ADB

Technical Assistance Report

Project Number: 38522
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Technical Assistance
Development and Dissemination of Water-Saving Rice Technologies in South Asia

Asian Development Bank

ABBREVIATIONS

ADB	–	Asian Development Bank
ARI	–	advance research institute
AWD	–	alternate wetting and drying
DMC	–	developing member country
ha	–	hectare
HYV	–	high-yield varieties
IA	–	implementing agency
IRRI	–	International Rice Research Institute
m^3	–	cubic meter
NARES	–	national agricultural research and extension system
PARC	–	Pakistan Agricultural Research Council
PVS	–	participatory varietal selection
RETA	–	regional technical assistance
RKB	–	Rice Knowledge Bank
TA	–	technical assistance

TECHNICAL ASSISTANCE CLASSIFICATION

Targeting Classification	–	General intervention
Sector	–	Agriculture and natural resources
Subsectors	–	Agriculture production, water resource management, and environment and biodiversity
Themes	–	Regional cooperation, sustainable economic growth, and environmental sustainability
Subthemes	–	Developing rural areas, natural resource conservation

NOTE

In this report, "$" refers to US dollars

Vice President	J. Eichenberger, Operations Group 2
Director General	H. Satish Rao, East and Central Asia Department (ECRD)
Director	K. Matsunami, Agriculture, Environment, and Natural Resources Division, ECRD
Team leader	T. Bayarsaihan, Senior Agricultural Economist, Agriculture, Environment, and Natural Resources Division, ECRD

I. INTRODUCTION

1. In 1995, the Board approved the Agriculture and Natural Resources Research (ANRR) Policy Paper, which focuses on three strategic objectives: sustainable management of natural resources, increases in agricultural productivity, and poverty reduction. Since 1996, the Asian Development Bank (ADB) has been supporting the international agriculture research centers through annual regional technical assistance (RETA). The present technical assistance (TA)[1] will support development and dissemination of water-saving rice production technologies in selected South Asian countries (Bangladesh, India, Nepal, and Pakistan) where productivity and profitability of rice farming are affected by drought and water shortage. The TA is in the interregional RETA program for 2005–2008 of the Regional and Sustainable Development Department.

II. ISSUES

2. Rice is basic to food security and economic development in Asia. Its production has increased by 2.5% annually since 1965, feeding an additional 600 million people and reducing the real price of rice by 75%. Reducing the income share spent by the poor on rice has been especially critical for poverty reduction in Asia. This historic achievement was made possible mainly due to productivity increases brought about by the green revolution, which introduced high-yielding modern varieties and promoted fertilizer use and expansion of irrigation. In the past decade, however, productivity increases have slowed, as resources have been stretched and growth of the irrigated area stagnated, while rice demand continues to increase. It has been estimated that Asian countries will need to increase rice production by 50% between 1997 and 2025 simply to keep pace with population growth. To meet this demand, rice production will need to grow by at least 1.5% per annum in the next two decades, but annual rice production growth in the region since 1997 has been only 1%.

3. Maintaining and increasing productivity growth in the irrigated rice systems have been severely constrained by the looming water crisis in Asia. Water usage in the current rice production agriculture system is extremely high. It takes about 3,000 liters of water to produce 1 kilogram of rice. Irrigated non-agriculture areas, which provide 75% of total Asian rice production, consume 50% of all freshwater diversions. This profligate usage of water in irrigated rice production is unsustainable, given the increasing demand for freshwater due to growth in rice demand and growing competition from other agriculture and nonagriculture sectors. With the current rate of water usage, even maintaining productivity in many currently irrigated areas will be difficult unless more water-efficient rice production technologies suitable for irrigated areas are developed.

4. It is also important to increase rice productivity in rain-fed (nonirrigated) fields, which occupy over 50% of the areas planted to rice in Asia. Despite their large share in total paddy areas, rain-fed fields produce only a quarter of Asia's rice output largely because the constant threat of drought prevents farmers from investing in yield-increasing technology. The major droughts of 2000 and 2002 seriously affected rice production in India. In the eastern states of Jarkhand, Orissa, and Chhattisgarh alone, rice production losses in severe droughts (about 1 year in 5) averaged 40% of total production with an estimated value of $650 million.[2] These losses affected the poorest farmers disproportionately. It is now widely recognized that any major productivity increases in rain-fed areas will require improved varieties that use water more efficiently.

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[1] The TA first appeared in *ADB Business Opportunities* (internet edition) on 5 January 2005.

[2] Pandey, S., H. Bhandari, R. Sharan, D. Naik, S. K. Taunk, and A. D. R. A. S. Sastri. 2005. *Economic Costs of Drought and Rainfed Rice Farmers' Coping Mechanisms in Eastern India*. IRRI: Los Baños (Final project report).

5. The development of rice systems that need less water has the potential to free enormous quantities of water for nonagricultural use. According to estimates of the International Rice Research Institute (IRRI), a 10% reduction in water use for rice irrigation would free 150 billion cubic meters (m^3), or 25% of the total freshwater used in Asia for nonagricultural purposes. Reducing water inputs to irrigated rice will also result in significant environmental benefits. In many high-input irrigated systems, percolation outflow from paddies results in nitrate and phosphate pollution of downstream lakes and rivers, and salinization. Water-saving irrigation systems eliminate percolation outflows, thus reducing pollution and salinization and enhancing the efficiency of fertilizer use. Also, by reducing diversion of surface water, water-saving rice production technologies can help maintain wetlands that provide important environmental services. In broader terms, the development of more efficient rice-based systems will significantly contribute to poverty reduction and achieving Millennium Development Goals in the region.[3]

6. Two principal water-saving rice technologies are being developed; both offer large potential for water savings relying mainly on seed- and knowledge-based technologies. In the alternate wetting and drying (AWD) system, conventionally transplanted (lowland) fields are allowed to drain between irrigations, retaining a water layer only during sensitive crop stages like flowering. AWD, which uses currently available high-yield varieties (HYVs), can reduce water usage by up to 15%, with little yield loss. However, AWD is a high-risk technology at present because current HYVs are very sensitive to dry soil conditions and require near-perfect irrigation control.[4] Adopting AWD on a larger scale will require new varieties with more tolerance to dry soils. Such varieties are being developed at IRRI, but need further refinement and extensive evaluation in farmers' fields. The aerobic production system is a radical approach that reduces water usage by up to 50%. Aerobic rice is sown in dry soil and grown without flooding. The system is a viable option now in low-input rain-fed systems facing drought risk, such as the Eastern Indian plateau. However, current aerobic rice yields are not high enough to be economically viable in irrigated areas, where input use and yield potential are high.[5] Also, it has been observed that rice yields under an aerobic production system decline considerably over time due to causes that are not fully understood but are thought to be biotic (disease- and insect-related). The development and extensive testing of higher-yielding aerobic rice varieties resistant to soil biotic stresses are needed to enhance the prospects of their adoption in irrigated fields.

7. IRRI has been at the forefront of this research. Since 2000, it has dedicated substantial resources to the development of water-saving varieties. IRRI's basic research on drought genetics has made significant progress in developing more water-efficient varieties. IRRI has also identified rice varieties that resist aerobic yield decline, tolerating continuous cropping in dry soils. IRRI has developed strong linkages with other advance research institutes in functional genomics and gene expression and also collaborates closely on rice technologies with national agricultural and extension systems (NARES) in Asian developing countries. These earlier research and networks of IRRI form a solid basis on which to continue with the new stage of technology development.

8. The TA will support the development and dissemination of water-saving rice technologies in drought-prone and water-short areas of Asia. The TA will also strengthen the capacities of participating NARES to develop locally adapted water-saving rice technologies, which are still at

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[3] Of the eight millennium development goals, two can relate directly (Goal 1: Eradicate Extreme Poverty and Hunger; Goal 7: Ensure Environmental Sustainability), and two indirectly (Goal 4: Reduce Child Mortality; Goal 5: Improve Maternal Health) to rice-based systems.

[4] Even brief periods of soil drying during the critical flowering stage, caused by failure of an irrigation system to deliver water in a timely manner, can easily reduce the yield of conventional high-yield varieties by over 50%.

[5] IRRI research indicates that current aerobic rice yields are 20-30% lower than yields under conventional irrigated management.

their infancy, and will promote a regional network for information dissemination to ensure the broader impacts of the project. The TA is fully consistent with ADB's policy on agricultural and natural resources research as it supports increased agricultural productivity and sustainable management of water resources in the region. Water-efficient and drought-tolerant varieties adapted to direct seeding, to be developed through this TA, will complement ADB's ongoing RETA 6208: Integrated Crop and Resource Management in the Rice–Wheat System in South Asia[6] (aimed at developing water-conserving rice–wheat systems), and RETA 6136: Improve and Stabilize Crop Productivity in Diverse and Less Favorable Rainfed Areas of Asia[7] (aimed at increasing crop productivity and reducing risks in drought-prone environments).

9. The TA will focus on South Asia, where water shortage and droughts are endemic. During the southern Indian drought of 2001–2004, competition for water led to disputes between the Indian states of Karnataka and Tamil Nadu. Groundwater overexploitation increased pumping costs and caused significant environmental problems in parts of India and Pakistan. It is estimated that, by 2025, 12 million hectares (ha) of irrigated rice in South Asia may suffer from severe water shortage,[8] with serious effects on food security and social stability of the region. For these reasons, the national research systems in South Asia identified the development of water-saving rice production technologies as high priority. The Pakistan Agricultural Research Council identified the development of water-efficient rice cultivars as one of five major research thrusts for collaboration between Pakistan and IRRI. The Nepal Agricultural Research Council expressed strong support for the TA. In Bangladesh, the high-productivity dry-season (*boro*) crop is largely dependent on pumped groundwater; its profitability is threatened by rising fuel prices. The development of water-saving rice varieties is a major thrust of the approved 2005–2008 IRRI-India work plan.

10. The TA design incorporated several key lessons from past research projects funded by ADB, including the need for greater emphasis on (i) strengthening the capacities of NARES, (ii) enhancing farmer participation in evaluating and disseminating new technologies, and (iii) increasing the focus of research themes on issues related to resource-poor farmers.

III. THE TECHNICAL ASSISTANCE

A. Impact and Outcome

11. The main expected impacts of the TA are enhanced food and income securities of the rural and urban population, and improved environmental sustainability of rice production systems in water-short and drought-prone areas of South Asia. The key outcomes of the TA will be

(i) enhanced rice productivity in water-short regions,
(ii) improved water use efficiency in rice production and better environmental conditions, and
(iii) self-sustaining national research capacities to develop water-saving rice technologies.

12. The expected outputs of the TA are (i) new water-saving rice production technologies based on improved varieties, (ii) improved water-saving technologies validated and disseminated

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[6] ADB. 2004. *Technical Assistance for the Ninth Agriculture and Natural Resources Research at International Agricultural Research Centers*. Manila.

[7] ADB. 2003. *Technical Assistance for the Eighth Agriculture and Natural Resources Research at International Agricultural Research Centers.* Manila.

[8] Tuong, T. P., and B. A. M. Bouman. 2003. Rice Production in Water-Scarce Environments. In J. W. Kijne, R. Barker, and D. Molden D. (eds.). 2003. *Water Productivity in Agriculture: Limits and Opportunities for Improvement*. United Kingdom: CAB International (pp. 53–67).

in farming communities, (iii) strengthened national capacities to develop and disseminate water-saving rice production technologies, and (iv) a regional network for exchange of information and experience in coping with water shortage in rice production systems. The specific quantifiable targets, monitoring mechanisms, and expected benefits are in the TA design and monitoring framework (Appendix 1).

B. Methodology and Key Activities

13. The TA will involve both basic and adaptive research at IRRI and in collaborating national agricultural research centers and in farmers' fields. Highly participatory approaches will be used in validating and disseminating suitable technologies. The TA will ensure that participation of women in project activities is maximized and their welfare is supported. In particular, they will (i) identify local, specific, and acceptable ways to disseminate the project information to women; (ii) encourage and ensure participation of women in technology dissemination activities; and (iii) ensure that women have equal access to new technologies developed by participating institutions.

14. The detailed description of the TA activities is in Appendix 2. Summaries are presented here.

(i) **Development of new water-saving rice production technologies based on improved varieties.** At IRRI, new varieties combining high yield with reduced water usage will be selected in managed-stress screening environments (AWD and aerobic). Biotic factors causing yield decline will be identified, and the genetic basis of tolerance will be determined. Tolerant lines will be used in developing new aerobic varieties that can be sustainably produced in dry soils without yield decline. At least 10 new varieties combining high yield potential, water-use efficiency, and tolerance to yield decline factors will be distributed annually to national partners for further refinement, evaluation, and dissemination.

(ii) **Participatory validation and dissemination of water-saving technologies suitable for drought-prone and water-short areas.** At target sites, communities and farmer-cooperators with a strong need for water-saving varieties will be identified via surveys and focus-group discussions by NARES collaborators. Available IRRI and national varieties producing high yields under water-saving irrigation or drought will be validated in on-station trials by each participating team. Promising varieties will be evaluated with farmer participation. Information will be packaged into extension-ready materials for dissemination as fact sheets and web pages.

(iii) **Development of the capacity to produce water-saving rice technologies.** At project initiation, an international workshop will be held to summarize knowledge on breeding and sustainability issues. Annually, three researchers from each participating national research institute will visit IRRI for 4 weeks for planning, data analysis, report preparation, and training in breeding, participatory research methods, impact assessment, and soil health management. In addition, a series of training courses on the development and use of water-saving technologies for rice production will be organized among national scientists, and extension workers of project sites.

(iv) **Development of a regional network for exchange of information on water-saving rice production systems in South Asia.** IRRI together with NARES teams will develop and maintain a regional network for exchange of information on development of water-saving rice systems for broader research and development communities. The research results will be disseminated through annual meetings, journal publications, and project websites.

C. Cost and Financing

15. The total cost of the TA is $2,306,000. ADB will provide $1,000,000 on a grant basis from ADB's TA funding program. IRRI will contribute $566,000 over 3 years. The participating national

research institutes of Bangladesh, India, Nepal, and Pakistan will provide counterpart funds of $740,000 in the form of staff time, land, and research facilities. The detailed cost estimates and a financing plan are in Appendix 3.

D. Implementation Arrangements

16. IRRI will be the Executing Agency, with whom ADB will enter into a TA agreement. The TA activities will only take place in a developing member country (DMC) after the Government of such DMC has given its no objection to the participation in the TA. IRRI will be fully responsible for the successful implementation and conclusion of the TA. Bangladesh Rice Research Institute, Tamil Nadu Agricultural University of India, Nepal Agricultural Research Council, and Pakistan Agricultural Research Council will be designated as national implementing agencies (IAs) and will closely collaborate with IRRI. IRRI will appoint a project leader (IRRI staff on part-time basis) and project coordinator (full time consultant), who will be responsible for planning, coordinating, and supervising all project activities, and submitting reports to ADB and other collaborating partners. Each IA will appoint a national team leader and researchers responsible for coordination, implementation, and reporting on the Project.

17. The TA activities will be implemented over 36 months beginning in January 2006 and ending in December 2008. The project steering committee consisting of the representatives of IRRI and of participating NARES will be established to provide regular policy guidance, monitor project implementation progress, and assess the project impacts. IRRI will hold an inception workshop within 3 months after the TA starts to finalize project plans and implementation arrangements with partners. IRRI will also organize annual planning and review meetings and a project completion workshop, which will be attended by all project partners and ADB. IRRI will submit the following reports to ADB: (i) an inception report within 3 months of the start of the TA, (ii) a semiannual progress report every 6 months, (iii) semiannual financial statements accounting for the use of project funds every 6 months, (iv) audited annual financial statements, and (v) a comprehensive completion report within 3 months of project closure. Funds will be drawn down in semiannual installments, based on IRRI's estimate of forthcoming expenditures, and subject to satisfactory liquidation of expenditures for previously disbursed funds. Project officers with suitable technical expertise will be assigned to administer the TA at ADB, and will undertake at least one supervisory mission each year.

18. The TA will finance 36 person-months of international and 180 person-months of domestic consulting services in project management, water-saving rice breeding, soil microbiology, and social science. IRRI will engage consultants on an individual basis in accordance with ADB's *Guidelines on the Use of Consultants* and other arrangements satisfactory to ADB for engaging domestic consultants. The outline terms of reference of the consultants are in Appendix 4. Before engaging any consultant, IRRI will submit his/her curriculum vitae to ADB for approval. IRRI will procure goods and materials to be financed by the TA in accordance with ADB's *Guidelines for Procurement* or other procedures acceptable to ADB. At the end of the TA, equipment purchased will be assigned to IRRI or the IAs concerned.

IV. THE PRESIDENT'S DECISION

19. The President, acting under the authority delegated by the Board, has approved the provision of technical assistance not exceeding the equivalent of $1,000,000 on a grant basis for the Development and Dissemination of Water-Saving Rice Technologies in South Asia, and hereby reports this action to the Board.

DESIGN AND MONITORING FRAMEWORK

Design Summary	Performance Targets/Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
Impact Enhanced food and income security of rural and urban population, and improved environmental sustainability of rice production systems in South Asia	Increased income of rural and urban households Enhanced environmental conditions in rice-growing areas due to reduced water usage and chemicals	Impact analysis Project final report Government statistics	**Assumptions** • Government policies conducive to efficient water use in agriculture • Commitment of participating countries
Outcome Enhanced rice productivity in water-short regions	Increased rice yields (20%) in project areas Widespread adoption of new water-saving rice technologies in project area (50% of farmers in target communities)	Project final report Provincial statistics	**Assumptions** • Availability of suitable germplasm
Improved water-use efficiency in rice production and better environmental conditions	Increased water savings (30%) demonstrated in project areas Enhanced environment in project areas	Project final report Impact assessment report	• Strong support of NARES partners in project site selection, community mobilization
Self-sustaining national research capacities to develop water-saving rice technologies	Strengthened capacity of NARES for independent development of water-saving technology	Project final report NARES program reports	• Building of a critical mass based on availability of trained research and extension personnel
Outputs 1. New water-saving rice production technologies based on improved varieties			**Assumptions**
1.1 New generation of aerobic varieties with improved yield and water savings	Four new aerobic varieties with 20% higher yield than current varieties under irrigation	Project progress and final reports One refereed article in an international	• Existence of adequate genetic variability for yield under aerobic management

Design Summary	Performance Targets/Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
	regimes that reduce water use by 50% compared with conventional irrigation	scientific journal	
1.2 New generation of AWD varieties with improved yield and water savings	Four new AWD varieties with 20% higher yield than current varieties under irrigation regimes that reduce water use by 50% compared with conventional irrigation	Project progress and final reports One refereed article in an international scientific journal	• Existence of adequate genetic variability for yield under AWD management
1.3 Causes of aerobic rice yield decline identified	Causal organisms confirmed through pot inoculation studies; results published in an international scientific journal	Project progress and final reports One refereed article in an international scientific journal	• Yield decline caused by biotic soil factors
1.4 Aerobic varieties tolerant to factors causing yield decline	Four new aerobic varieties tolerant to yield decline factors available in target areas	Project progress and final reports	• Causes of yield decline not site-specific, allowing development of varieties with generalized tolerance
2. Water-saving rice technologies based on AWD and aerobic varieties validated and disseminated			
2.1 Validated water-saving technology based on AWD and aerobic varieties	Yield increases of 20% and water savings of 30% in farmer-managed trials	Project progress and final reports One refereed article in scientific journal	• Interest of farmer groups in water-saving technology • Sufficient NARES support for on-farm research
2.2 Improved water-saving varieties and practices disseminated	Training and seed provided to at least 200 farmers per site Successful practices disseminated via website, extension materials	Project progress and final reports Training manuals Extension materials Web pages	• Successful seed increase in years 2 and 3 without severe weather, disease, or logistical problems

Design Summary	Performance Targets/Indicators	Data Sources/ Reporting Mechanisms	Assumptions and Risks
3. Strengthened national capacities to develop water-saving rice production technologies			
3.1 Strengthened national research capacity to develop water-saving rice technology	Acquisition by at least four key scientists per country of critical research skills in breeding, water-saving management, and participatory research	Project progress and final reports Training manuals Web pages	• Support of countries for participation of research leaders in training activities
3.2 Strengthened national extension capacity to adapt and disseminate water-saving rice technology	Acquisition by at least 10 extension leaders per country of knowledge and skills in water-saving rice production technology	Project progress and final reports Extension materials Web pages	• Support of countries/provinces for participation of extension leaders in training activities
4. Establishment of a well-functioning regional research network for water-saving rice technologies	Annual meetings held, rotating among country key sites Well-functioning websites and electronic bulletins are in place	Annual and final project reports Proceedings of annual meetings Websites, electronic bulletins	• Clearance for participants obtained from national authorities

Activities with Milestones	Inputs
1.1 Establish PMO and hire consultants (months 1–3). 1.2 Develop and fieldtest new aerobic and AWD rice varieties: • Develop fixed lines from 30 new IRRI crosses (year 1). • Evaluate 2,000 lines and hybrids under both severely restricted and full irrigation (year 2). • Deliver at least 50 promising advanced lines to national programs (year 3). 1.3 Identify causes of aerobic rice yield decline through field, greenhouse, and laboratory research: • Recruit postgraduate student (months 1–6); • Apply initial identification by selective treatments in field trials (year 1). • Confirm via inoculated pot experiments (year 2). 1.4 Develop varieties tolerant to yield decline-causing organisms: • Evaluate 500 advanced lines in hot-spot field trials (year 1). • Confirm tolerant varieties (year 2). • Deliver at least 4 tolerant varieties to NARES (year 3). • Identify NARES teams and hold initial site meeting held (months 1–2).	**ADB: $1,000,000** • Consultants - $218,000 • Research supplies and services - $91,000 • Travel - $60,000 • Collaboration - $327,000 • Workshop and Meeting - $54,000 • Administrative - $130,000 • Contingency- $120,000 **IRRI: $566,000** **Participating NARES** (BAN, IND, NEP, PAK) : **$740,000**

2.1 Define target domain for water-saving varieties: • Identify proposed target sites via GIS, consultations with local authorities (months 1-6). • Complete community surveys, and focus group discussions with at least 100 farmers/target site (year 1). 2.2 Conduct farmer-participatory evaluation of yield and water savings of aerobic and AWD varieties: • Carry out on-station testing of promising varieties under water-saving management (year 1). • Produce 1 ton of each of 3 promising varieties per country and initiate on-farm trials (year 2). • Conduct farmer-managed (baby trials) with at least 200 women and men farmers per site, and determine adaptability (year 3). • Quantify water savings and yield under reduced irrigation or drought stress on-farm with 10 farmers/site (year 3). 2.3 Disseminate improved water-saving varieties and practices • Provide training and seed to at least 200 women and men farmers per key site (year 3). At least 30% of recipients will be women. • Disseminate successful practices via website, extension materials (year 3). 3.1 Conduct project inception and ancillary research needs assessment workshop: • Hold inception workshop with ancillary research needs assessment at IRRI (months 1–3). • Summarize the information in proceedings (year 1). 3.2 Train collaborating NARES teams: • Conduct 36 person-months of training in breeding and management for water-saving systems, participatory research and dissemination (year 3) (at least four scientists/site trained). 3.3 Train extension leaders, research managers: • Deliver one workshop on water-saving technology to key extension and research leaders in each country (year 3). 4.1 Implement South Asian network on varietal development for water-saving systems: • Conduct annual workshops and publish proceedings (year 1, 2, 3). • Complete one cross-site visit per team (year 3). • Develop website for regional network and update regularly (year 1).	

AWD = alternate wetting and drying, BAN = Bangladesh, IND = India, IRRI = International Rice Research Institute, NARES = national agricultural research and extension system, NEP = Nepal, PAK = Pakistan.

DETAILED DESCRIPTION OF TECHNICAL ASSISTANCE ACTIVITIES

A. Development of New Water-Saving Rice Production Technologies Based on Improved Varieties

1. Although significant gains in yield under restricted irrigation and drought have been made by the International Rice Research Institute (IRRI) breeding program, yields of water-saving varieties need to be increased further to promote their adoption in irrigated areas where rice yields are currently high, but pumping costs and falling water tables are jeopardizing irrigated production. A new generation of higher-yielding, more water-efficient varieties for lowland and aerobic production will be developed at IRRI. Products (alleles, pyramided lines) from the research program on the functional genomics of rice yield under water stress will be used to make a major step forward in water-use efficiency and drought tolerance. Preparatory crosses were made for this output in 2004 and initial populations are now being developed, so a flow of materials for screening and delivery will be available at project start-up.

1. Hire Project Coordinator and Domestic Consultants

2. The following consultants will be hired within 3 months of project start-up.

(i) The international coordinator/agronomist will implement field research activities at IRRI and coordinate project documentation and reporting under the supervision of the project leader.

(ii) A domestic social scientist, agronomist, and soil microbiologist will be recruited to assist in implementing breeding, on-farm validation, and yield-decline studies.

(iii) A doctoral student working on yield decline and soil health will be recruited from one of the participating countries.

2. Develop Improved Aerobic and AWD Rice Varieties

3. New crosses and breeding lines will be developed for distribution to collaborators.

(i) At least 50 new crosses among first-generation aerobic rice and alternate wetting and drying (AWD) lines and elite irrigated high-yield varieties (HYV) will be generated annually at IRRI. Initial crosses have already been made and lines extracted.

(ii) Approximately 10,000 new breeding lines will be screened yearly from these populations in IRRI's breeding nurseries. Advanced lines will be screened under nonstress conditions for yield potential, quality, and disease resistance. They will also be screened under both AWD and aerobic management in the dry season under a regime wherein soil water potential is allowed to fall to –50 kPa or –30 kPa at 30 centimeters below the soil surface between irrigations for aerobic and AWD systems, respectively.

(iii) At least 50 lines with acceptable quality and improved tolerance to water-saving irrigation will be distributed annually to collaborating national programs. The performance targets for year 3 are varieties that yield 6 tons per hectare (t/ha) with water savings of 50% relative to full irrigation under aerobic management, and varieties that yield 7 t/ha under AWD management with water savings of 30%.

3. Identify Causes of Aerobic Yield Decline in Rice Crops Grown Continuously in Nonsaturated Soils

4. On the most drought-prone lands, the sustainability of water-saving rice production is jeopardized by a rapid decline in yield that occurs when soils are not saturated throughout the growing season. The biological causes of this decline need to be unambiguously identified so as to transfer tolerance to aerobic varieties. The organisms or soil conditions causing aerobic rice yield decline will be identified to develop reliable screening protocols for the breeding program.

(i) In year 1, selective control treatments (nematicide, insecticide, and fungicide) will be applied in replicated trials to plantings of susceptible varieties in fields showing severe yield decline in the Philippines and at partner sites. This treatment will allow principal causal factors to be differentiated. Collaborative support from an advanced research institute (ARI, to be identified) with expertise in soil microbiology will be acquired. Research will be conducted by the doctoral student and the domestic scientist, under the supervision of the ARI scientist. The travel budget will support two visits per year to IRRI and project sites by the ARI collaborator.

(ii) In years 2 and 3, specific causal organisms will be characterized through inoculated pot studies at IRRI. A survey of fields growing aerobic rice continuously will be conducted at collaborating national sites.

4. Develop Varieties Tolerant to Organisms Causing Yield Decline

5. Tolerance has been identified in traditional varieties of the Lao People's Democratic Republic in the IRRI genebank, and in the irrigated HYV IR72. The genetic basis for tolerance will be studied, and tolerant varieties developed.

(i) All advanced lines and hybrids (about 1,000 per year) from the aerobic and AWD breeding programs will be screened in replicated yield trials at Philippine sites characterized by severe yield decline, and where the causal agent has been identified in activities 3(i) and (ii). The screening will be concurrent with screening for tolerance to water-saving irrigation.

(ii) At least 20 lines exhibiting tolerance to the causal organisms as well as good performance under aerobic management will be delivered annually to national partners for local adaptation testing.

(iii) Genetic analysis of tolerance will be conducted by mapping populations derived from preexisting crosses between tolerant and susceptible lines. Screening will be conducted in years 2 and 3.

B. Validation and Dissemination of Water-Saving Rice Technologies Based on AWD and Aerobic Varieties

6. Currently available aerobic and AWD varieties developed produce yield gains of over 50% compared with widely used varieties like IR64 in research station trials under severely water-limited conditions. Those varieties will be evaluated by the collaborating teams under the management of and in the fields of farmers who are facing severe water shortage. The participatory experiments will monitor water savings, yield under restricted irrigation and drought, and farmer adoption. Promising varieties will be disseminated to farmers who express a strong need for the technology, and uptake will be monitored.

1. Identify NARES Teams and Initiate Site Planning

7. Within 1 month of project start-up, each collaborating NARES research institution will identify a team consisting of an agronomist, a breeder, a soil heath specialist, and a social scientist. Within 2 months of project start-up, an initial planning meeting will be held to begin the development of a detailed site work plan.

2. Define Target Domain for Water-Saving Rice Varieties in Partner Countries, and Identify Communities Willing to Participate in Evaluation

8. After the target site is identified, farmer-cooperators will be recruited for participatory on-farm evaluation.

(i) Each national research team will identify a proposed target site for on-farm evaluation and dissemination of water-saving rice varieties by consulting geographic information system databases, irrigation authorities, local extension services, and other sources of information. (to be completed within 3 months of project start-up)

(ii) After the site has been identified, local extension and irrigation managers will be contacted, and community meetings organized to explain the project and assess farmer interest. Focus group discussions and household surveys will be conducted to obtain detailed farmer input on water cost, availability, and risk of drought or irrigation failure. (to be completed within 6 months of project start-up)

(iii) Farmers expressing strong interest in water-saving varieties will be recruited for participatory on-farm evaluation. At least 30 farmer-collaborators per site will be recruited to participate in all phases of varietal assessment. They will be trained in water-saving management systems (AWD or aerobic management). (to be completed within one year of project start-up)

3. Conduct Farmer-Participatory Evaluation of Yield and Water Savings of Aerobic and AWD Varieties

9. Evaluation in years 1–3 will involve farmers, scientists, and extension workers.

(i) In year 1, varieties will be obtained from national sources and IRRI for preliminary evaluation in replicated yield trials under water-saving, aerobic, or rain-fed management, as appropriate for each site. All varieties will be evaluated under both full irrigation to assess yield potential and either water-saving irrigation or drought-prone rain-fed conditions to assess varietal tolerance to non-saturated soil conditions. With scientists, farmer-collaborators will evaluate varieties on-station with scientists under both full and water-saving irrigation. On-station trials will monitor irrigation and rainfall to estimate differences in water-use efficiency among varieties.

(ii) In year 2, varieties identified as promising under water-saving or drought-prone conditions will be evaluated by farmer-collaborators on their own farms, using a farmer-managed baby trial design. At least three varieties per site will be evaluated by a minimum of 10 farmers for yield, quality, water requirement or drought tolerance, and other parameters identified by farmers as critical to their variety adoption decisions.

(iii) Beginning in year 2, at least 1 ton of seed of promising water-saving varieties will be increased at each participating site. Detailed planning for year 3 scale-up of participatory varietal selection (PVS) using the baby trial model will be conducted with local extension services in the target region. There will be an on-site PVS training workshop for extension staff, and development and testing of questionnaires.

(iv) In year 3, an expanded baby trial program will be conducted using the year 2 seed increase. Five-kilogram seed lots will be distributed to at least 200 farmers per site. Farmer preference data will be collected by collaborating extension workers who were trained in the PVS training workshop as noted in (iii). After the growing season, participating farmers who have received project seed will be contacted for a survey of yield, water savings, eating quality, replanting plans, and dissemination through informal seed exchange.

(v) In year 3, approximate water-savings will be quantified by more detailed surveys of at least 10 farmer-adopters per site. Quantifying measures of water use will be frequency of irrigation, hours of pump operation, and fuel or electricity costs, compared with the practices of nonadopting control groups.

C. Strengthening the Capacities of Participating National Research Institutes to Develop and Disseminate Water-Saving Rice Production Technology

10. Most national partners do not currently have the capacity to develop varieties for water-saving systems, and need to develop improved capacity for stress tolerance screening and participatory research methods. The technical assistance will provide an intensive program of training and experience to national researchers that will result in self-sustaining programs for developing, disseminating, and monitoring the spread and impact of water-saving varieties. Extension leaders and other agricultural officials in the project target areas will also be trained on water-saving technologies.

1. Conduct Project Initiation Meeting and Ancillary International Workshop on Needs for Aerobic Rice Research

11. Within 3 months of project initiation, a project start-up workshop will be held at IRRI where detailed project planning will take place. An ancillary workshop on aerobic rice research priorities will occur immediately before, bringing together experts on water-saving rice production to assess the state of the art and assemble the latest information on promising

germplasm, screening methods, and sustainability issues. Proceedings of this workshop will be published.

2. Train NARES Research Teams in Methods of Developing, Validating, and Disseminating Water-saving Varieties

12. Three researchers from each site each year stay at IRRI for 1 month for an intensive period of planning, data analysis, report preparation, and training in breeding, participatory research methods, drought screening, water use monitoring or impact assessment depending on site needs. Over the course of the project, at least four researchers and research managers per country will be trained to a level where they can serve as trainers for the national system.

3. Extension Managers in Water-Saving Rice Production Technologies and Their Dissemination

13. Workshops on water-saving technology will be held for key extension and research leaders in each country in years 2 and 3. One of the objectives of the workshops will be to obtain the active support and collaboration of extension services for scaled-up PVS and dissemination activities in year 3.

D. A Regional Network for Exchange of Information in Coping with Water Shortage in Rice Production

14. The four participating South Asian countries face many similar problems with respect to water shortage in rice production. Direct exchange of experience and information among NARES will facilitate the development and adoption of water-saving rice production systems. The TA will support a regional network that is expected to be self-sustaining after the completion of the project.

(i) In addition to the project start-up workshop, an annual workshop will be conducted each year at one of the participating member sites where results will be presented, experiences exchanged, and research priorities set. Because most research activity will be conducted in the wet season (except for Bangladesh, where the focus will be on boro rice), the meeting will be conducted during the dry season.

(ii) Over the project life, each team will participate in at least one cross-site visit to observe the research program of another team facing similar problems.

(iii) Project results will be documented on a fully accessible web page maintained by IRRI as part of the ADB-supported Rice Knowledge Bank (RKB) (see RETA 9047).[1] Extension-ready materials, including variety descriptions and fact sheets on management practices will be maintained within the RKB; collaborating institutions will oversee translation into local languages. At least one scientific article, published in an international peer-reviewed journal, will be published on each of the following topics: aerobic rice cultivar agronomic performance and water, AWD cultivar agronomic performance and water use, causal organism for aerobic yield decline, cultivar tolerance to factors causing aerobic yield decline.

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[1] ADB. 2004. *Grant Assistance to Cambodia, Thailand, and Viet Nam for Improving Poor Farmers' Livelihood Through Rice Information Technology*. Manila.

COST ESTIMATES AND FINANCING PLAN

($'000)

Item	Total Cost
A. Asian Development Bank (ADB) Financing[a]	
1. International Consultants	123.5
2. Domestic Consultants	94.5
3. Research Supplies and Services[b]	91.0
4. International and local travel	60.0
5. Collaboration:[c]	
a. Tamil Nadu Agricultural University, India	63.0
b. Nepal National Agricultural Research Council	63.0
c. Pakistan Rice Research Institute	63.0
d. Bangladesh Rice Research Institute	63.0
e. Advanced Research Institute	75.0
6. Workshop and Meeting	54.0
7. Administrative Cost	130.0
8. Contingency	120.0
Subtotal (A)	**1,000.0**
B. IRRI	
1. Personnel Costs	383.0
2. Supplies and Services[d]	108.0
3. Training[e]	15.0
4. Contingency	60.0
Subtotal (B)	**566.0**
C. NARES	
1. Personnel costs	530.0
2. Supplies and services[d]	160.0
3. Contingency	50.0
Subtotal (C)	**740.0**
Total	**2,306.0**

IRRI = International Rice Research Institute, NARES = national agricultural research system.

[a] Financed by ADB's technical assistance funding program

[b] The collaboration costs consist of field research, equipment, agrochemicals, and casual labor, and exchange costs of research scientists.

[c] Field research and laboratory supplies, equipment, agrochemicals, and casual labor.

[d] Land, land preparation, crop protection, irrigation, software, and equipment.

[e] Training center staff time and facility use.

Source: ADB estimates.

OUTLINE TERMS OF REFERENCE FOR CONSULTANTS

1. The technical assistance (TA) will require 36 person-months international and 180 person-months domestic consulting services in the areas of water-saving rice breeding, social science, and soil health. The consultants will be recruited in accordance with the Asian Development Bank's *Guidelines on the Use of Consultants* and other acceptable arrangements for selecting international and domestic consultants.

2. The international consultant will be a postdoctoral scientist who will manage field research operations at the International Rice Research Institute (IRRI) and assist the project leader in monitoring finances, preparing project reports and scientific articles, facilitating training, and preparing annual project meetings and workshops. The domestic consultants (breeding/agronomy, social science, soil health, and field technicians) will assist the project leader and international consultant in implementing all aspects of the research and training activities.

A. International Consultant

1. Agronomist/Project Coordinator (international, 36 person-months)

3. The international consultant will serve as agronomist/project coordinator under the supervision of the project leader, and will assist the project leader in all aspects of project management. He/she will be responsible for day-to-day project management, including implementing the field research program at IRRI, ensuring that the agreed-upon experiments are properly designed and conducted, data analyzed, and results reported in a timely fashion as scientific journal articles.

4. The agronomist/project coordinator will be a rice breeder or agronomist (PhD level) with expertise in breeding and crop management for water-saving systems, and possess excellent managerial abilities, and strong written and oral communication skills in English. He/she will be hired at the IRRI position level of postdoctoral fellow. Specific tasks of the agronomist/project coordinator are as follows:

(i) Assist the project leader in communicating with collaborating national agricultural research and extension system (NARES) and advanced research institute (ARI) teams, and in monitoring the implementation of field research activities at the NARES sites.

(ii) Monitor the project budget and coordinate fund disbursements to partner sites; communicate with IRRI country offices and site coordinators to ensure timely disbursement and liquidation of fund transfers.

(iii) Prepare semiannual project reports and assist in preparing the final project report; help facilitate NARES training activities at IRRI, including liaising with the IRRI Training Center in identifying trainees and developing and delivering training activities and materials.

B. Domestic Consultants

1. Social Scientist/Project Administrator (domestic, 36 person-months)

5. The social scientist/project administrator will have a master of science degree in a relevant social science discipline, as well as a strong background in farmer-participatory research, and gender issues, excellent written and oral communication skills, and field research experience in South Asia. The specific tasks are as follows:

(i) Train and assist local teams in participatory methodology, surveys, monitoring of technology adoption, and impact assessment.

(ii) Ensure that participatory methods, surveys, trainings, and impact assessments include gender issues; and monitor women's participation in all aspects of evaluation and dissemination work.

(iii) Facilitate communication of project results by maintaining a website that documents progress and results; also develop extension-ready materials for water-saving technologies in collaboration with the NARES teams.

(iv) Serve as assistant to the agronomist/project coordinator in coordinating all aspects of project management, including site monitoring visits, preparation of semiannual progress and financial reports, budget monitoring and fund disbursement to sites, and delivery of workshop and training activities.

2. Agronomist (domestic, 36 person-months)

6. The domestic agronomist will be recruited to assist the project coordinator with implementing the breeding and agronomy field research at IRRI. The agronomist will be responsible for all aspects of breeding and screening activities under the supervision of the agronomist/project coordinator. His/her specific tasks are as follows:

(i) Produce detailed field plans, implement field trials, collect data and conduct preliminary statistical analysis, monitor water inputs to trials, and assist other team members with field research operations.

(ii) Be responsible for maintaining and documenting project seed stocks, and distributing seed to NARES collaborators; as requested by the project leader, participate in monitoring missions to collaborating NARES sites.

7. The agronomist will have an MS in plant breeding or agronomy, and at least 3 years experience in rice agronomic or plant breeding research; excellent written and oral communication skills; and ability to organize and maintain agricultural field research data.

3. Soil Health Specialist (domestic, 36 person-months)

8. The soil health specialist will implement research on the causes of aerobic rice yield decline, under the supervision of the agronomist/project coordinator. He/she will have an MS degree in plant pathology, soil microbiology, nematology, or a related discipline, plus at least 2 years of relevant research experience.

9. The specific tasks are as follows:

(i) Assist the ARI soil health collaborator and the PhD student in all aspects of the research program, including sampling, laboratory analysis, and field and greenhouse experimentation.

(ii) Assist the breeding team in screening germplasm for tolerance to the causal organism.

(iii) Coordinate the training of NARES site teams on sampling and identification of organisms causing yield decline, and may participate in sampling and monitoring missions to the collaborating NARES sites.

4. Research Technicians (domestic, 72 person-months)

10. The technicians will have experience in rice research field operations and data collection. They will assist the agronomist in implementing the breeding and water-monitoring research.