asian and Pacific region and future agricultural productivity increases will have to come from already cropped land. Agriculture and natural resources research (ANRR) conducted by various

[1] ADB. 2000. *Rural Asia: Beyond the Green Revolution*. Manila.

international agricultural research centers (IARCs) and national agricultural research systems (NARSs) in the DMCs will help overcome these problems in the coming decades.

5. Agricultural research has been a major concern of ADB since 1975 when three regional technical assistance (RETA) projects amounting to $739,000 were approved.[2] The rationale for this support was the surge in demand for products from the initial research breakthroughs of the green revolution. ADB support recognized the need for accelerating this work while providing support to IARCs, NARSs, and other regional research institutions.

6. ADB's involvement in agricultural research was modest in the late 1970s and early 1980s (Appendix 1). During this period, there was no focus or appropriate policy to guide ADB's funding in this sector. In June 1983, a Board Paper on agriculture and rural development was approved providing guidance on ADB's priorities to fund agricultural research activities.[3] The main rationale for ADB support for agricultural research was to meet the increasing food requirements of the Asian and Pacific region. Through increased food production, agricultural research contributed toward poverty reduction, one of ADB's major strategic objectives. Funding over the period 1983-1995 varied in the range of $2 million-$3 million per annum. From 1996 to the present, ADB's support to agricultural research has increased to about $6 million annually (Appendix 1, Table A1.1).

7. ADB's priorities and emphasis to fund agricultural research became more focused in 1995 when its policy paper on ANRR was adopted.[4] This paper recognized that research on agriculture and renewable natural resources conducted by various IARCs and NARSs has contributed substantially to the development process of most DMCs.

B. Objectives and Scope

8. The purpose of this study is to assess and evaluate the relevance, effectiveness, and impacts of ADB's policy on ANRR and to determine whether ADB's research projects have contributed to the achievement of its strategic objectives. The study objectives are to (i) assess the appropriateness of ADB's ANRR policy and contribution to support ANRR, (ii) evaluate the effectiveness of implementation and impact of ADB-funded research activities and projects, and (iii) determine the adequacy of ADB-financed ANRR activities in meeting ADB's policy requirements.

9. The study scope includes the following: (i) review and assess ADB's role and contribution to support ANRR; (ii) evaluate the implementation performance and effectiveness of ADB-funded research activities and projects; (iii) undertake a critical assessment on how the outcomes of ANRR have complemented ADB's financing in development projects; (iv) determine the adequacy of ADB-financed ANRR activities in meeting ADB's policy requirements; (v) determine the adequacy of ADB supervision, and monitoring and evaluation measures in implementing ADB-financed ANRR projects; (vi) evaluate potential economic impacts of the ANRR activities; (vii) evaluate the capacity of executing agencies to implement ANRR projects and programs; (viii) provide feedback and identify best practices to enhance ADB's future role in the region's ANRR; (ix) recommend appropriate refinement in ADB's policy on ANRR as necessary; and

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[2] RETA 5026: *International Rice Research Institute*, for $300,000, approved on 20 February 1975; RETA 5027: *Outreach Programs in Vegetable Research in Korea, Philippines, and Thailand*, for $390,000, approved on 15 April 1975; and RETA 5032: *Fish Market Study*, for $49,000, approved on 30 October 1975.

[3] R71-83: *Review of the Bank's Role in Agriculture and Rural Development*, 3 June.

[4] R2-95: *The Bank's Policy on Agriculture and Natural Resources Research*, 1 August.

(x) examine future needs for ANRR activities that could contribute toward achieving ADB's goal of reducing poverty in the region.

C. Approach and Methodology

10. The approach was to examine first current ADB policy on poverty reduction and assess the contribution that ANRR makes toward this strategic goal. Appropriateness and relevance of the current ANRR policy were examined for each of the policy agenda items. ADB funding of ANRR through RETA modality was then examined for its appropriateness and adequacy in administration and supervision. As part of the desk review, brief summaries on implementation performance, project focus, and geographic coverage of each technical assistance (TA) project were made. Given the range of TA activities supported, the long period that has elapsed for many TA projects, and lack of detailed impact measures and documentation, it was not practical to undertake detailed impact assessments for each project. Instead, an impact assessment of a sample of recent ANRR TA projects funded by ADB was carried out.

11. The projects in this sample were identified and grouped together under a common theme. TA projects that supported a similar line of work over a long period of time with ADB contributing at least $2 million to the research were selected. Four common themes were identified for economic impact assessment. The first theme evaluated was a single commodity research project focusing on productivity improvement in both less-favored and more-favored areas. The International Rice Research Institute (IRRI) with various collaborative NARSs did this. The second theme was a series of multi-commodity research projects focusing on increasing productivity of crops grown in less-favored environments, particularly under rain-fed conditions. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) carried this out. The third theme was a multi-commodity crop improvement program on vegetables using Asian-based networks (Asian Vegetable Research and Development Center [AVRDC]). The fourth theme was the improvement of fishery systems through genetic research, also using Asian networks. The International Center for Living Aquatic Resources Management (ICLARM) was responsible for this. Total funding for projects assessed at these four centers was about $11 million or 16 percent of all TA funding for ANRR by ADB since 1975.

12. The impact evaluation methodology used in the study is described in Appendix 2. For this assessment, the economic surplus method is used. This methodology is preferred because the economic surplus concept underlies the conventional economic rationale for investments in agricultural research through the public sector. This approach estimates returns on investments (generally a weighted average rate of return over time) by (i) calculating the change in consumer and producer surpluses that result from technological change brought about through research, and (ii) using estimated economic surplus together with research costs to estimate the net present value of the initial investments.

13. The study team comprised a senior evaluation specialist from the Operations Evaluation Office and two ANRR consultants. The team conducted a literature review of relevant ANRR TAs and other documents, interviewed ADB staff, conducted field visits to IARCs and NARSs, and completed a survey of questionnaires for the IARCs participating in the impact assessment. The field visits were carried out during April-June 2000.

II. ADB POLICY ON ANRR

A. Evolution of ADB Policy on ANRR

14. A 1983 Board Paper (footnote 3) set out the priorities for ANRR support with the primary objective of increasing food supplies to meet the growing regional demand for foodgrains. Secondary objectives were to use ANRR to contribute to poverty reduction through employment creation, export promotion, and import substitution. These guidelines supported ADB's wider development objectives of that time and supported DMCs in meeting their foodgrain production objectives. In the 1990s, attention turned to rising concerns about the persistence of poverty and population pressure relative to highly degraded and increasingly scarce land and water resources. This led to ADB formulating five strategic development objectives used in its first Medium-Term Strategic Framework (1992-1995), i.e., (i) promoting economic growth, (ii) supporting human development, (iii) alleviating poverty, (iv) improving the status of women, and (v) improving management of natural resources and the environment. Based on these strategic framework objectives, the 1995 ADB policy paper on ANRR was formulated. Investment in ANRR is expected to contribute in varying degrees to all these objectives, but the key areas for ADB support of ANRR will be reducing rural poverty, enhancing gender development, and protecting the environment.

15. The ADB policy for ANRR (footnote 4) comprises six main agenda items including (i) sustainable and remunerative farming systems for poor farmers, (ii) enhancing the incomes and living standards of rural women, (iii) sustainable management of agricultural and natural resources, (iv) enhancing the productivity of agriculture, (v) enhancing the capacity of national research systems, and (vi) public policy and socioeconomic research. The policy objectives are to be achieved both through funding for ANRR channeled through the Consultative Group on International Agricultural Research (CGIAR) to various IARCs and NARSs as well as a limited number of special grants to regional research centers outside the CGIAR system. Lending and TA operations are to focus on high-yield technology for less favorable environments and for crops with high-yield potential. Particular attention will be paid to (i) rain-fed farming; (ii) neglected crops; and (iii) integration of crop, livestock, and forestry activities.

16. Is the 1995 ANRR policy still compatible with ADB's current strategy? As an institution whose purpose is the economic development of the region, ADB has always been concerned with poverty reduction. Reduction of poverty is no longer just one of five strategic development objectives; it is ADB's overarching goal. To this end, the other strategic objectives (i.e., economic growth, human development, improving the status of women, and sound environmental management) are pursued in ways that contribute to poverty reduction. Within this general framework of poverty-reducing interventions that stimulate pro-poor sustainable growth, ADB is mainly concerned with interventions having a medium- to long-term impact.

B. Assessment of Current ANRR Policy Agenda

17. The ANRR policy is focused on six main agenda items. An assessment of each item is made below.

1. Sustainable and Remunerative Farming Systems for Poor Farmers

18. Poor farmers contribute substantially to crop production and play a critical role in the conservation and sustainable management of agriculture and natural resources. They form the bulk of the economically-disadvantaged population in the Asian and Pacific region. ANRR focuses on raising the income levels and living standards of this group. This agenda item focuses on improving sustainable incomes through multidisciplinary research on farming systems incorporating crops, livestock, forestry, and fisheries, or a combination of these. ADB has targeted research funding on those areas that offer opportunities for enhancing the status of women and on those crops and farming systems that take into account the gender division of labor in the farm household. The specific areas of research to raise the living standards of disadvantaged groups include (i) development of modules on sustainable farming systems; (ii) low input regenerative and organic cropping, and farm management practices; and (iii) postharvest loss reduction. This agenda item is appropriate and relevant to achieving ADB's strategic goal of poverty reduction, and should be continued.[5] A review of RETA grants to CGIAR centers and TA grants to three non-CGIAR centers from 1996 to 2000 indicated that about 8 percent of ADB funding went directly to this agenda item.[6] Over the past two decades, NARSs have been conducting in situ adaptive farming system research, and in many cases, in collaboration with IARCs. They have a comparative advantage in terms of cost and local agro-ecological knowledge, and are in the best position to conduct this type of research.

2. Enhancing the Incomes and Living Standards of Rural Women

19. Women play an important role in agricultural production and postharvest processing in addition to their household activities. However, rural women's lack of access to land, farm implements, credit, and skill enhancement, plus gender discrimination, keeps them among the poorest of the poor. To address these problems, the 1995 ANRR policy encouraged analysis of (i) the status of women and the gender division of labor; (ii) the social, cultural, and economic constraints faced by rural women and ways to reduce these constraints; and (iii) proactive public policies for raising the living standards and status of women. The review of ADB funding from 1995 to the present found no TA for ANRR directed specifically to these topics. This is because no CGIAR or regional research centers have specialized expertise in this area. A literature review (Appendix 3) indicates that the relationship between agricultural research, increased productivity, and the economic status of women is complex. On balance, however, increased farm and nonfarm incomes and employment have improved the economic status of women. Relationships between labor utilization patterns due to changes in agricultural technology and living standards are also complex, and must take into account intrahousehold allocation of resources, women's overall work burden, women's access to any increase in household earnings, women's consumption, and the health and well-being of children. This agenda item has not yielded any output under ADB's support for ANRR as IARCs have little or no expertise in conducting this aspect of research. The effectiveness of ANRR policy would be more enhanced if a focus could be made on agricultural productivity increases and the provision of better agricultural technology to poor farmers and those in less-favored environments. Such an approach would contribute to improving incomes and living standards of rural women. Thus, this agenda item requires refinement.

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[5] Appendix 3 provides a literature review indicating the linkages between improving productivity of smallholder farming systems and reducing rural poverty.

[6] Appendix 4, Table A4.3 details current RETA grant funding. A review of research project objectives relative to the six main agenda items was made. The budget was then allocated among these six items.

3. Sustainable Management of Agricultural and Natural Resources

20. This policy agenda item focuses on three major areas. The first is agricultural resources, where priority is given to research designed to increase yields with technologies that are environmentally benign but that allow for cost-effective and sustainable production. The second area is biodiversity and forest conservation where ADB funding emphasizes participatory management approaches involving forest dwellers who depend on forest resources for their livelihood. The third area is fisheries and fishery resource management, where research helps reduce poverty in fishing communities and ensure sustainable management of fishing resources, both in inland and coastal waters. This agenda item has played a vital role over the past few years for IARCs to generate improved agricultural technology and has contributed to significant agricultural productivity gains. Approximately 34 percent of ADB grants to IARCs from 1996 to 2000 went to this agenda item, and all three of the major areas defined above have received one or more grants of over $1 million each.[7] This agenda item is relevant and appropriate. It falls under the themes of (i) pro-poor sustainable growth using better policies to improve management and conservation of natural resources; and (ii) social development focusing on developing social capital to assist community-based organizations involved in natural resource management, land reform, security of tenure, and property rights.

4. Enhancing the Productivity of Agriculture

21. This agenda item supports farm productivity by increasing the yield of food and cash crops in an environmentally sustainable manner in less-favored production environments. Key research areas identified are (i) development of high-yield varieties of food and cash crops, (ii) more efficient and nutritionally important cropping systems, (iii) plant nutrition, and (iv) postharvest technologies. About 44 percent of TA grants since 1995 have been allocated to this item although not all of the funding went for research targeted specifically for less-favored areas. The high proportion of ADB funding for this agenda item has resulted in the majority of IARCs focusing in collaboration with NARSs, on crop and fisheries improvement research. Research on hybrid rice and vegetable production is typically more fruitful for better environments than the less-favored areas. This agenda item is relevant and appropriate to support pro-poor economic growth that focuses on policy instruments supporting labor-intensive rural growth, including development of less-favored areas.

5. Enhancing the Capacity of NARSs

22. This agenda item supports intensified interaction and collaboration among NARSs at different levels. More specifically, it promotes the strengthening both of capacity of NARSs to undertake multidisciplinary and systems approaches to ANRR, and of collaboration between public and private institutions. ADB supports capacity building within NARSs to address issues relating to poor farmers, women, and sustainable management of natural resources. By design, every project that ADB funds helps to enhance NARS capacity through provision of financial assistance, equipment, training, skills and technology transfers, material transfers, and publications. Projects with this agenda as the focal area represented about 9 percent of funding

[7] RETA projects to ICLARM for $1.4 million, ICRISAT for $1.25 million, International Water Management Institute for $1.25 million, International Center for Agricultural Research in the Dry Areas for $1.2 million, International Centre for Research in Agroforestry for $1.2 million, and Center for International Forestry Research for $1.1 million (Appendix 4, Table A4.4).

during 1996-2000. However, as all the TA projects provided some funding to collaborating NARSs, the proportion estimated is closer to 20 percent. ADB's support through the TA and loan mechanism has significantly improved management of NARSs, particularly priority setting, human resources management, and research-extension linkages. The easier reforms have been done but the difficult issues of adequate funding, flexibility, incentives, autonomy, and private sector cooperation are still present. This agenda item is relevant and appropriate, and contributes toward social development that emphasizes human capital development and increased capacity for social capital issues. Another role is the promotion of good governance for improving public expenditure policy and management of NARSs.

6. Public Policy and Socioeconomic Research

23. Inclusion of this area as a policy agenda item reflects the need for better public policy on trade, technological, and social issues supporting agricultural development and natural resource management. Policy research supports work on the consequences of new trading arrangements, discrimination against agriculture, and structural adjustment impacts on the poor and on natural resource degradation. Social issues are also studied, including impacts of land tenure on control of resources and empowerment of the poor, including women. Research on participatory approaches and impact of public policy on users of natural resources is needed. Again, while many projects had a public policy and socioeconomic component, funding for this agenda as the principal thrust represented about 5 percent of ADB TA funding during 1996-2000. As part of ADB's overarching goal of poverty reduction, this agenda item will be more important in terms of (i) promoting pro-poor sustainable economic growth, (ii) supporting research on policies to remove market-distorting incentives, and (iii) supporting research on economic and institutional policies to improve natural resources management. The agenda item will need to include more work on decentralized structures for natural resource management under the good governance strategic issue. It will also promote social capital by assessing the effectiveness of community-based organizations involved in natural resource management, land reform, property rights, and economic status of women and children. Public policy and socioeconomic research will be needed on the most appropriate macroeconomic framework to support agriculture and rural development.

C. Future ANRR Policy Agenda

24. The six agenda items of ANRR policy given above are comprehensive and in line with the central thrust of ADB's long-term goal of poverty reduction. Over the last five years, the ANRR policy has led to significant improvements in the identification, preparation, and implementation of numerous highly relevant ANRR TA projects conducted by IARCs in collaboration with NARSs (Appendix 3). The ANRR policy (i) provided guidelines and criteria for conducting specific projects which led to improved agricultural technology (both onfarm production and postharvest processing); and (ii) increased farm productivity and consequently poor farmers' incomes, particularly those in less-favored environments. ANRR helps to produce the technology and knowledge necessary for sustainable agricultural development which is necessary for economic growth in rural areas. A dynamic rural sector characterized by steady increases in agricultural productivity is an effective instrument for reducing poverty and improving food security in countries where the majority of the poor are in rural areas. The increased supply of food due to ANRR also results in lower food prices for both poor rural and urban consumers who spend proportionately more of their income on food. Rapid growth in more-favored areas has increased labor demand and wages there and has attracted labor from less-favored areas, leading to more wage equalization in rural areas. However, the overall

benefits have been most pronounced in more-favored areas. Limited progress has been made in addressing poverty, food security, and natural resources management in the more difficult areas.

25. The six ANRR agenda items overlap and even contradict each other in some areas. For example, IARCs do not focus research efforts specifically on development of technologies to enhance the incomes and living standards of rural women. This tends to be a secondary effect of research which leads to increased productivity of agricultural, fishery, or forest resources. Increasing productivity of agriculture can have uncertain effects on households, depending on their degree of participation in food and labor markets. However, lower food production costs could also be accompanied by slow increases in rural wages and rural employment. The nature of public policy and socioeconomic research allows it to contribute to or accelerate progress toward the other five agenda items but it does not in itself contribute to ADB's overall strategic objectives in the agriculture sector.

26. Given ADB's limited resources to contribute to ANRR (para. 60), a sharper focused agenda that follows more closely ADB's overarching goal of poverty reduction is required. In the rural sector, this means that three goals must be achieved: growth that is rapid, pro-poor, and environmentally sustainable. ANRR is well suited for this task. Improvements in the quality of life require a high degree of complementarity among the three goals.

27. A more refined ANRR agenda could be an effective tool for reducing poverty through enhancing productivity increases in less-favored areas, by targeting investments for research on technology known to increase the economic status of the poor, and by increasing research in areas prone to rapid resource degradation. The potential impact has yet to be fully realized because of weaknesses in NARSs and extension systems, and difficulties farmers face in securing the right mix of inputs to realize maximum returns. Degradation in intensifying systems is also evident.

28. Based on the above assessment, the future ANRR policy agenda should focus on (i) sustainable and remunerative farming systems for poor farmers, (ii) sustainable management of agricultural and natural resources, (iii) enhancement of agricultural productivity, (iv) strengthening of the capacity of NARSs and other DMC research agencies, and (v) improvement of public policy and socioeconomic research.

III. ANRR FUNDING AND EFFECTIVENESS OF TA IMPLEMENTATION

A. ADB Support for ANRR Systems

29. ADB's policy on ANRR has been implemented for about five years and funding of ANRR projects has expanded significantly over this time. Funds are put through TAs, using RETA grants for CGIAR centers and individual TAs for other centers based on proposals submitted by IARCs. Since the ANRR policy has been in effect, four RETAs have been processed with an ADB funding commitment of about $21.9 million, and another $26.4 million contributed to the projects from other sources (Appendix 4, Table A4.4). Altogether, 14 eligible CGIAR centers have received funding through the RETA process. Other grants outside the CGIAR system have been made to AVRDC (three grants for $1.75 million), International Board for Soil Research and Management (IBSRAM—one grant for $1.3 million), and International Centre for Integrated Mountain Development (ICIMOD—one grant for $600,000).

30. ADB support to IARCs was formalized as part of its 1995 policy on ANRR. The framework for providing support is through research in the areas of (i) increasing productivity; (ii) protecting the environment; (iii) saving biodiversity; (iv) socioeconomic, public policy, and management research; and (v) fortifying national programs. CGIAR's research agenda conforms closely with the key research issues of strategic concern to ADB. This linkage is given in Appendix 3. Given this confluence of interests, the quality of ADB's agricultural research projects would be enhanced if a reasonable level of ADB investment were channeled through the CGIAR system. Within the context of this system, ADB is currently providing RETA funding once a year covering research projects at several CGIAR centers. Other beneficiaries of ADB support include non-CGIAR centers and NARSs. They are now described.

1. CGIAR System

31. The rationale for the system of IARCs is derived from international spillover effects, the efficiencies of working freely across national boundaries for many research products, the productivity-boosting effects of scientific collaboration, and cost-reducing effects of sharing information and research materials (particularly genetic material). The CGIAR system was established on 19 May 1971. It is an association of 59 public and private sector investors supporting 16 IARCs located in 12 less-developed and three developed countries.

32. Poverty reduction is the guiding principle of CGIAR-supported research. CGIAR conducts impact assessments to ensure that its research contributes to fighting poverty. Soil and water management, agroforestry, agronomics, and the application of research directed at reducing the use of chemicals in agriculture are key priorities in efforts to nurture the environment. Biodiversity remains a major concern of CGIAR which holds in trust for the future one of the world's largest ex situ collections of plant genetic resources. Research alliances mobilize biotechnology to ensure that it can contribute to more sustainable agricultural growth in developing countries, with special care devoted to issues such as ethics, safety, and the access of developing countries to biotechnology products.

33. ADB's overarching goal of poverty reduction is in close alignment with the current CGIAR focus. A recent report prepared by the technical advisory committee of CGIAR recommended that CGIAR concentrate on reduction of poverty, hunger, and malnutrition in developing countries, and give highest priority to the research needs of South Asia and Sub-Saharan Africa.[8]

2. Summary of Main CGIAR Centers Receiving ADB Support for ANRR

34. ADB's first TA project with a CGIAR center was at IRRI in 1975 for buying equipment for its training center (Appendix 1). This was followed by small grants of less than $1 million per annum in total between 1976 and 1982. From 1983, the number and total sum of grants increased substantially to reach $4.2 million in 1990. Since the ADB policy on ANRR was approved in December 1995, four RETA grants have been processed with each RETA supporting several CGIAR center projects. RETA amounts approved for CGIAR center projects are between $5.2 million and $5.6 million annually. So far, ADB has supported 19 CGIAR center

[8] Examples of recent CGIAR documents are CGIAR. May 2000. *Charting the CGIAR's Future: A New Vision for 2010*. Dresden, and CGIAR. May 2000. *A Food-Secure World for All: Toward a New Vision and Strategy for the CGIAR (Companion Paper on Priority Research and Related Activity Themes)*, CGIAR Mid-Term Meeting 2000. Dresden.

projects at a total cost of $21.9 million. Contributions from the CGIAR centers, NARSs, and other donors amounted to another $26.4 million (Appendix 4, Table A4.4). As of 30 June 2000, ADB had disbursed a total of $10.8 million to the CGIAR centers, representing about 49 percent of the total approved RETA amounts of $21.9 million.

35. In terms of total funding budget, ADB support for CGIAR centers is low. For instance, the worldwide total CGIAR system budget in 2000 is about $390 million, of which expenditures in Asia will be about $123 million. ADB RETA funding for CGIAR centers in 2000 is $5.6 million, about 1.5 percent of the total CGIAR budget, and about 4.5 percent of the CGIAR budget for Asia. ADB funding represents a small contribution to internationally-supported research. In contrast, the World Bank provides core funding to the worldwide CGIAR system of about $45 million or 11.5 percent of the 2000 budget, significantly above the ADB contribution. Appendix 4, Table A4.4 provides details on recent ADB funding for CGIAR centers, including matching contributions from NARSs and other donors. ADB funding for ANRR is constrained by its pool of RETA funding available for DMCs and IARCs. (This is further discussed in para. 62).

36. IRRI, ICRISAT, ICLARM, and International Water Management Institute (IWMI) are the main recipients of ADB support for ANRR under the CGIAR system.

37. **International Rice Research Institute.** IRRI is located in Los Baños, Philippines. It is a nonprofit agricultural research and training center established to improve the well-being of present and future generations of rice farmers and consumers, particularly those with low incomes. It is dedicated to helping farmers in developing countries produce more food on limited land using less water, less labor, and fewer chemical inputs, without harming the environment. IRRI's objective is to generate and disseminate rice-related knowledge and technology with short- and long-term environmental, social, and economic benefits, and to help enhance national rice research systems.

38. IRRI's interdisciplinary research programs concentrate on the three major rice ecosystems: irrigated, rain-fed lowland, and upland. A fourth, the cross-ecosystems research program, focuses on research to generate knowledge applicable to several, or all, programs. Current projects include developing new plant types for the major rice ecosystems, rice genome studies, sustainability and biodiversity in rice, soil and nutrient management in different rice-growing environments, integrated pest management, and effect of global warming trends on rice growth. IRRI's institutional capacity is well developed with regular program reviews conducted by the technical advisory committee of CGIAR, strong linkages with NARSs, and country offices in many Asian countries. They also have country projects funded by donors in Cambodia and Lao People's Democratic Republic.

39. A list of ADB-funded projects conducted by IRRI is given in Appendix 1. ADB has provided about $15.39 million to IRRI, or about 2 percent of IRRI's total funding since 1975. Since then, ADB funding has supported rice research for less favorable environments (37 percent), integrated pest management (20 percent), research in biotechnology (18 percent), infrastructure (10 percent), hybrid rice (10 percent), and publishing and material dissemination (5 percent).

40. **International Crops Research Institute for the Semi-Arid Tropics.** ICRISAT was established in 1972 as a center under CGIAR. It is located in Hyderabad, India and has approximately 1,300 staff with an annual budget of about $26 million. ICRISAT's mandate is to help developing countries apply science and technology to increase crop productivity and food security, reduce poverty, and protect the environment. ICRISAT focuses on the semi-arid

tropical areas of the developing world, where low rainfall is the major environmental constraint. It emphasizes five crops that are particularly important in the diets of the poor in semi-arid regions: sorghum, millet, groundnut, chickpea, and pigeonpea. Coarse cereals and grain legumes are the major food crops in the arid and semi-arid tropics and have strong potential for improving the income of poor farmers in these areas. Grain legumes are also the major source of vegetable proteins, vitamins, and minerals. Vegetable proteins are the cheapest source of protein and especially important for vegetarians and the poorer sections of the population with limited disposable income. During the last two decades, the increase in area and yield of coarse cereals and grain legumes has been marginal compared with the increase in area and yield of rice and wheat. Moreover, important constraints in coarse cereal and grain legume production, such as unimproved cultivars, damage by pests and diseases, inadequate irrigation, and inappropriate crop management practices have hindered productivity increases. Research at ICRISAT has recently made significant advances in breeding high-yielding, early maturing varieties of its mandated crops and has identified solutions to many production management problems. It has developed many improved technologies that have been adapted to fit the needs of poor farmers in Asian countries. This is shown by the significant increases (10-100 percent) in yields of major coarse cereals and grain legumes.

41. ADB funding for ICRISAT to date amounts to about $7.2 million since the first grant in 1976, or slightly less than 1 percent of total ICRISAT funding. A list of ADB-funded ANRR projects is given in Appendix 1. Through ADB funding for ICRISAT, projects have (i) facilitated and catalyzed the development, testing, and adoption of improved technologies in DMCs; (ii) strengthened regional collaboration and network development with NARSs; and (iii) enhanced programs in coarse cereal and grain legume research. ADB has also provided support for research infrastructure at the genetic resources unit. Major projects supported by ADB include (i) strengthening grain legume research in South Asia; (ii) strengthening the genetic resources unit at ICRISAT; (iii) strengthening regional collaboration on cereal and legume research; (iv) developing legume-based technologies for rice-wheat production systems; (v) improving management of natural resources for sustainable rain-fed agriculture; (vi) establishing a biotechnology and training unit; and (vii) strengthening chickpea research in Pakistan, and adapting and producing pigeonpea varieties in Sri Lanka.

42. **International Center for Living Aquatic Resources Management.** ICLARM is an international scientific and technical center with responsibility to conduct, stimulate, and accelerate research on all aspects of fisheries and other living aquatic resources. It was conceived by the Rockefeller Foundation in 1973, and became a small program of the University of Hawaii in 1975. It was incorporated in Manila in March 1977 and became a member of the CGIAR system in May 1992. It moved its headquarters to Penang, Malaysia in 1999. ICLARM's work focuses on inland aquatic (mainly ponds and rice floodwaters) and marine (coastal and coral reef) systems of fisheries production in developing countries. Its main research is on ecosystem dynamics, investigating alternative management schemes, and improving the productivity of key fish species. The work includes cooperative research with institutions in developing countries, and supporting activities in information and training with NARSs.

43. Today, global fisheries are faced with the twin challenges of declining fish stocks and an ever-increasing demand for fish. In many parts of the world, including Asia, capture fisheries are reaching production limits that their resources cannot sustain. Many conventional fish stocks and fishing areas are overexploited or face the prospect of depletion. As production of capture fisheries continues to level off, aquaculture and the efficient and sustainable management of fish stocks assume a vital role in sustaining fisheries production.

44. ADB-funded projects directly address major concerns of the fisheries sector, including (i) genetic improvement of tilapia species in Asia, (ii) dissemination and evaluation of genetically-improved tilapia to DMCs, (iii) review of sustainable exploitation of coastal fish stocks in Asia, (iv) genetic improvement of carp species in Asia, and (v) sustainable management of coastal fish stocks in Asia. ADB funding for seven ICLARM projects has amounted to about $4.3 million or some 5 percent of ICLARM's budget since it joined the CGIAR. ADB's support has gone to genetic improvement of aquaculture species (55 percent), fish stock assessment and management (35 percent), rice-fish systems (8 percent), and research on alternative energy sources for fisheries (2 percent).

45. **International Water Management Institute.** IWMI is a scientific research organization based in Colombo, Sri Lanka, and is dedicated to studying the issues of sustainable and productive use of water resources, particularly as they relate to agriculture, water scarcity, and food security in the developing world. It is the only organization of its kind whose priority is to provide the scientific information necessary to help developing countries reduce poverty through more effective management of their water resources. It started operations as the International Irrigation Management Institute (IIMI) in 1983 with ADB providing a founding grant of $500,000; it joined CGIAR in 1991. It changed its name to IWMI in recognition of the larger role it needs to play in overall water research worldwide. The objectives of IWMI are to (i) identify the larger issues related to water management and food security that need to be understood and addressed by governments and policymakers; (ii) help developing countries build their research capacities to deal with water scarcity and related food security issues; (iii) clarify the link between poverty and access to water and help governments and the research community better understand the specific water-related problems of poor people; and (iv) develop, test, and promote management practices and tools that can be used by governments and institutions to manage water resources more effectively, and to address water scarcity issues.

46. ADB used IWMI extensively to carry out advisory TA related to loan projects in Indonesia, Pakistan, Philippines, and Sri Lanka (Appendix 1, Table A1.1). These TA studies were closely linked to the irrigation sector and had little emphasis on research in a traditional sense. In recent years, IWMI has played an important role in addressing issues relating to water scarcity. Until recently, the majority of DMCs had invested heavily in water development as a major engine for agricultural growth. However, the very success of these investments, coupled with success in agronomic improvements, has reduced food grain prices while releasing large amounts of water needed in other sectors of the economy. DMCs must urgently examine their policies, institutions, and strategies for the water sector. Since 1983, ADB has provided funding to IWMI for 13 TAs amounting to $5.89 million, or about 5 percent of its total budget since joining CGIAR in 1991 (Appendix 1).

3. Non-CGIAR Centers

47. The ADB policy paper on ANRR notes that support to the CGIAR system will not exclude other specialized research areas or institutions outside the CGIAR system. It also states that individual TA and loan projects will continue to be used to fund other research proposals or programs of interest to ADB. The inclusion of loans and advisory TAs for research in country programs is normally discussed and agreed upon during country strategy and program discussions with DMCs. This usually includes adaptive research following earlier IARC collaboration.

48. Several regional research centers, training centers, and ANRR-related organizations exist in the Asian and Pacific region. These are very diverse in size, mandate, and capacity. Some of them have received ADB support over the past 25 years. Appendix 1, Table A1.1

shows ADB's funding for non-CGIAR centers and other DMC organizations for research, training, workshops, and special studies. Since ADB support for ANRR began in 1975, 29 percent of all ADB funding for ANRR has gone to non-CGIAR institutions (Appendix 1, Table A1.3).

49. All non-CGIAR centers, except AVRDC, suffer from size and budget constraints making them unable to recruit and maintain a critical mass of scientific expertise or to stake out a clearly defined role within the complex and often overlapping mandates of CGIAR centers. Non-CGIAR centers are also constrained by a lack of core funding from donor agencies for research programs. In contrast, a certain level of core resources are provided to CGIAR centers by the World Bank's grant program, which matches funding from other donors on a formula basis. This helps pay essential overheads, maintenance, and staff salaries. Among non-CGIAR centers, only AVRDC receives substantial core financial support from the authorities in Taipei,China. Some of the non-CGIAR centers that are main recipients of ADB TA funds for ANRR are now described.

50. **Asian Vegetable Research and Development Center.** The idea of establishing an international vegetable research institute in Asia was conceived by the United States Agency for International Development in the early 1960s. AVRDC came into official existence in May 1971 with the signing of a memorandum of agreement and a charter by representatives of ADB, People's Republic of China (PRC), Japan, Republic of Korea, Philippines, Thailand, United States, and Viet Nam. AVRDC was officially opened at a dedication ceremony in October 1973 and is located in Tainan, Taipei,China. ADB is one of the founding members of AVRDC and has since supported many of its regional activities. AVRDC's mission is to enhance the nutritional well-being, and raise the incomes, of poor people in rural and urban areas of developing countries through improved varieties and methods of vegetable production, marketing, and distribution, which take into account the need to preserve the quality of the environment. ADB funding to AVRDC since 1975 has consisted of 13 TA grants amounting to $5.5 million, the largest of any non-CGIAR center.

51. **International Board for Soil Research and Management.** Located in Bangkok, Thailand, IBSRAM is mainly responsible for conducting research relating to soil in developing countries. Since 1986, IBSRAM has received three research grants from ADB and one grant for a workshop (Appendix 1). Total funding by ADB is about $2 million, with all grants supporting research and outreach activities on sloping land and soil conservation. IBSRAM undertakes major research on (i) strategies, technologies, and practices for sustainable land management (SLM); (ii) improved methodologies and diagnostic tools for SLM research; (iii) methods for assessing and monitoring the social, economic, and environmental impacts of sustainable and unsustainable land-use systems; (iv) accessible decision-support systems (models, expert systems, geographic information system, global databases, etc.) for generating, testing, and extrapolating SLM options; (v) enhanced capacity of NARSs to undertake SLM research, development, and implementation; (vi) a framework for priority setting and research planning on SLM among collaborating NARSs, nongovernment organizations (NGOs), and other research agencies; and (vii) mechanisms for training and providing information on SLM.

52. IBSRAM has focused on unfavorable environments, particularly on sloping lands. RETA 5284 assisted primarily with items (i), (ii), (v), and (vii) above in selected Asian countries.[9] RETA 5400 and the current project RETA 5803 address all elements above.[10,11] IBSRAM is too

[9] RETA 5284: *Research on Management of Sloping Lands for Sustainable Agriculture*, for $600,000, approved on 14 April 1988.

[10] RETA 5400: *Research on the Management of Sloping Lands for Sustainable Smallholder Agriculture in the South Pacific*, for $262,000, approved on 24 August 1990.

small relative to the mainstream centers to fashion a clear mandate to make a widespread impact and it has overlapping mandates with several CGIAR centers, regional centers, and other IARCs. ADB funding currently accounts for about 13 percent of IBSRAM's total budget.

53. **International Centre for Integrated Mountain Development.** ICIMOD is located in Kathmandu, Nepal, and has received four grants from ADB since 1988 for a total of about $2.3 million. A grant for $600,000 was made in 1998. All TA projects deal with sustainable mountain agriculture, including sustainable soil conservation practices. ICIMOD's mandate is to improve livelihoods in the Hindu Kush Himalayas and it conducts interdisciplinary research working closely with mountain communities and NARSs. ICIMOD has no biological research facilities at its headquarters so it works with collaborating NARSs, NGOs, communities, and farmers. The typical mountain farming environment is under significant stress and is characterized by high levels of poverty, with limited application of most CGIAR research products. The main forces reducing poverty have traditionally been outmigration both of working-age males as well as whole families.

4. Relevance of ANRR Projects Conducted by IARCs

54. Another aspect of the impact assessment was the degree to which IARCs' research agendas coincide with ADB's policy on ANRR. The research agendas for the CGIAR centers are elaborated in their medium-term plans and ADB considers these agendas in selecting specific projects for funding. An attempt to relate the research agendas of RETA-funded projects to ADB's ANRR policy agenda is made in Appendix 4, Table A4.5, which shows that a number of IARC research topics are highly relevant to ADB's ANRR policy agenda items. Such topics are in the areas of sustainable and remunerative farming systems for poor farmers, sustainable management of agricultural and natural resources, enhancing the productivity of agriculture, and enhancing the capacity of national research systems. Fewer projects relate to enhancing the incomes and living standards of rural women, and public policy and socioeconomic research. For the former item, this is because no IARC has a mandate dealing specifically with it, while for the latter, it is because of the small number of grants made to the International Service for National Agricultural Research (ISNAR) and the International Food Policy Research Institute (IFPRI), the two centers that deal primarily with policy and socioeconomic research. Detailed analysis of linkages between ANRR outputs and improvement in income level and poverty reduction, as presented in Appendix 3, also supports the above assessments on the relevance of ANRR conducted by IARCs.

B. ADB's Focus of ANRR

55. ADB provides support to IARCs as part of its strategic framework for ANRR. Most DMCs do not yet have the capacity or resources to undertake needed research without strong international support and partnerships. Developing countries in general underinvest in ANRR because they are unable to capture the full benefits of their investment due to high spillover effects across countries. For example, research funded by the Indian Government has provided crop varieties that are used extensively by their neighboring countries, and yet the countries have borne none of the development costs. Investments by ADB would help to make up for this underinvestment. To absorb funds needed to reduce the underinvestment gap, strong public

[11] RETA 5803: *Catchment Approach to Managing Soil Erosion in Asia*, for $1,300,000, approved on 13 August 1998.

institutions are needed to deliver public goods and services, while strong stakeholder participation is needed to guide the resource allocation process. ADB funding could assist in such an endeavor.

56. Initial TA funding provided by ADB to IARCs helped to establish infrastructure and institutional training facilities to strengthen research capabilities. The earlier grants to IRRI, IWMI, ICRISAT, and AVRDC were for basic infrastructure development such as genebanks, training centers, scientific laboratories, and laboratory equipment to help construct and equip the centers. These investments are still in place and have resulted in the establishment of research infrastructures that have played a significant role in the success of these centers in bringing about productivity increases in agriculture, provision for training to several generations of research scientists, and conserving germplasm and biodiversity.

57. In more recent years, funding shifted to a much broader set of themes with a commodity-research orientation. Four themes were evident during the 1980s: (i) outreach and information dissemination of research results (five grants), (ii) integrated pest management (four grants), (iii) crop productivity research for less-favored areas (seven grants), and (iv) advisory TAs to support ADB loans in crop production and irrigation research (eight grants). The last included grants for Indonesia, Pakistan, Philippines, and Sri Lanka for both IWMI and ICRISAT.

58. ADB's ANRR policy recognizes that agriculture is an important sector in itself and that agricultural growth benefits poor farmers who depend on it for their livelihood, in addition to those who consume its products. Since 1996, funding of research projects has closely followed ADB's policy for ANRR which recognizes the important linkages between ANRR, broad-based agricultural growth, poverty reduction, and sustainable management of natural resources. The primary mechanism to achieve maximum impact from limited funds is to support Asian networks as a means of strengthening NARSs while disseminating CGIAR products to clients. Many project activities have focused on research for less-favored environments, and involve collaborative research, training and skills enhancement, germplasm exchange, and limited financial support to NARSs. These networks have four major subthemes of support: (i) commodity research focused on less-favored areas; (ii) natural resources research; (iii) biotechnology of crop production; and (iv) non-cereal commodities including aquaculture, livestock, vegetables, potato, and pasture research. Several grants were provided to support institutional strengthening of NARSs, in a more general way, including grants to ISNAR for general strengthening of research management capacity and to IFRPI for policy research.

59. ADB funding for IARCs has gradually shifted to support sustainable natural resources management and cutting-edge research in line with the changing nature of the Asian agricultural research system. As the IARCs and NARSs have reached a more mature stage of development, there is less need for funding for basic infrastructure, much of which has been financed by loan projects. Most training and development of research skills previously carried out by IARCs is being done by NARSs. Based on discussions with officials of IARCs and NARSs, their need is for (i) support in strategic research with strong linkages to NARSs, (ii) continuation of research support on less-favored areas, (iii) support for regional research networks, and (iv) more research on natural resources management. ADB's current policy agenda for ANRR is consistent with these needs and specifies that policy objectives are to be achieved through funding of IARCs under the CGIAR system in close collaboration with NARSs with a small number of grants being made to other regional (non-CGIAR) centers outside the RETA framework.

C. Adequacy of ADB Resources

60. Current ADB funding for ANRR is from the RETA fund of $28 million (2000 estimates). The fifth RETA for ANRR at the CGIAR centers is $5.8 million or 27 percent of the total funds available for RETA activities within ADB. As said earlier, current levels of RETA funding represent about 1.5 percent of the total worldwide CGIAR budget for 2000 ($390 million) or about 4.5 percent of all CGIAR expenditures in Asia, significantly less than World Bank funding. There is no evidence that either the amount or proportion of World Bank funds to support the CGIAR system is optimal. However, some type of equilibrium level of funding to support the CGIAR system at a minimum level seems to have been reached following the funding crisis of the early 1990s.

61. ADB, as a key development institution in Asia, has significant potential to expand its role in supporting ANRR in Asia. Additional funding to IARCs would allow ADB to participate in a broader portfolio of research projects to better promote its policy agenda. This could include (i) practices and policies for more sustainable natural resource management; (ii) socioeconomic research to better understand linkages among ANRR, poverty reduction, income distribution, and impacts of ANRR on the economic and nutritional status of women and children; and (iii) rural investment policies to complement technological progress in agriculture. Projects in ANRR need to be better designed to encourage collaborative effort among IARCs, NARSs, and other DMC research agencies with capacity to contribute to multidisciplinary field level research in this area.

D. Funding Arrangements

62. Current funding arrangements are through two channels. RETA funding provides competitive grants to eligible CGIAR centers with four or five centers receiving funds from each RETA (Appendix 4, Table A4.2). Amounts per center vary between $600,000 and $1.5 million. The procedure for selection and approval of RETAs for ANRR is described in Appendix 5. Currently, ADB funding for CGIAR centers is through an annual RETA and for non-CGIAR centers is through standalone TA on a case-by-case basis. The process of providing funding to IARCs is complicated and time-consuming, as potential projects have to be identified and evaluated before they are selected for funding under the TA process. In view of constraints in staff resources, the process could be simplified by processing a RETA for all IARCs through a cluster TA approach. The RETA would be processed once every three years. This would significantly reduce staff resources used in ANRR TA processing. The ADB policy on funding ANRR through the TA project mode is consistent with evolving trends in public funding of agricultural research.[12] Donors are tying their funding more closely to projects that are consistent with the policies of their governments for provision of foreign aid. This results in moving away from providing block grants of unrestricted (core) funding and toward the use of specific project funding tied to donor interests. Competitive grants to research agencies, universities, and NGOs are a feature of recent funding arrangements, particularly in Latin America. ADB funding arrangements follow its TA funding mode with the results expected to contribute to ADB's strategic objectives for the region. This funding arrangement largely supports operating costs but does not provide core funding for staff salaries and other overheads of IARCs. Currently, the World Bank provides most of this core support through a formula-based funding mechanism.

[12] Byerlee, D. 1998. The Search for a New Paradigm for the Development of National Agricultural Research Systems. *World Development* 26(2), 1049-1056.

E. Supervision and Monitoring of ANRR Projects

63. A review of project documents on ANRR indicated that only two assessments were made for all ANRR projects funded between 1975 and 1995. Until 1995, the ANRR projects were ad hoc responses to IARCs' requests for funding. The normal ADB evaluation process was apparently not applied to the ANRR projects. Since the 1995 policy on ANRR was put in place, project supervision and progress assessment have been more formalized. Projects to the CGIAR centers are funded via ADB's standard procedures for RETA projects. Funding for non-CGIAR centers follows the standard TA process. Project completion reports are now required from the recipients. Administration of the RETA process has improved and the allocation of management responsibilities for individual TA projects is handled by two agriculture departments, i.e., Agriculture and Social Sectors Department East (AED) and West (AWD). Preliminary evaluation of this portfolio indicates that of the nine TA studies made under the first and second RETAs, eight have been judged successful and one partly successful. The 19 TA studies funded under the first four RETAs are in various stages of implementation with elapsed periods ranging from 14 percent (for newly approved RETA 5866[13]) to about 99 percent (for RETA 5711[14] which will be completed in late 2000 or early 2001). The performance of the studies is monitored and evaluated by the concerned staff every three months. The reports reviewed by this study indicated a generally good understanding of the work in progress. An example for the recent review of the ANRR portfolio under the RETA grants and an overall assessment of the RETA projects is given in Appendix 4. The bulk of the RETA projects are currently being satisfactorily implemented.

64. Operation of RETA assistance to CGIAR centers is now more systematic than prior to 1995 when reports submitted by the centers were the main source of information on progress, problems, and accomplishments. The process is well understood within ADB and the amount of RETA funds is relatively stable. However, much effort is still required by ADB staff, as well as by the IARCs, in formulating and administering the RETA projects. In formulating the proposals for funding, the centers must prepare comprehensive proposals at a considerable effort of time, and less than half of the proposals submitted are selected for funding. This is a significant drain on the centers' resources. Shortcomings on ADB financial and technical reporting procedures were identified, including:

(i) the reporting process and format are not well specified in the TA documents. This causes uncertainties as there is no standardized reporting framework within which research progress can be easily summarized. The first draft reports always seem to attract many comments from ADB staff, often leading to extensive revisions;

(ii) scientists from the centers are not familiar with the formats and procedures of submitting biannual reports with extensive documentation of activities undertaken, detailed trip reports, procurement, procedures, and logical framework charts;

(iii) financial reporting has been simplified, and centers only have to submit a breakdown of costs, not itemized lists supported by receipts. However, cash flow

[13] RETA 5866: *Fourth Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 14 October 1999.

[14] RETA 5711: *Agriculture and Natural Resources Research at CGIAR Centers*, for $5,200,000, approved on 12 December 1996.

of IARCs is a problem because of the need to liquidate an advance before the next advance can be made. This is made even more time-consuming by delays in accounting for funds advanced to NARSs by IARCs. Lack of adequate receipts and accounts from NARS collaborators often mean further delays in liquidation of ADB advances. Cash flow constraints are a problem for IARCs as they have to spend their own core funds while waiting for the next ADB advance;

(iv) the ADB policy limits overheads to 15 percent of total direct costs which is less than institutional overheads. Neither does the ADB policy allow for payment of staff salaries from RETA funds. This means IARCs must use World Bank core resources to meet these costs, reducing their pool of unrestricted core funds.

65. These shortcomings are a result of ADB using a standard project framework for providing support to CGIAR research centers. RETA projects for ANRR are formulated, executed, and administered in the same fashion as other RETAs and the procedure is long and time-consuming for ANRR-type activities. It requires excessive time of ADB and IARC staff in preparing proposals and in subsequent progress reporting. Research is different from ADB's typical project work. Some simplification of procedures and requirements are necessary to increase the efficiency of ANRR TA project formulation and supervision for ANRR TAs. However, despite the various shortcomings in TA project implementation, TA implementation is positive and satisfactory.

F. Constraints on ANRR TA Administration and Supervision

66. ADB has no line staff position designated as the point person for ANRR. In contrast, the World Bank provides a vice president to chair the CGIAR and to act as its advocate for ANRR. Presently, ADB's lead person for RETA administration is a lead agronomist with previous experience as a scientist within the CGIAR system. ADB has two agronomists, both of whom will retire over the next two years. If they are not replaced with experienced senior agriculturists, this could lead to loss of institutional memory in ADB and lack of internal capacity both to evaluate ANRR proposals and project progress, and to adequately manage and supervise the project portfolio. Current ADB staff resources are overstretched in supervising and administering ANRR projects. Other than the lead agronomist (who works full time on RETA and TA processing for ANRR projects, as well as project administration), the second agronomist is involved with ANRR project supervision and administration on a part-time basis. For the 23 ongoing ANRR projects, and the need to identify and evaluate future ANRR projects, available staff resources need to be supplemented. The second constraint is that RETA administration is not considered a mainstream activity among ADB operations staff.[15] Successful management of the RETA portfolio for ANRR contributes to ADB's higher-level objectives but does not lead to loan projects. Staff tasked with managing individual center grants are reluctant to spend substantial amounts of time managing these projects to the detriment of their main operational activities.

67. Consultations with ADB staff indicated that more emphasis on ANRR is needed. The country operations strategy documents prepared by the programs departments did not usually include a discussion on ANRR. This means limited opportunities for dialogue with governments on ANRR organizational issues, policies, or funding levels. It also means little or no discussion

[15] A similar view was expressed in para. 124 of the Operations Evaluation Office's impact evaluation study—IES: REG 99026: *Asian Development Bank's Program of Subregional Economic Cooperation in the Greater Mekong Subregion*, December 1999.

with governments on how ANRR could be used to strengthen the performance of loan projects in agricultural and rural development. There has been some dialogue on ANRR strategy with the governments of Bangladesh and Nepal in the context of regional agricultural development projects, but it lacked any deep understanding of the issues and possible solutions to make the NARSs more responsive and effective. This lack of emphasis on long-term planning to increase productivity in agriculture is reflected in declining trends for funding of agriculture, particularly agricultural research. This will eventually reflect on a country's competitiveness and on its ability to maintain growth of rural incomes.

68. In view of the above constraints and to improve future effectiveness of TA implementation, ADB needs to continue to provide a senior officer (preferably a lead specialist) to oversee the ANRR activities and supervise all ANRR project implementation. ADB also needs to review the format of the project performance report and the financial reporting requirements with a view to simplifying the format so that relevant data are submitted for monitoring and evaluation purposes. It is expected that the number of ongoing projects will increase to about 25 annually, from the current level of 23. For effective monitoring and supervision, it would be more cost effective to contract out the supervision of TA projects to an international consulting firm or a reputable international NGO to be selected on a competitive basis once every three years.

IV. EMPIRICAL EVIDENCE ON ANRR RETURNS

A. Returns on ANRR Investments

69. Agricultural research is an investment that affects future productivity, income growth, environmental quality, food security and farmer safety, and the quality of rural life. Increased productivity means that more output can be produced with the same amount of total inputs or the same amount of output can be produced with a smaller quantity of inputs. At the industry level, a productivity-improving technical change typically results in both an increase in output and an increase in output per unit of input, while total input levels may fluctuate. Productivity improvements lead to a reduction in cost per unit of output.

70. Economic evaluations of agricultural research increase our understanding of the payoffs to investing in research compared to alternative public or private investments. All investments have opportunity costs in terms of what those same resources could have earned in alternative uses. Economic evaluations can quantify net research benefits in order to help funding agencies decide if they are making the correct investment decisions.

71. Economists have completed several studies of the economic benefits of agricultural research. Authors such as Evenson, Waggoner, and Ruttan (1979), Echeverria (1990), and Alston and Pardey (1996) have investigated returns from agricultural research over the past 30 years.[16,17,18] The most recent attempt to quantify returns on research was made by Alston et al. (2000) who sought to obtain every published study from every country through to 1997.[19] A

[16] Evenson, R.E., P.E. Waggoner, and V.W. Ruttan. 1979. Economic Benefits from Research: An Example from Agriculture. *Science* 205: 1101-1107. Washington, DC.

[17] Echeverria, R.G. 1990. Assessing the Impact of Agricultural Research. In *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research*. Vol. 2. The Hague: ISNAR.

[18] Alston, J.M., and P.G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy*. Washington, DC: American Enterprise Institute.

[19] Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and T. J. Wyatt. 2000. *Ex Pede Herculem?: A Meta-Analysis of Rates of Return to Agricultural R&D.* Washington, DC: IFPRI.

summary of the rates of return on ANRR investments is given in Appendix 6. In almost all cases, empirical evidence suggests that the benefits are significant.

72. The rate of return studies suggest that agricultural research has been a good investment. Typically, the empirical internal rate of return (IRR) ranges from 20 to 60 percent, with a few exceeding 100 percent. These returns exceeded those expected for most public or private investments. It should be noted that the more disaggregated the analysis, the higher the variation expected in rates of return. Average IRRs from maize, wheat, and rice research were 138, 51, and 75 percent, respectively. Median IRRs, which may be a more important measure of returns to research, were 48, 42, and 51 percent, respectively, for the three commodities. Returns are generally highest in Asia and lowest in Africa. NARS investments returned 80 percent for wheat, over 80 percent for other cereals, and 59 percent for rice. For IARCs, returns were over 80 percent for maize, millet, and sorghum in Asia. The variation in rates of return in Appendix 6, Table A6.1 also reflects differences in time periods and model specification. While the size of these IRRs indicates positive benefits of research, the variation demonstrates that they should only be interpreted as rough orders of magnitude.

73. Recent work at the Economic Research Service of the United States Department of Agriculture also reevaluated the returns to agricultural research and considered the full economic cost of public expenditures, and costs incurred by the private sector in technology development; it used conservative assumptions about research lag. These factors reduced the estimated rate of return from about 60 to 35 percent. In general, although these revised estimates are lower than previous estimates, they are still high relative to government (or donor) costs of funds, returns from alternate investments, and private sector rates of return.

B. ANRR Contributions of ADB-Funded IARCs

74. This section highlights research contributions conducted by major IARCs with ADB support. It includes the empirical impact assessment of economic costs and benefits for selected sample TA projects conducted by IRRI, ICRISAT, and AVRDC. Appendix 6 provides details of ANRR estimates and results.

75. **International Rice Research Institute.** Over the last 25 years, research at IRRI in collaboration with NARSs has resulted in genetically-improved seeds; improved rice cultivation practices; and improved management practices for soil, water, and biotic resources. These factors have resulted in impressive growth for the rice sector in Asia. Recently, IRRI has emphasized more research in less favorable rice-producing ecosystems and has increased resources in this area of work. IRRI's research supports ADB's objectives for ANRR through increasing rice productivity, reducing chemical inputs, improving the nutrient value of rice, and reducing the real cost of rice production. Since its release of the modern variety, IR8, in 1966, IRRI has produced a large number of IR-parented varieties resulting in average rice yields increasing from 2.1 tons/hectare (t/ha) in 1966 to about 4 t/ha in 1999. This significant increase was achieved under the irrigated ecosystem. However, in flood-prone and upland rain-fed areas, where most poor farmers live, the average yield achieved has been low, at about 1.5 t/ha and 1.1 t/ha, respectively. IRRI's focus on ANRR in recent years has been directed toward these areas, particularly research on the improvement of rice varieties, crop management practices, and the strengthening of NARSs in their rice research capacity.

76. IRRI has been conducting relevant research consistent with ADB's ANRR policy objectives. Among the major relevant items of research are (i) intensification of rice research in

disadvantaged areas, (ii) development of rice varieties tolerant to problem soil conditions, (iii) strengthening of rice crop protection and minimizing environmental damage in DMCs, (iv) decentralized participatory research for less favorable rice ecosystems and rice-wheat systems in Asia, and (v) establishing an Asian rice biotechnology network. The early years of IRRI research concentrated on developing rice genetic resources and breeding high-yielding rice varieties. The need for developing an effective network for collaborative research has generally been neglected. As a result, many DMCs have been unable to fully adopt research results. In recent years, IRRI has recognized such weaknesses and striven to overcome them. ADB provided three RETA projects toward establishing the Asian biotechnology network. The projects aimed to build and support the capacity of Asian national rice improvement programs to conduct biotechnology research and to conduct collaborative research that will result in improved cultivars. To date, these projects have achieved good results in the DMCs, particularly on (i) improved rice cultivars and breeding lines, (ii) greater knowledge on the pest-pathogen population structure, (iii) improved marker and gene tagging/mapping techniques, and (iv) better NARSs training and access to high-technology laboratories.[20] These results, and other research on rice breeding, cultivation, and management practices, have brought about significant increases in rice yields and hence better living standards to poor farmers.

77. Despite the large differences in yield increases, ADB-supported IRRI research has produced broad-based benefits. In general, when both direct and indirect effects are taken into account, differential adoption of modern varieties (MVs) of rice across different production environments has improved income distribution.[21] As MV adoption increases, labor demand in favorable areas increases due to greater labor requirements per crop and higher cropping intensity, while growth linkage effects provide significant onfarm employment. Interregional migration from unfavorable to favorable areas is induced, largely equalizing wages across production environments. Rapid income growth induced by the new technologies has increased nonfarm employment, also helping to raise wage rates and reduce regional inequalities. MV adoption has resulted in factor and product market adjustments that has largely counteracted the potentially adverse effects of technological change in favorable areas on poor people in unfavorable areas. This has been especially true when technical change lowered the real rice price, thus providing greater benefits to poor people who are generally net rice consumers.

78. Another notable contribution is IRRI's involvement in the rice-wheat consortium for the Indo-Gangetic plains (partly funded by ADB). This consortium is a major CGIAR system eco-regional initiative to promote research on issues that are fundamental to achieving enhanced productivity and sustainability of rice-wheat cropping systems in South Asia. Since 1990, IRRI, in collaboration with NARSs and other IARCs (particularly the International Maize and Wheat Improvement Center), has developed a strong system for rice-wheat production models. This has resulted in substantial improvement in farm productivity in the Indo-Gangetic plains.

79. To capture the overall economic impacts, an assessment of the economic impacts of ADB's investment in a subset of IRRI rice research projects has been carried out (Appendix 2, Tables A2.1 and A2.2) and the results are summarized in Table 1.

Table 1: IRRI Case Studies

[20] IRRI and Thailand Development Research Institute. 1998. *Impact of Rice Research.* Edited by P.L. Pingali and M. Hossain. Manila.

[21] David, C.C. and K. Otsuka. 1990. *Differential Impact of Modern Rice Varieties in Asia*. Colorado: Lynne Reinner Press.

Project Name	Surplus ($'000)		IRR
	Producer	Consumer	(%)
Development of Rice Varieties Tolerant to Problem Soil Conditions	12,102	24,845	57
Rain-Fed Lowland Rice Ecosystem Resources	1,182,977	2,434,228	80
Development and Use of Hybrid Rice in Asia	1,607,938	3,314,127	88
Exploiting Biodiversity for Sustainable Rice Pest Management	25,173	51,900	108
Asian Rice Biotechnology Network	192,712	396,682	82
Total Surplus and Average Rate of Return	**3,020,902**	**6,221,782**	**83**

IRR = internal rate of return.

80. The first theme for IRRI was the evaluation of single-commodity projects focusing on three major rice ecosystems: irrigated, rain-fed lowland, and upland. Projects evaluated included (i) development of rice varieties tolerant to problem soil conditions; and (ii) rain-fed lowland rice ecosystem resources. The second theme was a cross-ecosystems research program that generates knowledge applicable to several, or all, IRRI programs. Projects evaluated included (i) development and use of hybrid rice in Asia, (ii) exploiting biodiversity for sustainable rice pest management, and (iii) Asian rice biotechnology network.

81. The largest impacts are from the hybrid rice and rain-fed lowland rice projects (92 percent of the total potential economic surplus) while the exploiting biodiversity for sustainable rice pest management project gave the highest rate of return. This technology has been successfully adopted in the PRC where rice-planted areas under this technology have increased tenfold in recent years. The technology is now being duplicated in Viet Nam and efforts are being made in other Asian countries. The total potential economic surplus of the subset of ADB-funded projects at IRRI over a 15-year period is estimated to be about $9.24 billion with an average IRR of 83 percent. The rain-fed lowland rice and hybrid rice projects accounted for the majority of benefits. Overall, the IRR for the IRRI projects ranged from 57 to 108 percent.

82. The main impacts are reflected in the productivity increase of rice areas and in reducing the rice price to consumers (the consumer surplus) through the adoption of the technologies. This lower price is consistent with the long-term trend in world rice prices since the early 1960s, and has a significant impact on reducing poverty through increasing purchasing power of the poor, most of whom are net rice consumers. The major impacts on producers (the producer surplus) in the less-favored areas have been felt through the project on rain-fed lowland rice where the potential target area is large. The project on problem soils, while very successful, had less impact because the target area is smaller. The implications are that research on less-favored environments provides somewhat lower returns than research on more-favored environments (such as the projects on exploiting biodiversity and hybrid rice). However, returns on research in less-favored areas were acceptable and are helping achieve ADB's objective of reducing poverty.

83. **International Crops Research Institute for the Semi-Arid Tropics.** The semi-arid tropics are home to more than 300 million of the world's poor. ICRISAT has a primary focus on

putting in place mechanisms to strengthen linkages between agricultural research and poverty reduction. Since most of the semi-arid tropics are ecologically fragile, ICRISAT strongly emphasizes the linkage between resource degradation and poverty. Of equal importance is research carried out on developing improved varieties of ICRISAT's mandate crops, which have significantly enhanced crop yields and quality. Unlike the green revolution, which was not scale-neutral and which increased farmer dependence on a variety of rural and urban institutions, ICRISAT focuses on open-pollinated varieties, which helps farmers to maintain the improved germplasm. The ICRISAT research agenda (of working with crops grown in the less-favored semi-arid tropics to improve sustainability of farming systems) fits well with ADB's policy on enhancing sustainable and remunerative farming systems, poverty reduction, and enhancing the economic status of women. Adoption of ICRISAT's groundnut production technology in India generated 71 percent more income while reducing the labor burden of women. In addition, improved productivity of these mandate crops promotes rural growth and more sustainable management of natural resources in a fragile agricultural environment.

84. ADB's support for ICRISAT in the 1990s focused on strengthening grain legumes, wheat-legume mixtures, coarse grain cereal production, and improving the management of natural resources for sustainable rain-fed agriculture. A list of ADB-funded TAs is given in Appendix 1, Table A1.1.

85. As of 1999, a total of 399 improved cultivars developed by ICRISAT and NARSs had been released throughout the world. Studies carried out by ICRISAT's research evaluation and impact assessment team from 1994 onwards have clearly established large-scale adoption of several technologies that are products of germplasm breeding as well as natural resource management research. All five of ICRISAT's mandate crops have seen the adoption of improved technologies.

86. The impact of ICRISAT research has been felt in many DMCs, particularly in South Asia, through the legume network established in these countries. ICRISAT's materials for sorghum and millet have been widely used for hybrid seed breeding lines in South Asia. ICRISAT has also developed cytoplasmic male sterile lines for pigeonpea which are used for producing hybrid pigeonpea lines. In this aspect, pigeonpea varietal adaptation and production in Sri Lanka (para. 41) have had a significant impact on increasing the income of the marginal farmers by utilizing previously unproductive land for pigeonpea production.

87. An economic impact assessment based on a theme of sample projects conducted by ICRISAT, i.e., commodity improvement for multiple crops grown in less favorable ecosystems, was conducted (Appendix 2, Table A2.1). Projects selected included (i) strengthening regional collaboration on cereals and legume research, and (ii) legume-based technologies for rice and wheat production. The objectives of the research projects were to (i) strengthen collaboration and network development among member countries, (ii) increase NARS capability to carry out research, (iii) enhance research programs in coarse cereals and grain legumes, and (iv) release the improved high-yield varieties in member countries. Coarse cereals and grain legumes covered by the studies include groundnut, sorghum, pigeonpea, and chickpea. Results of the analysis are given in Table 2.

88. The economic impact assessment depicted an economic surplus of about $1.32 billion with an average IRR of 45 percent. The largest economic impacts are from research on groundnuts in PRC, Indonesia, and Viet Nam; on pigeonpeas in India; and on chickpeas in Bangladesh. The highest IRRs are from research impacting the larger countries. Returns estimated for the ICRISAT projects were more variable (than for IRRI projects) because of large

differences in the value of the crops and the size of domestic markets. IRRs ranged from 9 to 96 percent with an average of 43 percent for all projects. The benefits accruing to producers and consumers depended on the crop, with producers benefiting much more from groundnut and pigeonpea research and consumers benefiting much more from chickpea research. Returns on investment for research on crops grown in less-favored environments (all the ICRISAT mandate crops) generally show good returns except for the countries with very small markets such as Nepal, Philippines, and Sri Lanka.

89. **Asian Vegetable Research and Development Center.** Balanced diet, rather than just more carbohydrate, is an emerging definition of food security, and improving the overall nutritional status of low-income groups at least cost is an important element in combating the poverty-malnutrition linkage. This is done by analysis of the impact of lowering the cost of various food items on the consumption of various food groups and on the nutritive elements of these groups. Research and development has the effect of lowering the cost of food. Vegetables grown in backyard gardens for home consumption also have an impact on the health of poor households.

Table 2: ICRISAT Case Studies

Crop	Country	Surplus ($'000)		IRR (%)
		Producer	Consumer	
1. Strengthening Regional Collaboration on Cereal and Legume Research				
Chickpea	Bangladesh	29,977	309,774	48
Groundnut	China, People's Rep. of	117,337	28,131	51
Sorghum	India	29,282	29,277	72
Groundnut	Indonesia	254,244	60,966	52
Pigeonpea	Nepal	5,423	1,300	23
Groundnut	Philippines	2,123	507	34
Groundnut	Sri Lanka	944	226	10
Groundnut	Thailand	13,462	3,230	40
2. Legume-Based Technologies for Rice and Wheat Production				
Chickpea	Bangladesh	5,213	1,178	67
Pigeonpea[a]	India	289,408	69,421	96
Pigeonpea[a]	India	15,471	3,502	56
Chickpea[a]	Nepal	1,818	435	13
Chickpea[a]	Nepal	1,389	314	9
Groundnut	Viet Nam	33,126	7,947	59
Total Surplus and Average Rate of Return		**799,217**	**516,208**	**45**

IRR = internal rate of return.

[a] Results are from two different subprojects under the same regional technical assistance.

90. Improving the productivity of vegetables has been a key component in increasing the income of DMC farmers, as vegetables are high-value crops planted in rural areas. AVRDC has been an important research center in helping establish extensive collaborative vegetable research networks in Asia. In this respect, the most notable work done by AVRDC in the 1990s

has been funded by ADB's seven TA projects totaling about $3.44 million. Major projects include (i) Southeast Asian Vegetable Network (AVNET); (ii) South Asian Vegetable Research Network (SAVERNET); (iii) Cambodia, Lao PDR, and Viet Nam Research Network (CLVNET); and (iv) collection, conservation, and utilization of indigenous vegetables in Asia. Through networking among the NARSs, collaborative research activities among the NARSs, AVRDC, and donors such as ADB have brought about (i) enhancement of national research capacities and institutional strengthening through training, meetings, and infrastructure development; (ii) a spirit of cooperation among scientists and researchers in the region by working on common goals and concerns; and (iii) attention to vegetable production and consumption in developing countries through improved vegetable varieties and information drives on nutrition and health benefits. The success of this networking has highlighted the importance of having a mechanism for effectively sharing improved crop varieties, resources, and technologies among the NARSs, national and regional institutions, and international organizations.

91. With the establishment of AVNET, SAVERNET, and CLVNET, this study estimated that the overall vegetable yield in South and Southeast Asia has increased by an average of about 110 percent (all vegetables) while production costs have fallen by an average of 27 percent. Such outputs have not only improved agricultural productivity but have also significantly improved farmers' income and living standards. As most of the vegetable crops (including beans, like soybean and pea) are planted off season, there is a significant need for NARSs to conduct localized research to assist the farmers in selecting appropriate off-season crops (adaptable to local climate) and in adopting the right cultivation practices. AVRDC continues to play an important role in helping NARSs through these vegetable research networks.

92. During the 1990s, AVNET and SAVERNET made available to farmers many improved vegetable varieties, which resulted in a significant increase in bean and vegetable production. The networks sought to enhance research capabilities of participating NARSs through skill training and infrastructure development, and work toward the transfer of appropriate technologies to farmers in partner countries. Vegetable crops covered by the AVRDC projects included tomato, cucumber, yard-long beans, hot pepper, chili, cabbage, and onions. An economic impact assessment of these networks was conducted and the results are summarized in Appendix 2, Table A2.2. The research theme selected is multi-commodity research on vegetables using regional networks. The mix of vegetables in each network reflects their importance and potential within the Asian and Pacific region. The projects selected were (i) establishment of a collaborative vegetable research program in Southeast Asia (AVNET) phase I, (ii) SAVERNET phase I, (iii) AVNET phase II, and (iv) SAVERNET phase II. Results of the analysis are given in Table 3.

Table 3: AVRDC Case Studies (AVNET and SAVERNET)

Crop	Region	Surplus ($'000)		IRR
		Producer	Consumer	(%)
Cabbage	South Asia	237,010	324,975	81
Hot Pepper and Chili	South Asia	2,178,387	2,981,840	126
Onion	South Asia	453,385	621,226	93
Tomato	South Asia	3,771,115	5,145,848	139
Cucumber	Southeast Asia	19,620	14,307	39

Hot Pepper and Chili	Southeast Asia	1,260,949	9,176	100
Tomato	Southeast Asia	427,149	309,774	89
Yard-long Beans	Southeast Asia	75,054	54,579	59
Total Surplus and Average Rate of Return		**8,422,669**	**9,461,725**	**91**

AVNET = Southeast Asian Vegetable Network, IRR = internal rate of return, SAVERNET = South Asian Vegetable Research Network.

93. The total economic surplus for AVNET and SAVERNET was estimated at about $17.88 billion with an average IRR of 91 percent. The high returns at AVRDC are attributed to the large areas grown of the target crops in South and Southeast Asia, the high per unit value of vegetable crops, and the large yield gains derived from the regional research results. Tomato, hot pepper, and chili provided the highest IRRs with three projects returning an IRR of 100 percent or more. Returns from the AVRDC networks were high ranging from 39 to 139 percent with an average IRR of 91 percent. Overall, the benefits between consumers and producers were similar although the proportions of the consumer and producer surplus varied a great deal by crop and country. The large producer surplus for some crops showed substantial potential to increase farm incomes through vegetable research.

94. **International Center for Living Aquatic Resources Management.** ICLARM research influences poverty reduction via several avenues: a lower cost of fishery products leading to improved diet and purchasing power of the poor; improved access to fisheries resources by lower-income fishing communities leading to higher incomes; and land limitations, often associated with the rural poor, that can be overcome by aquaculture under environment-friendly conditions. Other activities assisting with poverty reduction are (i) conserving and rebuilding fish stocks, (ii) providing policy advice on management arrangements for common aquatic resources, (iii) providing insights into the many external factors impinging on aquatic resource use and management, (iv) providing information that can empower communities to manage their own resources and protect biodiversity, and (v) creating alternative livelihoods in coastal zones. An example of ICLARM work with particular benefits to the poor is its program to refine and expand carp polyculture aquaculture systems. These systems are particularly oriented for poverty reduction due to the limited inputs required. Basic ponds available in rural areas (without infrastructure for cleaning and draining) can be stocked with four to seven species of carp that have different feeding niches to increase system efficiencies. The only input required is the fertilization of the pond. Feed inputs are not required. Fertilization can be achieved through application of chemical fertilizers or low-cost agricultural wastes. Yields under such a system can exceed 2,000 kilograms (kg)/ha. The expansion of such systems in Bangladesh and India has the potential to substantially increase fish production by poor farmers and to decrease fish prices through expanded supply. ADB contributed to two phases of funding for a fish genetic improvement project.

95. ICLARM conducted detailed assessments of its TA projects on genetic improvement of tilapia species in Asia and dissemination and evaluation of genetically-improved tilapia. The regional dissemination project included collaborators in Bangladesh, PRC, Philippines, Thailand, and Viet Nam. In phase I, classical genetic selection was based on four local strains and four strains brought from Egypt, Ghana, Kenya, and Senegal. Intensive selection resulted in an approximately 85 percent increase in productivity over the original strains. Currently, parent stocks provided to hatcheries are eighth generation stocks. This productivity gain has provided

an incentive to growers that has resulted in strong demand for fingerlings from the hatcheries. To maintain the genetic improvement program and quality control of the hatcheries, the Genetically-Improved Farm Tilapia (GIFT) Foundation International was set up with support provided by a fee on each fingerling sold by the hatcheries. Currently, about 15 percent of tilapia in the Philippines are GIFT fingerlings. Female fingerlings are sex-reversed so that only male fingerlings are provided to growers. Fresh tilapia are produced by commercial growers, sold at 200-250 grams after four months at a current price of approximately $1.23/kg. Production costs consist of fingerlings, fertilizer for algae, fish-food supplement, labor, and other miscellaneous costs totaling approximately $0.69/kg, giving the growers a profit of about $0.54/kg. The network of seven licensed hatcheries in the Philippines produced approximately 105 million fingerlings in 1999 and plans to double sales volume in 2000. Using 1999 sales as a base and assuming 10 percent mortality and other losses, profits from growers amounted to about $12.7 million. Thus, producer profits in 1999 alone in the Philippines paid off total accumulated research investment by all donors over three times. Additional employment generation and linkages through construction, marketing, transportation, and processing are significant secondary benefits.

96. **Overall Assessment.** Total ADB investment in ANRR for all TA projects (CGIAR and non-CGIAR) from 1975 through 2000 was $67.5 million. Based on the economic model estimation of the subset of projects that ADB funded in IRRI, ICRISAT, and AVRDC as just described, a total economic surplus of $28.4 billion is generated (Appendix 2, Table A2.2). However, not all of these benefits can be attributed to ADB funding. Total investment for the subset of ADB-funded projects evaluated is estimated to be $75 million with ADB contributing $11 million or 14.6 percent of the total research and development budget. The balance came from the IARCs, NARSs, and other donors. The producer, consumer, and total economic surplus attributed directly to ADB funding is estimated at $1.8 billion in producer surplus, $2.4 billion in consumer surplus, for a total of $4.2 billion in total economic surplus.[22] The average IRR for all funds invested for the projects evaluated is 65 percent (Appendix 2, Table A2.2). These figures clearly indicate that the ADB policy of funding ANRR has paid high dividends.

V. CHALLENGES AHEAD

97. Asia showed remarkable economic growth from 1970 to 1995. Despite a 60 percent increase in population (from 1.75 billion in 1970 to 2.79 billion in 1995), cereal production almost doubled, and used only 4 percent more land. Calories available per person per day increased by 24 percent. Cereal production in India increased from 92.8 million metric tons (mt) in 1970 to 174.6 million mt in 1995, an increase of 88 percent (footnote 1). Similarly, cereal production in other South Asian countries increased from 25.4 million mt to 48.1 million mt; in the PRC from 161.1 million mt to 353.3 million mt; and in Southeast Asia from 33.8 million mt to 73.6 million mt. Cereal yields for all Asia increased by 99.5 percent over this period. Poverty in Asia declined from 60 percent in 1975 to about 30 percent in recent years. However, regional differences in performance are significant. About half the world's poor (522 million) remain in South Asia. A total of 900 million poor (75 percent of the total) live in the Asian and Pacific region. Of the nearly 1 billion poor identified in 59 poverty profiles completed by the World Bank (1997), 72 percent live in rural areas. Therefore, continued agricultural growth is essential in areas with large, impoverished rural populations so that farm and nonfarm incomes can rise sufficiently to enable the rural poor to afford more and better food. The challenge is to provide the increases in

[22] The attribution of benefits uses the same proportion of total cost funded by ADB (14.6 percent).

agricultural productivity to continue these trends over the next 20 years in the face of a declining resource base.

98. IFPRI has recently updated food prospects for the Asian and Pacific region under several scenarios.[23] IFPRI forecasts population in Asia to grow from 2.8 billion in 1990 to 4.2 billion in 2020, an increase of about 1.4 billion people. The urban population will almost double, from 1.2 billion to 2 billion. Annual demand for wheat in Asia will rise from 185 million mt to 351 million mt, rice from 307 million mt and 495 million mt. Meat demand will almost triple, from 38 million mt in 1990 to 111 million mt in 2020. The same pattern holds for eggs. As a consequence, the growth in demand for animal feed is enormous over this period. Demand for maize will increase from 123 million mt to 238 million mt; other coarse grains from 48 million mt to 77 million mt. Food production will have to increase by 40 percent from the current level of 650 million mt, or by another 260 million mt. The increased cultivated area is expected to contribute only one fifth of the gain. Food prices will continue to fall but at a much slower rate as the growth rate in crop yields is forecast to continue to decline.

99. Growth in population, urbanization, and per capita consumption caused by income growth will create significant demand for meat consumption in Asia. Producing sufficient animal protein to meet the demand will be a major challenge. IFPRI forecasts annual average growth in demand (1990-2020) in Asia for beef at about 4.1 percent, pork at 3.5 percent, poultry at 3.9 percent, eggs at 3.5 percent, and total meat at about 3.7 percent.[24] On average, people in developing countries worldwide have increased consumption of meat by 50 percent over the past 10 years. In response to the strong demand for meat, developing countries' demand for feedgrains is projected to double between 1995 and 2020 while demand for cereals for direct human consumption is projected to increase by 40 percent. For milk, the projection is about 3.3 percent per annum. There is, thus, an urgent task to increase agricultural productivity from the limited resource base of the world and ANRR would play a major role in overcoming these challenges.

100. Globalization of markets and the opening of national economies imply that localized improvements in agricultural technology may be less effective than in the past in reducing real food prices to consumers. Globalization will affect food security in most DMCs marginally because the amounts of food traded internationally are small relative to local production and consumption. For Asia in 1990, 17 percent of total production of wheat was traded; 4 percent for maize; 2 percent for rice and coarse grains; and 2 percent for other coarse grains.

101. The challenge of maintaining food supplies in Asia over the next 20 years is made more difficult by shrinking supplies of water and declining quality of land. A recent study by IFPRI reported significant soil degradation based on comprehensive mapping of global agricultural practices. Soil degradation has already had significant impacts on the productivity of about 16 percent of the world's agricultural land, including 11 percent in Asia. Increases in food supplies must come from increased biological yields rather than from area expansion and expansion of irrigated areas. Most new lands brought under cultivation are marginal and cannot make up for the land being lost each year due to urbanization and land degradation.

102. Overexploitation of groundwater resources suggests that past achievements in poverty reduction in irrigated areas may be at risk. In 1999, IWMI reported that 2.7 billion people would

[23] Rosegrant, M., M. Agcaoili-Sombilla, and N.D. Perez. 1995. Global Food Projections to 2020: Implications for Investment. *2020 Food, Agriculture and the Environment Discussion Paper 5*. IFPRI.

[24] Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui, and C. Courbois. 1999. Livestock to 2020: The Next Food Revolution. *Food, Agriculture and the Environment Discussion Paper 28*. Washington, DC: IFPRI/FAO/ILRI.

experience severe water scarcity within the next 25 years. The majority of this population reside in the semi-arid regions of Asia. Due to overexploitation of groundwater, food production will be adversely affected in two of Asia's major breadbaskets—the North China Plain and the Punjab. Overexploitation of groundwater resources by tubewell irrigation now poses a major threat to the environment, health, and food security. The groundwater problem has two components. First is the rapid drawdown of freshwater aquifers due to the use of wells and pumps for irrigation, and for domestic and industrial water supplies. Second is the opposite problem of rising water tables with high salinity. In addition, aquifers are being contaminated by toxic elements. The recent discovery of extensive arsenic poisoning of the aquifers in Bangladesh provides a striking example of the effects of groundwater mismanagement.

103. Improvements in crop, fish, and livestock yields in Asia will remain the avenue of growth as IFPRI forecasts virtually no increase in planted areas in Asia. However, growth in cereal yields is slowing worldwide, partly due to reduced inputs in response to lower prices and in part to low levels of investment in agricultural research and technology. This implies a continued effort to improve biological efficiency. Over the period 1990-2020, this improvement will be about 2.2 percent per annum for wheat, 2.2 percent for maize, 1.6 percent for rice, and 1.6 percent for other coarse grains.

VI. ISSUES

A. Pressure in Meeting Food Demand in Asia

104. Over the period 1990-2020, Asia's population will increase by about 1.4 billion. Over the same period, Asia will need to produce another 260 million mt of grain and 73 million mt of meat. Increases in food supplies must come from increased biological yields rather than from area expansion and expansion of irrigated areas. Less land and water will be available for agriculture, while land resources will show increasing signs of degradation and stress. Areas showing the most such signs are also areas where poverty is the most pervasive. Despite this challenge, funding for international agricultural research has declined and long-term support from traditional donors is also in question.

B. Need for New Breakthroughs in ANRR

105. Recent research by IARCs and NARSs has lagged behind the needs of DMC populations for increased food productivity. Most IARCs are facing perennial funding constraints and uncertainty in ANRR. The needs in the future for more breakthroughs are enormous, even though partnerships between IARCs, the private sector, and the stronger NARSs have identified a range of promising technologies to stabilize and increase yields and, in some cases, improve the micronutrient quality of grains. Recent ADB support for biotechnology research at IARCs highlights the potential for biotechnology to increase productivity, lower chemical inputs, and increase yield stability. However, investment costs are high and IARCs badly need support to conduct such research. Donor support for ANRR is lagging and becoming diffused over a growing mandate of non-core research topics, such as gender and other socioeconomic issues.

C. Rationalizing ADB Support for ANRR

106. ADB support for ANRR is spread too thin for maximum impact, both in terms of the number of centers funded, and the research agendas it is expected to support. Since 1996, RETA grants have supported projects at 14 of the 16 CGIAR centers. An additional three non-CGIAR centers are also currently receiving TA support for ANRR. Research must focus on obtaining maximum increases in productivity from a shrinking resource base. Spreading a limited pool of funds over a wide range of research topics is not an efficient use of ADB funds as a tool for poverty reduction. ADB needs to set a clear objective and establish criteria which meet the ANRR policy agenda for selection of RETA projects.

D. Inadequate Capacity for Networking and Dissemination of Research Results to NARSs

107. Due to remoteness of many rural areas and lack of facilities to conduct adaptive research in many DMCs, many valuable research results are not readily made available to NARSs for further adaptive research. Networking is an important aspect of ANRR where NARSs of DMCs can obtain exotic breeding materials and research findings and conduct adaptive research under the guidance and advice of IARCs. In recent years, IARCs have been focusing on networking among DMCs and strengthening their efforts to disseminate research results to NARSs for adoption by rural farmers. This is an important aspect of ANRR where rural farmers could greatly benefit in the future. Greater networking among DMCs and collaborative research among NARSs should be given top priority. Funding to IARCs in this area is relatively insignificant. ADB should consider incorporating this aspect of ANRR as a component in its project funding for the agriculture sector.

E. Weak NARSs

108. One major constraint for effective ANRR is weak technical and institutional capacity in NARSs. Part of this is due to declining funding by Asian governments and donors for ANRR in general, and in the rural sector in particular. Another issue is slow progress by NARSs in making fundamental policy and organizational changes in response to the changing environment under which ANRR is conducted. Most of the NARSs in Asia are small and have insufficient funding to make an effective contribution to increasing agricultural productivity. A few large NARSs have adequate capacity to fully integrate strategic research by the CGIAR system into their programs and receive high payoffs. The rest of the NARSs are being increasingly left behind due to remoteness, inadequate numbers of well-trained staff, lack of operational and maintenance budgets; they are also less able to capitalize on IARC research products. Networking—allowing research staff easier access to germplasm, research techniques, and literature under the guidance of IARC scientists—has been effective in many NARSs.

F. Inadequate Resources and Incentives for Supervision and Monitoring of ANRR Projects

109. Currently, 23 TA projects are under way at IARCs and five studies are to commence in 2001 under the fifth RETA to CGIAR centers. These TA projects cover a wide geographic spread of DMCs. In terms of TA project administration, supervision, policy dialogue with IARCs, NARSs, and other independent research entities in DMCs, ADB has not provided adequate

resources for supervision and monitoring. In addition, staff resources are also needed for formulating and processing new TA projects each year. However, ADB staff have little incentive to effectively administer ANRR project activities. RETA administration is not considered a mainstream activity among operations staff. Successful management of the RETA portfolio for ANRR contributes to ADB's higher-level objectives but does not lead to loan projects. Staff tasked with managing the individual center grants are reluctant to spend much time managing these projects (para. 66).

VII. CONCLUSIONS AND RECOMMENDATIONS

110. ANRR has played an important role in promoting agricultural and rural development in Asia over the past 30 years. Changes that ANRR set in place have contributed significantly to improving the living conditions of poor farmers. ADB's investments have paid large dividends, with much of these gains occurring in less-favored environments characterized by a high incidence of poverty. Furthermore, in less-favored environments, investment in ANRR consistently gives the highest returns and has a significant impact on poor farmers which in turn leads to poverty reduction.

111. ADB provides support to ANRR as part of its strategic framework for poverty reduction. Most DMCs do not yet have the capacity or resources to undertake needed research without strong international support and partnerships. The products of most research efforts are international public goods with high spillover effects across countries. This leads to underinvestment by the private sector, which is unable to capture most benefits, and by individual countries, which are also unable to capture these spillover effects for their farmers and consumers. To absorb funds needed to reduce the underinvestment gap, strong public institutions are needed to deliver public goods and services, and strong stakeholder participation is needed to guide the resource allocation process.

112. The current policy for ADB funding of ANRR remains relevant and consistent with ADB's new poverty reduction strategy. Benefits of research reach the poor through four main avenues: (i) raising farm income and employment; (ii) lowering food prices in the market; (iii) providing pathways out of poverty by raising incomes thus providing more education for children, better health and other household services, and creating rural and urban employment; and (iv) promoting broad-based economic growth. An additional environmental consequence of the green revolution technologies is the saving of land not required to produce today's food output at pre-green revolution yield levels. However, not all the agenda items fit into the current policy of supporting ANRR through the CGIAR centers. A broader range of research institutions needs to be considered for ADB support, including NARSs, universities, NGOs, and specialized research institutes with more expertise in local issues.

113. ADB's funding for ANRR has been appropriate to the evolving needs of Asian agriculture. Initial investments were for basic infrastructure development such as genebanks, training centers, scientific laboratories, and laboratory equipment, and for founding grants to help construct and equip the centers. These investments are still in place, having played a significant role in the success of these centers by helping increase the productivity of Asian agriculture, by training several generations of Asian scientists, and by conserving germplasm and biodiversity.

114. Since 1996, funding of research projects has closely followed ADB's policy for ANRR. The primary mechanism to achieve maximum impact from limited funds is to support Asian

networks as a means of strengthening NARSs while disseminating CGIAR products to the clients. Many project activities focused on research for less-favored environments. CGIAR's research agenda conforms closely with the key research issues of strategic concern to ADB. ADB provides RETA funding once a year with these funds covering research projects at several centers. Since ADB's policy on ANRR was implemented in 1995, CGIAR centers have received $21.9 million in RETA funds.

115. The main recipients of ADB support for ANRR under the CGIAR system are IRRI, ICRISAT, IWMI, and ICLARM. The main recipient outside the CGIAR system is AVRDC.

116. The impact assessment indicated that ADB investments in a selected group of projects provided high rates of return, averaging 82 percent for IRRI projects, 43 percent for ICRISAT projects, and 91 percent for AVRDC projects. Research on genetic improvement of fish also showed high rates of return. These returns provide economic benefits to both producers and consumers and justify continuing ADB involvement in ANRR.

117. ADB funding for ANRR increased since the policy on ANRR was implemented. However, the amount is small relative to other important donors in this area and rationalization of funding by geographic coverage and agenda items for ANRR is needed to make better use of ADB's limited resources for ANRR. To streamline ADB's funding for ANRR through the RETA mechanism, it would be appropriate to include both CGIAR and other IARCs in the funding process.

118. The study's specific recommendations are as follows:

(i) **ANRR Research Agenda.** The present policy on ANRR is largely appropriate and consistent with ADB's main thrust of development objectives and closely follows the focus on pro-poor growth, poverty reduction, and environmental protection. However, as indicated in paras. 26 and 27, the policy requires some refinements to bring about a sharper focus in its policy agenda to realize ADB's development goals more effectively. To this end, selection of future ANRR projects should be based on a set of specific development objectives and criteria which emphasize: sustainable farming systems for poor farmers; sustainable management of agricultural and natural resources; enhancement of agricultural productivity increases; strengthening the capacity of NARSs; and promoting public policy and socioeconomic research. AED or AWD should develop these objectives and criteria, ensuring their relevance for each IARC to facilitate its submission of research project proposals.

(ii) **ANRR Implementation Strategies.** ADB should embark on a two-pronged approach to ANRR. For IARCs, RETA projects should focus on the cutting edge of research with the objective of bringing about another quantum jump in yield and productivity in agricultural production to meet the future food demand of DMCs and reducing the poverty level. New breakthroughs in agricultural productivity are needed. ADB must include innovative policy elements to enable it to maintain its role as a leader in funding cutting-edge science in the region. The 1990s witnessed the unfolding biotechnology revolution in agriculture that has the potential to dramatically transform agricultural production and processing in the future. ADB has provided substantial funding to this type of work, i.e.,

RETA 5510.[25] ADB should consider expanding its funding to take advantage of the comparative advantage of the expertise in IARCs. In addition, IARCs should receive continuous support for networking projects for effective dissemination of research results to the NARSs and for strengthening their technical and institutional capabilities. Parallel to supporting IARCs through RETAs, ADB should provide loan and TA funding for NARSs, universities, and NGOs, to focus adaptive research based on local needs and production factors. These should include sustainable farming systems, sustainable management of agricultural and natural resources, environment conservation, and socioeconomic studies.

(iii) **Funding Modality.** To be able to select the relevant and appropriate RETA projects for funding, the current modality of restrictive funding of ANRR for IARCs should be continued. However, in view of constraints in staff resources and in improving the efficiency of ANRR RETA processing, it is recommended that AED and AWD jointly forward a cluster RETA proposal to the RETA Screening Committee once every three years for financing a three-year ANRR RETA program for all participating IARCs. The funding level of about $20 million every three years in real terms should be maintained.

(iv) **Geographic Focus.** Based on existing poverty incidence of DMCs and the considerable evidence that investments in ANRR for less-favored environments provide high returns, the focus of research should be in agro-ecological areas characterized by a high incidence of rural poverty. Research should continue to target crops and livestock grown under less-favored environments within these broad geographic regions. Some research is equally applicable across all environments, however, and if the benefits are judged to be sufficiently widespread, such research should be encouraged.

(v) **Strengthening of ADB's Institutional Capacity to Administer, Supervise, Monitor, and Promote ANRR.** ADB has no line staff position designated as the point person for ANRR. It is recommended that AED and AWD jointly create a lead ANRR specialist position (project economist or natural resources specialist or agriculturist) to formally oversee, supervise, and act as the focal person for all ANRR activities. He or she would also be responsible for liaison with IARCs, NARSs, DMC universities, and NGOs to plan and formulate ANRR projects. To overcome the constraint of staff resources in administering and supervising ANRR projects, a reputable international consulting company or NGO experienced in ANRR activities should be recruited to administer, supervise, and monitor all ANRR projects under implementation. Both AED and AWD should allocate an adequate consultancy budget for ANRR project administration and monitoring.

(vi) **Adequate Government Funding for NARSs.** Although AED and AWD regularly conduct policy dialogues with some DMC governments on the need to promote ANRR and support NARSs, there is a general view in ADB for increased emphasis to pursue policy dialogue on ANRR with DMC governments. This means increasing opportunities for dialogue with governments on ANRR organizational issues, policies, and funding levels to adopt a long-term planning

[25] RETA 5510: *Establishment of the Asian Rice Biotechnology Network*, for $900,000, approved on 24 November 1992.

process to increase productivity in the agriculture sector. This will eventually reflect on a country's competitiveness and on its ability to maintain growth of rural incomes. It is recommended that the new country strategic plan include a section on ANRR, where appropriate, to highlight the importance of ANRR and the need for DMC governments to allocate adequate funding for ANRR and extension. This would enable AED and AWD to emphasize ANRR during their regular sector studies and policy dialogue consultations with DMC governments.

APPENDIXES

ADB SUPPORT TO AGRICULTURE AND NATURAL RESOURCES RESEARCH

Table A1.1: ADB Support for International Agricultural Research Centers and Other DMC Organizations

TA No.	TA Name	Date Approved	TA Amount ($'000)
1. CGIAR CENTERS			
A. Center for International Forestry Research			
RETA 5812[a]	Planning for Sustainability of Forest Through Adaptive Co-Management	22 Oct 1998	1,100
B. International Center for Agricultural Research in the Dry Areas			
RETA 5866[b]	Onfarm Soil and Water Management for Sustainable Agricultural Systems in Central Asia	14 Oct 1999	1,200
C. International Center for Living Aquatic Resources Management			
RETA 5068	Workshop on Appropriate Technology for Alternative Energy Sources in Fisheries	7 Jul 1980	70
RETA 5245	International Center for Living Aquatic Resources Management for a Research on Rice-Fish Farming Systems	15 Apr 1987	350
RETA 5279	ICLARM for Genetic Improvement of Tilapia Species in Asia	8 Mar 1988	475
RETA 5558	Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia	14 Dec 1993	600
RETA 5651	Review of Sustainable Exploitation of Coastal Fish Stocks in Asia	4 Dec 1995	100
RETA 5711[c]	Genetic Improvement of Carp Species in Asia	12 Dec 1996	1,300
RETA 5766[d]	Sustainable Management of Coastal Fish Stocks in Asia	29 Dec 1997	1,400
	Subtotal (C)		**4,295**
D. International Centre for Research in Agroforestry			
RETA 5711[c]	Policy Research for Sustainable Upland Systems	12 Dec 1996	1,200
E. International Center for Tropical Agriculture			
RETA 5866[b]	Developing Sustainable Forage Technologies for Resource-Poor Upland Farmers in Asia	14 Oct 1999	1,200
F. International Crops Research Institute for the Semi-Arid Tropics			
RETA 5036	International Crops Research Institute for the Semi-Arid Tropics	17 Jun 1976	325
RETA 5087	Establishment of a Genetic Resources Laboratory at ICRISAT	22 Sep 1981	450
RETA 5118	Strengthening Chickpea Research in Collaboration with the International Crops Research Institute for the Semi-Arid Tropics	15 Feb 1983	300
AOTA 0882	Strengthening Chickpea Research in Collaboration with ICRISAT, Phase II	9 Jun 1987	350
RETA 5268	International Crops Research Institute for the Semi-Arid Tropics for the Strengthening Grain Legume in South Asia	4 Dec 1987	350
AOTA 1139	Pigeonpea Varietal Adaptation and Production Studies in Collaboration with International Crops Research Institute for the Semi-Arid Tropics	16 Mar 1989	230
RETA 5331	International Crops Research Institute for the Semi-Arid Tropics for Establishment of Plant Biotechnology Research and Training Unit	25 Apr 1989	1,250
RETA 5393	International Crops Research Institute for the Semi-Arid Tropics for Strengthening Grain Legume Research in Asia	10 Jul 1990	590
RETA 5405	International Crops Research Institute for the Semi-Arid Tropics for Strengthening the Genetic Resources Unit	7 Sep 1990	600
AOTA 1742	Pigeonpea Intercropping and Diversification Study	18 Aug 1992	350
RETA 5603	Strengthening Regional Collaboration on Cereals and Legumes Research in Asia	24 Nov 1994	600
RETA 5711[c]	Legume-Based Technologies for Rice and Wheat Production	12 Dec 1996	600
RETA 5812[a]	Improving Management of Natural Resources for Sustainable Rain-Fed Agriculture	22 Oct 1998	1,250
	Subtotal (F)		**7,245**

ADB = Asian Development Bank, AOTA = advisory and operational technical assistance, CGIAR = Consultative Group on International Agricultural Research, DMC = developing member country, ICLARM = International Center for Living Aquatic Resources Management, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, RETA = regional technical assistance, TA = technical assistance.

[a] A component of 5812-REG: *Third Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 22 October 1998.

[b] A component of 5866-REG: *Fourth Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 14 October 1999.

[c] A component of 5711-REG: *Agriculture and Natural Resources Research at CGIAR Centers*, for $5,200,000, approved on 12 December 1996.

[d] A component of 5766-REG: *Second Agriculture and Natural Resources Research at CGIAR Centers*, for $5,500,000, approved on 29 December 1997.

TA No.	TA Name	Date Approved	TA Amount ($'000)
G. International Food Policy Research Institute			
RETA 5116	Study of Food Demand and Supply and Related Strategies for Developing Member Countries	4 Feb 1983	248
RETA 5160	Study of Food Demand and Supply and Related Strategies for Developing Member Countries (Phase II)	23 Oct 1984	500
RETA 5420	Study of Food Situation and Outlook for Asia	2 Jan 1991	598
RETA 5866[b]	Irrigation Investment, Fiscal Policy, and Water Resource Allocation	14 Oct 1999	1,200
	Subtotal (G)		**2,546**
H. International Irrigation Management Institute			
RETA 5136	International Irrigation Management Institute	29 Nov 1983	500
AOTA 0654	Study on Irrigation Management for Crop Diversification	20 Dec 1984	250
AOTA 0673	Study of Irrigation Management	27 Mar 1985	350
RETA 5172	Regional Study on Irrigation Service Fees	16 May 1985	100
RETA 5209	Regional Seminar on Irrigation Service Fees	7 May 1986	125
RETA 5234	A Course on Planning and Management of Irrigation Schemes	5 Jan 1987	55
AOTA 0846	Study of Irrigation Management and Crop Diversification	16 Jan 1987	350
AOTA 0859	Study on Irrigation Management for Diversified Crops (Phase II)	26 Feb 1987	350
AOTA 0937	Efficient Irrigation Management and Systems Transfer	17 Dec 1987	600
RETA 5273	Research Support to IIMI for Study on Irrigation Systems Rehabilitation and Improved Operations and Management	8 Jan 1988	350
AOTA 1481	Study on Crop-Based Irrigation Operations in Northwest Frontier Province	19 Feb 1991	860
AOTA 1480	Study of Irrigation Management and Crop Diversification (Phase II)	19 Feb 1991	750
RETA 5812[a]	Development of Effective Water Management Institutions	22 Oct 1998	1,250
	Subtotal (H)		**5,890**
I. International Livestock Research Institute			
RETA 5812[a]	Increasing Productivity of Crop-Livestock Systems in Asia	22 Oct 1998	1,000
J. International Maize and Wheat Improvement Center			
RETA 5766[d]	Application of Biotechnology to Maize Improvement in Asia	12 Dec 1997	1,400
K. International Plant Genetic Resources Institute			
RETA 5590	Coconut Genetic Resources Network in Asia and the Pacific Region	29 Jul 1994	800
RETA 5766[d]	Coconut Genetic Resources Network and Human Resources Strengthening in Asia and the Pacific (Phase II)	29 Dec 1997	1,200
RETA 5866[b]	Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia	14 Oct 1999	1,200
	Subtotal (K)		**3,200**
L. International Potato Center			
RETA 5533	Field Testing of True Potato Seed in the Lowland Tropics	24 May 1993	433
RETA 5711[c]	Field Testing of True Potato Seed (Phase II)	12 Dec 1996	600
	Subtotal (L)		**1,033**
M. International Rice Research Institute			
RETA 5026	International Rice Research Institute	20 Feb 1975	300
RETA 5039	Establishment of a Rice Genetic Resources Laboratory	29 Mar 1977	500
RETA 5059	Intensification of Rice Research for Disadvantaged Areas	26 Jul 1979	700
RETA 5125	International Rice Research Institute Demonstration-Cum-Training Center on Rice Production, Post-Harvest Technology and Biomass Utilization	9 Jun 1983	400
RETA 5167	International Rice Research Institute for the Establishment of Research and Training Facilities to Enhance Regional Collaboration on Rice Virus Diseases	14 Dec 1984	350
RETA 5194	International Rice Research Institute for Strengthening Research on Integrated Pest Management for Deepwater Rice Farming Systems	18 Dec 1985	350
RETA 5200	International Rice Research Institute for Printing and Distribution of Rice Abstracts Journal	31 Dec 1985	110
RETA 5208	International Rice Research Institute for Research on Botanical Pest Control	7 May 1986	250

IIMI = International Irrigation Management Institute.

TA No.	TA Name	Date Approved	TA Amount ($'000)
RETA 5227	International Rice Research Institute for Research Demonstration and Training on Rice Production, Post Harvest Technology and Biomass Utilization (Phase II)	30 Oct 1986	650
RETA 5261	Technical Assistance to IRRI for the Development of Rice Varieties Tolerant to Problem Soil Conditions	20 Aug 1987	500
RETA 5299	International Rice Research Institute for Strengthening Research on Integrated Pest Management in Deepwater Rice Farming Systems (Phase II)	12 Jul 1988	400
RETA 5336	Strengthening Agricultural Science and Information Services in the Bank's DMCs	31 May 1989	180
RETA 5349	Strengthening Rice Crop Protection Research and Minimizing Environmental Damage in DMCs	26 Sep 1989	850
RETA 5414	Decentralized Participatory Research for Less Favorable Rice Ecosystems and Rice Wheat Systems	13 Nov 1990	3,000
RETA 5510	Establishment of the Asian Rice Biotechnology Network	24 Nov 1992	900
RETA 5606	International Rice Research Institute for Rain-Fed Lowland Rice Ecosystem Research	6 Dec 1994	1,100
RETA 5667	Asian Rice Biotechnology Network—From Products to Impact	9 Jan 1996	850
RETA 5711[c]	Exploiting Biodiversity for Sustainable Rice Pest Management	12 Dec 1996	1,500
RETA 5766[d]	Development and Use of Hybrid Rice in Asia	29 Dec 1997	1,500
RETA 5812[a]	Asian Rice Biotechnology Network: Achieving Impact and Sustainability	22 Oct 1998	1,000
	Subtotal (M)		**15,390**
N. International Service for National Agricultural Research			
RETA 5254	Regional Workshop on Planning and Management of Agriculture Research in the South Pacific	23 Jun 1987	75
RETA 5341	Strengthening Agricultural Resources Management in Asia with Special Emphasis on Management Information Systems	4 Jul 1989	480
RETA 5866[b]	Building Performance-Based Management Systems in the National Agricultural Research Systems in Asia	14 Oct 1999	800
	Subtotal (N)		**1,355**
	Subtotal (1)		**48,054**
2. OTHER CENTERS AND ORGANIZATIONS			
A. Asian Vegetable Research and Development Center			
RETA 5027	Outreach Programs in Vegetable Research in Korea, Philippines and Thailand	15 Apr 1975	390
RETA 5119	Strengthening Vegetable Research in Collaboration with the Asian Vegetable Research and Development Center	15 Feb 1983	475
RETA 5143[e]	Regional Training Program in Vegetable Production and Research	20 Dec 1983	175
RETA 5253[e]	Regional Training Program in Vegetable Production and Research (Phase II)	18 Jun 1987	350
RETA 5282	Planning and Organization Workshop to Establish Collaborative Vegetable Research Program in Southeast Asia	28 Mar 1988	75
RETA 5322	Asian Vegetable Research and Development Center to Establish a Collaborative Vegetable Research Program in Southeast Asia	17 Mar 1989	600
RETA 5402[e]	Regional Training Program in Vegetable Production and Research (Phase III)	28 Aug 1990	400
RETA 5461	South Asia Vegetable Research Network	25 Sep 1991	600
RETA 5517	Collaborative Vegetable Research Program for Southeast Asia (Phase II)	21 Dec 1992	600
RETA 5582	Workshop on Vegetable Research and Development in Cambodia, Lao PDR and Viet Nam	6 Jun 1994	94
RETA 5680	Establishment of a Vegetable Research Network for Cambodia, Lao PDR and Viet Nam	8 Apr 1996	600
RETA 5719	RETA to AVRDC for South Asia Vegetable Research Network (Phase II)	10 Jan 1997	600
RETA 5839	Collection, Conservation, and Utilization of Indigenous Vegetables	29 Mar 1999	550
	Subtotal (A)		**5,509**
B. Center for Integrated Rural Development for Asia and the Pacific			
RETA 5248	Study of the Role of Women in Rural Industries	26 May 1987	180

AVRDC = Asian Vegetable Research and Development Center, IRRI = International Rice Research Institute, Lao PDR = Lao People's Democratic Republic.

[e] Amount includes funds directly contributed by ADB and excludes funds channeled through ADB by foreign government.

TA No.	TA Name	Date Approved	TA Amount ($'000)
C. Fisheries Research Studies, Seminars, and Training			
RETA 5032	Fish Market Study	30 Oct 1975	49
RETA 5077	Regional Training Program in Fisheries Stock Assessment and Statistical Data Collection	25 Dec 1980	200
RETA 5082	Second Fish Market Study	3 Jun 1981	220
RETA 5109	Research and Training in Aquaculture	30 Aug 1982	220
RETA 5142	South Pacific Training in Fisheries Statistics, Interpretation and Stock Assessment	4 Nov 1983	50
RETA 5150	Regional Training Program in Fish Handling and Quality Control	13 Mar 1984	50
RETA 5252	Fisheries Sector Development Strategies Study for South Pacific DMCs	9 Jun 1987	350
RETA 5316	Third Fish Market Study	18 Jan 1989	334
RETA 5358	Study on Fish Disease and Fish Health Management	22 Dec 1989	380
RETA 5534	Regional Study and Workshop on Aquaculture Sustainability and the Environment	1 Jun 1993	600
RETA 5566	Tuna Industry Development in Pacific Island Countries	29 Dec 1993	495
	Subtotal (C)		**2,948**
D. Forestry Research Studies, Seminars, and Training			
RETA 5049	Regional Seminar on Application of Appropriate Technology in Forestry and Forest Industries	15 Jun 1978	90
RETA 5224	Regional Training Center in Community Forestry (Supplementary)	17 July 1987	350
RETA 5409[e]	Forestry Research Support Program for the Asia and Pacific Region	17 Oct 1990	1,500
RETA 5595[e]	Regional Community Forestry Training Center in Kasetsart University, Thailand	5 Sep 1994	600
RETA 5612	Forestry Research Support Program for Asia and the Pacific (Phase II)	22 Dec 1994	600
	Subtotal (D)		**3,140**
E. International Board for Soil Research and Management			
RETA 5218	Regional Workshop on Soil Management	10 Sep 1986	40
RETA 5284[e]	International Board for Soil Research and Management for Research on Management of Sloping Lands for Sustainable Agriculture	14 Apr 1988	350
RETA 5400	Research on the Management of Sloping Lands for Sustainable Smallholder Agriculture in the South Pacific	24 Aug 1990	262
RETA 5803	TA to the International Board for Soil Research and Management for the Catchment Approach to Managing Soil Erosion in Asia	13 Aug 1998	1,300
	Subtotal (E)		**1,952**
F. International Centre for Integrated Mountain Development			
RETA 5293	International Centre for Integrated Mountain Development for a Study of Strategies for the Sustainable Development of Mountain Agriculture	10 Jun 1988	540
RETA 5443	International Centre for Integrated Mountain Development	18 Apr 1991	600
RETA 5565	Appropriate Technology for Soil Conserving Farming Systems	29 Dec 1993	600
RETA 5784	Appropriate Technology for Soil Conserving Farming Systems (Phase II)	23 Mar 1998	600
	Subtotal (F)		**2,340**
G. International Jute Organization			
RETA 5235	International Jute Organization for Collection, Conservation, Characterization and Exchange of Germplasm of Jute, Kenaf and Mesta	5 Jan 1987	350
RETA 5375	International Jute Organization for the Development of Improved Varieties of Jute and Allied Fiber Crops (Phase II)	28 Mar 1990	600
	Subtotal (G)		**950**
H. Livestock Research Studies, Seminars, and Training			
RETA 5135	Regional Workshop on Livestock Production Management	21 Nov 1983	130
RETA 5272	Regional Workshop on Animal Disease Reporting System	8 Jan 1988	150
RETA 5505	Regional Seminar on Policies and Strategies for Livestock Development	20 Aug 1992	220
	Subtotal (H)		**500**

TA No.	TA Name	Date Approved	TA Amount ($'000)
I. Other Research Studies and Training			
RETA 5319	Workshop and Symposium on Strengthening Pesticides Regulations	16 Jan 1989	250
RETA 5336	Strengthening Agricultural Science and Information Services in the Bank's DMCs	31 May 1989	180
RETA 5434	Regional Conference on Integrated Pest Management	13 Mar 1991	270
RETA 5514	TA to Commonwealth Agricultural Bureaux International for Integrated Pest Management in Cotton	8 Dec 1992	760
RETA 5618	Establishment of the Asian Maize Training Center	29 Dec 1994	600
	Subtotal (I)		**2,060**
	Subtotal (2)		**19,579**
	Total		**67,633**

Source: ADB project files.

Table A1.2: Summary of ADB Support to IARCs and Other DMC Organizations, 1975-1999
($'000)

Center/ Organization	1975-1980	1981-1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	No.	Total
CGIAR Centers																		
IRRI	1,500	1,210	900	500	400	1,030	3,000	0	900	0	1,100	0	2,350	1,500	1,000	0	20	15,390
ICRISAT	325	750	0	700	0	1,480	1,190	0	350	0	600	0	600	0	1,250	0	13	7,245
IWMI	0	1,200	125	1,355	350	0	0	1,610	0	0	0	0	0	0	1,250	0	13	5,890
ICLARM	0	70	0	350	475	0	0	0	0	600	0	100	1,300	1,400	0	0	7	4,295
CIMMYT	0	0	0	0	0	0	0	0	0	0	0	0	0	1,400	0	0	1	1,400
CIP	0	0	0	0	0	0	0	0	0	433	0	0	600	0	0	0	2	1,033
IFPRI	0	748	0	0	0	0	0	598	0	0	0	0	0	0	0	1,200	4	2,546
ISNAR	0	0	0	75	0	480	0	0	0	0	0	0	0	0	0	800	3	1,355
IPGRI	0	0	0	0	0	0	0	0	0	0	800	0	0	1,200	0	1,200	3	3,200
ICRAF	0	0	0	0	0	0	0	0	0	0	0	0	1,200	0	0	0	1	1,200
ILRI	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,000	0	1	1,000
CIAT	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,200	1	1,200
ICARDA	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,200	1	1,200
CIFOR	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1,100	0	1	1,100
Subtotal	**1,825**	**3,978**	**1,025**	**2,980**	**1,225**	**2,990**	**4,190**	**2,208**	**1,250**	**1,033**	**2,500**	**100**	**6,050**	**5,500**	**5,600**	**5,600**	**71**	**48,054**
Non-CGIAR Centers																		
AVRDC	390	650	0	350	75	600	400	600	600	0	94	0	600	600	0	550	13	5,509
CABI	0	0	0	0	0	180	0	270	760	0	0	0	0	0	0	0	3	1,210
IBSRAM	0	0	40	0	350	0	262	0	0	0	0	0	0	0	1,300	0	4	1,952
ICIMOD	0	0	0	0	540	0	0	600	0	600	0	0	0	0	600	0	4	2,340
IJO	0	0	0	350	0	0	600	0	0	0	0	0	0	0	0	0	2	950
CIRDAP	0	0	0	180	0	0	0	0	0	0	0	0	0	0	0	0	1	180
FAO	0	0	0	0	0	250	0	0	0	0	0	0	0	0	0	0	1	250
DMC Fisheries Agencies	249	540	0	350	0	714	0	0	0	1,095	0	0	0	0	0	0	11	2,948
DMC Livestock Agencies	0	130	0	0	150	0	0	0	220	0	0	0	0	0	0	0	3	500
DMC Forestry Agencies	90	0	0	350	0	0	1,500	0	0	0	1,200	0	0	0	0	0	4	3,140
Asian Maize Management and Training Center	0	0	0	0	0	0	0	0	0	0	600	0	0	0	0	0	1	600
Subtotal	**729**	**1,320**	**40**	**1,580**	**1,115**	**1,744**	**2,762**	**1,470**	**1,580**	**1,695**	**1,894**	**0**	**600**	**600**	**1,900**	**550**	**47**	**15,579**
Total	**2,554**	**5,298**	**1,065**	**4,560**	**2,340**	**4,734**	**6,952**	**3,678**	**2,830**	**2,728**	**4,394**	**100**	**6,650**	**6,100**	**7,500**	**6,150**	**118**	**67,633**

ADB = Asian Development Bank, AVRDC = Asian Vegetable Research and Development Center, CABI = Commonwealth Agricultural Bureaux International, CGIAR = Consultative Group on International Agricultural Research, CIAT = International Center for Tropical Agriculture, CIFOR = Center for International Forestry Research, CIMMYT = International Maize and Wheat Improvement Center, CIP = International Potato Center, CIRDAP = Center for Integrated Rural Development for Asia and the Pacific, DMC = developing member country, FAO = Food and Agriculture Organization, IBSRAM = International Board for Soil Research and Management, IARC = international agricultural research center, ICARDA = International Center for Agricultural Research in the Dry Areas, ICIMOD = International Centre for Integrated Mountain Development, ICLARM = International Center for Living Aquatic Resources Management, ICRAF = International Centre for Research in Agroforestry, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, IFPRI = International Food Policy Research Institute, IJO = International Jute Organization, ILRI = International Livestock Research Institute, IPGRI = International Plant Genetic Resources Institute, IRRI = International Rice Research Institute, ISNAR = International Service for National Agricultural Research, IWMI = International Water Management Institute.

Sources: ADB project files and IARC documents.

Table A1.3: ADB Portfolio of ANRR Projects in IARCs, 1975-1999

($'000)

Center/ Organization	No. of Projects	Completed	Ongoing	Total ADB Funding	% of Funding (CGIAR/Non-CGIAR)	% of Total ANRR Funding
CGIAR Centers						
IRRI	20	17	3	15,390	32.0	22.0
ICRISAT	13	11	2	7,245	15.0	11.0
IWMI	13	12	1	5,890	12.0	9.0
ICLARM	7	5	2	4,295	9.0	6.0
CIMMYT	1		1	1,400	3.0	2.0
CIP	2	1	1	1,033	2.0	2.0
IFPRI	4	3	1	2,546	5.0	4.0
ISNAR	3	2	1	1,355	3.0	2.0
IPGRI	3	1	2	3,200	7.0	5.0
ICRAF	1		1	1,200	3.0	2.0
ILRI	1		1	1,000	2.0	1.0
CIAT	1		1	1,200	2.0	2.0
ICARDA	1		1	1,200	3.0	2.0
CIFOR	1		1	1,100	2.0	1.0
Total	**71**	**52**	**19**	**48,054**	**100.0**	**71.0**
Non-CGIAR Centers						
AVRDC	13	11	2	5,509	28.0	8.0
CABI	3	3		1,210	6.2	1.7
IBSRAM	4	3	1	1,952	10.0	3.0
ICIMOD	4	3	1	2,340	12.0	4.0
IJO	2	2		950	5.0	1.0
CIRDAP	1	1		180	0.9	0.3
FAO	1	1		250	1.2	0.4
DMC Fisheries Agencies	11	11		2,948	15.0	4.0
DMC Livestock Agencies	3	3		500	3.0	0.7
DMC Forestry Agencies	4	4		3,140	16.0	5.0
Asian Maize Management and Training Center	1	1		600	3.0	0.9
Total	**47**	**43**	**4**	**19,579**	**100.0**	**29.0**

ADB = Asian Development Bank, ANRR = agriculture and natural resources research, AVRDC = Asian Vegetable Research and Development Center, CABI = Commonwealth Agricultural Bureaux International, CGIAR = Consultative Group on International Agricultural Research, CIAT = International Center for Tropical Agriculture, CIFOR = Center for International Forestry Research, CIMMYT = International Maize and Wheat Improvement Center, CIP = International Potato Center, CIRDAP = Center for Integrated Rural Development for Asia and the Pacific, DMC = developing member country, FAO = Food and Agriculture Organization, IBSRAM = International Board for Soil Research and Management, IARC = international agricultural research center, ICARDA = International Center for Agricultural Research in the Dry Areas, ICIMOD = International Centre for Integrated Mountain Development, ICLARM = International Center for Living Aquatic Resources Management, ICRAF = International Centre for Research in Agroforestry, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, IFPRI = International Food Policy Research Institute, IJO = International Jute Organization, ILRI = International Livestock Research Institute, IPGRI = International Plant Genetic Resources Institute, IRRI = International Rice Research Institute, ISNAR = International Service for National Agricultural Research, IWMI = International Water Management Institute.

Sources: ADB project files and IARC documents.

IMPACT EVALUATION METHODOLOGY AND RESULTS OF ANALYSIS

A. Methodology for Economic Surplus Model of Impact Valuation

1. Agricultural research is an investment that affects future productivity, income growth, environmental quality, food security and farmer safety, and the quality of rural life. Increased productivity means that more output can be produced with the same amount of total inputs or the same amount of output can be produced with a smaller quantity of inputs. At the industry level, a productivity-improving technical change typically results in both an increase in output and an increase in output per unit of input, while total inputs may fluctuate.[1] Productivity improvements lead to a reduction in costs per unit of output.

2. Economic evaluations of agricultural research increase our understanding of the payoffs to investing in research compared to alternative public or private investments. All investments have opportunity costs in terms of what those same resources could have earned in alternative uses. Economic evaluations can quantify net research benefits in order to help funding agencies decide if they are making the correct decisions with respect to their investments. Asian Development Bank (ADB) support to the agriculture and natural resources research (ANRR) program is now 25 years old and an evaluation of impacts and general alignment with ADB's strategy and policy for ANRR is needed. It will, thus, be useful for ADB to have at its disposal information on the net economic benefits of a sample of its projects. Not all research projects are successful, as research is by its very nature a risky endeavor. Also, many research benefits cannot be quantified in economic terms. Nevertheless, the evaluations presented in this report provide insights into what the ADB support program means to the economic well-being of producers and consumers.

3. For this study, the economic surplus method is used. This methodology is preferred because the economic surplus concept underlies the conventional economic rationale for investments in agricultural research through the public sector. This approach estimates returns on investments (generally a weighted average rate of return over time) by (i) calculating the change in consumer and producer surpluses that result from technological change brought about through research, and (ii) using estimated economic surplus together with research costs to estimate the net present value of the initial investments.

4. The theory underlying the economic surplus approach is based on the material benefits to society from technological change. The adoption of new technology reduces the unit cost of production, shifting the supply curve to the right and increasing consumer and producer surpluses. Consumers gain from the new technology because they can consume more at a lower price, and producers gain because their unit costs of production fall. The distribution of benefits between the two groups depends on the elasticity of demand and supply curves, and on the nature and magnitude of the supply shift. The combined total benefit to consumers and producers, measured in monetary units, is the change in economic surplus. The basic formula for estimating the change in economic surplus in year t ($-ES_t$) is:

[1] Alston, J.M. and P.G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy*. Washington, DC: American Enterprise Institute.

$$-ES_t = K_t P_t Q_t \frac{(1 + 0.5\, k_t \varepsilon\gamma)}{\varepsilon + \gamma}$$

where: P_t is the price of a commodity affected by research in year *t*;

Q_t is the quantity of production in year t of the commodity affected by research;

ε is the elasticity of supply;

γ is the elasticity of demand; and

K_t is the proportionate downward shift in the supply curve in year *t* due to research.

5. The most critical parameter, the variable *K*, is calculated as the net change in the cost of production due to new technology (sometimes approximated by the yield increment due to the new technology), weighted by the rate of adoption of the new technology in year *t*.

6. Time lags between the investment and realization of benefits are crucial in estimating economic returns. Three related lag components need to be estimated:[2] (i) the research lag (the time between an item of research expenditure and the release of new technologies), (ii) the adoption or uptake phase, and (iii) the depreciation phase (the time it takes for research knowledge to become obsolete). As a rule of thumb, the time lag for adaptive research is six years, for applied research 15 years, and for strategic research 25 years. Most of the research work supported by ADB is adaptive and applied in nature and represents additional funding for ongoing programs so the time lag assumption becomes more complex. The questionnaires used for this study reached consensus on these lags through roundtable discussions with researchers involved.

7. A basic economic framework can be used to measure the economic effects of productivity changes and of certain other types of research-induced changes. That framework includes (i) a supply and demand model of a commodity market to measure economic benefits at each of several points in time, and (ii) benefit-cost analysis techniques that consider the importance of the timing of the benefits and costs. The basic supply and demand model, as described in Alston and Pardey (1996), is represented in Figure A2.1. In this model, S_0 represents the supply curve before a research-induced technical change and *D* represents the demand curve. The initial price and quantity are P_0 and Q_0. Suppose research leads to savings of *R* per unit in the average and marginal cost of production, reflected as a shift down in the supply curve to S_1. This research-induced supply shift leads to an increase in production and consumption to Q_1 (by $-Q = Q_1 - Q_0$) and the market price falls to P_1 (by $-P = P_0 - P_1$). Consumers are better off because the research enables them to consume more of the commodity at a lower price. Consumers benefit from the lower price by an amount equal to their cost savings on the original quantity (Q_0 x $-P$) plus their net benefits from the increment in consumption. Although they receive a lower price per unit, producers are better off too, because their costs have fallen by *R* per unit, an amount greater than the fall in price. Producers gain the increase in profits on the original quantity, i.e., Q_0 x ($R - -P$) plus the profits earned on the additional output. Total benefits are obtained as the sum of producer and consumer benefits. As

[2] Alston, J.M., G.W. Norton, and P.G. Pardey. 1995. *Science Under Scarcity: Principles and Practice for Agricultural Research Evaluation and Priority Setting*. Ithaca, New York: Cornell University Press.

an approximation, the cost savings per unit multiplied by the initial quantity, R x Q_0, is often used.

Figure A2.1: Basic Supply and Demand Model for Research Benefits

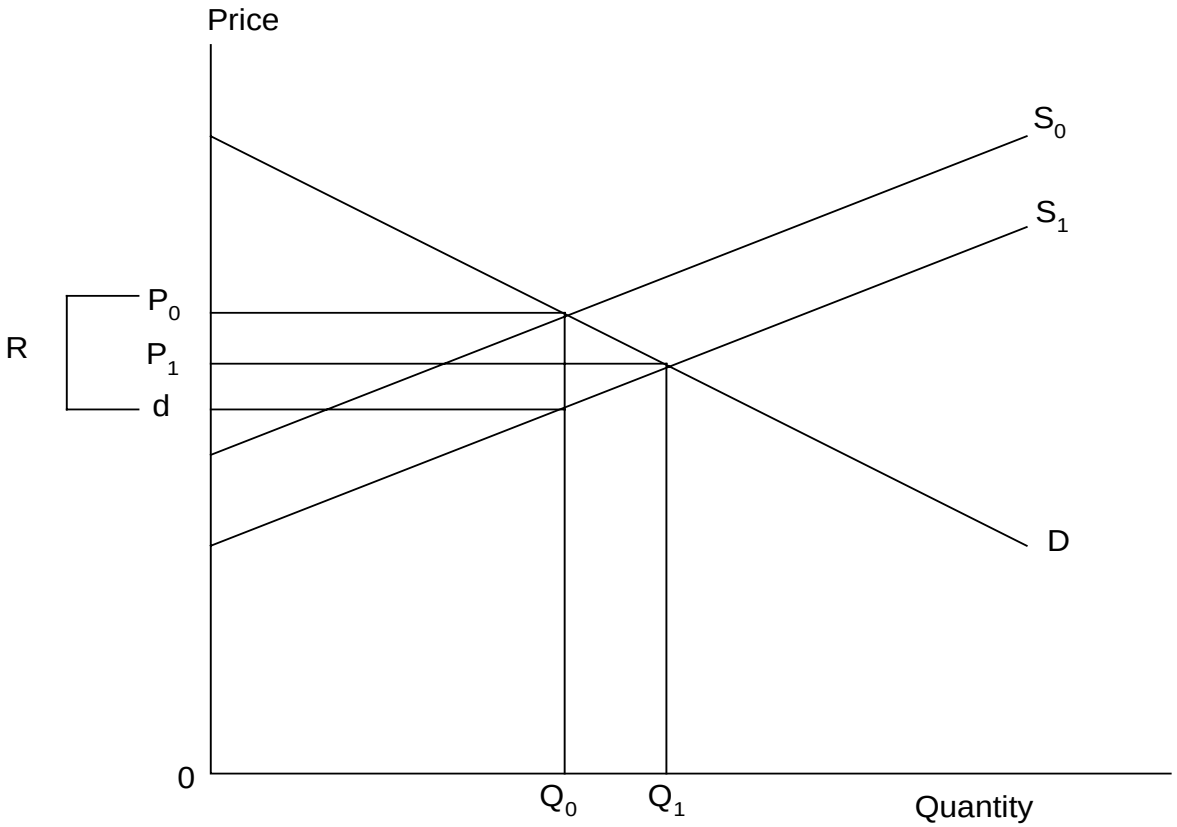
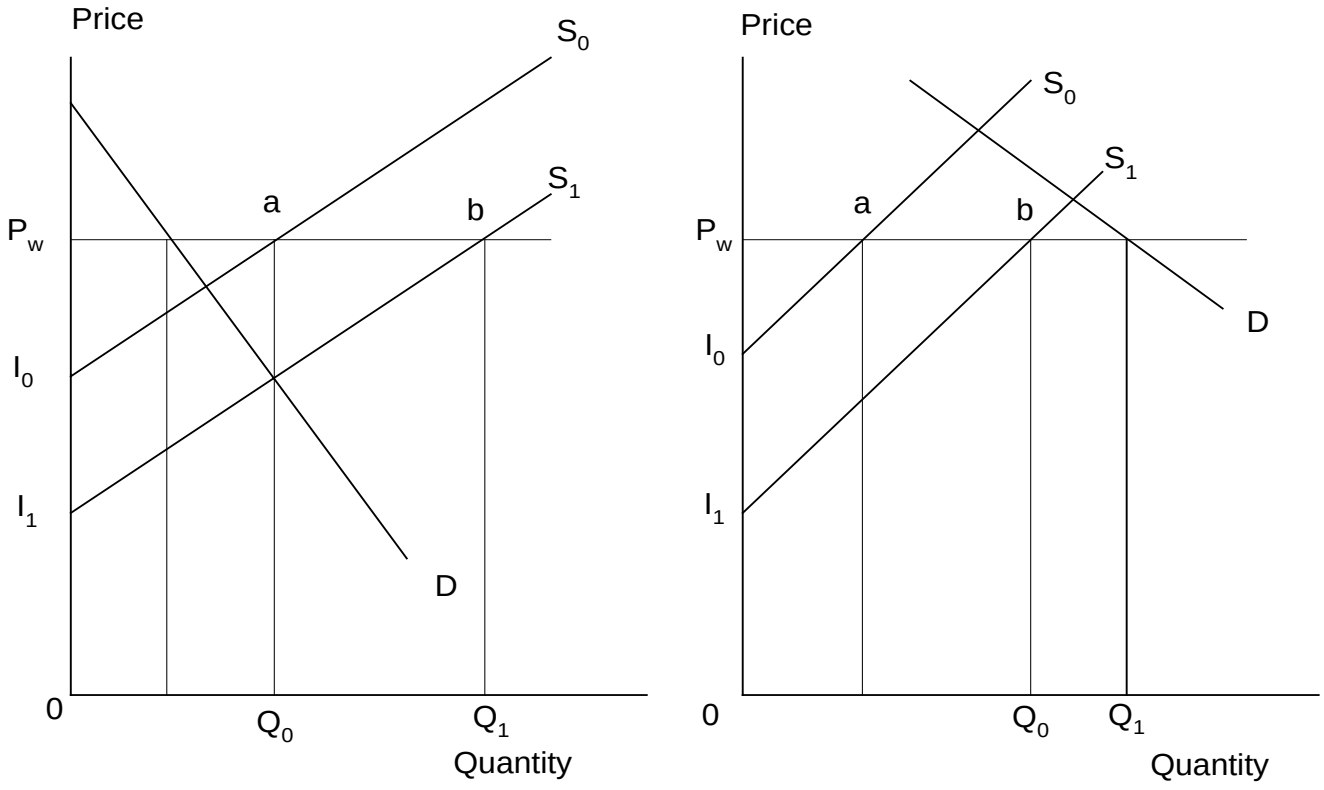


Figure A2.2: Effects of Research on Small-Country Exporter or Importer



8. The basic model pertains to a closed economy where the impacts are confined to the domestic economy of the nation as a whole, or to a state or region within a national economy. When a good is traded and not consumed or produced entirely domestically, the research will usually have a small or no price effect, because the world price is little influenced by the country's production or consumption. If the country is a small trader in the world market, the price can be taken as given, as illustrated in Figure A2.2. The benefits of research in this case (area I_0abI_1) accrue almost completely to producers, who experience a cost reduction with little corresponding drop in price.

9. The models illustrated in Figures A2.1 and A2.2 can be modified further to account for other market situations where government policies come into play, benefits are received at different levels in the marketing chain, and so on. Environmental benefits can even be measured by taking into account the divergence between private and social cost (supply) curves.

10. Most of the markets for commodities affected by ADB-assisted research fall under the small-country trade assumption as a reasonable approximation. The areas in the figures above that represent economic benefits can be measured by simple equations provided in Alston, Norton, and Pardey (1995) (footnote 2). These areas (called economic surpluses) are measured on a year-by-year basis, taking into account the time pattern of research and adoption/depreciation of research results. Different degrees of technology adoption imply different sizes of shift in the industry supply curve.

11. Using estimates of the annual flows of economic benefits and costs, a net present value can be computed that takes into account the fact that costs or benefits that occur or are received earlier are worth more than those that are received later. In the report that follows, all costs and benefits of the sample of research projects have been discounted or compounded as appropriate.

B. Data Requirements

12. The methods described above imply a requirement for several types of data as follows:

(i) data on prices and quantities of the commodities subject to the sample of research projects are needed, both historical and any expected increases or decreases due to non-research factors;

(ii) supply and demand elasticities that measure price responsiveness are needed for several of the commodities;

(iii) information on research costs is required for each project;

(iv) estimates are needed of the reductions in costs or increases in production for those who adopted the research results;

(v) estimates of expected or actual adoption rates for the results are required, including timing as well as levels;

(vi) information on any actual or expected depreciation of the technologies is needed;

(vii) a discount rate is needed to take into account the fact that benefits and costs occur over time; and

(viii) the proportion of benefits attributable to ADB funding is needed for those projects for which ADB-assisted research represents only a portion of the total research program on the subject.

C. Data Collection Procedures

13. Price, quantity, and elasticity information are obtained from published sources in Asia and the United States. Other data and information are obtained from a series of interviews with project scientists and other experts. For the latter, a set of questionnaires was designed for each project and utilized through face-to-face interviews during the field visits. The questionnaires are given in pages 6 to 8 of this appendix.

Questionnaire Used for Commodity-Oriented Center Impact Evaluations (IRRI, ICRISAT, AVRDC)

Checklist of Data Required for Overall Impact Using theEconomic Surplus Approach

Research-Related Data Required	Market-Related Data Required
Key technologies generated by the selected research program over the period of analysis. Proportionate yield change due to the new technologies. Proportionate change in variable input costs per hectare, if any, to achieve the expected yield change. Probability of research success. *Research lag:* observed or expected time from the beginning of research activities to the release of a new technology. *Development and adoption lag:* observed or expected time between first adoption and first adoption by farmers. *Adoption path:* observed or expected time between first adoption and full adoption (for simplicity, a linear adoption path is often assumed). *Adoption ceiling:* maximum number of farmers likely to adopt the new technology or maximum number of production units expected to be affected by the new technology. Period of time that the new technology will generate full benefits. *Depreciation factor:* the rate at which the benefits of new technology will depreciate after the period of full benefits. Annual total research expenditures for each selected research program from the beginning of research activities to the time of the new technology release. This will also need ADB grant funding as a percentage of the total expenditure for the project, by year.	Quantities produced and consumed. Detailed data on prices and quantities for a commodity aggregate of interest on an annual basis for years for which the benefits are assessed. Prices received and paid. Price elasticities of supply and demand for each group of producers and consumers. *Exogenous output growth rate:* anticipated proportionate change in output not due to research in each year (growth rate of area plus growth rate if yield not due to research). Discount rate.

AVRDC = Asian Vegetable Research and Development Center, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, IRRI = International Rice Research Institute.

Project Numbers and Costs

Respondent : _____

Affiliation : _____

1. Please describe the Project's principal objectives and results.

2. Which of the following best describes the output of the research projects:

   a) New/improved product
   b) New/improved treatment or procedure
   c) Contribution to scientific knowledge

3. Please describe the extent to which you believe these projects are responsible for the development of these outputs. What proportion of these results are attributable to the ADB funding? _____

4. What is the estimated maximum increase in yield expected from the Project? _____

5. How many years do you think it will be before that maximum is attained? _____

6. What is the estimated maximum increase in area planted using these technologies expected from the Project? _____

7. How many years do you think it will be before that maximum is attained? _____

8. Do you expect this technology will become obsolete?

   ☐ Yes (Go to Question 8a)

   ☐ No (Go to Question 9)

   8a. When do you expect it will become obsolete? _____

9. Please estimate the cost of producing a kilogram of rice in the target agro-ecosystems without this technology. _____

10. If a producer were to adopt this technology, which production costs would increase? _____

    By what percent would each of these costs of producing a kilogram paddy incrase? _____

    Prior to adoption of these results, what percentage of the total cost of producing a kilogram of paddy do each of these costs represent? _____

11. Which production costs would decrease? _____

    By what percent would each of these costs of producing a kilogram of paddy decrease? _____

    Prior to adoption of these results, what percentage of the total production budget do each of these costs represent?

Paddy/Other Crops	Input	Increase/Decrease (%)	Total Budget (%)

12. Will the quality of the product increase, decrease, or remain the same as a result of adopting this technology? _____

13. Will the higher quality product receive a different price? _____

14. Please estimate, as a percentage of the price of the lower quality product, the difference in price between the higher and lower quality products? _____

15. In the absence of the results of this project, would you expect the total kilogram of paddy production in the target agro-ecological zone to increase, decrease, or remain the same over the coming years? _____

16. By what percent per year? _____

17. Please provide basic data on production and prices for paddy in the target agro-ecological zones over the past 10 years.

    _____

    _____

    _____

18. Please provide recent estimates of the elasticities of demand and supply for paddy in the target agro-ecological zones or in other comparable production zones/markets?

    _____

    _____

    _____

19. What is the estimated spillover of these research products into other regions/target agro-ecological zones in terms of areas affected or incremental production attributable to this research?

    _____

    _____

    _____

Table A2.1: ANRR-Funded Projects Selected for IRR Analysis[a]

Center/ RETA No.	RETA Project Name	Year Funded
1.	**International Rice Research Institute** **Theme: Single Commodity Assessment**	
5261	Development of Rice Varieties Tolerant to Problem Soil Conditions	1987
5510	Establishment of the Asian Rice Biotechnology Network	1992
5606	International Rice Research Institute for Rain-Fed Lowland Rice Ecosystem Research	1994
5667	Asian Rice Biotechnology Network—from Products to Impact	1996
5711[b]	Exploiting Biodiversity for Sustainable Rice Pest Management	1996
5766[c]	Development and Use of Hybrid Rice in Asia	1997
5812[d]	Asian Rice Biotechnology Network (Phase III)	1998
2.	**International Crops Research Institute for the Semi-Arid Tropics** **Theme: Multi-Commodity Crops Grown in Less-Favored Environments**	
5603	Strengthening Regional Collaboration on Cereals and Legumes Research in Asia	1994
5711[b]	Legume-Based Technologies for Rice and Wheat Production	1996
3.	**Asian Vegetable Research and Development Center** **Theme: Multi-Commodity Development through Regional Networks**	
5322	Asian Vegetable Research and Development Center to Establish a Collaborative Vegetable Research Program in Southeast Asia	1989
5461	South Asia Vegetable Research Network	1991
5517	Collaborative Vegetable Research Program for Southeast Asia (Phase II)	1992
5719	South Asia Vegetable Research Network (Phase II)	1997

ADB = Asian Development Bank, ANRR = agriculture and natural resources research, CGIAR = Consultative Group on International Agricultural Research, IRR = internal rate of return, RETA = regional technical assistance.

[a] The International Center for Living Aquatic Resources Management is not listed in Table A2.2 as it was not evaluated using the Dynamic Research Evaluation for Management model but used a general equilibrium approach.

[b] A component of 5711-REG: *Agriculture and Natural Resources Research at CGIAR Centers*, for $5,200,000, approved on 12 December 1996.

[c] A component of 5766-REG: *Second Agriculture and Natural Resources Research at CGIAR Centers*, for $5,500,000, approved on 29 December 1997.

[d] A component of 5812-REG: *Third Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 22 October 1998.

Source: ADB project files.

Table A2.2: Summary of Case Study Results

RETA No.	RETA Project Name	Target Crop/Country	Surplus ($'000)			IRR (%)
			Producer	Consumer	Total	
1.	**International Rice Research Institute**					
5261	Development of Rice Varieties Tolerant to Problem Soil Conditions	Rice/Asia	12,102	24,845	36,947	57
5510, 5667, 5812[a]	Asian Rice Biotechnology Network	Rice/Asia	192,712	396,682	589,394	82
5606	Rain-Fed Lowland Rice Ecosystem Research	Rice/Asia	1,182,977	2,434,228	3,617,205	80
5711[b]	Exploiting Biodiversity for Sustainable Rice Pest Management	Rice/Asia	25,173	51,900	77,073	108
5766[c]	Development and Use of Hybrid Rice in Asia	Rice/Asia	1,607,938	3,314,127	4,922,065	88
	Total Surplus and Average IRR		**3,020,902**	**6,221,782**	**9,242,684**	**83**
2.	**International Crops Research Institute for the Semi-Arid Tropics**					
5603	Strengthening Regional Collaboration on Cereals and Legumes Research in Asia	Chickpea/Bangladesh	29,977	309,774	399,751	48
		Sorghum/India	29,282	29,277	58,559	72
		Groundnut/PRC	117,337	28,131	145,468	51
		Groundnut/Indonesia	254,244	60,966	315,210	52
		Pigeonpea/Nepal	5,423	1,300	6,723	23
		Groundnut/Philippines	2,123	507	2,630	34
		Groundnut/Sri Lanka	944	226	1,170	10
		Groundnut/Thailand	13,462	3,230	16,692	40
5711[b]	Legume-Based Technologies for Rice and Wheat Production	Chickpea/Nepal	1,818	435	2,253	13
		Groundnut/Viet Nam	33,126	7,947	41,073	59
		Pigeonpea/India	289,408	69,421	358,829	96
		Chickpea/Bangladesh	5,213	1,178	6,391	67
		Chickpea/Nepal	1,389	314	1,703	9
		Pigeonpea/India	15,471	3,502	18,973	56
	Total Surplus and Average IRR		**799,217**	**516,208**	**1,315,425**	**45**
3.	**Asian Vegetable Research and Development Center**					
5322, 5517	Collaborative Vegetable Research Program in Southeast Asia (Phases I and II)	Cucumber/SE Asia	19,620	14,307	33,927	39
		Tomato/SE Asia	427,149	309,774	736,923	89
		Yard-long Beans/SE Asia	75,054	54,579	129,633	59
		Hot Pepper & Chili/SE Asia	1,260,949	9,176	1,270,125	100
5461, 5719	South Asia Vegetable Research Network (Phases I and II)	Cabbage/S Asia	237,010	324,975	561,985	81
		Tomato/S Asia	3,771,115	5,145,848	8,916,963	139
		Hot Pepper & Chili/S Asia	2,178,387	2,981,840	5,160,227	126
		Onion/S Asia	453,385	621,226	1,074,611	93
	Total Surplus and Average IRR		**8,422,669**	**9,461,725**	**17,884,394**	**91**
	Total Surplus for All 27 Projects Evaluated		**12,242,788**	**16,199,715**	**28,442,503**	
	Average IRR[d]					**65**

CGIAR = Consultative Group on International Agricultural Research, PRC = People's Republic of China, IRR = internal rate of return, S = South, SE = Southeast, RETA = regional technical assistance.

[a] A component of 5812-REG: *Third Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 22 October 1998.

[b] A component of 5711-REG: *Agriculture and Natural Resources Research at CGIAR Centers*, for $5,200,000, approved on 12 December 1996.
[c] A component of 5766-REG: *Second Agriculture and Natural Resources Research at CGIAR Centers*, for $5,500,000, approved on 29 December 1997.
[d] Simple (unweighted) mean of IRR for all 27 projects evaluated.

REVIEW OF LINKAGES CONCERNING ANRR, POVERTY REDUCTION, AND THE ECONOMIC STATUS OF WOMEN

A. Agricultural Research, Agricultural Productivity Growth, and Poverty Reduction

1. One rationale for Asian Development Bank (ADB) support to agriculture and natural resources research (ANRR) for crops and farming systems that are prevalent in less-favored areas (dryland/rain-fed lowland rice, problem soils, flood prone areas, etc.) was to use research to increase farmer income from agricultural production in less favorable environments. A study on the impact of rice research on productivity increases and rural poverty by David and Otsuka[1] showed that the production gap between favorable and unfavorable areas has widened within and across countries in South and Southeast Asia. The populations in rain-fed areas within a country or region are generally poorer. To a large extent, Asian countries with a greater proportion of unfavorable production areas are poorer than other rice-growing countries. There is a common belief that a sharp tradeoff exists between efficiency and equity in allocating rice research investments among different production environments or regions. This study examined the impact of different technology adoption across production environments on income distribution in seven countries in 1987. This study examined not only the direct effects of technology on productivity, factor use, and income but also the indirect effects of technology through labor, land, and product market adjustments that can potentially mitigate the assumed inequitable impact of differential technology adoption.

2. The country studies reported in David and Otsuka (footnote 1) generally found that when both direct and indirect effects are taken into account, differential adoption of modern varieties (MVs) across different production environments has not significantly worsened income distribution. As MV adoption increases, labor demand in the favorable area increases due to greater labor requirements per crop, higher cropping intensity, and growth linkage effects on nonfarm employment. Interregional migration from unfavorable to favorable areas is induced, largely equalizing wages across production environments. Also, rapid income growth induced by the new technologies has increased nonfarm employment, helping to raise wage rates and reduce regional inequalities. This study showed that factor and product market adjustments largely counteracted the potentially adverse effects of technological change in favorable areas on poor people in unfavorable areas. This was especially true when technical change lowered the real rice price, thus providing greater benefits to poor people who are generally net rice consumers. There is clear empirical evidence of a long-run trend toward lower real prices of rice in developing member countries (DMCs). Targeting rice research toward unfavorable rice-growing environments will thus not generally be an effective means of improving income distribution if efficiency is largely sacrificed (footnote 1). An exception maybe in countries or large regions (Northeast Thailand, West Bengal) where irrigated areas constitute a small proportion of rice area and work on rain-fed systems must take priority. Otherwise, rice research should make its major effort the production of technology for the favorable areas, while the public sector invests in research and in production and marketing infrastructure for introducing alternative crops in the less-favored areas. The current ADB funding portfolio for ANRR strikes an appropriate balance between research funding for these two groups of areas.

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[1] David, C.C. and K. Otsuka. 1990. *Differential Impact of Modern Rice Varieties in Asia: An Overview*. Modern Rice Technology and Income Distribution in Asia. Colorado: Lynne Reinner Press.

3. Essential elements of food security are availability of food and the ability of people to acquire it. Although investments in international agricultural research resulting in the green revolution technologies have dramatically increased the production of food in DMCs (particularly rice and wheat), a segment of the population may not have the ability to access it because of insufficient employment opportunities, low productivity of labor, low wage rates, and low incomes. It has been argued that what matters to the poor is not the rate at which food production is growing but the manner in which this growth affects their employment, incomes, and economic capacity to access food from the markets.[2] Given the unequal access to land and the inequitable social structure this leads to, adoption of green revolution technologies could be expected to worsen income distribution through these negative effects. Poor peasants would be unable to access working capital and insurance needed to purchase water, fertilizer, and new seeds. Larger farmers with access to working capital and better able to bear the risks would be able to take advantage of the new technologies to a greater extent than small farmers. The non-adopters (small farmers or tenant farmers) would face lower output prices but would be unable to lower production costs by growing new varieties. Additional profits made by large farmers would enable them to purchase non-adopters' land, increasing landless populations and rural poverty.

4. Empirical research reviewed indicates that these arguments do not hold true. On balance, the forces impinging on small peasants, tenant farmers, and wage laborers appear to be beneficial. First, MVs were adopted earlier on larger, owner-operated farms but small farms and tenant operators soon followed suit. Adverse environmental factors (lack of irrigation, risk of drought and flooding, poor drainage, underdeveloped market infrastructure) were more important than socioeconomic factors in explaining adoption. Public policies often helped smaller farmers through easy terms for credit and subsidized water and fertilizer. Second, the spread of MVs increased the demand for labor, lowered commodity prices, and increased real wage rates for rural workers. Larger farm households experienced higher farm incomes, substituted labor for leisure, and hired more landless workers to do tasks previously done by family labor. Third, increases in agricultural productivity and agricultural incomes generated additional employment through indirect linkage effects in rural processing, trade, and transport. This poverty reduction effect on real rice prices began to erode in the late 1980s as the rate of yield increase also slowed.

5. A detailed examination of these hypotheses was undertaken by S.R. Osmani.[3] He found that the economies of scale supposedly associated with green revolution technologies were minimal, expansion of credit through a variety of means helped reduce the operating capital constraint, risk was reduced by demonstration effects and stability of the new technologies, and input subsidies also reduced both the credit and risk constraints. Basically, the green revolution technologies were scale-neutral as access to rural resources, particularly land, has been the major determinant of equitability of agricultural growth. The impact on employment and wages of agricultural laborers is critical to reducing poverty through green revolution technologies. Evidence

[2] Hossain, M. and P. Pingali. 1998. *Rice Research, Technological Progress and Impact on Productivity and Poverty: An Overview.* Impact of Rice Research. Proceedings of the International Conference on the Impact of Rice Research, 3-5 June 1996, Bangkok, Thailand.

[3] Osmani, S.R. 1998. *Did the Green Revolution Hurt the Poor? A Re-Examination of the Early Critique*. In: Pingali, P. and M. Hossain (eds). Impact of Rice Research. Proceedings of the International Conference on the Impact of Rice Research, 3-5 June 1996, Bangkok, Thailand. Thailand Development Research Institute, Bangkok, and International Rice Research Institute, Manila, Philippines.

throughout Asia shows that adoption of MVs has increased the absorption of hired labor more than family labor and that total labor absorption in agriculture has risen because of the increase in gross cropped area.

6. The nonfarming poor have benefited by lower food prices and from higher incomes as the increased prosperity of the farm population impacts on the nonfarm sector through linkage effects. However, despite widespread adoption of MVs, levels of poverty have improved only slowly, particularly in South Asia. Osmani provides some explanation of the MV-poverty mystery. Exogenous factors help explain why poverty reduction has been so slow despite the achievements of the green revolution. One important factor is the closing of the land frontier, especially in Bangladesh and India: land expansion was a traditional source of entitlement for rural poor. Population growth has been the other major exogenous factor limiting the potential impact of MV technologies in several ways.

B. Linkages Between AVRDC Research on Vegetables and Poverty Reduction

7. **Consumption.** Balanced diet, rather than just more carbohydrate, is an emerging definition of food security, and improving the overall nutritional status of low-income groups at the least cost is an important element in combating the poverty-malnutrition linkage. This is done by analysis of the impact of lowering the cost of various food items on the consumption of various food groups and on the nutritive elements of these groups. Research and development (R&D) has the effect of lowering the cost of food. A recent paper by Asian Vegetable Research and Development Center (AVRDC) researchers estimated demand elasticities of food groups, individual foods, and the nutrients in each food.[4] The impact of a 1 percent decrease in the price of food groups found that the vegetable group had the highest nutritive efficiency gain, followed by meat, seafood, fruit, egg and milk, and cereals. Vegetables can also have a major impact on poor households through kitchen gardens for home consumption.

8. **Income generation.** Vegetable production is by its nature labor intensive in all stages of production, transport, processing, and marketing. Its ability to generate value added for household labor as well as hired labor is high.

9. **Health.** R&D has produced results which have allowed certain groups of producers to reduce pesticide use by 90 percent or more and in some cases to stop its use altogether. Impact of this on rural poverty is through reduced adverse effects of pesticides on producers and workers.

10. **Trends.** Although there has been a slow increase in vegetable production, the potential impact of vegetables to assist with poverty reduction is not fully being realized as the demand-supply gap in all Asian countries remains substantial and real prices have been increasing throughout most of the period 1980-1993.[5] High variations in seasonal supply and prices also lead to seasonal fluctuation in micronutrient status.

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[4] Mubarak, Ali, Shu-nu Wu, and Mei-huey Wu. 2000. Valuing the Nutritive Efficiency of Policy Intervention: An Application to Taiwan Household Survey Data. Manuscript, AVRDC, Shanhua, Tainan, Taipei,China.

[5] Mubarak, Ali, (ed.). 2000. *Dynamics of Vegetable Production, Distribution and Consumption in Asia.* AVRDC. Publication 00-498, pp. 9-10.

C. ICLARM Research and Poverty Reduction

11. International Center for Living Aquatic Resources Management (ICLARM) research influences poverty reduction via several avenues. Research lowers the cost of fishery products leading to improved diet and purchasing power of the poor; improving access to fisheries resources by low-income fishing communities leads to higher incomes; and land limitations, often associated with the rural poor, can be overcome by aquaculture in some cases, under environment-friendly conditions. Other activities assisting with poverty reduction are (i) conserving and rebuilding fish stocks, (ii) providing policy advice on management arrangements for common resources, (iii) providing insights into the many external factors impinging on aquatic resource use and management, (iv) providing information that can empower communities to manage their own resources and protect biodiversity, and (v) creating alternative livelihood in coastal zones. These efforts aim to increase fisheries productivity and so result in lower costs for fisheries products, and to establish access and management responsibility for the poor.

12. An example of ICLARM work with particular benefits to the poor is its program work to refine and expand carp polyculture aquaculture systems. These systems are particularly oriented for poverty reduction due to the limited inputs required. Basic ponds available in rural areas (without infrastructure for cleaning and draining) can be stocked with four to seven species of carp that have different feeding niches to increase system efficiencies. The only inputs required are for fertilization of the pond. Feed inputs are not required. Fertilization can be achieved through application of chemical fertilizers or low-cost agricultural wastes. Yields under such a system can exceed 2,000 kilogram/hectare. The expansion of such systems in Bangladesh and India has the potential to substantially increase fish production by smaller poorer farmers and to decrease fish prices through expanded supply.

D. ILRI's Livestock Research and Poverty Reduction

13. The strategy document of the International Livestock Research Institute (ILRI) sets out the potential role of livestock research for poverty reduction.[6] Worldwide, two thirds of the rural poor keep livestock and almost 60 percent of this livestock is in mixed crop-livestock systems. This is also true for Asia. The International Food Policy Research Institute (IFPRI) impact model shows that there will be modest decreases in prices of milk and some meat products worldwide over the next 20 years which will have a significant impact on the nutritional status of the poor.[7] Increasing conversion efficiency of livestock feed and expanding areas of high quality forage will reduce upward pressure on feed grains that are also used as food, particularly by the poor. The rural poor, especially women, derive a larger share of their income from livestock than do the relatively wealthier male-dominated farmer groups/sectors in Asia. The projected increases in livestock product demand (footnote 7) offer opportunities for the rural poor, with little access to land or capital, to benefit from a rapidly growing market. Livestock also represents a source of cash income, inflation-proof and mobile liquid capital assets, and acts as a buffer against poor crop yields.

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[6] ILRI. 2000. *Livestock Strategy to 2000: Making the Livestock Revolution Work for the Poor.* Nairobi, Kenya.

[7] Delgado, C., M. Rosegrant, H. Steinfeld, S. Ehui, and C. Courbois. 1999. Livestock to 2020: The Next Food Revolution. *2020 Vision for Food, Agriculture and the Environment Discussion Paper 28.* IFPRI. Washington, DC.

14. Research by ILRI has shown the role of livestock in overgrazing and degradation of arid rangelands has probably been relatively more important. Animals, by providing manure and power, encourage more sustainable, intensive crop production, a fact also noted in the ADB-supported grant to International Rice Research Institute on Intensification of Less Favorable Environments, Including Rice–Wheat Systems. Owning ruminants also encourages planting of browse trees, shrubs, leguminous forages, and grass. These interventions control erosion, promote water conservation, and increase soil fertility. A major threat to the environment from livestock in Asia is the threat from intensive peri-urban and industrial enterprises that generate enormous amounts of livestock waste. Research is needed to identify policies that have encouraged these types of enterprises.

E. IWMI Research Impacts on Poverty Reduction

15. Irrigation advances and expansion have played a critical role in increasing agricultural productivity in Asia, which has led to falling real food grain prices.[8] Between the 1960s and 1990s, real food grain prices fell by approximately 50 percent. This decline was principally due to the impact of the green revolution in developing countries. Estimating the precise share of the gains in cereal grain production attributable to irrigation is a problematic task. However, there is no doubt that without the advances in irrigation technologies and the extraordinary investments in irrigation expansion by both the public and private sectors, the impact of the green revolution would have been greatly reduced.

16. The benefits of lower food grain prices to the poor are clear. Sixty percent of the money spent on food by people below the poverty line in Asia is apportioned for cereals (which provide as much as 70 percent of their total nutrients). Decreasing this cost has a very substantial impact on the welfare of the poor and their ability to purchase a nutritionally sufficient diet.

17. A second major impact of irrigation on the poor is employment (both on and off the farm) that provides increased purchasing power. For landless laborers, increased cropping intensity has resulted in increased labor demand and wages. Irrigation means more work in more days of the year. The employment impact is felt not only in the irrigated but also rain-fed areas. Landless workers in rain-fed areas migrate long distances to take advantage of opportunities in irrigated areas. A multiplier effect is also at work, with higher incomes in agriculture creating employment opportunities off the farm in the general economy.

18. An important contributor to poverty reduction has been the growth in public-sector-funded canal irrigation and largely private-sector-funded tubewell irrigation.[9] Technological advances in storage dam construction, tubewells, and lift pumps facilitated this expansion and allowed a larger percentage of crops to be produced during the dry season. Crops in the dry season environment have a higher response to fertilizer application because of higher solar energy and lower pest infestations. The tubewell technologies in particular were instrumental in poverty reduction in Bangladesh and eastern India. The initial importance of publicly financed deep tubewells has

[8] The following discussion is based on Randolph Barker and Barbara van Koppen, IWMI Water Brief 3, April 1999.

[9] Shah, T. 1993. Groundwater Markets and Irrigation Development. *Political Economy and Practical Policy*. Oxford University Press.

declined with increased private investment in shallow tubewells.[10] Many of the poor who could not afford these technologies directly accessed irrigation water through the development of water markets and microcredit systems. It should be noted that lack of irrigation in rain-fed areas has greatly hampered poverty reduction. Little progress has been made in raising agricultural productivity in the water-scarce rain-fed areas of Asia, where efforts to mobilize water resources have been largely unsuccessful. Scientists have shown that a number of cheaper water-harvesting and supplemental irrigation technologies have the potential to greatly increase crop yields. However, adoption by farmers has been limited because costs seem to have outweighed benefits.[11] Finding the combination of low-cost technologies and management practices to increase productivity will continue to be a major challenge to researchers at International Water Management Institute (IWMI) and elsewhere.

19. **Impact of Impending Water Shortages on Poverty Reduction.** Overexploitation of groundwater resources suggests that past achievements in poverty reduction in irrigated areas may be at risk. IWMI has undertaken a long-term program to analyze water availability through the major river basins of the world.[12] Initial findings of this study indicate that 2.7 billion people will experience severe water scarcity within the next 25 years. The majority of this population will reside in the semi-arid regions of Asia. Due to overexploitation of groundwater, food production will be adversely affected in two of Asia's major breadbaskets—the Punjab and the North China Plain. Overexploitation of groundwater resources by tubewell irrigation now poses a major threat to the environment, health, and food security. The groundwater problem has two components. First is the rapid drawdown of freshwater aquifers due to the use of wells and pumps for irrigation, and for domestic and industrial water supplies. Second is the opposite problem of rising water tables of saline and sodic water. In addition, aquifers are being contaminated by toxic elements. The recent discovery of extensive arsenic poisoning of the aquifers in Bangladesh provides a striking example of the effects of groundwater mismanagement.

F. Agricultural Research and Poverty Alleviation: Some ICRISAT Impact Studies[13]

20. The semi-arid tropics are home to more than 300 million of the world's poor. The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), since its inception in 1972, has therefore had a primary focus on putting in place mechanisms that would strengthen the linkages between agricultural research and poverty alleviation. The political economy, as well as the agroecological conditions of the semi-arid tropics, is considered in the development of the research agenda of ICRISAT. Pioneering village-level studies and research on distributional effects, risk, gender dimensions, nutrition, and employment have been carried out which fed into the research process for agricultural innovations. Poverty alleviation or changes in welfare are shown to be influenced by adoption of agricultural innovation and by factors including socioeconomic

[10] International Irrigation Management Institute and Bangladesh Agricultural University (Bureau of Socioeconomic Research and Training of the Bangladesh Agricultural University). 1996. *Study on Privatization of Minor Irrigation in Bangladesh.* Mymensingh, Bangladesh.

[11] Oweis, T., A. Hachum, and J. Kijine. 1999. Water Harvesting and Irrigation for Improved Water Use Efficiency in Dry Areas. SMIM Paper 7. IWMI. Colombo, Sri Lanka.

[12] Seckler, D., D. Molden, and R. Barker. 1998. Water Scarcity in the Twenty-First Century. IWMI Water Brief 1. IWMI. Colombo, Sri Lanka.

[13] This section is abstracted from Agricultural Research and Poverty Alleviation: ICRISAT Impact Studies by Bantillan, M.C.S., D. Parthasarathy, and R. Padmaja. ICRISAT draft manuscript.

conditions, policy environment, and infrastructure facilities. Since most of the semi-arid tropics are ecologically fragile, the linkage between resource degradation and poverty is given prime emphasis. Of equal importance is research carried out on developing improved varieties of ICRISAT's mandate crops, which have significantly enhanced crop yields and quality. Unlike the green revolution, which was not scale-neutral and which increased farmer dependence on a variety of rural and urban institutions, ICRISAT focuses on open pollinated varieties, which helps farmers maintain improved germplasm.

21. Evidence from the literature shows that agricultural research has been instrumental in introducing improved technologies that have raised agricultural production, stimulated economic growth, and helped poor people through lower food prices and higher incomes.[14] However, there are legitimate concerns that research-led technological change in agriculture has favored wealthy farmers at the expense of poor producers and laborers (Freebairn, 1995 and Pearse, 1980).[15,16] Concerns regarding the environmental impact of new technologies have also been expressed. The relationship between poverty and environmental degradation is especially important in the world's semi-arid tropics.

G. Evidence of Adoption and Positive Impact

22. As of 1999, a total of 399 improved cultivars developed by ICRISAT/national agricultural research systems had been released throughout the world. Studies carried out by ICRISAT's research evaluation and impact assessment (REIA) team from 1994 have clearly established large-scale adoption of several technologies that are products of germplasm breeding as well as natural resource management research. A summary of adoption rates for some technologies in Asia is presented in Table A3.1. All five of ICRISAT's mandate crops have seen the adoption of improved technologies.

23. Three kinds of impact resulting from technology adoption were identified: (i) spillover effects of germplasm research, (ii) improved crop and resource management options, and (iii) output of ICRISAT breeding efforts/genetic enhancement research. The impacts observed and analyzed were mainly in terms of yield enhancement, income increase, net present value, internal rate of return, sustainability, and gender. A summary is presented in Table A3.1, and a brief discussion of the nature and kinds of impact follows.

Table A3.1: Summary of Adoption Data Generated from ICRISAT REIA Studies in India

Region	Crop/Technology	Current Adoption Levels (%)
Andhra Pradesh Border	Pigeonpea ICP 8863	52
Karnataka State	(Wilt Endemic Region in Production System 7)	59

[14] Lipton, M., and R. Longhurst. 1989. *New Seeds and Poor People*. Baltimore: Johns Hopkins University Press.

[15] Freebairn, D.K. 1995. Did the Green Revolution Concentrate Incomes? A Quantitative Study of Research Reports. *World Development* 23(2):265-279.

[16] Pearse, A. 1980. *Seeds of Plenty, Seeds of Want: Social and Economic Implications of the Green Revolution.* New York: Clerendon Press and Oxford University Press.

Maharashtra Border		59
Maharashtra State		18
Western Maharashtra	Pigeonpea ICPL 87 (Short Duration)	57
Maharashtra	Improved Pearl Millet Cultivars	89
Gujarat		95
Rajasthan		56

ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, REIA = research evaluation and impact assessment.

Source: ICRISAT Research Evaluation and Impact Assessment Study.

24. In a case study on the impact of groundnut production technology in India, Joshi and Bantillan (1999) found partial and step-wise adoption of different components of the technology that ranging between 31 and 84 percent in comparison to the prevailing technology.[17] The technology gives 385 percent higher yields, generates 71 percent more income, and reduces unit costs by 16 percent. The technology also contributes to improving the natural resource base, and eases certain women-specific agricultural operations. The total net present value of benefits from collaborative research and technology transfer is more than $3 million, representing an internal rate of return of 25 percent.

25. A study by Bantillan and Parthasarathy (1999), established an important connection between farmers' concerns regarding sustainable farming and the adoption of improved technologies.[18] Results from a formal onfarm survey and rapid rural appraisals conducted in a drought-prone area in central India revealed that (i) farmers are well aware of the effects of intensive cultivation of cash crops, such as sugarcane or cotton in irrigated tracts, in terms of reduced yields and increasing use of inputs; (ii) appropriate crop/varietal adoption and management practices are consciously implemented to maintain long-term productivity levels for existing and desired cropping systems; and (iii) farmers strive to maintain or increase soil fertility by including nitrogen-fixing legumes in crop rotations—in this case, short-duration pigeonpea. Widespread adoption of short-duration pigeonpea (56 percent) made farming profitable in the short term (from higher yields and 30 percent higher income) and helped sustain productivity in the long run via crop rotation to maintain soil fertility.

26. Kolli and Bantillan (1997) studied the gender-related impacts of a crop and resource management technology package in Maharashtra, India.[19] The following indicators emerged with strong implications on gender due to the introduction of the technology: (i) labor-activity pattern and time allocation, (ii) decision-making behavior of men and women with regard to resource use and utilization of crop products, and (iii) user perspective—differential perceptions of men and women with implications for technology

[17] Joshi, P.K. and M.C.S. Bantillan. 1999. Impact Assessment of Crop and Resource Management Technology: A Case of Groundnut Production Technology. *Working Paper*. ICRISAT. Patancheru, India.

[18] Bantillan, M.C.S. and P. Parthasarathy. 1999. Efficiency and Sustainability Gains from Adoption of Short-Duration Pigeonpea in Non-Legume-Based Cropping Systems. *Working Paper*. ICRISAT. Patancheru, India.

[19] Kolli, R.D., and C. Bantillan. 1997. Gender-Related Impacts of Improved Agricultural Technologies: Identification of Indicators from a Case Study. *Gender, Technology, and Development*. 1(3).

development. The study shows that, to ensure effective and committed involvement of men and women in agriculture, both genders of the farming communities need to incorporate their views and perceptions during technology generation and development. A research and development agenda which incorporates analysis of gender-desegregated farmer perspectives is likely to lead to a more appropriate and acceptable technology which will gain wider adoption.

27. The following two examples document some impacts on poverty reduction and changes in social welfare from adoption of improved technologies generated by one of the Consultative Group on International Agricultural Research centers. In the first, a study on the impact of ICRISAT pearl millet technologies in Rajasthan, some of the major indicators of welfare changes found in key informant surveys included (i) change from kutcha (traditional) to pucca (modern) houses, (ii) better clothes, (iii) self-sufficiency in food, (iv) increased spending on household essentials due to increased availability of cash, (v) higher spending on education of children (including girls), (vi) greater onfarm investments, (vii) more employment opportunities, and (viii) increased cropping intensity.

28. The focus group meetings also revealed that benefits accrued because of two interrelated changes:

(i) increased yields enable farmers to retain more for consumption and spend less on purchases of food grains. Also, farmers have enough left over after retaining enough for self-consumption, to sell in the market and earn cash incomes;

(ii) increased yields enabled farmers to decrease the area under pearl millet cultivation and increase the area for cash crops, especially those which require less water and can germinate and mature utilizing soil residual moisture. In villages where ICRISAT cultivars have been introduced, the choice of varieties has changed significantly. Earlier, the choice was between desi and improved cultivars and hybrids. Now, the choice is essentially between ICRISAT open-pollinated varieties and private sector hybrids, many of which have ICRISAT parents.

29. In the second example, a study tracking poverty-reduction impacts of adoption of groundnut production technology in Maharashtra, before and after analysis revealed that a large number of welfare changes have occurred: (i) changes in cropping pattern (more diversified cropping system, larger basket of commodities); (ii) bringing more land under cultivation (increased capacity to invest, more crop options); (iii) increased area under cultivation during Rabi and summer; (iv) more area under irrigation (availability of sprinklers, pumpsets); (v) reduced dependence on risky crops and crops requiring more inputs; (vi) increase in yields; (vii) increase in income and profits; (viii) generation of permanent and semi-permanent assets, including land, livestock, pumpsets, sprinklers; (ix) changes in land holding pattern (some agricultural laborers have bought land, while marginal farmers have increased their landholding); (x) increase in wages for agricultural workers; (xi) increased availability of employment throughout the year; (xii) improved choice of work and workplace; (xiii) wider basket of commodities consumed by farmers as well as agricultural laborers; (xiv) reduced spending on food items; (xv) increased capacity to support nonworking family dependents; (xvi) reduction of indebtedness; and (xvii) easier availability of credit.

30. Some results from these surveys show a high degree of correspondence between the results of improved agricultural productivity and welfare measures for target poverty groups that are similar to ADB's poverty reduction strategy. Some basic conclusions that we can be drawn from example 2 are:

(i) adoption of groundnut production technology (GNPT) has contributed directly to increases in income and yields;

(ii) greater stability of the cropping system has been achieved;

(iii) indirectly, GNPT has improved food availability, improved nutrition, led to crop diversification, and increased ownership of assets;

(iv) assets acquired for GNPT are being used for other crops, and have enabled cultivation in other seasons;

(v) initial benefits in the form of higher profits and income were reinvested in order to obtain long-term benefits and to stabilize the farming system;

(vi) stability of the farming system increases the freedom of farmers to take decisions regarding the cropping pattern (cash versus subsistence crops or market versus subsistence orientation, investing in production versus investing in education, housing, household assets, etc.);

(vii) positive changes in the condition of labor. Outmigration of labor has been replaced by inmigration of labor. Employment opportunities for women have gone up;

(viii) credit rating has improved;

(ix) government programs have enabled purchase of accessories. Equally, government programs targeted the village studied after its visibility improved due to technology adoption and resultant impact;

(x) general improvements have occurred relating to health, sanitation, housing, and common facilities, as well as an improvement in the level of food security, especially for marginalized groups in the village;

(xi) feeling of empowerment: general improvement in self-esteem, confidence, ability to innovate, etc. Empowerment is also reflected in an increased choice of crops that are cultivated, choice of investments, access to credit, information, and agents of various government bodies;

(xii) reduction in the social distance between groups of different social status. Feelings of social isolation both within the community, as well as with reference to the wider world has decreased. The community has become more socially inclusive, with greater interaction between members of different social categories.

H. Increasing Agricultural Productivity in Asia: General Observations

31. Data on yield increase in Asia shows that investment in less favorable environments is paying off. Another factor is that yield increases in more favored irrigated areas are leveling off as farmers often obtain yields approaching those achieved on experiment stations. Table A3.2 shows these trends for rice.

Table A3.2: Trends in Rice Yields in Asia, 1967-1996[20]

Ecosystem	Average Yield (ton/hectare)			Yield Growth Rate (%/year)	
	1967-69	1984-86	1994-96	1967-85	1985-96
Irrigated	3.3	5.3	5.9	2.7	1.2
Largely Irrigated	1.8	2.8	3.5	2.6	2.4
Rain-Fed	1.4	1.7	2.1	0.8	1.8

CIAT = International Center for Tropical Agriculture, IRRI = International Rice Research Institute, WARDA = West Africa Rice Development Association.

Source: *IRRI-WARDA-CIAT Rice Almanac* (Second Edition). 1997. International Rice Research Institute. Philippines.

32. Another set of data on rice and wheat yields in the rice-wheat region of South Asia indicates the same pattern. The less favorable environments in Table A3.3 are Nepal, West Bengal, Bihar, and Pakistan. In every case, except for wheat yields in Pakistan, growth rates of yield have increased in the 1985-1998 period relative to the period 1970-1985, where maximum green revolution effects were being felt in the more favorable environments.

Table A3.3: Growth Rate of Yields by Country and by Region

Region	Rice			Wheat		
	Average Yield (t/ha^{-1}) 1996-98[a]	Rate of Growth (%/year) 1970-85	1985-98[b]	Average Yield (t/ha^{-1}) 1996-98	Rate of Growth (%/year) 1970-85	1985-98[b]

[20] Hossain, M. and P.L. Pingali. 1998. *Rice Research, Technological Progress, and Impact on Productivity and Poverty: An Overview*. Impact of Rice Research. Proceedings of the International Conference on the Impact of Rice Research, 3-5 June 1996. Bangkok, Thailand.

Bangladesh	2.79	2.03	1.99	2.11	7.71	0.75
India						
West Bengal	3.17	1.20	2.66	2.47	0.58	2.00
Bihar	2.11	0.69	2.28	2.07	1.42	2.89
Uttar Pradesh	3.07	3.64	3.35	2.57	3.75	2.53
Punjab	5.00	3.61	0.66	4.07	2.88	1.97
Haryanam	4.01	3.42	0.70	3.75	3.05	2.33
Nepal	2.42	(0.16)	1.49	1.60	1.76	2.16
Pakistan	2.84	0.71	1.51	2.11	2.58	2.06

ha = hectare, t = ton.

[a] Refers to average yield for 1995-1997 in selected Indian states.
[b] Refers to rate of growth for 1985-1997 in selected Indian states.

Source: International Rice Research Institute's presentation to Asian Development Bank team on 27 April 2000.

33. Cost and return studies have shown that the cost per ton of rice was 20-30 percent lower for MVs compared to traditional varieties and lower for irrigated rice than for rain-fed lowland rice. However, due to the relatively inelastic demand for rice, prices fell even faster. In general, however, increased output more than compensated for lower prices resulting in higher household income.

I. Impacts of Agricultural Research in Less-Favored Areas

34. One objective of ADB's policy for funding ANRR is to invest in research for less-favored areas. A recent analysis examined returns to various types of public investments in less-favored areas.[21] These areas are characterized by lower agricultural potential, often because of poorer soils, shorter growing seasons, lower and more uncertain rainfall, limited infrastructure, and poor access to markets. In India, for example, 40 percent of total agricultural output comes from less-favored areas. The logic of higher returns to investments in more-favored (irrigated and high-potential rainfall lands) areas is that these investments generate more agricultural output and higher economic growth at lower cost than investments in less-favored areas. Faster growth leads to more employment and higher wages while increased agricultural output leads to lower food prices, both of which help the poor. Less-favored areas benefit by cheaper food, higher wage rates as workers migrate to more-favored areas, and reduced population pressure on their environments.

35. However, recent trends find that rapid agricultural growth has not been able to rapidly bring down poverty levels in most areas as productivity growth in favored areas is slowing. Emerging evidence shows that the right kinds of investments in less-favored areas can actually increase agricultural productivity much more than previously thought possible. Data for India showed 192 million rural poor in 1972 and 184 million rural poor in 1993, of which 84 percent lived in rain-fed areas. An econometric analysis of district-level data by Fan and Hazell (1999) shows that the highest marginal impact on agricultural production and poverty reduction from investments occurs in high-potential

[21] Fan, S. and P. Hazell. 1999. Are Returns to Public Investment Lower in Less-Favored Areas? An Empirical Analysis of India. *Environment and Production Technology Division Discussion Paper* 43. IFPRI. Washington, DC.

and low-potential rain-fed areas. Low-potential rain-fed areas had the highest marginal returns to production through investments in high-yielding varieties, roads, canal irrigation, private irrigation, and electrification while ranking second in education to high-potential rain-fed areas. Highest marginal returns for poverty reduction in low-potential rain-fed areas were found in high-yielding varieties, roads, private irrigation, and electrification; these areas were ranked second for canal irrigation and education. Investments in infrastructure, agricultural technology, and human capital are now at least as productive in many rain-fed areas as in irrigated areas and have a much greater impact on poverty reduction.

36. In a related study, IFPRI examined the impact of different types of public investment in rural areas on agricultural growth and rural poverty.[22] Government expenditures can directly benefit the poor through spending on rural development programs directly targeted to the poor as well as indirect effects that arise through investments in rural infrastructure, agricultural research, and the health and education of rural people. These latter investments stimulate both agricultural and nonagricultural growth, lead to greater employment and income-earning opportunities for the poor, and reduce the cost of food.

37. To provide a permanent solution to poverty, government spending must also stimulate economic growth. Therefore, the effect of government expenditure on economic growth is also modeled so that the different types of investment (agricultural research and development, public and private sector irrigation, rural roads, rural electrification, soil and water conservation, education, health, and rural development) are ranked according to their impact on growth and poverty, and any tradeoff or complementarities are weighted.

38. The Indian data indicate that all the investments considered increased agricultural productivity and reduced poverty. However, there are sizable differences in the productivity gains and poverty reductions obtained from these investments. Government expenditure on roads has by far the largest impact on rural poverty, almost twice as large as those of the next best poverty reducer, agricultural R&D. Such R&D has the second largest impact on rural poverty, but by far the largest impact on productivity growth. The rankings on poverty reduction are then education, followed by rural development, irrigation, and power.

39. When roads, electricity, and certain other forms of rural infrastructure are provided to the rural economy, the saving in postharvest losses of vegetable production is higher than in cereal crops, and vegetables become more profitable than cereals in the cropping system. As vegetables normally generate more income, they are important means to improve returns on investment for infrastructure developed to reduce poverty. Vegetable cultivation, in some cases, actually creates demand for physical infrastructure development.

J. Impacts of Social Science and Policy Research

40. ADB's ANRR policy lists policy and socioeconomic research as a priority area. However, there is not a large body of evidence that investments in this type of research generate returns comparable with other types of public investments in agricultural research.

[22] Fan, S., P. Hazell, and S. Thorat. 1999. Linkages between Government Spending, Growth and Poverty in Rural India. *Research Report* 110. IFPRI, Washington, DC.

The practical difficulties of measuring benefits is due to the uncertain path of causation between research and policy change, the fact that policies are diverse in nature as are their intended and unintended effects, and that some effects of policy research are not priced in the market.[23] The demand for policy research is derived from the demand for institutional change. Most of the benefits of policy research stem from reductions in the cost of welfare-improving institutional change. The economic surplus approach was applied to estimate differences in demand and supply curves caused by divergences between private and social costs caused by policy distortions and imperfections in market pricing. The model was applied to deforestation in the Brazilian Amazon and pesticide use in the Philippines. The calculations indicated high rates of return to policy research.

K. Impact of Agricultural Research and the Green Revolution on Women

41. ADB's policy on ANRR includes the agenda item of enhancing the incomes and living standards of rural women. A review by Paris examines the impact of agricultural research (expressed in new rice technologies) on women in Asian rice farming.[24] Women's participation in rice farming is highest in South Asia, amounting to more than one half in India and Nepal to roughly one fourth in Southeast Asian countries. Rural women cannot be treated as a homogenous class and the impact of new technologies on their living standards will depend on their status as (i) female family members of small landowning households, (ii) female hired agricultural laborers of landless households, (iii) female members of large landowning households, or (iv) female heads of poor landowning households.

42. Effects of technological change on female family members will depend on (i) technologies that increase land productivity, (ii) machinery or tools for harvest operations, (iii) labor-saving crop management technologies, and (iv) postharvest operations.

43. The effects of MVs showed increasing demand for female hired labor as a result of intensive crop-care requirements and higher yields, and declining female family labor among landowning households resulting from substitution by hired labor. Weeding, harvesting, and postharvest operations are all activities that employ more women than men. Females from landholding households increased their role in management and supervision of field labor and also spent more time on domestic activities and leisure. The other technologies such as machinery or tools for harvesting, labor-saving crop management, and postharvest operations all tended to reduce both demand for hired women laborers and drudgery associated with these tasks. In addition, the use of many of these technologies substituted male for female labor.

44. Relationships between labor utilization patterns due to changes in agricultural technology and living standards are complex and must take into account intrahousehold allocation of resources, impact on women's overall work burden, women's access to any increase in household earning, their consumption, and the health and well-being of children.

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[23] Norton, G.W. and J. Alwang. 1998. Policy for Plenty: Measuring the Benefits of Policy-Oriented Social Science Research. *Impact Assessment Discussion Paper* 16. IFPRI, Washington, DC.

[24] Paris, T.R. 1998. The Impact of Technologies on Women in Rice Farming. In: Pingali, P. and M. Hossain. *Impact of Rice Research.* Proceedings of the International Conference on the Impact of Rice Research. 3-5 June 1996, Bangkok, Thailand. Thailand Development Research Institute, Bangkok, Thailand, and IRRI, Manila, Philippines.

L. Some Impacts of ICRISAT Research on the Well-Being of Women

45. The impact of improved chickpea varieties in the Barind area of Bangladesh also had a favorable impact on women in the area.[25] Chickpeas provided a reservoir of green vegetative material during the dry season. Women started to harvest the top twigs of the plant for consumption or sale as a green vegetable. This has excellent market value in the Barind as other green vegetable crops are not available in the dry season. Because women harvest the crop, they control the income obtained from its sale. The twigs sell for about the market price of chickpea grain. Another example is the use of GNPT package introduced to farmers in the late 1980s through ICRISAT's legumes onfarm testing and nursery project in Maharashtra State in western India.[26] This comprehensive project included technology options and recommendations about land preparation, manuring, fertilizers, seed rate, seed treatment, plant spacing, weed control, pest and disease control, irrigation, and harvesting. The study found that adoption of new technologies may enhance task specialization where activities are performed exclusively by a particular gender in order to optimize available household labor resources. The new technology also required more labor input by both men and women, about 26 hours in male labor requirements and 16 hours in female labor requirements for the summer crop. The adoption of the GNPT package also significantly increased the use of female hired labor.

46. Higher yields from the new technology allowed households to diversify use of the products of the groundnut crop. In this process, women gained control over the products retained for household use. Men were mostly concerned about financial viability of the technology while women were found to perceive the advantage of the new technology options in terms of workability and implications for drudgery and occupational hazards. Gender races are segregated into types of work (men do heavier jobs and women do lighter jobs) and into market and domestic activities where men gain greater control over market-related activities and women over the domestic realm.

[25] Food From Thought. 1996. *Making a Difference—Chickpea in the Barind*. ICRISAT, Patancheru, India.
[26] Kolli, R.D. and C. Bantillan. 1997. Gender-Related Impacts of Improved Agricultural Technologies: Identification of Indicators from a Case Study. *Gender, Technology and Development* 1(3).

THE CGIAR SYSTEM AND CURRENT STATUS OF ONGOING TECHNICAL ASSISTANCE

A. CGIAR System

1. In the 1950s and 1960s, concern grew that developing countries would be unable to feed their populations. This concern led to gradual reorientation of domestic policies, increased research capacity by developing-country scientists, and more focus on international agricultural research for tropical agriculture. Based largely on new varieties of rice and wheat developed through collaborative international research, coupled with large government investments in adaptive research, extension, irrigation, and agricultural credit, the resulting green revolution raised hopes that the scope of agricultural transformation could be extended worldwide.

2. As a result, high-level local and international consultations explored how best the international community could (i) protect and strengthen the existing international research centers supported by Ford and Rockefeller foundations (International Center for Tropical Agricuture [CIAT] in Colombia and International Institute for Tropical Agriculture in Nigeria working on general tropical agriculture; International Research Institute (IRRI) in the Philippines (rice), and International Maize and Wheat Improvement Center in Mexico (maize and wheat); (ii) consolidate and spread the benefits of international agricultural research worldwide; and (iii) respond to the Pearson Commission[1] recommendation for an international effort to support research specializing in food supplies and tropical agriculture. This led the World Bank, which had already established consultative groups for individual countries, to create a Consultative Group on International Agricultural Research (CGIAR).

3. CGIAR was born on 19 May 1971, when its first formal meeting was held at the World Bank under the chairmanship of a vice president of the World Bank. The founding meeting (i) adopted a resolution setting out the objectives, composition, and organizational structure of the CGIAR; (ii) decided to support the four existing international centers established by the Ford and Rockefeller foundations; (iii) established a technical advisory committee to provide CGIAR with independent scientific advice; (iv) invited the Food and Agriculture Organization (FAO) of the United Nations to arrange a rotational system for a maximum of five governments to represent developing countries at CGIAR for two years at a time; and (v) received pledges of financial support from founding members.

4. The rationale for the system of international agriculture research centers is derived from international spillover effects, the efficiencies of working freely across national boundaries for many research products, and the productivity-boosting effects on scientific collaboration and cost-reducing effects of sharing information and research materials (particularly genetic material). CGIAR is currently jointly sponsored by the World Bank, FAO, the United Nations Development Programme, and the United Nations Environment Program. It is an association of 59 public and private sector investors supporting 16 international agriculture research centers located in 12 less-developed and three developed countries. Member from the Organisation for Economic Co-operation and Development provide almost two thirds of CGIAR resources from their development assistance budgets while multilateral institutions (primarily the World Bank) contribute over 30 percent of the finances.

[1] The Pearson Commission on World Development was chaired by former Canadian Prime Minister Lester Pearson and recommended that a global effort be made in international agricultural research to confront the looming food crisis and reduce rural poverty.

5. Key characteristics of the system include (i) a global perspective of mandates and programs that facilitates a clear focus on problems that cut across national borders and lend themselves to international solutions; (ii) international status of centers and their governance, staffing, program design, and resource support, which protects their mandates and programs from undue political pressure and purely national or regional influences; (iii) international mobility of germplasm, center staff, and knowledge; and (iv) the principle of universality, which provides the accessibility of research results to all interested parties and openness of centers to all partners seeking collaboration.

6. Poverty reduction is the guiding principle of CGIAR-supported research. CGIAR conducts impact assessments to ensure that the research it supports contributes to fighting poverty. Soil and water management, forestry and agroforestry, and the application of research directed at reducing the use of chemicals in agriculture, are key priorities in efforts to nurture the environment. Biodiversity remains a major concern of the CGIAR which holds in trust for the future one of the world's largest ex situ collections of plant genetic resources, containing over 600,000 accessions of more than 3,000 crop, forage, and pasture species. Duplicates of these materials are freely available to researchers around the world so that new gene combinations can be used to increase productivity and sustainability. Biotechnology is mobilized through research alliances to ensure that it can contribute to more sustainable agricultural growth in developing countries, with special care devoted to issues such as ethics, safety, and the access of developing countries to biotechnology products.

7. Asian Development Bank's (ADB's) overarching goal of poverty reduction is in close alignment with the current CGIAR focus. A recent report prepared by the technical advisory committee of the CGIAR recommended that CGIAR focus sharply on reduction of poverty, hunger, and malnutrition in developing countries; and give highest priority to the research needs of South Asia and Sub-Saharan Africa.[2] Congruence of ADB's policy guidelines for agriculture and natural resources research is compared to CGIAR program thrusts as depicted in Table A4.1.

8. The initial grant by ADB to a CGIAR center was to IRRI in 1975 for $300,000 for equipment for the training center. This was followed by small grants of less than $1 million per annum in total between 1976 and 1982. Starting in 1983, the number and total funding of grants increased substantially to $1.448 million in 1983, reaching $4.19 million in 1990. Since the ADB policy on ANRR was approved in December 1995, four regional technical assistance (RETA) grants have been processed with each RETA supporting several CGIAR center projects. RETA amounts approved so far are between $5.2 million and $5.6 million. These comprised 19 projects at a total cost to ADB of $21.9 million (Table A4.2). Additional contributions for these projects totaled $26.373 million. As of 30 June 2000, ADB had disbursed a total of $10.8 million to the CGIAR centers representing about 49 percent of the total RETA amounts of $21.9 million. Total expenditure amounted to about $6.5 million, leaving an outstanding advance of $4.3 million.

[2] CGIAR. 2000. *Charting the CGIAR's Future: A New Vision for 2010* and *A Food Secure World for All: Toward a New Vision and Strategy for the CGIAR*. Papers presented at the CGIAR midterm meeting. Dresden, Germany.

Table A4.1: CGIAR Program Thrusts and ADB Policy for Supporting ANRR

CGIAR Program Thrust	Corresponding ADB Policy Guideline
Research to increase productivity of resources committed for farmers' food production.	Enhancing the productivity of agriculture.
Improved management of natural resources.	Sustainable management of agriculture and natural resources.
Improved policy environment by assisting countries in formulating and implementing food, agricultural, and research policies.	Public policy and socioeconomic research.
Capacity building by strengthening NARS and by training.	Enhancing the capacity of NARSs.
Germplasm conservation by collecting and classifying genetic resources and maintaining genebanks and other means of conservation.	No specific policy for this thrust.
Building linkages between institutions in national systems and other components of the global agricultural research system.	No specific policy addresses this thrust.

ADB = Asian Development Bank, ANRR = agriculture and natural resources research, CGIAR = Consultative Group on International Agricultural Research, NARS = national agricultural research system.

Table A4.2: Technical Assistance Grants to CGIAR Centers

RETA No.	RETA Title	Approval Date	No. of Projects	Amount ($ million)
5711	Agriculture and Natural Resources Research at CGIAR Centers	12 Dec 1996	5	5.2
5766	Second Agriculture and Natural Resources Research at CGIAR Centers	29 Dec 1997	4	5.5
5812	Third Agriculture and Natural Resources Research at CGIAR Centers	22 Oct 1998	5	5.6
5866	Fourth Agriculture and Natural Resources Research at CGIAR Centers	14 Oct 1999	5	5.6
	Total		**19**	**21.9**

ADB = Asian Development Bank, CGIAR = Consultative Group on International Agricultural Research, RETA = regional technical assistance.

Source: ADB project files.

B. Ongoing ANRR Projects

9. Assessments of ongoing ANRR projects are summarized in the following tables.

Table A4.3: ANRR Projects Funded by RETA, 1996-1999
($'000)

CGIAR Center		Project Name	Amount Provided	Project Cost
A.	**RETA 5711**	**Agriculture and Natural Resources Research at CGIAR Centers**		
	IRRI	Exploiting Biodiversity for Sustainable Rice Pest Management	1,500	2,110
	CIP	Field Testing of True Potato Seed, Phase II	600	1,120
	ICRISAT	Legume-Based Technologies for Rice-Wheat Production	600	1,000
	ICLARM	Genetic Improvement of Carp Species in Asia	1,300	2,600
	ICRAF	Policy Research for Sustainable Upland Systems	1,200	3,720
		Subtotal	**5,200**	**10,550**
B.	**RETA 5766**	**Second Agriculture and Natural Resources Research at CGIAR Centers**		
	CIMMYT	Application of Biotechnology to Maize Improvement in Asia	1,400	2,000
	ICLARM	Sustainable Management of Coastal Fish Stocks in Asia	1,400	2,860
	IPGRI	Coconut Genetic Resources Network and Human Resources Strengthening in Asia and the Pacific, Phase II	1,200	4,880
	IRRI	Development and Use of Hybrid Rice in Asia	1,500	2,420
		Subtotal	**5,500**	**12,160**
C.	**RETA 5812**	**Third Agriculture and Natural Resources Research at CGIAR Centers**		
	CIFOR	Planning for Sustainability of Forest Through Adaptive Co-Management	1,100	3,240
	ICRISAT	Improving Management of Natural Resources for Sustainable Rain-Fed Agriculture	1,250	3,000
	IWMI	Development of Effective Water Management Institutions	1,250	2,500
	ILRI	Increasing Productivity of Crop-Livestock Systems in Asia	1,000	3,625
	IRRI	Asian Rice Biotechnology Network: Achieving Impact and Sustainability	1,000	1,680
		Subtotal	**5,600**	**14,045**
D.	**RETA 5866**	**Fourth Agriculture and Natural Resources Research at CGIAR Centers**		
	CIAT	Developing Sustainable Forage Technologies for Resource-Poor Upland Farmers in Asia	1,200	2,660
	ICARDA	Onfarm Soil and Water Management for Sustainable Agricultural Systems in Central Asia	1,200	2,100
	IFPRI	Irrigation Investment, Fiscal Policy, and Water Resource Allocation	1,200	2,200
	IPGRI	Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia	1,200	3,150
	ISNAR	Building Performance-Based Management Systems in the National Agricultural Research Systems in Asia	800	1,408
		Subtotal	**5,600**	**11,518**
		Total	**21,900**	**48,273**

ADB = Asian Development Bank, ANRR = agriculture and natural resources research, CGIAR = Consultative Group on International Agricultural Research, CIAT = International Center for Tropical Agriculture, CIFOR = Center for International Forestry Research, CIMMYT = International Maize and Wheat Improvement Center, CIP = International Potato Center, ICARDA = International Center for Agricultural Research in the Dry Areas, ICLARM = International Center for Living Aquatic Resources Management, ICRAF = International Centre for Research in Agroforestry, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, IFPRI = International Food Policy Research Institute, ILRI = International Livestock Research Institute, IPGRI = International Plant Genetic Resources Institute, IRRI = International Rice Research Institute, ISNAR = International Service for National Agricultural Research, IWMI = International Water Management Institute, RETA = regional technical assistance.

Source: ADB project files.

Table A4.4: Financial Plans for ANRR Projects, 1996-1999
($'000)

Project Name	CGIAR Center	Amount Provided				Project Cost
		ADB	IARC	NARS	Others	
A. RETA 5711 Agriculture and Natural Resources Research at CGIAR Centers (Approved on 12 Dec 1996)						
1. Exploiting Biodiversity for Sustainable Rice Pest Management	IRRI	1,500	375	235	0	2,110
2. Field Testing of True Potato Seed, Phase II	CIP	600	330	190	0	1,120
3. Legume-Based Technologies for Rice-Wheat Production	ICRISAT	600	200	200	0	1,000
4. Genetic Improvement of Carp Species in Asia	ICLARM	1,300	810	490	0	2,600
5. Policy Research for Sustainable Upland Systems	ICRAF	1,200	615	265	1,640	3,720
Subtotal		**5,200**	**2,330**	**1,380**	**1,640**	**10,550**
B. RETA 5766 Second Agriculture and Natural Resources Research at CGIAR Centers (Approved on 29 Dec 1997)						
1. Application of Biotechnology to Maize Improvement in Asia	CIMMYT	1,400	400	200	0	2,000
2. Sustainable Management of Coastal Fish Stocks in Asia	ICLARM	1,400	1,000	460	0	2,860
3. Coconut Genetic Resources Network and Human Resources Strengthening in Asia and the Pacific, Phase II	IPGRI	1,200	950	1,400	1,330	4,880
4. Development and Use of Hybrid Rice in Asia	IRRI	1,500	240	460	220	2,420
Subtotal		**5,500**	**2,590**	**2,520**	**1,550**	**12,160**
C. RETA 5812 Third Agriculture and Natural Resources Research at CGIAR Centers (Approved on 22 Oct 1998)						
1. Planning for Sustainability of Forest Through Adaptive Co-Management	CIFOR	1,100	1,560	580	0	3,240
2. Improving Management of Natural Resources for Sustainable Rain-Fed Agriculture	ICRISAT	1,250	1,000	750	0	3,000
3. Development of Effective Water Management Institutions	IWMI	1,250	737	513	0	2,500
4. Increasing Productivity of Crop-Livestock Systems in Asia	ILRI	1,000	765	750	1,110	3,625
5. Asian Rice Biotechnology Network: Achieving Impact and Sustainability	IRRI	1,000	350	330	0	1,680
Subtotal		**5,600**	**4,412**	**2,923**	**1,110**	**14,045**
D. RETA 5866 Fourth Agriculture and Natural Resources Research at CGIAR Centers (Approved 14 Oct 1999)						
1. Developing Sustainable Forage Technologies for Resource-Poor Upland Farmers in Asia	CIAT	1,200	380	1,080	0	2,660
2. Onfarm Soil and Water Management for Sustainable Agricultural Systems in Central Asia	ICARDA	1,200	420	330	150	2,100
3. Irrigation Investment, Fiscal Policy, and Water Resource Allocation	IFPRI	1,200	580	380	40	2,200
4. Conservation and Use of Native Tropical Fruit Species Biodiversity in Asia	IPGRI	1,200	260	1,690	0	3,150
5. Building Performance-Based Management Systems in the National Agricultural Research Systems in Asia	ISNAR	800	280	200	128	1,408
Subtotal		**5,600**	**1,920**	**3,680**	**318**	**11,518**
Total		**21,900**	**11,252**	**10,503**	**4,618**	**48,273**

ADB = Asian Development Bank, CIAT = International Center for Tropical Agriculture, CIFOR = Center for International Forestry Research, CIMMYT = International Maize and Wheat Improvement Center, CIP = International Potato Center, IARC = International Agriculture Research Center, ICARDA = International Center for Agricultural Research in the Dry Areas, ICLARM = International Center for Living Aquatic Resources Management, ICRAF = International Centre for Research in Agroforestry, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics, IFPRI = International Food Policy Research Institute, ILRI = International Livestock Research Institute, IPGRI = International Plant Genetic Resources Institute, IRRI = International Rice Research Institute, ISNAR = International Service for National Agricultural Research, IWMI = International Water Management Institute, NARS = national agricultural research system, RETA = regional technical assistance.

Source: ADB project files.

Table A4.5: Summary of Project Key Issues and Assessment of its Relevance to ANRR Policy Agenda

ANRR Project	Relevance and Key Issues Encountered	Relevance to ADB's ANRR Objectives[a]					
		A	B	C	D	E	F
1. International Livestock Research Institute (Los Baños, Philippines)							
RETA 5812[b]: Increasing Productivity of Crop-Livestock Systems in Asia	Highly relevant but economic competition not fully considered, feed research repetitive.	9	8	8	3	5	4
2. International Potato Center (Los Baños, Philippines and Bogor, Indonesia)							
RETA 5533 and RETA 5711[c]: Field Testing of True Potato Seed in the Lowland Tropics (Phases I and II)	Relevant research for testing economic viability, some pockets of adoption.	3	3	3	5	4	4
3. International Center for Tropical Agriculture (Los Baños, Philippines)							
RETA 5866[d]: Forages for Smallholders Project	Highly relevant but spread too thinly for available resources.	10	3	9	4	6	4
4. International Board for Soil Research and Management (Bangkok, Thailand)							
RETA 5284: Research on Management of Sloping Lands for Sustainable Agriculture	Highly relevant but virtually every topic covered by other, larger centers.	7	2	9	5	3	3
RETA 5400: Research on the Management of Sloping Lands for Sustainable Smallholder Agriculture in the South Pacific	Marginal relevance given status and potential of crop agriculture in South Pacific, grant too short to produce results.	4	2	6	3	3	2
RETA 5803: Catchment Approach to Managing Soil Erosion in Asia	Marginal relevance as catchment management problematic in most situations.	3	2	8	3	3	2
5. Asian Vegetable Research and Development Center (Taipei,China)							
RETA 5322: Asian Vegetable Research and Development Center to Establish a Collaborative Vegetable Research Program in Southeast Asia RETA 5517: Collaborative Vegetable Research Program for Southeast Asia (Phase II)	Successful model of decentralized research, initial problems of focus.	7	4	4	8	5	5
RETA 5461: South Asia Vegetable Research Network RETA 5719: South Asia Vegetable Research Network (Phase II)	Good NARS strengthening, uneven participation by network countries	8	5	4	8	8	6
RETA 5680: Establishment of a Vegetable Research Network for Cambodia, Lao PDR, and Viet Nam	Still in execution, Viet Nam has most potential, uneven participation.	9	5	4	8	4	4

ADB = Asian Development Bank, ANRR = agriculture and natural resources research, CGIAR = Consultative Group on International Agricultural Research, Lao PDR = Lao People's Democratic Republic, NARS = national agricultural research system, RETA = regional technical assistance.

A = Sustainable and remunerative farming systems for poor farmers, B = Enhancing the incomes and living standards of rural women, C = Sustainable management of agricultural and natural resources, D = Enhancing the productivity of agriculture, E = Enhancing the capacity of national research systems, F = Public policy and socioeconomic research.

[a] Ranking of relevance per objective: 10 is highest and 0 is not applicable or not a stated objective of the research. These do not represent some type of ranking/scoring.

[b] A component of 5812-REG: *Third Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 22 October 1998.

[c] A component of 5711-REG: *Agriculture and Natural Resources Research at CGIAR Centers*, for $5,200,000, approved on 12 December 1996.

[d] A component of 5866-REG: *Fourth Agriculture and Natural Resources Research at CGIAR Centers*, for $5,600,000, approved on 14 October 1999.

ANRR Project	Relevance and Key Issues Encountered	Relevance to ADB's ANRR Objectives[a]					
		A	B	C	D	E	F
6. Center for International Forestry Research (Bogor, Indonesia)							
RETA 5812[b]: Planning for Sustainability of Forest Through Adaptive Co-Management	Highly relevant, complex processes may limit uptake.	0	0	10	4	8	9
7. International Center for Research in Agroforestry (Bogor, Indonesia)							
RETA 5711[c]: Policy Research for Sustainable Upland Systems	Highly relevant, key issues well defined.	8	6	10	8	6	10
8. International Center for Living Aquatic Resources Management (Penang, Malaysia)							
RETA 5279: Genetic Improvement of Tilapia Species in Asia RETA 5558: Dissemination and Evaluation of Genetically Improved Tilapia Species in Asia	Highly relevant, risk-taking work, wide impact.	2	2	6	10	5	6
RETA 5711[c]: Genetic Improvement of Carp Species in Asia	Great potential, ongoing research, wide adaptation.	3	2	6	10	6	6
RETA 5766[e]: Sustainable Management of Coastal Fish Stocks in Asia	Highly relevant for resources management, long-term impact.	8	2	10	6	9	10
RETA 5245: Research on Rice-Fish Farming Systems	Led to long-term program with innovative start-up funding.	6	5	8	7	9	5
9. International Crops Research Institute for the Semi-Arid Tropics (Hyderabad, India)							
RETA 5268: Strengthening Grain Legume in South Asia RETA 5393: Strengthening Grain Legume Research in Asia	Led to long-term collaboration, NARS strengthening.	7	5	7	8	9	4
RETA 5603: Strengthening Regional Collaboration on Cereals and Legumes Research in Asia	Led to long-term networks, NARS strengthening.	7	5	7	8	9	4
AOTA 0882: Strengthening Chickpea Research in Collaboration with ICRISAT (Phase II)	Good impacts but weak NARS a problem.	8	2	5	7	7	3
AOTA 1139: Pigeonpea Varietal Adaptation and Production Studies in Collaboration with ICRISAT AOTA 1742: Pigeonpea Intercropping and Diversification Study	Innovative, risky project led to large impact.	6	4	0	8	5	3
RETA 5711[c]: Legume-Based Technologies for Rice-Wheat Production	Close links to RETA 5603, enhances other CGIAR programs.	6	5	8	9	8	5
10. International Rice Research Institute (Los Baños, Philippines)							
RETA 5510: Establishment of the Asian Rice Biotechnology Network RETA 5667: Asian Rice Biotechnology Network-From Products to Impact RETA 5812[b]: Asian Rice Biotechnology Network: Achieving Impact and Sustainability	Good example of long-term ADB investment with significant potential.	2	2	5	10	9	5

AOTA = advisory and operational technical assistance, ICRISAT = International Crops Research Institute for the Semi-Arid Tropics.

[e] A component of 5766-REG: *Second Agriculture and Natural Resources Research at CGIAR Centers*, for $5,500,000, approved on 29 December 1997.

ANRR Project	Relevance and Key Issues Encountered	Relevance to ADB's ANRR Objectives[a]					
		A	B	C	D	E	F
RETA 5766[e]: Development and Use of Hybrid Rice in Asia	Large potential impact in favored areas, will enhance food security.	2	2	5	10	9	5
RETA 5261: Development of Rice Varieties Tolerant to Problem Soil Conditions	Large impact in limited areas, needs follow-on work in NARS.	9	3	9	7	7	3
RETA 5414: Decentralized Participatory Research for Less Favorable Rice Ecosystems and Rice-Wheat Systems	Highly relevant, long-term institution building, and leadership. Management of complex interdisciplinary research under decentralized conditions needs leadership.	5	5	9	9	10	7
RETA 5606: Rain-Fed Lowland Rice Ecosystem Research	Medium potential impact over very large area.	10	7	8	8	9	5
RETA 5711[c]: Exploiting Biodiversity for Sustainable Rice Pest Management	Innovative approach to lower costs in more-favored areas, excellent synthesis of disciplines.	2	0	8	10	8	3
11. International Water Management Institute (Colombo, Sri Lanka)							
AOTA 0654: Study on Irrigation Management for Crop Diversification AOTA 0859: Study on Irrigation Management for Diversified Crops (Phase II)	Difficult to assess impact, institutional problems major constraint.	4	4	7	8	5	5
AOTA 846: Study on Irrigation Management and Crop Diversification AOTA 1480: Study on Irrigation Management and Crop Diversification (Phase II)	Difficult to assess impact, institutional problems major constraint.	5	5	7	8	5	5
12. International Maize and Wheat Improvement Center (New Delhi, India)							
RETA 5766[e]: Application of Biotechnology to Maize Improvement in Asia	Strong capacity building for national agricultural research system, potential impact very large.	6	4	5	9	9	7
13. International Rice Research Institute (Rice-Wheat Consortium, New Delhi, India)							
RETA 5414: Decentralized Participatory Research for Less Favorable Rice Ecosystems and Rice-Wheat Systems	Highly relevant, long-term institution building, and leadership. Management of complex interdisciplinary research under decentralized conditions needs leadership.	8	3	9	10	10	6

Source: ADB project files.

C. Overall Assessment of RETA Portfolio[1]

10. As of 30 June 2000, ADB had disbursed a total of $10.8 million to the CGIAR centers representing about 49 percent of the total grant of $21.9 million. Of this amount, the total expenditure amounted to about $6.5 million, leaving an outstanding advance of $4.3 million. The 19 projects are in various stages of implementation with elapsed periods ranging from 14 percent (for newly approved RETA 5866) to about 99 percent (for RETA 5711 which will be completed in late 2000 or early 2001). The progress of implementation of all the studies, except one, has been generally satisfactory. A brief assessment of the RETA projects is given below.

1. RETA 5711: Agriculture and Natural Resources Research at CGIAR Centers (1996)

11. The RETA consists of five independent but mutually supportive research studies. Implementation began in April 1997. As of June 2000, total disbursements amounted to $4.2 million or 81 percent of the total grant of $5.2 million. The studies are expected to be completed in late 2000 or early 2001. Their status are as follows.

12. **Exploiting Biodiversity for Sustainable Rice Pest Management (IRRI).** The main project objective is to conduct collaborative, interdisciplinary research on incorporating biodiversity into pest management practices. During the past three years, progress has been satisfactory in research and training activities. Research to deploy and enhance microbial biological control (MBA) agents to improve habitat and genetic diversity management, to use rice genotype variation, and to integrate genetics, species, and habitat for controlling diseases and insect pests is well under way. The results have so far been encouraging. For example, in Yunnan province, People's Republic of China, lower incidence of blast disease and higher rice yields were obtained on 33,400 hectare (ha) by planting nonresistant rice varieties between resistant varieties. A large number of plant protection agents and farmers have been trained on the use of MBA which control sheath blight disease in rice. The Project is expected to be completed in December 2000.

13. **Second Phase Research Project on Field-Testing of True Potato Seed (International Potato Center).** The main objective of the study is to test and disseminate the low-cost technology of using true potato seed. Under the traditional system of potato cultivation, farmers usually need about 2,000 kilograms (kg) of tubers to plant 1 ha of potato. Using this technique, planting material accounts for more than half the production cost. The International Potato Center developed a low-cost technology using true seed instead of tubers. Farmers need only 0.1 kg of seed to plant 1 ha of potato at a cost of only a fraction of the traditional method. Farmers also save money in transportation expenses because they do not have to move huge amounts of tubers from the buying centers to their farms. The advantages of the new technology have resulted in significant savings in production costs, higher yields, and better quality of potato. The technology has been disseminated in Viet Nam on 3,200 ha and in the southern Philippines on 89 ha. However, the technology was not well received by farmers in Indonesia and Sri Lanka because they were not convinced about its advantages. Further research is needed to solve the problems associated with the

[1] ADB. 2000. Proposed RETA for Fifth Agriculture and Natural Resources Research at CGIAR Centers. Staff Review Committee Meeting. Manila.

technology such as difficulty in storing planting materials between the growing seasons and multiplying hybrid potato seed on a large scale. The Project is expected to be completed in late 2000.

14. **Legume-Based Technologies for Rice and Wheat Production Systems in South and Southeast Asia (International Crops Research Institute for the Semi-Arid Tropics[ICRISAT]).** The Project's objective is to develop technological options that will encourage farmers to grow more grain legumes in rice-wheat cropping systems. The technological options being investigated under the study are (i) sustainability and profitability of cereal-legume cropping systems; (ii) soil, water, and nutrient management; and (iii) integrated insect, pest, disease, and nematode management. Some promising results have been obtained in Bangladesh, India, and Nepal in these experiments. Constraints and opportunities for growing legumes in rice and wheat cropping systems in the Indo-Gangetic Plain have been evaluated. Potential growing areas of legumes in rice areas have been characterized and mapped using a geographic information system (GIS). The yield advantage of extra-short duration pigeonpea over short duration pigeonpea in wheat-growing areas has been demonstrated in India. Including pigeonpea in this cropping system reduces weed growth. Applying boron has improved the yield of pigeonpea in Nepal. In a different experiment, solar heating effectively controlled pests of pigeonpea seeds during storage. Integrated disease and insect pest management has increased yields of peanut and chickpea while reducing production costs in Bangladesh, Indonesia, and Viet Nam. The Project is expected to be completed in April 2001.

15. **Genetic Improvement of Carp Species in Asia (International Center for Living Aquatic Resources Management [ICLARM]).** The Project's objectives are to increase fish production and improve the nutrition and income of small-scale fisherfolk by developing genetically improved carp breeds with sustainable productivity. Under the Project, substantial information on carp genetic resources has been collected and compiled in Bangladesh, PRC, Thailand, and Viet Nam and to lesser extent, in India and Indonesia. Socioeconomic surveys are being carried out in the six participating countries among carp producers, consumers, and hatchery operators. Research to develop improved carp species has been initiated with promising results, but more research is required to confirm the initial findings. In addition, the six countries exchanged carp germplasm to facilitate genetic improvement. The Project is expected to be completed in late 2000.

16. **Policy Research for Sustainable Upland Systems (International Centre for Research in Agroforestry).** The study's objectives are to identify the necessary conditions and develop policy options for intensifying production on upland soils in Indonesia, Philippines, and Thailand. During 1997-1999, collection, compilation, and analysis of data on externalities, biodiversity, and carbon stocks, and economic analysis of seven land-use systems (natural forest, community forests, agroforests, tree crop plantations, shifting cultivation, intensive crop production systems, and degraded cassava lands) in Sumatra, Indonesia, were completed. This analysis will be expanded to damar agroforestry systems, smallholder robusta coffee, and cinnamon monoculture. In the Philippines and Thailand, a similar exercise recently commenced. A review of community forestry approaches has been completed in Indonesia and is nearing completion in Thailand. However, progress has been slow in the Philippines. A GIS database on forest cover, smallholder land use, and large-scale projects is nearing completion in Indonesia, and is in progress in Thailand. A regional training course on the policy analysis matrix in June 1997 and a regional workshop on environmental issues

and land use change in June 1999 were held in Thailand. Overall, the progress of the study is slower than expected, particularly in the Philippines. The study has been rated partly satisfactory and will be closed in December 2000.

2. RETA 5766: Second Agriculture and Natural Resources Research at CGIAR Centers (1997)

17. The RETA comprises four independent yet mutually supportive research studies that were begun in March 1998. As of June 2000, disbursements of the four studies amounted to $3.5 million or 64 percent of the total grant of $5.5 million. The status of the four projects is given in the following paragraphs.

18. **Application of Biotechnology to Maize Improvement in Asia (CIMMYT).** The Project's objective is to build and support the capacity of national maize improvement programs in PRC, India, Indonesia, Philippines, and Thailand through a network to adopt biotechnological tools for maize improvement. Good progress has been made after two years of implementation. Nineteen scientists from the participating countries were trained at CIMMYT on new advances in maize biotechnology. Five biotechnology laboratories in the participating countries have been constructed and are now operational. Biotechnology research network is well established. Substantial progress has been made on the development and use of molecular markers in creating improved maize varieties resistant to downy mildew disease and virus diseases, and tolerant of drought and low nitrogen.

19. **Sustainable Management of Coastal Fish Stocks in Asia (ICLARM).** The Project's objective is to provide selected countries (Bangladesh, India, Indonesia, Malaysia, Philippines, Sri Lanka, Thailand, and Viet Nam) with better tools and strategies to improve the management and sustainable use of their coastal fisheries and related ecological systems. ICLARM has developed the protocol for the Fisheries Resource Information System. Based on this system, socioeconomic information is collected and compiled and existing policy, strategy, and development plans are evaluated. Regional training on the use of the database system, fish stock assessment, ecological analysis, and socioeconomic, management, and policy planning has been conducted. Draft technical reports for the various research components are now in preparation. Staff training on Trawl Base use and development has been completed.

20. **Coconut Genetic Resources Network and Human Resources Strengthening in Asia and the Pacific (International Plant Genetic Resources Institute)**. The Project's objective is to develop sound environmental management of coconut genetic resources in Asia and the Pacific through sustainable conservation and use of coconut, and strengthening of human resources. The achievements during the past two years include (i) 952 samples of coconut germplasm have been registered in the International Coconut Genetic Resources database; (ii) three regional gene banks in India, Indonesia, and Papua New Guinea have been officially established; (iii) the performance of high-yielding hybrids and varieties is being evaluated in India, Papua New Guinea, Philippines, Samoa, Sri Lanka, and Vanuatu; (iv) effective collaboration in coconut research has been established with advanced laboratories in Australia, Costa Rica, France, Germany, and United Kingdom; (v) a manual for standardized research techniques in coconut breeding has been published and distributed to coconut researchers; (vi) the proceedings of the ADB-funded workshop to promote multipurpose uses of coconut has been published and distributed; and (vii) seven short-term training

courses involving 80 participants have been held; and (vii) ten graduate students have been awarded Master of Science scholarships to study coconut genetic resources at the University of the Philippines, Los Baños.

21. **Development and Use of Hybrid Rice (IRRI).** The Project's objectives are to (i) strengthen the capability of national agricultural research systems (NARSs) in Bangladesh, India, Indonesia, Philippines, Sri Lanka, and Viet Nam to conduct applied research to develop and use hybrid rice technology expeditiously, and (ii) strengthen the hybrid seed production capability of private, public, and nongovernment organization-based seed industries. During the past year, progress in implementing the Project has been satisfactory. Six short-term training courses were conducted at IRRI, PRC, and India. Training for hybrid rice breeding and hybrid seed production has been conducted. Coordinated trials were constituted and dispatched to evaluate elite hybrids and parental lines in trials at multiple locations in the six participating countries. Recommendations to strengthen the hybrid seed industry in the participating countries have been prepared.

3. RETA 5812: Third Agriculture and Natural Resources Research at CGIAR Centers (1998)

22. The RETA consisted of five independent and mutually supportive projects. As of 30 June 2000, total disbursements amounted to $2.4 million or 43 percent of the total grant of $5.6 million. A brief summary of each follows.

23. **Planning for Sustainability of Forests through Adaptive Co-Management (Center for International Forestry Research [CIFOR]).** The Project's objectives are to (i) develop an adaptive co-management system (ACM) and monitoring mechanism for sustainable forest management of communal natural forests and smallholder plantations, (ii) identify forest policies and institutional constraints to ACM in forestry, and (iii) prepare measures for policy and institutional reforms to facilitate ACM in forestry. Thus far, preparatory work to identify potential partner institutions and national researchers, and to sign memoranda of understanding has been completed in the participating countries which include Indonesia, Nepal, and Philippines. Research activities have just commenced. CIFOR has engaged a multidisciplinary research team to support the implementation of research activities by the national teams.

24. **Improving Management of Natural Resources for Sustainable Rain-Fed Agriculture (ICRISAT).** The Project's objectives are to develop environment-friendly research management parameters that will conserve soil and water resources, and increase productivity and sustainability of Vertisols and Vertic Inceptisols in India, Thailand, and Viet Nam. So far, four watershed sites in India, two in Thailand, and one in Viet Nam have been established to study the effect of soil erosion on crop yields and to develop improved management to conserve soil and water resources. Socioeconomic surveys of the selected sites have been completed. Field experiments have been initiated and training on data collection and analysis for NARS staff in charge of the research projects has been undertaken.

25. **Development of Effective Water Management Institutions (International Water Management Institute [IWMI]).** The Project's objective is to develop institutions for integrated water resources management for improved management of scarce water supplies for agriculture in priority river basins of five countries (PRC, Indonesia, Nepal, Philippines, and Sri Lanka). Thus far, IWMI has completed the preparation of

methodological guidelines and an analytical framework for integrated water resources management. Based on these guidelines, the participating countries have identified their priority basins where the study will focus on. The preparation of the mapping of the physical and institutional profile of the selected river basins has been completed. In addition, two river basins, one each in Australia and Japan, have been selected to study the policy, regulations, and institutional structure and water management performance in developed countries.

26. **Increasing Productivity of Crop-Livestock Systems in Asia (International Livestock Research Institute).** The Project's objectives are to conduct collaborative multidisciplinary research to generate technology and policy options to increase the productivity and economic viability of smallholder crop-livestock systems in Southeast and East Asia. Thus far, 20 research staff from the participating countries have been trained on research methods to be used in the study. Research on crop-livestock systems has commenced. A computer simulation model to compare the performance of traditional and improved farm models has been completed. A methodology and experimental procedure has been developed to study the year-round supply land utilization of feed resources. Maps on livestock densities by species and agro-ecozones have been generated to prepare recommendations for possible interventions.

27. **Asian Rice Biotechnology Network: Achieving Impact and Sustainability (IRRI).** The Project's objective is to intensify application of biotechnology tools for the development of locally adapted, high-yielding rice varieties with durable resistance to disease and insect pests. Thus far, the quality of network science using a molecular marker to develop resistant varieties is well advanced, particularly for resistance to bacterial leaf blight. A newsletter and World Wide Web home page have been established. The Network's testing and support research laboratory has been upgraded to accommodate more NARS researchers.

4. RETA 5866: Fourth Agriculture and Natural Resources Research at CGIAR Centers (1999)

28. The RETA consists of five independent and mutually supportive research studies. These are (i) developing sustainable forage technologies for resource-poor upland farmers (CIAT); (ii) onfarm soil and water management for sustainable agricultural systems in Central Asia (International Center for Agricultural Research in the Dry Areas); (iii) irrigation investment, fiscal policy, and water resource allocation (International Food Policy Research Institute); (iv) conservation and use of native tropical fruit species biodiversity in Asia (International Plant Genetic Resources Institute); and (v) building performance-based management systems in the NARSs in Asia (International Service for National Agricultural Research).

29. RETA implementation commenced in January 2000. During January-June 2000, the progress of the five studies was limited to the preparation of annual work plans, appointment of study team leaders, and establishment of on-station or onfarm research. As of 30 June 2000, ADB had provided a total advance of $0.7 million to four of the five centers.

CURRENT ADB PROCEDURES FOR IMPLEMENTING ANRR PROJECTS

Umbrella RETA To CGIAR Centers: ADB Processing Procedure

1. The four agriculture divisions receive, review, and select the project proposals submitted by Consultative Group on International Agricultural Research (CGIAR) centers. Divisions need to keep a clear record of what proposals they have received and the status of the proposals (refused, postponed, evolving, etc.).

2. The Standing Committee for Agriculture and Natural Resources meets to consider project proposals which will be included in the umbrella regional technical assistance (RETA) in a given year, with the understanding that the total package of the project proposals must be between $5 million and $6 million.

3. Concerned staff in the four agriculture divisions circulate the selected project proposals ("the studies") for interdepartmental comments within the Agriculture and Social Sectors Department East (AED) and West (AWD).

4. Concerned staff in the four agriculture divisions revise the studies on the basis of the comments received.

5. The four managers of the agriculture divisions submit the selected studies to the Directors, AED and AWD, for approval to be included in the scope of the umbrella RETA.

6. The directors, AED and AWD, submit the studies to the vice presidents for regions East and West for approval by the RETA Screening Committee on a no-objection basis.

7. The lead agronomist prepares and circulates a draft TA report containing the selected studies for interdepartmental comments.

8. The lead agronomist revises the draft TA report on the basis of the comments received in consultation with concerned staff in the four agriculture divisions.

9. The directors, AED and AWD, circulate the final draft TA report for consideration of the Staff Review Committee meeting.

10. The lead agronomist revises the TA report on the basis of the comments raised at the Staff Review Committee meeting, in consultation with concerned staff in the four agriculture divisions.

11. The lead agronomist submits the revised TA report to the Economics Editor for editing.

12. The lead agronomist submits the edited TA report to the Directors, AED and AWD, the Counsel, and the Secretary's Office for clearance.

13. The directors, AED, AWD, Programs Department East (PED) and West (PWD), submit the TA report to the vice president for regions East and West, and President for approval to circulate the TA report to the Board.

14. The lead agronomist submits the TA report to the Printing Office for printing.

15. The Secretary's Office circulates the TA report to the Board of Directors for approval on a no-objection basis.

16. The Board of Directors approves the TA Report.

17. The counsel assigned by the Office of the General Counsel prepares, circulates, revises, and finalizes the TA Agreement for each of the studies included in the umbrella RETA.

18. The following process is used for project selection and subsequent supervision and monitoring. The medium-term plan for each CGIAR center sets out the priority areas of research for ADB consideration for funding. The current guideline is approximately $1.2 million maximum funding per center so four to five grants are made for each RETA annual cycle. Funding is for three years for each grant. Proposals must represent joint efforts between centers and national agricultural research systems. Formation and support of networks is a common feature of these projects. Proposals that address more than one ADB policy objective for agriculture and natural resources research are encouraged. All CGIAR centers can submit proposals for funding. ADB provides 15 percent administrative fees to the centers. Funding of salaries of research scientists at the centers is not allowed. These costs are typically provided on a matching basis from CGIAR unrestricted funding.

19. The non-CGIAR centers submit proposals somewhat outside the above framework as their proposals are submitted on an ad hoc basis but usually following preliminary discussions with ADB staff. The three centers receiving regular ADB support are International Board for Soil Research and Management, Asian Vegetable Research and Development Center, and International Centre for Integrated Mountain Development. There is no per-specified limit on funding requests but most funding is between $0.6 million and $1 million. Proposals under $1 million can be approved by the President whereas grants over $1 million require Board approval.

20. Once proposals are selected and funded, supervisory assignments are made among staff of AED and AWD.

SUMMARY OF PUBLISHED RESULTS ON ECONOMIC BENEFITS OF AGRICULTURAL RESEARCH

1. Agricultural research is an investment that affects future productivity, income growth, environmental quality, food security and farmer safety, and the quality of rural life. Increased productivity means that more output can be produced with the same amount of total inputs or the same amount of output can be produced with a smaller quantity of inputs. At the industry level, a productivity-improving technical change typically results in both an increase in output and an increase in output per unit of input, while total input levels may fluctuate (Alston and Pardey, 1996). Productivity improvements lead to a reduction in cost per unit of output.

2. Economists have completed several previous studies of the economic benefits of agricultural research. This matter has been studied widely and investment in research has been shown to generate consistently higher returns than investment in conventional inputs in agriculture. Furthermore, the security of agricultural investments is improved by an appropriate research investment component. Previous rate-of-return studies suggest that agricultural research has been a good investment. A summary of rates of return estimated in a comprehensive review of previous studies for various commodities has shown that these rates range from 20 to 60 percent, with a few exceeding 100 percent. These returns exceed those expected for most public or private investments.

3. Returns of similar magnitudes have been estimated for international research on crops. An analysis of 15 research themes at the International Potato Center (CIP) yielded internal rates of return ranging from 13 to 51 percent (Walker and Collion, 1997).[1] The same can be said for the International Crops Research Center for the Semi-Arid Tropics (ICRISAT) which ranked returns to research from 110 different research areas. The average internal rate of return (IRR) for research for the top 20 research areas at ICRISAT was 39 percent according to Kelley, et al. (1995).[2]

4. Authors such as Evenson, Waggoner, and Ruttan (1979),[3] Echeverria (1990),[4] and Alston and Pardey (1996)[5] have investigated returns from agricultural research over the past 30 years. The most recent attempt to quantify returns on research was done by Alston, et al. (2000)[6] who sought to obtain every published study from every country since Schultz (1953) to 1997.[7]

5. The study by Alston, et al. (1999) reviewed rates of return of agricultural R&D from 294 publications with a total of 1,858 observations. In the study, a sample of 1,819 usable

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[1] Walker, T. and M. Collion. 1997. *Priority Setting at CIP for the 1998-2000 Medium Term Plan*. International Potato Center, Lima, Peru.

[2] Kelley, T.G., J.G. Ryan, and B.K. Patel. 1995. Applied Participatory Priority Setting in International Agricultural Research: Making Trade-Offs Transparent and Explicit. *Agricultural Systems* 49(2):177-216.

[3] Evenson, Waggoner, and Ruttan. 1979. Economic Benefits from Research: An Example from Agriculture. *Science* 205:1101-1107. Washington, DC.

[4] Echeverria, R.G. 1990. Assessing the Impact of Agricultural Research. In: Echeverria, R.G. (ed.) *Methods for Diagnosing Research System Constraints and Assessing the Impact of Agricultural Research, Vol. II, Assessing the Impact of Agricultural Research.* ISNAR, The Hague.

[5] Alston, J.M. and P.G. Pardey. 1996. *Making Science Pay: The Economics of Agricultural R&D Policy*. Washington DC.: American Enterprise Institute.

[6] Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and T.J. Wyatt. 2000. *Ex Pede Herculem?: A Meta-Analysis of Rates of Return to Agricultural R&D*. IFPRI, Washington, DC.

[7] Schultz, T.W. 1953. *The Economic Organization of Agriculture*. New York: McGraw-Hill.

observations ("full sample") was used and summary statistics on the distributions of rates of return to research, extension, and both research and extension was determined (Table A6.1). The overall rate of return across a sample of 1,128 observations used in the regression was 64.66 percent per annum, with a standard deviation of 86.08 percent. In the sample, the estimated annual rates of return averaged 80 percent for research only, 80 percent for extension only, and 47 percent for combined research and extension. These statistics are similar to their counterparts for the full sample. The overall mean rate of return on research across all 1,819 observations was 82 percent per annum, 101 percent for research, 86 percent for extension, and 48 percent for both research and extension.

Table A6.1: Range of Rates of Return for Agricultural Research

Full Sample[a]	Number of Observations	Estimated Rate of Return (%)				
		Mean	Mode	Median	Minimum	Maximum
Research Only	1,112	101.3	46.0	48.9	(7.4)	5,645
Extension Only	79	85.5	47.0	63.1	0.0	636
Research and Extension	628	47.6	28.0	37.0	(100.0)	430
All Observations	1,819	82.1	46.0	45.0	(100.0)	5,645
Regression Sample[b]						
Research Only	598	79.6	19.0	49.0	(7.4)	910
Extension Only	18	80.1	91.0	58.4	1.3	350
Research and Extension	512	46.6	28.0	36.0	(100.0)	430
All Observations	1,128	64.6	28.0	42.0	(100.0)	910

[a] The original full sample comprised 294 publications reporting 1,858 observations. Of these, five publications were dropped because rather than specific rates of return they reported such as ">100 percent" or "<0." As a result of these and other exclusions for similar reasons, 37 observation were lost. Of the remaining 1,821, two observations were dropped as extreme (and influential) outliers. These two estimates were 724,323 percent and 455,290 percent per annum.

[b] Excludes outliers and observations that could not be used in the regression owing to incomplete information on explanatory variables.

Source: Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and T.J. Wyatt. 2000. *Ex Pede Herculem?: A Meta-Analysis of Rates of Return to Agricultural R&D*. IFPRI, Washington, DC.

6. From the same study using a sample of 1,740 rates of return from the full sample, Alston et al. (1999), summarize the distributions of rate of return estimates according to the "commodity" orientation of the research being evaluated (Table A6.2). The mean for the sample is 82 percent per annum with a median of 44 percent, and the range is from -100 to 5,645 percent per annum. Rates of return from maize, wheat, and corn research were 138, 51, and 75 percent, respectively. The median rate of return, which may be a more important measure of returns to research, was 48, 42, and 51 percent for the three commodities.

Table A6.2: Rates of Return on Agricultural Research by Commodity

Item	Number of Observations	Rate of Return (%)				
		Mean	Mode	Median	Minimum	Maximum
Multi-Commodity[a]	**423**	**81.6** (112.1)	**58.0**	**48.0**	**(1.0)**	**1,219.0**
All Agriculture	329	77.5 (112.7)	58.0	44.0	(1.0)	1,219.0
Crops and Livestock	**80**	**106.3** (115.5)	**45.0**	**59.0**	**17.0**	**562.0**
Unspecified[b]	14	42.1 (19.8)	16.4	35.9	16.4	69.2
Field Crops[c]	898	75.1 (140.6)	49.0	44.0	(100.0)	1,720.0
Maize	164	138.4 (275.3)	29.0	48.5	(100.0)	1,720.0
Wheat	149	51.2 (40.0)	23.0	41.9	(47.5)	290.0
Rice	81	75.0 (75.8)	37.0	51.3	11.4	466.0
Livestock[d]	233	120.7 (481.1)	14.0	53.0	2.5	5,645.0
Tree Crops[e]	108	87.6 (216.4)	20.0	33.3	1.4	1,736.0
Resources[f]	78	37.6 (65.0)	7.0	16.5	0.0	457.0
Forestry	60	42.2 (73.0)	7.0	13.6	0.0	457.0
All Studies	**1,740**	**81.9** (218.0)	**46.0**	**44.0**	**(100.0)**	**5,645.0**

[a] Includes research identified as "all agriculture" or "crops and livestock," as well as "unspecified."
[b] Includes estimates that did not explicitly identify the commodity focus of the research.
[c] Includes all crops, barley, beans, cassava, groundnuts, maize, millet, other crops, pigeonpea/chickpea, potato, rice, sesame, sorghum, wheat.
[d] Includes beef, swine, poultry, sheep/goat, all livestock, dairy, other livestock, pasture, dairy, and beef.
[e] Includes "other tree" and "fruits and nuts."
[f] Includes fishery and forestry.

Source: Alston, J.M., C. Chan-Kang, M.C. Marra, P.G. Pardey, and T.J. Wyatt. 2000. *Ex Pede Herculem?: A Meta-Analysis of Rates of Return to Agricultural R&D*. IFPRI, Washington, DC.

7. According to the Alston and Pardey (1996) (footnote 5) as quoted from the Bilateral Agricultural Research and Development Fund (BARD)[8] study, agriculture is an investment that affects future productivity, income growth, environmental quality, food security and farmer safety, and the quality of rural life, as productivity improvements lead to a reduction in cost per unit of output.

8. In a study by Evenson (1991) assessing the role of international agricultural research centers (IARCs), and national agricultural research centers (NARCs), and extension programs

[8] Norton, G., J. Mullen, Z. Tropp, M. Keynan, and A. Cohen. 2000. *BARD 20-Year Review: Economic Evaluation of Selected BARD Projects.* Washington, DC and Tel Aviv, Israel.

on field crop productivity, research directed toward the discovery and development of new agricultural technology has a significant impact on productivity growth.[9] Studies have documented high productivity of IARC and NARC programs in wheat and rice, but relatively little systematic study of the impact on other commodities has been undertaken. Table A6.3 reports a summary of IRRs to investments in national research, national extension, and IARC research by region.

Table A6.3: Summary of Internal Rates of Return

Program IRR	Wheat	Rice	Other Cereals	Cassava	Potatoes	Sweet Potatoes	Groundnuts
NARC	>80	59	>80	>80	19	>80	44

Program IRR	Cereals			Staple Crops			Maize/Millet/Sorghum		
	Latin America	Africa	Asia	Latin America	Africa	Asia	Latin America	Africa	Asia
NARC	44	—	50	—	>80	>80	—	—	—
National Extension Program	>80	34	>80	—	>80	>80	—	—	—
IARC	>80	>80	>80	79	51	68	>80	>80	>80

— = no data available, IARC = international agricultural research center, IRR = internal rate of return, NARC = national agricultural research center.

Source: Evenson, R.E. 1991. IARC, NARC and Extension Investment, and Field Crop Productivity: An International Assessment. In: Evenson R.E., and Pray C.E. (eds.), *Research and Productivity in Asian Agriculture.* Cornell University Press.

9. Data compiled by Evenson (1991) show that high rates of return have been realized for all forms of investment in agricultural research. Returns are generally highest in Asia and lowest in Africa. Returns to cereal research and related extension are higher than returns to the staples group. IARC research investment yields IRRs in excess of 100 percent in the cereals and other programs as well. Evenson also noted that it is not very meaningful to dwell on the actual levels of these extraordinarily high returns since even if productivity is overestimated by a factor of 10, research projects yielding IRRs above 50 percent would still yield a competitive return on investment.

10. Methods for evaluating research payoffs have been significantly refined over time and these refinements have yielded lower social rates of return. According to Barry (1997), a study by Alston, Craig, and Pardey considered how more realistic specification of time lags in research and development would affect output growth.[10] Their revised estimates show annual rates of return in the 17-31 percent range for agricultural research. Recent work at the Economic Research Service of the United States Department of Agriculture also reevaluated the returns to

[9] Evenson, R.E. 1991. IARC, NARC and Extension Investment, and Field Crop Productivity: An International Assessment. In: Evenson R.E, and Pray C.E (eds.), *Research and Productivity in Asian Agriculture.* Cornell University Press.

[10] Barry, P.J. 1997. Rates of Return to Public Investment in Agricultural Research and Education*. Choices*. pp. 13-15. Fourth Quarter.

agricultural research considering the full economic cost of public expenditures and costs incurred by the private sector in technology development, and used conservative assumptions about research lag. These factors reduced the estimated rate of return from about 60 to 35 percent. In general, although these revised estimates are lower than previous estimates, they are still high relative to the government's (or donor's) costs of funds, the returns from alternative investments, and private sector rates of return.

Table A6.4: Estimated Annual Rates of Return to US Agricultural Research
(percent)

Study	Year	All Agriculture	Cash Grains	Vegetables	Fruits	Other Crops	Dairy	Poultry	Other Livestock
Griliches	1964	35-40	—	—	—	—	—	—	—
Lattimore	1964	*	—	—	—	—	—	—	—
Peterson	1967	—	—	—	—	—	—	21-25	—
Evenson	1968	47	—	—	—	—	—	—	—
Cline	1975	28-50	—	—	—	—	—	—	—
Bredahl and Peterson	1976	—	36	—	—	—	43	37	47
Peterson and Fitzharris	1977	34-51	—	—	—	—	—	—	—
Evenson, et al.	1979	45-130	—	—	—	—	—	—	—
Davis	1979	37-100	—	—	—	—	—	—	—
Knutson and Tweeten	1979	38-47	—	—	—	—	—	—	—
Norton	1981	—	31-57	—	—	—	27-50	30-55	56-111
Smith, et al.	1983	—	202	—	—	—	25	61	22
Lyu, White, and Liu	1984	23-30	—	—	—	—	—	—	—
Braha and Tweeted	1986	47	—	—	—	—	—	—	—
Huffman and Evenson	1989	43	—	—	—	—	—	—	11
Norton and Ortiz	1992	30	31	19	33	34	—	46	55

— = no data available, * = insignificant.

Source: Bilateral Agricultural Research and Development Fund.