CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE AND CGIAR SECRETARIAT

Report of the Fifth External Programme and Management Review of the International Rice Research Institute (IRRI)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

This report comprises:

(a) Extract from "Summary of Proceedings and Decisions", Mid-Term Meeting 1998, Brasilia, Brazil, 25-29 May 1998

(b) Letter from TAC Chairman and CGIAR Executive Secretary, transmitting the Report of the Fifth External Programme and Management Review

(c) TAC Commentary on the Fifth External Programme and Management Review of IRRI

(d) IRRI's response to the Report of the Fifth External Programme and Management Review

(e) Transmittal letter from Panel Chairman to TAC Chairman and CGIAR Executive Secretary

(f) Report of the Fifth External Programme and Management Review of the International Rice Research Institute (IRRI)

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

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REPORT OF THE

FIFTH EXTERNAL PROGRAMME AND MANAGEMENT REVIEW

OF THE

INTERNATIONAL RICE RESEARCH INSTITUTE

(IRRI)

TAC SECRETARIAT

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

November 1998

From: The Secretariat August 1998

CGIAR Mid-Term Meeting
May 25-29, 1998
Brasilia, Brazil

Fifth External Program and Management Review of IRRI[1]

At a parallel session chaired by Weimin Yang, members discussed the fifth external review of IRRI. Review Panel Chair Bernard Tinker presented a summary of the findings and recommendations. Interim Director General Robert Havener read a written statement from Board Chair R. Rabbinge and presented the center's response. Lucia de Vaccaro presented the TAC commentary, which was followed by a general discussion. Many CGIAR members and IRRI's partners expressed appreciation for the Panel's report and pledged continued support for IRRI's work, which they view as very professional.

Highlights of Panel Recommendations

The Panel made 11 recommendations, which TAC fully endorsed. Highlights include the following:

- combine the three separate rainfed programs into a single program;
- design a strategic program on soil carbon nitrogen dynamics;
- strengthen the International Network for Genetic Evaluation of Rice and evaluate the bioinformatics program;
- update the policies on intellectual property rights and the private sector's involvement;
- undertake an annual assessment of performance of the board and director-general;
- strengthen the center's management systems; and
- prepare a capital plan and document future adjustments.

[1] Extract from *Summary of Proceedings and Decisions: Mobilizing Science for Global Food Security*, CGIAR Mid-Term Meeting 1998, Brasilia, Brazil.

Discussion and Conclusions

The IRRI Board and Management responded to the recommendations. The participants noted the following points with satisfaction:

- IRRI's significant accomplishments;
- IRRI's strong emphasis on new developments in biotechnology and rice genomics, and its increasing collaboration with the private sector;
- IRRI's progress in overcoming management difficulties and the early results of the institutional stabilization process;
- IRRI's good financial health.

The participants endorsed the main recommendations of the Panel and:

- concurred with the integration of the three rainfed programs, with special consideration to ecoregional variations;
- commended IRRI's decision to modify its intellectual property rights and biotechnology policies in light of changes in the external environment and the CGIAR system;
- urged IRRI to continue to develop new rice varieties that are not only drought and pest resistant, but also have high nutritional content to serve rice producers and consumers;
- supported IRRI's planned study of soil carbon and nitrogen in coordination with other centers;
- encouraged greater focus on training, the social dimensions of research, and strengthened participatory research in cooperation with national agricultural research systems (NARS) and others; encouraged increased support of INGER in partnership with NARS;
- urged IRRI to make greater efforts to maintain institutional stability; and
- suggested regular assessments by the board and director general.

The Group accepted the review panel's recommendations and:

- thanked the panel for its excellent and highly professional work and endorsed its recommendations;
- commended the IRRI Board and Management for creating conditions in which high quality research work can continue;
- confirmed full support to IRRI.

Consultative Group on International Agricultural Research (CGIAR)

TECHNICAL ADVISORY COMMITTEE

Donald Winkelmann, Chairman

10 April 1998

Dear Mr. Serageldin,

The Report of the Fifth External Programme and Management Review of IRRI, which was completed by a Panel chaired by Dr. Bernard Tinker of the UK, is attached. It, and the response of the IRRI Board of Trustees, were discussed by TAC at its 74th meeting held at Hyderabad in March 1998. IRRI was represented at the meeting by the Board Chair, the Interim Director General, and the Deputy Director General, Research.

Also attached is IRRI's response to the Report, together with the TAC Commentary summarizing the Committee's reactions to the Panel's Report and to IRRI's response.

We are pleased with the positive findings of the Review Panel. IRRI remains a strong flagship Centre in the CGIAR System, with very significant scientific accomplishments during the review period, and research of high quality and relevance. TAC concurs with the Panel that IRRI must continue to concentrate on more and better rice that can be grown in sustainable ways, and that no other organization is as well placed to do so. We are pleased that IRRI is taking advantage of new developments in biotechnology and rice genomics, and is increasing its collaboration with the private sector.

We are also pleased that the recent difficulties in management of IRRI have been largely overcome, and the stabilization process now underway is producing the desired results. The Institute is presently in good financial health, and does not expect any drastic changes in staffing or funding in the near future.

IRRI has an important strategic role to play in achieving sustainable food security for a large majority of poor people. We fully endorse the Panel's conclusion that if IRRI did not exist, it would have to be invented.

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Given its record and prospects, IRRI should be strongly supported by the CGIAR.

Yours sincerely,

Alexander von der Osten
Executive Secretary, CGIAR

Donald Winkelmann
TAC Chair

TAC COMMENTARY ON THE FIFTH EXTERNAL PROGRAMME AND MANAGEMENT REVIEW OF IRRI

TAC expresses its thanks to the Chair and members of the Panel for a comprehensive and constructive Report which was discussed at TAC 74, in the presence of the Panel Chair, Dr. Bernard Tinker, the Chair of IRRI's Board, Dr. Roelof Rabbinge, the Interim Director General, Dr. Robert Havener, and the Deputy Director General Research, Dr. Kenneth Fischer.

The Review Report is positive and optimistic about IRRI's strategic role in achieving sustainable food security in the future, and concludes that IRRI represents a high-return investment that deserves the full support of the CGIAR. TAC is pleased that IRRI's research is of high scientific quality and relevance. The Panel Report provides valuable insights into IRRI's strengths and weaknesses as well as the opportunities and challenges faced by the Institute.

The Panel has made 11 recommendations which TAC fully endorses. The Committee notes that IRRI agrees with all the recommendations, although it is still reviewing how best to implement three of them.

TAC commends the Report for careful consideration, and offers the following commentary, prepared with inputs from the CGIAR Secretariat, to supplement the Panel's Report.

Rainfed Rice Programme

TAC notes that the Panel has recommended that there should be a single rainfed rice programme in which related lines of work can be brought together, emphasizing those where prospects for success and impact are greatest while at the same time making efficiency gains in operating a single programme. TAC appreciates the cautious response from IRRI regarding the way it should implement this recommendation. TAC considers that the underlying reasons for this recommendation are compatible with IRRI's and NARS' desire to retain the identities of the research activities of the three rainfed ecosystems and the associated specialized groups of scientists. TAC agrees that a single administration for the rainfed rice programme, with ecosystem-based projects can lead to an improvement in research focus, greater flexibility and impact, and closer linkage with resource allocation within the programme.

Biotechnology and Rice Genomics

TAC agrees that IRRI must continue to concentrate on more and better rice that can be grown in sustainable ways. We note that IRRI is already taking advantage of new developments in biotechnology and rice genomics; and that it is increasing its collaboration with the private sector.

Carbon and Nitrogen Dynamics

TAC recognizes that greater research attention to soil carbon and nitrogen dynamics in intensive rice systems, as recommended by the Panel, is appropriate and timely because of the accumulating evidence that productivity decline is often associated with nitrogen supply. The work of IRRI on such processes in soils with alternating anaerobic/aerobic fluctuations will be complex but highly important. TAC believes that the proposed initiative is of strategic relevance to the CGIAR System as a whole. It is essential that contact be made and maintained among Centres and others who are working on carbon and nitrogen dynamics across a range of environments within the CGIAR System and among the advanced laboratories that will be assisting them. TAC hopes that IRRI will play a role in reinforcing such contacts.

TAC notes that the Panel Report, in the body of its text, concentrated on the ability of the soil to supply nitrogen as the primary factor in long-term yield decline. Reduced yields, in long-term experiments were reversed by greater application rates of nitrogen fertilizer. While soil nitrogen supply is a significant factor, the reader is cautioned to not conclude that the problem is simple, and solved by merely increasing nitrogen fertilizer rates. The complex bio-geochemical processes involved are closely tied to changes in soil carbon and micro-organisms, to pest population interactions, and to a range of management options.

International Network for Genetic Evaluation of Rice (INGER)

TAC is pleased that IRRI is fully committed to supporting the primary function of INGER which it will relaunch as a high-quality service. This will be based on the outcome of a workshop IRRI plans to hold to assess the structure and operations of INGER in the light of the needs of NARS and the expected funding environment. TAC applauds IRRI's effort to put INGER on a more secure financial footing, and to work out a cost-sharing arrangement with NARS. TAC notes that a large portion of the germplasm tested through INGER originates from the participating NARS, and hopes that in organizing monitoring tours of INGER locations IRRI will give preference to younger scientists from partner NARS.

Intellectual Property Rights (IPR)

The Panel has argued that, in the light of the changing international perceptions to IPR, IRRI should re-examine its policy. TAC concurs with the Panel. The CGIAR has commissioned two panels to address general issues in biotechnology and IPR, and the CGIAR will be formulating a policy on IPR in the near future. It is TAC's expectation that IRRI and CGIAR policies be consistent, and it encourages IRRI to work closely with the CGIAR to ensure uniformity in the primary principles of the IPR policy.

TAC notes that IRRI is planning a stakeholders meeting of NARS, donors, NGOs, farmer groups, IPR specialists and members of the private sector to develop guidelines which TAC feels will need to facilitate decisions about protection for IRRI-developed intellectual property to be made on a case-by-case basis.

Partnerships

The Panel considered it appropriate that IRRI's unique role in partnership is highlighted, for it is a story worth telling. TAC commends IRRI for this special achievement which it has continued to sustain effectively. However, TAC notes that IRRI and its partners operate in a fast changing environment, especially in the IPR area. While TAC has no particular recommendation to make, it wishes to point out that as IRRI makes hard choices, it will be exposed to conflicting views regardless of its decision, and will need to have its NARS partners fully committed to supporting the joint decisions and follow up action.

Governance

TAC supports the Panel recommendation that the Board undertake more systematic annual self-assessments, and annual assessments of the DG. TAC notes that the Board is also in agreement with the recommendation.

The Board plans to evaluate its current approach to self-assessment at a future Board meeting. An assessment of the appropriateness and effectiveness of the oversight function of the Board can only be of benefit to the Board and the Centre. When specific issues are identified during a self-assessment, then the action taken by the Board should be recorded in the Board minutes which serve as an important component of the Board's institutional memory.

With regard to annual assessments of the DG, it is considered that these should be conducted against a set of agreed criteria, and in a transparent and open manner between the Board and the DG.

Management

The Institute is presently in good financial health, and does not expect any drastic changes in staffing or funding in the near future. TAC notes that IRRI has been through a difficult period during the past two years. However, it is pleased to learn that the situation has begun to stabilize, and commends the Board, Management and staff for their dedication and effort to ensure the continuation of the stabilization processes now underway. TAC hopes that IRRI will move expeditiously in recruiting a new Director General and other members of the senior management team.

TAC notes that IRRI has had a lengthy experience in use of a matrix system for maintaining disciplinary excellence while mobilizing resources into problem-solving projects. It agrees with the Panel that IRRI needs to continue its efforts to improve the effectiveness and efficiency of this evolving system through staff training and the consideration of rewards for high-quality managerial input.

IRRI
INTERNATIONAL RICE RESEARCH INSTITUTE

16 February 1998

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Chairman
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Dear Dr. Winkelmann and Dr. von der Osten:

On behalf of the IRRI Board of Trustees and Management, we are pleased to respond to the recommendations and constructive suggestions presented in the Report of the Fifth External Programme and Management Review of the International Rice Research Institute.

The report gives a comprehensive and well documented description and account of IRRI's achievements, strategic choices, impact, partnerships and organization and management. The document expresses the review panel's appreciation of the quality and productivity of the research but also flags important points that need careful consideration in the near future. It underlines the need to strengthen the role of research on rice and rice ecosystems to guarantee food security for future generations.

The Board and Management are pleased with the review panel's approval of the overall directions and composition of IRRI's research agenda. The Panel also positively assesses IRRI's research and scientists, ranging from acceptable to excellent. The conclusion that IRRI's research is first class and the observation that IRRI is still the flagship of the CGIAR are highly appreciated. The high marks for IRRI's partnerships and the impact of IRRI's research achievements, training and services to various clients are very welcome.

The panel's conclusions regarding the major issues that need further discussion and intensive attention of IRRI are congruent with those of IRRI itself. These include the following:

- Intellectual property and private sector linkage policies.
- Further development, use and implementation of innovative biotechnology and related bioinformatics.
- Strengthening research on natural resource management including water, as part of the development of sustainable rice agro-ecosystems.

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- Governance and management procedures to guarantee IRRI's position on the forefront of scientific research in various disciplines.

We concur with these conclusions and agree that IRRI must continue to advance its problem-oriented biotechnological endeavors. The need to formulate a more explicit policy on intellectual property rights, patenting and linkages with the private sector has been identified in various preliminary discussions and policy papers of the BOT and staff. IRRI will continue to take the lead in this field and hopes that it may contribute to the development of CGIAR policy in this important area.

The need to increase rice production in the next decades with less land, less water, less labor, less nutrients and more advanced pest and disease-control methods that maximize biological potentials and eco-technological approaches has been highlighted in the panel's report. In its MTP, IRRI has given high priority to such approaches and has made clear that considerable impact may be expected by using a combination of technological innovations, such as envisaged biotechnological and eco-technological advancements, and interventions on higher aggregation levels. Land use studies as part of eco-regional approaches that integrate biophysical and socioeconomic approaches and enable the fine tuning of interventions are considered to be an integral part of IRRI's core research agenda.

The last two years have been a period of considerable change at IRRI culminating in a significant staff separation and restructuring program and a change in management. Increased efficiency, efficacy and refocusing of the Institute are envisioned and the first signs of such change are already visible. IRRI believes that it is ready for the challenges and to address the long-term research agenda formulated in the panel's report. The MTP (1999-2001) is an appropriate response to meeting these challenges.

Our responses to 11 specific recommendations made by the review panel are attached. Beyond these, the report contains a valuable set of proposals, suggestions, and observations. We wish to assure you that IRRI's Board and Management will make full use of these suggestions in our ongoing effort to adapt the Institute and its work to the continuously changing needs in our dynamic environment.

We would like to express our great appreciation to the Review Panel for a valuable report and to the TAC and CGIAR Secretariats for their assistance and support provided during the review.

Sincerely yours,

R D Havener

ROBERT HAVENER
Director General

ROELOF RABBINGE
Chairman, Board of Trustees

<u>IRRI's Board and Management Joint Response to the Report of the Fifth External Programme and Management Review February 1998</u>

Chapter 4 – Research Programmes

Recommendation 1

> *The Panel* ***recommends*** *that the Rainfed Lowland, Rainfed Upland and Flood-prone Programmes be combined into a single Rainfed Rice Programme, in which related lines of work can be brought together, emphasizing those where prospects for success are greatest.*

We agree with the Panel's recommendation to combine into one Rainfed Program the three Programs that deal with rainfed rice. This will have main benefits of streamlining the management of IRRI research with one Program Leader for the three rainfed ecosystems.

However, we do not agree fully with the Panel's view on the opportunities to merge ongoing activities. Rather, we believe that each ecosystem should retain specialized groups of scientists at the Project Level for each of the rainfed ecosystems.

This is necessary for two reasons. One is related to our partnership with National Agricultural Research Systems (NARS); the other is related to the difference in the biophysical constraints that are unique to each ecosystem. Most NARS in Asia have recognized the need for specific programs to target each of the rainfed rice ecosytems. They have established their own research stations and programs for these ecosystems, and are members of the ecosystem-specific research Consortia. Thus, it is important that IRRI maintain a specialized group of scientists that can respond to specific needs and support the NARS.

The careful characterization of the rainfed systems into upland, rainfed lowland, and flood-prone is done to recognize the different adaptive processes of the rice plant for these important ecosystems and to target the science for impact at the local level. For example, rice growing in the uplands requires improvement in the mechanisms for the exploitation of water and nutrients under aerobic soil conditions. In this, it is the same as any other crop. But rice in the rainfed lowlands needs to exploit the soil for these elements under both puddled soil conditions with excess water and under water deficits in the same cycle. Thus, the basic mechanisms for rice adaptation to the uplands and the lowlands are very different. And even in the flood-prone ecosystem where rice is grown under conditions more similar to the rainfed lowlands, rice must adapt to excesses in water levels that are not found in the rainfed lowlands. We will examine the limited opportunities for streamlining the projects while maintaining the focus on the specific adaptive processes that are required for each of the ecosystems.

Recommendation 2

The Panel ***recommends*** *that the research staffing in the Irrigated Rice Programme be reassessed with the aim of filling key positions, including an IRS agronomist with wide experience and certain skilled support staff in critical areas of work .*

We agree fully with the Panel's recommendation and we plan to recruit an agronomist who can integrate the various new approaches for rice production in the Irrigated rice system.

The Panel recognized the important advances in new approaches for rice production. The yield frontier is being raised through conventional breeding with yield gains of 1.0% per year, through tropical hybrids with yield increases of 10-15%, and through the potential opportunity from the non-conventional and new approach of the New Plant Type. They also noted the increased efforts on integrated weed management -- an important component for direct seeded rice. Moreover, direct seeding of rice, driven by changes in the cost and availability of labor, can also reduce water use -- an issue of importance raised by the Panel. Thus, it is timely that the Panel has recommended the hiring of an agronomist with a capability to integrate these components into new technologies for the well-watered rice systems.

Chapter 5 – Research Divisions and Services

Recommendation 3

The Panel ***recommends*** *that IRRI evaluate carefully the developments in bioinformatics with a view to determining IRRI's future in this area.*

We agree with the Panel's recommendation and plan to strengthen our capacity in bioinformatics taking into consideration our comparative advantage and, at the same time, collaborating with ARIs .

IRRI's unique role in bioinformatics is in providing the phenotypic information that must be linked to molecular information to maximize the functional usefulness of biotechnology. IRRI, along with other centers, has developed a comprehensive data management system that can interlink germplasm information, nursery performance, pedigrees, and field performance of varieties. The key role now is to link this traditional data with that of the molecular data of the rice genome. Most of the genomic data (for rice) is with the ARIs, particularly in Japan and the USA. Increasingly, functional information for rice will become important for other crops. Thus, IRRI plans to provide an important linkage between the traditional and the genomic data sets and ensure that this functional information is shared with NARS.

Recommendation 4

> *The Panel **recommends** that: (a) a meeting of CORRA be convened with a specific agenda to design a high-quality INGER that meets NARS and IRRI breeders' needs and achieves scientific ends of value to all; (b) IRRI give the highest priority to running INGER according to this agreed programme; and (c) the vacant position of INGER coordinator should be filled as a matter of urgency with an energetic and respected rice scientist.*

We are pleased that the Panel supports IRRI's earlier decisions to maintain a strong Program for impact built around Networks such as INGER and in training activities. And we appreciate the particular importance that the Panel has given to INGER and its role in the safe exchange of rice varieties to enhance the diversity of rice breeding programs worldwide.

INGER has been in existence for more than 20 years and has enjoyed special donor support. Its members realize that now it must find its own means as a mature and valued network. There is a joint commitment by all partners to sustain the core activities of INGER. IRRI is fully committed to support the primary function of INGER -- the safe international exchange and evaluation of elite germplasm. At the same time, we aim to enhance the knowledge about the germplasm through research and training.

We can report that plans have already been made to hold a workshop during the first half of 1998, to assess the structure and operations of INGER in the light of the needs of NARS and the expected funding environment. The proposed meeting of CORRA will provide the forum to consolidate these ideas, reach agreement on the way forward, and have commitment from all interested parties. The recruitment of the INGER coordinator is already underway. We expect to fill this position by the third quarter of 1998.

Chapter 6 -- Issues

Recommendation 5

The Panel ***recommends*** *that IRRI, the donors, and the NARS convene to address potential problems related to IRRI's current private sector and intellectual property policies, after the reports of the CGIAR Panels on Biotechnology and Proprietary Science are published.*

We agree with the Panel's recommendation of the need for IRRI to define its role as a provider of rice research products in a rapidly changing environment of IPR and access to modern technology, processes, and information.

But we believe that it is in our best interest to define our own policy, which will be unique for rice in Asia. We plan to do so in full discussions with our many stakeholders, and we will neither take unilateral steps that compromise the status of the rice germplasm collection under the agreement with FAO nor action that is not consistent with the Convention of the Biological Diversity.

We are planning such a stakeholders meeting of NARS, donors, NGOs, farmer groups, IPR specialists and members of the private sector. They will review and suggest policy and operational changes to safeguard our intellectual property while retaining our overall goal of the free availability of public goods for rice research. We agree with the Panel's assessment that there is much of IRRI's IP that is potentially valuable as collateral for exchange with others who possess patented technology that we need to fulfill our public mission.

We anticipate that the outputs from this stakeholders workshop will also contribute to CG-wide efforts toward developing realistic approaches for partnerships with the private sector and in evolving guidelines for Policy in Intellectual Property Rights for the Centers.

Recommendation 6

The Panel recommends that a strategic programme on soil carbon nitrogen dynamics in flooded soils should be designed and mounted in collaboration with appropriate centers of excellence.

We welcome and agree with the Panel's recommendation to strengthen our strategic research on understanding the processes governing carbon and nitrogen fluxes and balances in intensive irrigated rice systems.

We note that the Panel endorses the systematic manner by which we are examining the issue of Productivity Decline in Intensive Rice. The emerging information of declining yields at the same inputs in long-term experiments and the observations that farmers may require more inputs for the same outputs (yield) were raised by the previous (1992) EPMR Panel as the most important research issues for IRRI to address. We put experiments in place to monitor changes in farmers' fields and we posed and tested various hypotheses that enabled us to better define the factors required for maintaining yields in intensive irrigated rice systems. These studies now indicate the importance of the unique changes in soil carbon and nitrogen dynamics under intensification of flooded rice as the driving processes that affect nutrient supply for the crop. We are now in a position to focus our strategic research on these fundamental and critical soil processes.

Already, we have established links with ARIs such as Rothamsted to assist in this research and we will strengthen such collaboration with this and other institutes.

Chapter 7 - Organization and Management

Recommendation 7

The Panel ***recommends*** *that the Board undertake annual self-assessments, and annual assessments of the DG, and that records be kept.*

The Panel recommends a formal self-assessment of the BOT. The IRRI Board agrees that self-assessments are important, but believe that as Asian culture dominates the BOT, a rigid written formal system would be counter-productive. However, the current system will be evaluated at a future Board meeting.

The composition of IRRI's BOT is such that all requirements concerning balance in gender, North-South disciplines, etc., are fulfilled. In its aim to strengthen the support for IRRI in the region, the BOT has invited senior policy makers, such as Ministers and top business and NGO representatives to participate in the BOT. Their willingness to serve illustrates IRRI's ownership by the stakeholders in the region.

The Panel rightly stresses the importance of formal assessment procedures of the Director General and it is the intention of the BOT to employ such procedures with the new Management.

Recommendation No. 8

The Panel ***recommends*** *that no major changes are made to the current organizational structure before the new DG has had time to consider whether changes are necessary.*

IRRI is fully aware that changes in organizational structure should be done only when really needed. Structure follows strategy. It is for that reason that an IRRI Task Force carefully studied the organizational structure that is needed now that the new MTP has been accepted and is implemented. The proposals prepared by that Task Force will be used in an *ex ante* evaluation of future organizational structures.

IRRI's intention to strengthen the relation with its various partners, to increase the transparency of the research programmes and divisions, and to amplify public awareness and fund generation have to be taken into account in the organizational structures. Full implementation of a new structure at this moment is not the intention of IRRI. However, the filling of vacancies for the Directors of Finance, Administration and Human Resources, and External Operations is considered necessary. The DDG position for Partnerships and Liaison is vacant and will not be filled until the new DG is identified. In this way, it is possible to create maximum flexibility for the new DG and guarantee continuity and stability for the Institute.

Recommendation 9

> *The Panel* ***recommends*** *that a review be undertaken of management methods, including rewards for carrying managerial responsibility within the matrix; the efficient conduct of meetings; streamlining the interface between research, finance and administration; and appropriate delegation. This initiative must be seen to have the full commitment of the senior management team.*

IRRI Management is fully aware that matrix management is a complex endeavor. In a world where financial resources, hence human resources, are unconstrained, a full hierarchical structure incorporating all relevant disciplines is easier to manage. Given the funding realities of the CGIAR System today, however, human talents must be shared and thus optimized. Some form of matrix management has become the norm in most modern research organizations, including those of the CGIAR System. As pointed out in the report under section 7.4, in the case of IRRI, "the matrix was adopted as a means of ensuring relevance of the research programs and projects to IRRI's goals, while maintaining scientific excellence".

IRRI agrees that better management could enhance performance. As recommended by the Panel, steps are being taken to further clarify and strengthen relationship between the finance and administration supporting units and the research projects. IRRI management is in the process of establishing responsibility/performance bonus premiums for Project Team Leaders. Substantial training has already taken place for staff on matrix management. Future training programs will emphasize efficient and effective ways to reduce transaction costs. IRRI senior management is fully committed to this effort.

Chapter 8 – Administration and Operations

Recommendation 10

*The Panel **recommends** that IRRI prepare a current Capital Plan, and that IRRI management and the Board of Trustees decide the appropriate level of the Capital Fund, and that all future adjustments to the Operating Fund and Capital Fund be carefully and clearly documented.*

It is our understanding that the Panel Chair checked with the CGIAR Secretariat and verified that the accounting methods followed by IRRI were consistent with the requirements of the CGIAR Accounting Systems Manual and that IRRI was not in violation of any such requirements. With regard to the existing Board-approved Capital Plan, IRRI plans to review and update it and present for Board approval any recommendations for revisions.

Recommendation 11

*The Panel **recommends** that IRRI ensure that the internal audit function becomes fully effective in improving internal financial and operational controls, by reviewing the current level of skills available within IRRI for the Internal Audit function, deciding which skills it is necessary to have internally and which skills might be out-sourced, and implementing the organizational and staffing changes required.*

The IRRI Board of Trustees and Management agree that the Internal Auditor function needs to be strengthened and are actively addressing this issue.

A report outlining alternative strategies is being prepared for consideration by Audit Committee and Board of Trustees. In the near future, concrete steps will be taken to strengthen the IRRI internal audit system.

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17 February 1998

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11 February 1998

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Dear Dr. Winkelmann and Mr. von der Osten,

It is my privilege to transmit to you the Report of the Panel that conducted the Fifth External Programme and Management Review (EPMR) of the International Rice Research Institute (IRRI).

Since the 1992 EPMR, the global rice community has become even more sophisticated and diversified; and the new sciences, particularly that of biotechnology, have made remarkable advances enabling major discoveries to be made concerning the rice genome. These developments are presenting new opportunities for strategic and applied research for IRRI and its NARS partners, some of whom have themselves made rapid advances in R & D capacity. The Panel has recommended that IRRI should determine how to position itself within this fast-moving science to ensure that the interests of IRRI and its stakeholders are safeguarded for the future.

The turbulent events at IRRI over the last few years led to instability and lower morale. However, all this is now over, and IRRI has survived and learnt from these shocks. The Panel has recommended that the Board and Management must now concentrate on creating a stable enabling environment for research so that IRRI staff can return to giving undivided attention to their research and its application by their partner countries.

Overall, the Panel considers that IRRI has relevant and good quality programmes, which are well supported. The Panel has made recommendations where it has seen weaknesses or where greater focusing is necessary. Improvements are needed, however, in making the current organizational structure work more efficiently. In this regard the Panel has recommended that no major structural reorganization should be attempted until some time after the new DG and other senior staff are in post, and then only if they conclude that they can find an organizational structure that is significantly better than the present one.

Despite the recent difficulties, IRRI remains a strong flagship Centre in the CGIAR System whose scientific accomplishments during the review period are significant, particularly those: in germplasm enhancement and biotechnology; in yield frontier research; in productivity decline research; and in IPM. Similarly, IRRI's relationships with its partner countries and their NARS, as well as with advanced laboratories world-wide, are impressive. The Panel concluded that IRRI has a central role to play in the future food security, and represents a high return investment that deserves the full support of the CGIAR.

I would like to thank you for assembling a capable and experienced team for the challenging task of conducting this Review. The Panel members worked exceptionally well together, and I want to add my own warm personal thanks to them all for their hard work and good humour. I would like to express the Panel's appreciation for the excellent contributions made by Ronnie Coffman and Henri Maraite in their capacities as consultants to the Panel.

We express our special thanks to the resource persons assigned to the Panel, Amir Kassam from the TAC Secretariat, and Pammi Sachdeva from the CGIAR Secretariat for their excellent support and advice to the Panel. Without them, the Panel would have found it difficult to complete the task on time.

We are grateful to IRRI Board, Management and staff for giving us every assistance and enabling us to carry out our task smoothly.

Finally, all the Panel members join me in expressing appreciation for the opportunity to be part of the Review Panel.

Yours sincerely,

Bernard Tinker
Chair, External Review Panel

SDR/TAC:IAR/98/1

CONSULTATIVE GROUP ON INTERNATIONAL AGRICULTURAL RESEARCH

TECHNICAL ADVISORY COMMITTEE AND CGIAR SECRETARIAT

REPORT OF THE
FIFTH EXTERNAL PROGRAMME AND MANAGEMENT REVIEW
OF THE
INTERNATIONAL RICE RESEARCH INSTITUTE
(IRRI)

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

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FOREWORD

This is the Report of an External Review Panel appointed to evaluate the programme and management of the International Rice Research Institute (IRRI). The membership of the Panel and their backgrounds are given in Appendix I.

The Terms of Reference for this Fifth External Programme and Management Review (EPMR) of IRRI are shown in Appendix II. In conducting the Review, the Panel was requested to interpret the Terms of Reference and the general guidelines for the CGIAR review process in the light of the new approach to EPMRs. The new approach comprises a single integrated system with two components: (i) a set of Centre Commissioned External Reviews (CCERs); and (ii) the CGIAR external review of the Centre. The CCERs are expected to generate information which would serve as inputs to the EPMRs, thus allowing the latter panel to concentrate on the most important strategic issues facing the Centre. However, because of the change and turbulence at IRRI over the past 18 months or so, the Institute was not able to provide the CCERs that are now regarded as a normal part of the external review process. Consequently, after the initial visit to the Centre, the Panel was strengthened by adding two consultants, and in the period between the initial and main phase of the Review, IRRI was requested to prepare special papers on key topics.

The Panel's approach to the Review has been open, participatory and forward-looking. The information on which the Panel based its assessments and conclusions was gathered in a number of ways. These included visiting the Institute and interacting with the Board, management and staff; meeting and discussing with national programme representatives and government officials; undertaking examination of specific aspects of the Institute through Panel consultants; interviewing Board members; and obtaining information through a survey letter sent to all CGIAR institutions collaborating with IRRI, and to all CGIAR Members and Regional Representatives. The itinerary of the Panel is shown in Appendix III.

Finally, the Panel had access to a large array of documents and data made available by IRRI. Additional documents were provided by the TAC and CGIAR Secretariats. A complete list of documents provided to the Panel is shown in Appendix IV. One of the documents furnished by the Centre was the response of the Institute to the recommendations of the 1992 External Review, which is reproduced with the Panel's comments as Appendix V.

SUMMARY AND RECOMMENDATIONS

The EPMR Panel summarizes, below, its main findings and recommendations. These highlight IRRI's recent evolution, programme accomplishments, managerial effectiveness and its future over the next decade. The Panel has also made a number of important suggestions which should be considered in conjunction with the recommendations.

Recent Evolution

During the first half of the Review period, IRRI completed a major infrastructure rehabilitation and refurbishment programme for which the then DG had successfully canvassed for funds. In 1996, the IRRI Board elected a new Chair to take over from the previous Chair who had served for 16 months. About halfway during the review period, a new DG was appointed, with a management style that was different from that of the previous DG. After his arrival, IRRI implemented a Staff Restructuring Programme (SRP) starting in late 1996. During 1997, several members of the senior staff, including the DG, resigned or retired. These events have meant that IRRI has been through a difficult period. The Panel believes that there was a need for an SRP but it is highly probable that the optimum staffing level was not obtained in every case, so that in some research programmes and divisions, the ratio of NRS to IRS is below optimum.

Since the last review in 1992, the external environment of IRRI has become even more sophisticated and complex. The new sciences - biotechnology, informatics, NRM research - have all made remarkable advances, opening new opportunities for strategic and applied research for IRRI and its partners. The most prominent of these advances has been in biotechnology, which has enabled major discoveries to be made concerning the rice genome, thus presenting real prospects for employing new strategies for genetic enhancement of rice germplasm with novel material and its incorporation into improved genotypes. The relevance of this achievement to the CGIAR goals is obvious, but the Panel points to the need for IRRI, in concert with its partners, to examine urgently its policies on protecting germplasm and on intellectual property protection of discoveries in the light of the current attitudes in public and private research organizations elsewhere. Any decisions by the IRRI Board and Management should be taken in the light of the policies determined by the CGIAR, and in consultation with its partner countries.

Programmes

The Panel found that by and large IRRI's priorities are consistent with its mission and the CGIAR's goals, and that the quality of science is generally good, ranging from acceptable to excellent. Nowhere did the Panel find scientifically deficient work. The Panel is pleased with IRRI's overall performance, which includes some outstanding achievements made possible by its scientific and high-quality support staff. IRRI can boast about several of its accomplishments including those in germplasm enhancement and biotechnology using marker technology and genetic transformation, in shifting the yield frontier with the hybrid rice and the new plant type, in IPM, and in understanding the cause of productivity decline in intensive systems.

Plant breeding, in which IRRI has such a distinguished history, is linked closely with biotechnology and plant protection. It continues to produce improved germplasm for the irrigated ecosystems, including the more radical achievements such as the hybrid rices that are now being used by several of IRRI's partners. In addition, research on the new plant type has made steady progress. For the rainfed ecosystems, the Panel noted the slow pace of achievements, and has recommended that the three rainfed ecosystems programmes should be combined into a single programme so that complementarities across these ecosystems are captured and that resources are allocated where prospects for success are greatest.

Research on natural resources management is well integrated with productivity improvement research. Since the last EPMR, IRRI has mounted a sizeable programme to understand the reasons for productivity decline in intensive rice systems observed on experiment stations. However, the Panel concluded that this work requires organizing in ways that allow the interdisciplinary potential to be realized in a strategic programme.

Other accomplishments have opened up new opportunities for strategic research. For example, the successful implementation of the IPM strategy against insect pests in some Asian countries is leading to new possibilities for the application of integrated management tactics for diseases and weeds.

The relationships of IRRI and its partner countries and their NARS are changing significantly, while at the same time the global rice community has become even more complex and diversified. IRRI has responded well to the rapid development of some NARS, and the Panel is pleased with the ways by which IRRI is managing the evolution of its partnerships within the global rice community. The new consortia have impressed us, and the networks INGER (International Network for Genetic Evaluation of Rice) and CREMNET (Crop Resources Management Network) have continued to be valued very highly by IRRI's partners, as is the ARBN (Asian Rice Biotechnology Network).

Governance and Management

The Panel has pointed out that the IRRI Board and Management must remain aware of the Institute's two great needs. The first is the need to stay at the forefront of scientific research in its various subjects, to continue to attract and retain world-class scientists, to make the right decisions regarding its initiatives in molecular biology and its relationships with the private sector, and to show clearly that its research is having impact. If IRRI can meet these needs, then it has nothing to fear.

The second is the need for institutional stability so that staff can give their undivided attention to their research and its application by IRRI's partner countries to raise rice output. The Panel has recommended that IRRI should concentrate on putting matters right within the current structure. The arrival of an Interim DG and the search for replacements in senior positions are steps in the right direction, but the Panel has recommended that no major structural reorganization should be made until some time after the new DG and other senior staff are in post, and then only if they conclude that they can develop an organizational structure that is significantly better.

In addition, the Panel has recommended changes so that the Board and Management can improve their understanding and reporting of financial results.

Future of IRRI

The Panel believes that the task ahead for IRRI is clear and well-documented. Asia's agricultural economy will continue to be dominated by rice, which is a staple food for most of the rural and urban dwellers. The demand for rice is expected to rise by more than 60% by 2025, and IRRI in partnership with NARS must concentrate on more and better rice grown in more sustainable ways. The Panel believes that no other organization is better placed to do so than IRRI, which has a long record of delivering both scientific advances and impact. The Panel has no hesitation in concluding that IRRI has a central strategic role to play in achieving sustainable food security in the future, and represents a high return to investment that deserves the full support of the CGIAR.

LIST OF RECOMMENDATIONS

CHAPTER 4 - RESEARCH PROGRAMMES

1. The Panel **recommends** that the Rainfed Lowland, Rainfed Upland and Flood-prone Programmes be combined into a single Rainfed Rice Programme, in which related lines of work can be brought together, emphasizing those where prospects for success are greatest.

2. The Panel **recommends** that the research staffing in the Irrigated Rice Programme be reassessed with the aim of filling key positions, including an IRS agronomist with wide experience and certain skilled support staff in critical areas of work .

CHAPTER 5 - RESEARCH DIVISIONS AND SERVICES

3. The Panel **recommends** that IRRI evaluate carefully the developments in bioinformatics with a view to determining IRRI's future in this area.

4. The Panel **recommends** that: (a) a meeting of CORRA be convened with a specific agenda to design a high-quality INGER which meets NARS and IRRI's breeders' needs and achieves scientific ends of value to all; (b) IRRI give the highest priority to running INGER according to this agreed programme; and (c) the vacant position of INGER coordinator should be filled as a matter of urgency with an energetic and respected rice scientist.

CHAPTER 6 - ISSUES

5. The Panel **recommends** that IRRI, the donors and the NARS convene to address potential problems related to IRRI's current private sector and intellectual property policies, after the reports of the CGIAR Panels on Biotechnology and Proprietary Science are published.

6. The Panel **recommends** that a strategic programme on soil carbon and nitrogen dynamics in flooded soils should be designed and mounted in collaboration with appropriate centres of excellence.

CHAPTER 7 - ORGANIZATION AND MANAGEMENT

7. The Panel **recommends** that the Board undertake annual self-assessments, and annual assessments of the DG, and that records be kept.

8. The Panel **recommends** that no major changes be made to the current organizational structure before the new DG has had time to consider whether changes are necessary.

9. The Panel **recommends** that a review be undertaken of management methods, including rewards for carrying managerial responsibility within the matrix; the efficient conduct of meetings; streamlining the interface between research, finance and administration; and appropriate delegation. This initiative must be seen to have the full commitment of the senior management team.

CHAPTER 8 - ADMINISTRATION AND OPERATIONS

10. The Panel **recommends** that IRRI prepare a current Capital Plan, that IRRI Management and the Board of Trustees decide the appropriate level of the Capital Fund, and that all future adjustments to the Operating Fund and Capital Fund be carefully and clearly documented.

11. The Panel **recommends** that IRRI ensure that the internal audit function becomes fully effective in improving internal financial and operational controls, by reviewing the current level of skills available within IRRI for the Internal Audit function, deciding which skills it is necessary to have internally and which skills might be out-sourced, and implementing the organizational and staffing changes required.

CHAPTER 1 - RICE IN THE WORLD

1.1 Rice in Asia

Rice is a major food crop for the people of the world in general and Asians in particular; nearly 90% of the world's rice is produced and consumed in this region (Table 1.1). Furthermore, rice is a staple food for nearly 2.4 billion people in Asia, and except for Pakistan and some parts of India and China, rice provides two thirds of the calories for most Asians with rice-based diets.

Following the introduction of IR-8 rice during the 1960s, rice production in Asia grew at an unprecedented annual rate of 3.0% during 1967-85. Similar growth of world rice production also occurred during this period. For Asia, the output growth rate exceeded the population growth rate, which was about 2.14% (Tables 1.2 and 1.3).

During the post-green revolution period, most growth in rice production was due to yield increases brought about by the introduction of new seed and fertilizer technology. The contribution of area increases to growth of output was small and declined over time (Figure 1.1). However, the growth rate in rice production has declined sharply from about 3% during the period 1967-85, to 1.7% during 1985-95 due primarily to a decline in the growth rate of rice yields, from 2.32% per annum during 1967-85 to 1.35% during 1985-95. A decline in growth rates of both output and yield has taken place in all the major rice producing countries in Asia except in India, where growth rates of both output and yield of rice rose significantly during 1985-95, (Tables 1.2 and 1.3 and Figure 1.1) because of the spread of new seed and fertilizer technology to the rainfed eastern regions where improved water management and irrigation facilities are being introduced.

The rapid growth in rice output during 1967-85 had positive effects. Firstly, it resulted in a decline in the real price of rice over the period, thereby benefiting a large percentage of the rural and urban poor people living in South and South East Asia (Figure 1.2). Secondly, the poor benefited because the yield increases led to increases in the incomes of numerous small and marginal farmers in that region who form a major proportion of the poor. However, the success achieved caused a general complacency about food security, and led to less investment in irrigation, agricultural research and extension, and other rural infrastructure that contributed to increased rice production.

The problems increased during the 1990s because of economic liberalization and tight fiscal policies, at both global and national levels. Agricultural research and investment commitments by multilateral agencies, already reduced during the 1980s, became even smaller. At the same time, there were indications of a further decline in the growth rate of yield increase, and stagnation of the highest yield levels attained in high-output irrigated rice, the predominant source of rice output. Despite the increasing use of fertilizers and other inputs, further increases in yields were becoming more difficult to achieve and more costly in terms of inputs, so that total factor productivity was tending to decline.

Table 1.1 Production, Import, and Export of Rice During the Triennium Ending 1995 (million tons)

Country/Continent	Production	Export	Import	Net Trade	Consumption	Self-Sufficiency Ratio (%)
ASIA	**329.4**	**12.6**	**9.1**	**3.4**	326	**101**
South Asia						
India	80.9	2.0	0.1	1.9	79	102
Bangladesh	17.5		0.5	-0.5	18	97
Pakistan	3.8	1.3	0.0	1.3	2	152
Sri Lanka	1.5		0.1	-0.1	2	94
China	121.1	1.1	1.0	0.1	121	100
East Asia						
Indonesia	31.8	0.2	1.3	-1.1	33	97
Vietnam	16.4	2.1		2.1	14	115
Thailand	13.5	5.1		5.1	8	161
Myanmar	12.1	0.0	0.4	-0.4	12	97
Japan	8.5	0.1	0.9	-0.7	9	92
Philippines	7.0		0.2	-0.2	7	98
Korea, Rep. of	4.4		0.0	0.0	4	100
Korea, DPR	2.0	0.0		0.0	2	100
AFRICA	**9.2**	**0.3**	**3.7**	**-3.4**	13	**73**
North Africa	3.0		0.2	-0.2	3	94
Egypt	3.0	0.2	0.0	0.2	3	108
Sub-Saharan Africa	6.1		3.5	-3.5	10	64
Western Africa	3.5			0.0	3	100
Central+Eastern & Southern Africa	2.6			0.0	3	100
CENTRAL AMERICA	**1.2**	**0.0**	**1.2**	**-1.2**	2	**49**
SOUTH AMERICA	**12.0**	**1.1**	**1.3**	**-0.2**	12	**98**
Brazil	7.0		0.9	-0.9	8	89
NORTH AMERICA	**5.3**	**2.8**	**0.4**	**2.4**	3	**182**
United States	5.3	2.8		2.8	2	214
EUROPE	1.4	0.3	1.1	-0.8	2	64
CIS	1.0	0.0	0.3	-0.3	1	76
OCEANIA (Australia)	**0.7**	**0.5**	**0.3**	**0.2**	0	**148**
WORLD	**360.2**	**17.6**	**17.4**	**0.1**	360	**100**
Asia	329.4	12.6	9.1	3.4	326	101
Rest of the World	30.9	5.0	8.3	-3.3	33	-1.0
Developing Countries	343.3	13.8	14.1	-0.3	344	100
Developed Countries	17.0	3.8	3.3	0.5	17	103

Source: FAO Food Outlook. Various Issues

Table 1.2 Rate of Growth of Population, Area, Production, and Yield

Region/Country	Population (m) in	Population Growth Rate (%)		Rate of Growth 1967 to 1985 (%)			Rate of Growth 1985 to 1996 (%)		
	1995	1965-85	1985-95	Area	Production	Yield	Area	Production	Yield
World	**5716.0**	**1.82**	**1.66**	**0.69**	**2.88**	**2.19**	**0.36**	**1.73**	**1.37**
Asia	**3458.0**	**2.14**	**1.75**	**0.57**	**2.89**	**2.32**	**0.33**	**1.68**	**1.35**
East Asia	**1424.0**	**1.84**	**1.25**	**0.09**	**2.81**	**2.72**	**-0.65**	**0.47**	**1.12**
China	1221.0	1.92	1.33	0.23	3.37	3.14	-0.60	0.75	1.35
Japan	125.1	1.00	0.35	-2.00	-1.68	0.32	-0.58	-0.82	-0.24
Korea, Rep. of	45.0	1.81	0.99	0.18	2.74	2.56	-1.80	-2.30	-0.50
South Asia	**1239.0**	**2.26**	**2.18**	**0.66**	**2.42**	**1.76**	**0.31**	**2.50**	**2.19**
Bangladesh	120.4	2.66	2.02	0.32	1.92	1.60	0.31	1.92	1.61
India	935.7	2.22	2.00	0.66	2.51	1.85	0.48	2.84	2.36
Nepal	21.9	2.49	2.58	1.06	0.98	-0.08	-0.04	1.08	1.12
Pakistan	140.5	2.97	3.21	2.09	3.53	1.44	1.14	1.81	0.67
Sri Lanka	18.4	1.84	1.32	2.42	4.32	1.90	0.68	-0.89	-1.57
South East Asia	**484.3**	**2.34**	**1.92**	**0.96**	**3.70**	**2.74**	**1.25**	**2.78**	**1.53**
Indonesia	197.6	2.26	1.68	1.26	5.26	4.00	1.33	2.48	1.15
Myanmar	46.5	2.24	2.18	-0.12	4.25	4.37	3.18	3.73	0.55
Philippines	67.6	2.71	2.14	0.08	3.73	3.65	1.10	1.99	0.89
Thailand	58.8	2.60	1.40	2.37	2.88	0.51	-0.69	0.75	1.44
Vietnam	74.5	2.26	2.22	1.21	2.95	1.74	2.27	5.21	2.94

Source: United Nations World Urbanization Prospects: The 1994 Revision, New York 1995
FAO electronic database, 1997.

Table 1.3 Progress Made in Raising Productivity of Riceland in Different Parts of the World, 1951 to 1996

Region/country	Average yield 1994-96 (tons/ha)	Increase in yield rates[b] (kg/ha/year) 1951 to 1965	1965 to 1975	1975 to 1985	1985 to 1990	1990 to 1995
Asia	3.77	26	41	83	54	36
China[a]	5.97	28	53	181	60	72
India	2.82	16	29	53	80	41
Japan	5.93	101	85	37	-103	-15
Korea	6.12	43	119	93	-33	-23
Sub-Saharan Africa	1.62	16	11	9	34	-8
South & Central America	3.03	-1	13	44	64	89
World	3.69	26	39	78	53	37

Notes: [a]China includes Taiwan; [b]Based on three-yearly averages centered around the year.
Source: IRRI, World Rice Statistics, 1993-95 and FAO electronic database, 1997.

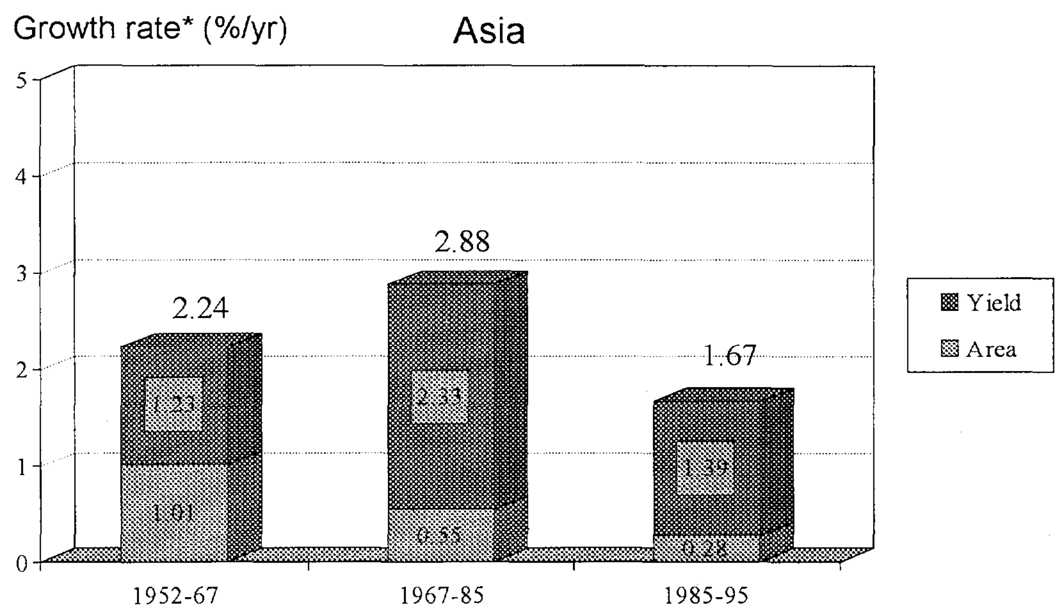
The sustainability of high yields was also becoming more doubtful because the heavy use of water and fertilizer in intensive systems was leading to some complex environmental hazards, such as pollution of groundwater and changes in soil structure.

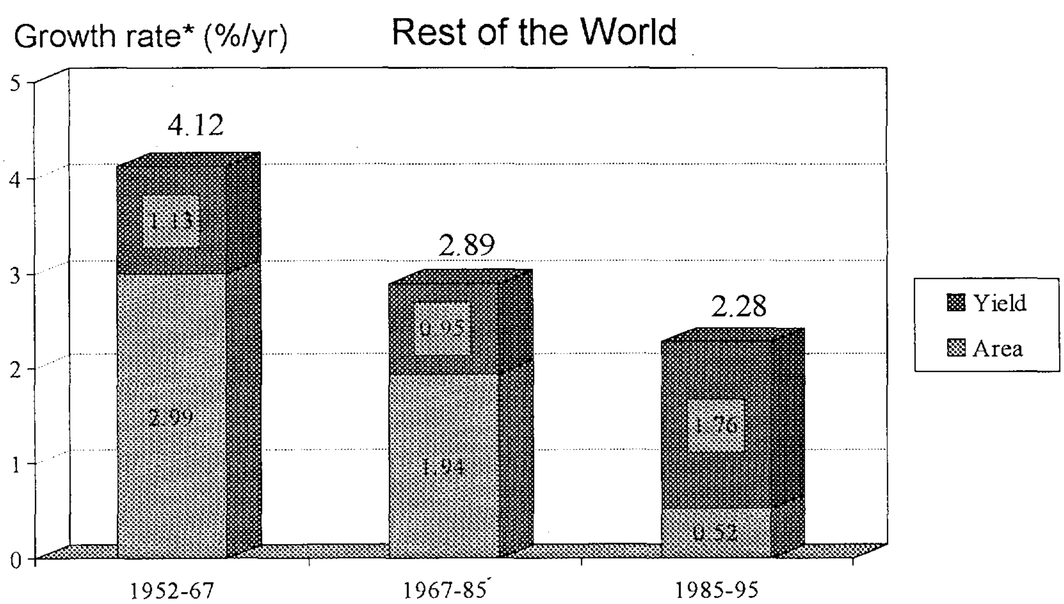
1.2 The Demand for Rice

Against the scenario of increasing rice production and supply, there was an increase in the growth rate of demand for rice. Also, the rice and total cereal demand scenario became more complex. Increased demand for rice was greatest in low-income countries and regions, where cheap carbohydrates to meet energy requirements are still the primary need of consumers. In these countries, despite a declining trend, the demand elasticities for rice and other cereals for both the low-income and high-income groups were quite high (Table 1.4). This increase in demand was caused both by accelerating growth of *per capita* incomes in most of these countries, and by quite high population growth rates. The food grain demand growth was particularly high in China, which had to resort to large imports of wheat. Trends for high growth in demand for total cereals including rice, are likely to continue in the low-income developing countries for at least the next two or three decades.

On the other hand, in some high-income Asian countries there were factors that caused a decline in total demand for rice and other food grains. Firstly, there was increasing

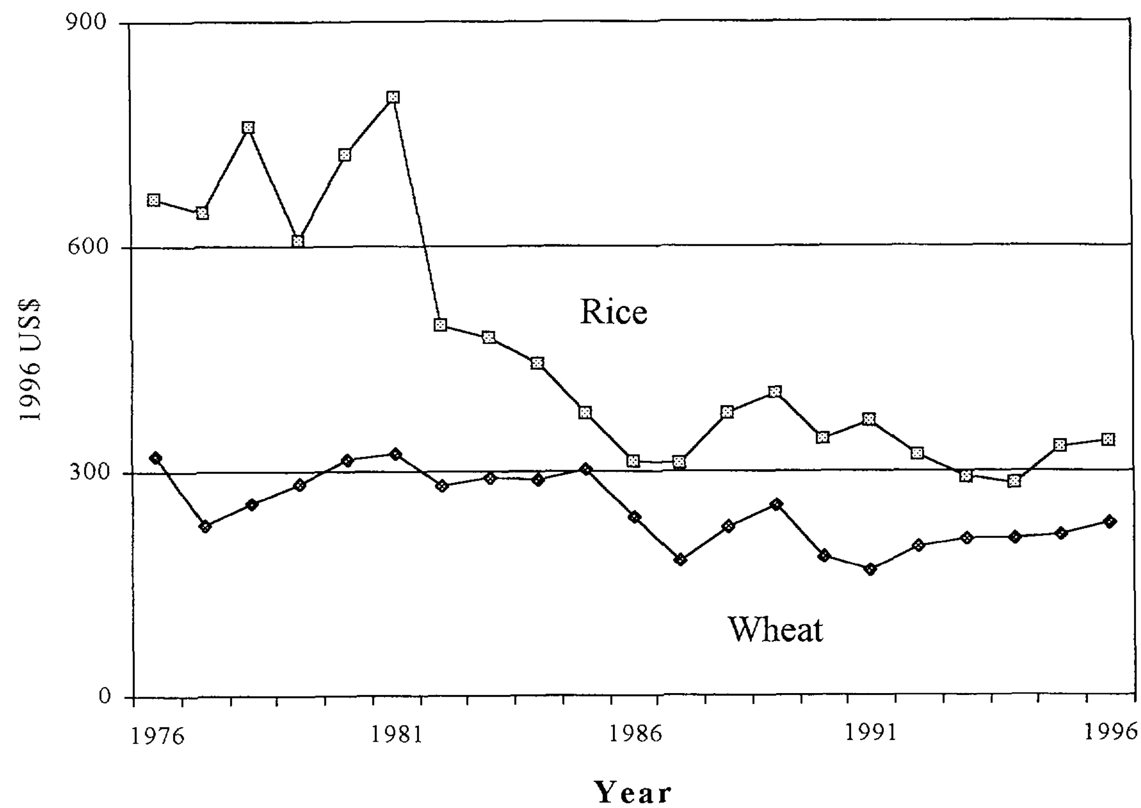
Figure 1.1 Percentage Growth in Rice Production and Productivity: Pre- and Post-Green Revolution Period





* Growth rate estimated by fitting semi-logarithmic trend line on estimate based on time series data.
Source: FAO electronic database, 1997.

Figure 1.2 Trend in World Rice and Wheat Prices, 1976-96.



Source: Rice Price: Relate to Thai rice 5%-broken deflated by G-5 MUV Index
Wheat Price: US No.2 yellow, fob Gulf ports deflated by G-5 MUV Index
Source: World Bank Quarterly Review of Commodity Markets

evidence of declining population growth rates (Table 1.2). Secondly, and more importantly, the rapid rise in *per capita* incomes in countries such as Japan, Korea, and Taiwan, resulted in diversified food habits, with consumers moving away from rice and cereals to other foods. In these countries, the demand elasticity for rice had become very low, was declining, and (in a few cases) had even become negative. The economic prosperity in middle- and high-income countries caused smaller increases (for some countries even a decline) in *per capita* rice consumption (see Figure 1.3). There was much greater diversity in diet pattern, and willingness to pay higher prices for better quality rice. This tendency is likely to become even stronger in the future as more countries reach high-income status. Even for low-income countries with high growth rates in *per capita* income, food demand is likely to diversify from rice to fruits, vegetables, livestock products, and processed products. For rice, this could mean that the demand pattern may change more from table rice as a source of staple carbohydrates to processed rice and non-rice substitutes.

Table 1.4 Demand Elasticities for Rice in Selected Asian Countries

Country	Type of Household	Elasticity
South Korea	(Income Elasticity)	
	Farm Households	-0.135
	Non-Farm Households	-0.089
Thailand	(Expenditure Elasticities)	
	Rural Households	-0.136
	Urban Households	-0.211
Taiwan	(Expenditure Elasticities)	
	Farm Households	0.02
	Non-Farm Households	-0.21
Bangladesh	(Expenditure Elasticities)	
	All Rural Households	0.41
	All Urban Households	0.27
India	(Expenditure Elasticities)	
	Rural Households	0.20
	Urban Households	0.05

On balance, however, despite the visible decline in rice demand in high-income Asian countries, the aggregate demand for rice is expected to continue to grow at a rapid rate for decades. Such growth will be due to the twin influence of expected rapid income growth and relatively high population growth in low-income South Asian countries.

Population growth rates in Asia have declined (Table 1.2), but despite this, the population is likely to grow at a relatively high rate of 1.7 to 1.8% per annum during 1995-2010. Demand elasticities for rice are also declining, but are likely to be in the range of 0.15 to 0.20 during the next fifteen years (Table 1.4). Taking both these into account, total rice demand in Asia is likely to grow by not less than 1.8 %, and in South Asia by more than 2% per annum.

Figure 1.3 Changes in *Per Capita* Rice Consumption, 1974-76 to 1989-91

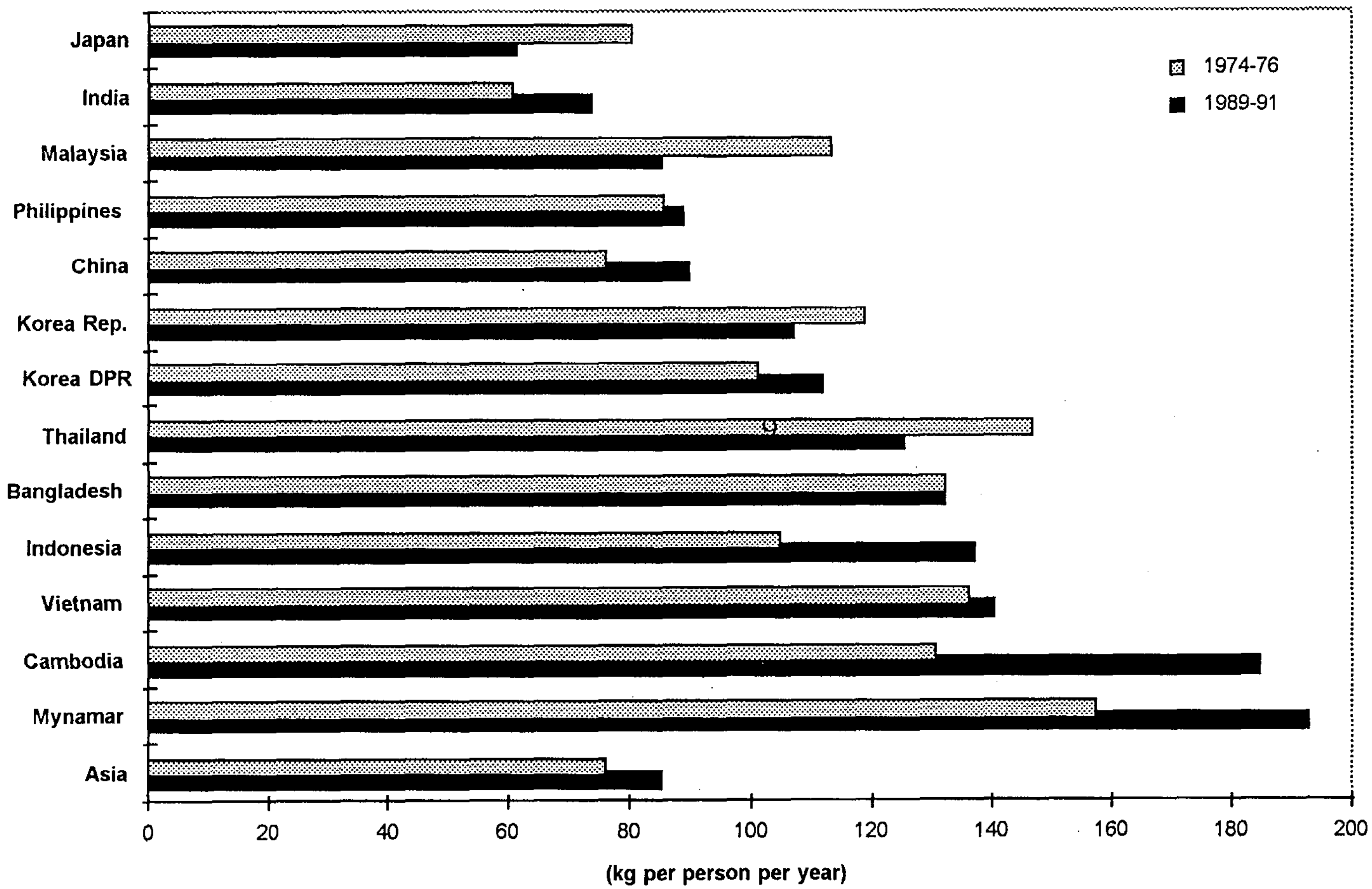


Table 1.5 gives alternative demand projections for 2010 as estimated by IRRI, FAO and IFPRI. Except for IFPRI, which gives a low figure of 578 million tons, the other estimates project demand at about 612 million tons, up by about 150 million tons compared with the estimated current production of 463 million tons for Asia. The demand is thus expected to grow at a rate of 1.66% per annum, which is much higher than the demand growth rate of 1.43% recorded during 1985-95. Because of significant increases in food and feed demand consequent on the diversification of diets, total cereal demand is likely to grow at a much higher rate (Figure 1.4), and is likely to put pressure on the area under rice as cropping systems diversify. Hence, the entire growth in rice demand would have to be met through increased yield growth because more rice land may be diverted to other crops and to non-agricultural uses.

Table 1.5 Actual Output in 1993, and Alternative Projections of the Demand for Rice in Developing Asia (million tons of rice paddy)

Country/region	1993 Actual Output	Projections for 2010		
		FAO	IFPRI	IRRI
China	187	n/a	216	228
India	116	n/a	154	160
Indonesia	49	n/a	62	66
East Asia	200	396	230	243
Southeast Asia	110	n/a	142	152
South Asia	153	216	206	216
Asia	**463**	**612**	**578**	**611**

Growth Rate in Demand (% per year)

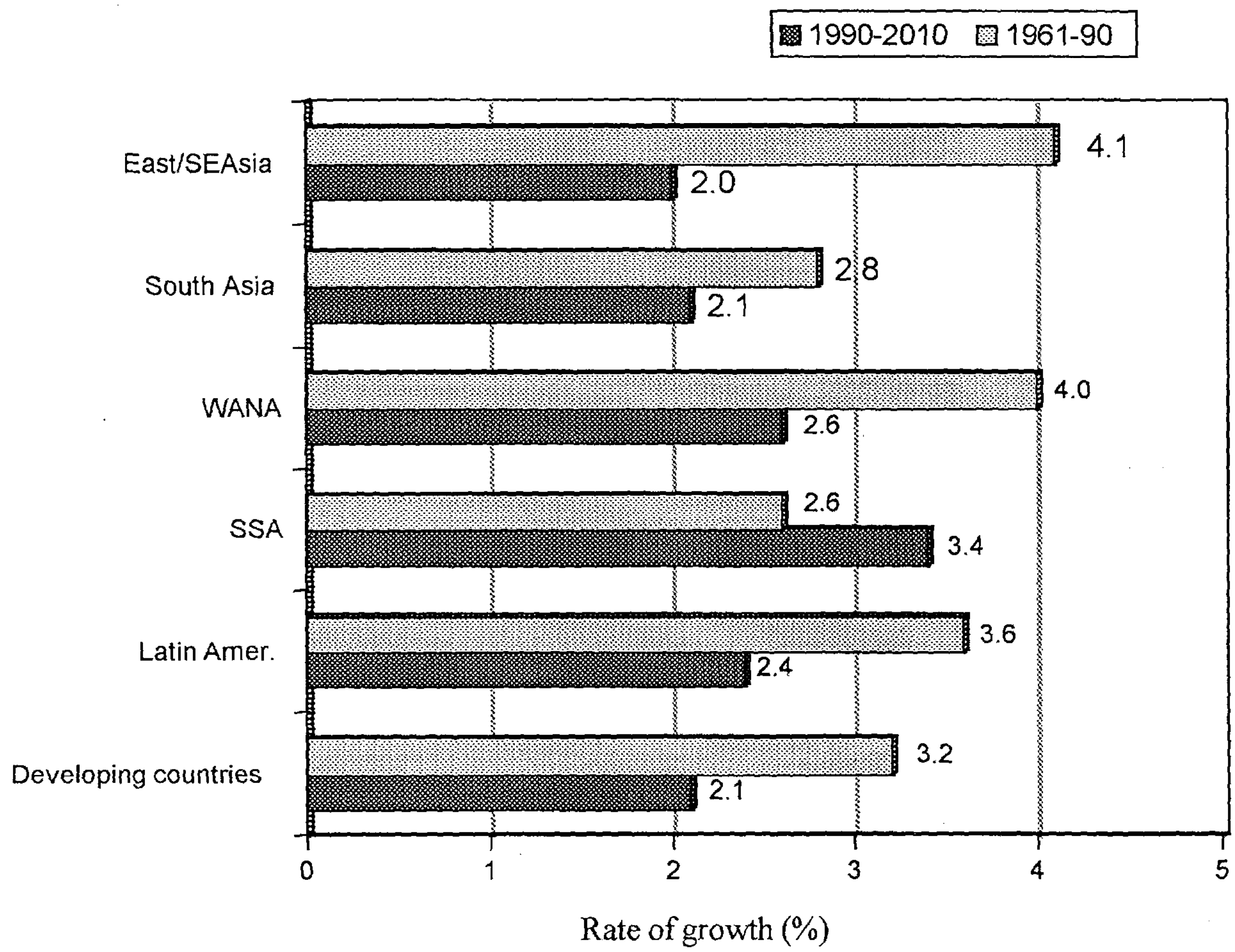
	Asia	South Asia	China
IFPRI	1.31	1.76	0.85
FAO/IRRI	1.66	2.05	1.17

1.3 The Demand-Supply Gap

Currently, Asia is not only meeting its own rice consumption demand, but also enjoys a net trade surplus of 3.4 million tons (Table 1.1). Since the rice production in the rest of the world is not expected to rise significantly, not much surplus is likely to emerge there in the future. In fact, without a technological breakthrough, Africa is likely to continue to depend on rice imports and food aid. The problem may become even more serious, because the 20 million tons of paddy grown in Japan and Korea, at a very high cost, is likely to decline in the future if they implement the GATT provisions on the liberalization of rice trade.

Consequently, the entire increase in rice demand would have to be met through enhanced production in Asia. Rice output in Asia should, therefore, grow at a minimum

Figure 1.4 Projected Change in the Growth Demand for Cereals



Source: Alexandratos, N. 1995. World Agriculture Towards 2010. FAO, Rome.

of 1.66% per annum during 1995-2010 to meet the growth in demand projected above. Notably, during the next period, almost the entire growth in output will have to come from growth in yield since there is little scope for the area under rice to increase. In fact, as discussed above, because of its likely diversion to other crops, the area under rice might even decline.

During the decade 1985-95, rice production in Asia grew at 1.68% per annum. The growth rates of output and yield already show a perceptibly declining trend compared with the earlier period 1965-85 (Table 1.2). Especially notable is the decline in growth rate of yields from 2.32% per annum during 1967-85 to 1.35% during 1985-95. The deceleration in rate of growth of yield increase during the last decade took place because of a decline in investment in irrigation, and because farmers were approaching the yield ceiling with existing technologies, particularly in high-output irrigated systems.

This trend would have to be reversed and rates of yield growth would have to rise to 1.66% per annum from the current level of 1.35%. Keeping in view the current trend, this would be a challenge. Hence, it is necessary to take measures to raise rice production in Asia to avoid a serious erosion of the food security so painstakingly achieved during the last decade. This would require investment in irrigation, other infrastructure, and rice research. Special efforts would be needed to shift the yield frontier in irrigated systems and to close yield gaps, along with introducing yield-enhancing technologies in rainfed areas.

1.4 Rice Outside Asia

Only about 9% of the total world harvest is produced outside Asia, the other major producers being South and Central America, and Africa (Table 1.1). In South and Central America, rice production is scattered throughout the region, but taken together, these regions are self-sufficient.

The story is slightly different for Sub-Saharan Africa. In Madagascar and parts of West Africa, some populations eat rice as a staple diet. With rapid population growth, the demand for rice outstrips the supply, and Sub-Saharan Africa has resorted to large-scale imports; in 1995, these reached 35% of the consumption demand. This has serious implications for the food security of a large proportion of the poor in that region.

Current trends in production and consumption of rice in Sub-Saharan Africa highlight the serious food security challenges that many developing and poor countries and regions are likely to face during the early part of the next century. They further reinforce the urgent need to augment rice supplies by research and development.

CHAPTER 2 - GLOBAL RICE RESEARCH COMMUNITY

2.1 Rice Research Community

The size and capacity of the international rice research community has expanded rapidly over the last decade. The globalization of rice research has been due to several factors: expansion of the research agenda and more emphasis on partnerships because of (i) increased concerns about sustainability and management of natural resources, (ii) funding pressures, and (iii) very recently, the success of international rice biotechnology initiatives that led to upgrading of research capability in developing country laboratories. The enhanced research capacity as well as new scientific opportunities promise to help bring us nearer the goal of increasing food production sufficiently to feed the greater populations of the 21st century.

The expanded rice research agenda will require broader, more sophisticated and integrated approaches. IRRI by itself will not be able to fulfill the expanded agenda requirements; indeed, no single research organization will be able to do so. What is needed is an array of institutions working together around the world to carry out basic research in, *inter alia*, the biological, chemical and physical sciences, coupled with strategic and applied agricultural research, including inputs from extension services and sometimes NGOs, to develop and deliver an array of improved technologies to farmers.

New partnerships will be required to deal with the new realities facing the research systems of rice-producing countries. Some partners will be new to agricultural research, but will be brought into rice research because of developments in biotechnology, molecular genetics and global change. Today, rice is about to become a 'model' organism for genetic research, particularly for genome and molecular biology studies relating to all major cereals.

A decade ago, IRRI was the centre of strategic and applied rice science. Today, IRRI still holds its position as a major centre of *indica* germplasm improvement for the tropics and subtropics and in rice technology transfer to developing countries, but soon it may no longer be their only provider.

The changes in rice research are most dramatic in biotechnology. Ten years ago, most scientists working in rice were based in agricultural research institutions and were grounded in agricultural research and development. When in 1986 the Rockefeller Foundation (RF) established its Rice Biotechnology Programme, a number of advanced molecular laboratories in the USA, Europe, and Australia began rice research. Early on, the RF programme provided a means for many promising Asian students, initially from China, India, Korea, Pakistan, and the Philippines, to train in basic research laboratories in industrialized countries. Research in the Programme became more focused as major factors in rice production were analyzed to determine the likelihood of their solution through biotechnology. Today, the Programme is centred almost entirely in advanced laboratories of the developing countries from whence came the first groups of students, and the laboratories that supplied the first waves of scholars are now equipped to carry out modern molecular genetics research.

Using IRRI materials, the first molecular map of rice was developed at Cornell University as part of the RF Programme; this map, along with the DNA markers used to produce it, was central to much of the later work. National rice genome programmes were established first in Japan, and then in China and Korea. Japan's Rice Genome Programme at Tsukuba took genetic maps to a new level of precision and provided a new analytical method to produce the first physical maps, a prelude to obtaining the entire DNA sequence of rice. A laboratory in Shanghai arguably leads the world in rice physical mapping, and a more modest programme at Suwon, Korea, is attaining the same capability.

Rice transformation - genetic modification by the introduction of isolated genes - has been achieved in many laboratories. IRRI has become a major centre for rice transformation, but still probably holds a secondary position to the Scripps Oceanographic Institute in San Diego, USA, and the John Innes Centre in the United Kingdom. IRRI's transformation programme focuses on rice improvement for diverse ecosystems.

Today, a large number of laboratories can provide information on genetic control of key agronomic traits in both *indica* and *japonica* rices and, through genetic modification, apply isolated and engineered genes to rice improvement. Many such laboratories are in NARS that IRRI serves, and are linked collaboratively with IRRI research groups.

Private sector laboratories have become interested in rice biotechnology. Also, questions of 'ownership' have come into play in both publicly funded and private laboratories, not only regarding potential income, but also as a way to gain access to the intellectual property of others and to control to some degree the use of a scientist's own discoveries. Today, life in rice science is complex indeed.

But it is not only in the fields of biotechnology and genetic engineering that life has become complex for IRRI and its collaborators. In the last decade the International Convention on Biodiversity has taken effect, the United Nations Conference on Environment and Development issued its Agenda 21, and the International Convention on Biological Diversity was signed. These developments were brought about by a worldwide shift in attitude concerning the environment and sustainability. As a consequence, questions have been raised about the role and effects of rice production - as well as other agricultural practices - on such matters as (potential positive and negative) effects of global warming, water quality, ownership of genetic resources, agricultural sustainability, and global food security. Each of these developments has brought new concerns and partners into the rice research community. A notable development has been the increasing involvement of Non-Governmental Organizations (NGOs) in CGIAR research efforts.

The above discussion covers mostly developments in science and the consequences of international meetings and/or agreements. But we cannot go further here without coming back to the reasons why the CGIAR was established, to help increase food production and raise the well-being of the poor in developing countries. Here too, changes have taken place that affect the global rice community. The NARS in some countries have been strengthened and are now taking their place as full partners in planning and carrying out research. For years, scientists and decision-makers from NARS have been members of TAC, IARC boards, and the advisory committees that help define priorities and strategies for rice research. New partnership arrangements to improve rice science are being made by IRRI, CIAT, and WARDA in improving the productivity, profitability, and sustainability of rice farming. However, in spite of this, there are still rice-producing countries whose NARS are unable to develop the quality and quantity of technology required to meet national needs. In such countries, IRRI and the international rice research community must help them obtain needed technologies, and assist in training and strengthening their national capacity. It would be ideal if all rice-producing countries could participate in rice research partnerships as full peers, but, unfortunately, that is still not possible. Therefore, strategies and support to strengthen some NARS will still be necessary for at least the next decade. To illustrate this, IRRI's efforts through the ARBN foster capacity in biotechnology and its integration with breeding programmes.

To sum up the global situation facing rice research today, the tasks of IRRI and its research collaborators - traditional, emerging, and novel - are likely to remain complex and lively.

2.2 Challenges for Rice Research

The rice research challenge is even more daunting than before. Gains in productivity are essential to meet human needs. In Asia, where more than 90% of rice is grown and consumed and where the land frontier is mostly closed, the only option is to produce even more on existing lands. To meet India's needs in 2020, and with little scope for bringing more land under rice, yield improvement of no less than 2.5% per year must be achieved. Other Asian countries also face the need to intensify rice production; this remains a major challenge for IRRI and its partners. The promising results with hybrid rice in China, India, and Vietnam are exciting and interesting in raising yield potential, as are the initial efforts to modify plant architecture to raise the basis for higher yield. Also, the fact that IRRI's conventional breeding programme still is able to maintain a 1% annual yield improvement rate is noteworthy and commendable.

Continuing intensification of rice farming also brings other challenges for IRRI's four existing ecosystem programmes. These involve managing inputs, including increasingly scarce water resources, achieving higher input use efficiencies, raising yields on less favourable lands, and achieving all of these without degrading the natural resource base and the environment. Another challenge will be to help meet rice needs in countries that are moving toward agricultural diversification and high-value crops. Each year, urbanization and industrial growth are removing good rice lands from production and placing even greater production pressures on remaining rice lands, both favoured and less favoured. Crop intensification brings problems of crop establishment and management, in nearly year-round systems of double or triple cropping of rice and other crops. Here direct seeding, with related factors including tillage, land levelling, dry or wet seeding, broadcast or line sowing, weed control, and water management, raises all kinds of questions for IRRI and its partners.

Keeping ahead of pests and diseases is as always a challenge. Solutions to some of these challenges may emerge as new molecular genetic tools are made available to breeders, pathologists, and entomologists. Further challenges are to understand soil nutrient deficiencies in the various rice cropping systems, determine optimum systems of nutrient management, and minimize pollution problems.

New plant materials from biotechnology will pose new questions for IRRI and its collaborators, particularly regarding matters relating to proprietary science and the new working arrangements and agreements that may be required. In particular, partnerships with the private sector will increasingly become important, especially in matters pertaining to access to new technologies or tools developed in private laboratories.

In the middle of all these problems will be IRRI, which has always sought to position itself in the most suitable role(s) to work with, and serve, NARS partners. Such partnerships have usually required both peer and mentor relationships to identify and solve pressing problems and thereby improve productivity and the welfare of rice producers and consumers.

2.3 IRRI in the Rice Research Community

Few institutions, if any, have had a more profound effect on how research is done in a crop and in its global development than has IRRI. Thirty-eight years ago, when IRRI was formed, there was almost no collaboration between countries in rice research. No global germplasm collections had been made, and prospects for rice improvement - especially in the tropics - appeared bleak. When IRRI was formed, many questioned what a small staff of international scientists located in the Philippines could do to improve rice in the developing countries. And, some said, *indica* rices had little scope for improvement. With the release of IR8 and IR5 in the late 1960s, a new era of rice research and rice productivity began. And with it came a global rice research community, growing, strengthening, moving ahead. And as the global community changed and developed, so IRRI also had to change.

Over the years, IRRI has proved its worth in developing successful research, first to raise the productivity of irrigated rice in Asia where for centuries little yield improvement had been gained, and later extending that work to problems of rice in less favoured areas. Genetic improvement work proved to be the first major innovation of the Institute. Then, as the new genotypes began to spread and boost agricultural production, other problems appeared requiring new arrangements for collaboration with national programmes for which there was no operational model. Some attempts at collaboration were successful, some less so. But each time new lessons were learned in the process of finding out just how an international centre with a limited staff could serve as catalyst, mentor, training centre, and bridge to agricultural and basic science elsewhere.

Today, IRRI has become a centre of knowledge of rice science. Its library is unparalleled in the world. Several of its scientists have become recognized as international authorities in their areas of specialization. Many national programme leaders and research scientists have received part of their research training or education at IRRI or through the help of IRRI. These people have returned to their countries to lead research efforts and are key persons in helping to find ways to collaborate with colleagues in other countries on similar problems that cross national borders. The enabling function of IRRI has perhaps been overlooked in many cases, but it is certainly true that many developments in rice science and knowledge generation could not have been made without the leadership, help, and support of IRRI. NARS scientists appreciate opportunities to participate in monitoring tours, e.g., those of INGER, to see their own and others' genetic materials elsewhere under different threats and ecological conditions, and for the career development afforded by their contacts with IRRI.

IRRI has had many challenges over the years, but perhaps it faces some of its greatest challenges now. There is a vastly different situation now than at the time of the last EPMR. The developments in science coming from molecular biology have changed tremendously the environment in which IRRI works. The first meeting of an international group to formulate plans for sequencing the entire rice genome took place during the time of this EPMR. By the time of the next EPMR, a large proportion - maybe all - of the 25,000 or so rice genes will be known, and many of them may have been patented. IRRI will have to change again to meet the challenges and the needs, and in doing so it will have to change somewhat the way it deals with the rice research community. To do so will require forward vision, intelligence, care, agility, and, perhaps above all, goodwill on the part of its partners and constituencies.

CHAPTER 3 - EVOLUTION AND STRATEGY

3.1 Origin and Evolution of IRRI

Nearly four decades ago, the Ford and Rockefeller Foundations formally laid the groundwork for the International Rice Research Institute. In 1960, IRRI's headquarters and research facilities were constructed at Los Baños, adjacent to the College of Agriculture, University of the Philippines, on some 80 hectares of land.

The research during the first decade focused on raising the yield potential of irrigated rice almost to its present levels, predominantly by changing the morphological and physiological characteristics of the rice plant. IR8, the semi-dwarf, early maturing, non-photosensitive, nitrogen responsive rice that launched the modern changes in the rice world in the mid-1960s, was followed by varieties with increased insect and disease resistance and improved grain quality, such as IR20 and IR22 in 1969. Work on upland rice began in the early 1960s as well. At the same time, a programme of institution building was developed to strengthen national rice research systems through training and information dissemination and the development of a capacity in a number of disciplines, including economics.

During the 1970s, IRRI's work was extended to include lowland and deepwater rice, and expanded in the areas of economics and problem soil research. Interdisciplinary work on evaluation and utilization of rice germplasm and its systematic collection, storage, distribution and testing was established during this period, as was the International Rice Testing Programme (IRTP). The successes of the first decade were followed during the second decade by varieties with multiple stress resistance and improved grain quality, such as IR24 in 1971, IR32 and IR34 in 1975, IR36 in 1976, and IR42 in 1977. IR36 was widely accepted, due in part to its resistance to nine pests and tolerance to seven adverse soil conditions and drought, and became the world's most widely grown crop variety.

During IRRI's third decade, there was further expansion of the research programme, strengthening of national rice research systems, growing concern for women in rice farming and for integrated pest management (IPM), and movement into biotechnology and strategic research on genetics and germplasm enhancement. In 1985, IRRI produced IR64, the first IR cultivar with highly palatable grain plus high yield potential and multiple pest resistance, and followed it by success with its IPM programme in several Asian countries. By the mid-1980s, besides producing new varieties, IRRI had published 120 books in 34 languages and distributed them in 25 countries.

By the end of its third decade, IRRI was successfully applying biotechnology to accelerate genetic studies and wide hybridization, had defined new plant types that it hoped would further raise yield potentials, developed its "Strategy Toward 2000 and Beyond," and trained some 6,000 national programme scientists and technicians. Also, to reflect its full scope of activities, IRTP was redesignated the International Network for Genetic Evaluation of Rice (INGER) in 1989. INGER today is the largest single pathway for distributing, exchanging, and testing new rice varieties and elite breeding lines in the developing world. IRRI therefore entered its fourth decade as a partner in a growing global community of national rice research systems, and facing a far more complex rice-farming world (see Chapter 2).

At the time of the Third External Review in 1987, IRRI's research was organized and managed through 13 disciplinary research departments, and employed some 72 internationally recruited staff (IRS) (62 core and ten complementary), and 2,300 nationally recruited staff (NRS) in its core and complementary programmes as of 31 December 1987. Since then, IRRI's research management has evolved to a project-based system implemented through a matrix involving five ecosystem-based research programmes and eight disciplinary-based divisions which were reduced to six in 1993. In 1992, when the Fourth EPMR took place, IRRI employed 81 IRS (61 core and 20 complementary) and 1,787 NRS. In 1997, IRRI employed 67 IRS (52 core, three seconded from or in partnership with other institutes, and 12 in non-agenda bilateral country/regional programmes), five affiliate scientists, 19 project and visiting scientists, and 849 NRS.

3.2 IRRI Today and Tomorrow – Its Role and Mandate

IRRI's role today and in the decades ahead is defined by its goal, objectives, and guiding principles.

Goal: Improved well-being of present and future generations of rice farmers and consumers, particularly those with low incomes.

Objectives: To (a) generate and disseminate rice-related knowledge and technology of short- and long-term environmental, social and economic benefit; and (b) help enhance national rice research systems.

The achievement and the relevance of IRRI's work depend largely on partnerships and information exchange with farming communities, national scientists, extension and development workers, and policymakers.

Role and responsibility: IRRI's role as part of an international scientific community is to contribute worldwide to the improvement of rice technology and maintenance of the natural resource base, and to the development of human resources in research and related activities. National governments are responsible for the formulation of appropriate agricultural research policies. IRRI's role is to draw attention to the socioeconomic and policy research results that are relevant to the establishment of such policies, and that will help in achieving the goals of both national governments and IRRI.

Guiding principles: To be an effective research organization, IRRI believes that it must provide appropriate support to talented and dedicated scientists through modern management principles and procedures. IRRI management therefore aims to provide:

- a research environment conducive to innovation, creativity, and excellence;
- a multicultural, institute-wide social system that encourages all staff members to learn from one another, to share resources and knowledge, and to freely exchange ideas and information;

- management policies that encourage open communication in all directions and that continue to promote standards of scientific integrity – which include moral accountability, honesty, commitment, enthusiasm, and cost consciousness;
- decentralized management based on visible leadership, interactive problem analysis, and shared responsibility;
- transparency in all research undertakings;
- compensation levels based on performance, fully competitive with market standards.

IRRI expects to maintain several important global functions relating to rice research well into the 21st century. Beyond IRRI's lifetime in its present form, a politically neutral and commercially disinterested clearinghouse will continue to be needed to lead a global rice knowledge network. Its main functions could be: to house the base collection of the world's rice germplasm and to perform the many evaluation, research, preservation, and service functions that this responsibility entails; and to collect, evaluate, select, and make accessible information on current rice research and development programmes, rice and rice-related research results, and global rice research resources (human, financial, physical). Such a future role needs much consultation with its partners.

Over a relatively short period, of time the knowledge of the sequence of the rice genome will be completed and will be combined with efficient, cultivar-independent methods of gene transfer to give subsequent generations of rice scientists and breeders the power to understand how some 25,000 rice genes work together to promote growth, self-defense, and reproduction in the face of environmental change in the world. IRRI will endeavour to have access to the largest collection of isolated rice genes of known function, and to alter this system in beneficial ways, including allelic variants derived from the existing germplasm collection and novel variants created by gene technology. This intellectual property will be freely available to NARS and on mutually beneficial terms to the private sector to enable new or modified traits to be introduced at will.

3.3 IRRI's Strategic Plan and 1994-98 Medium-Term Plan

The 1994-98 MTP was guided by *IRRI: Toward 2000 and Beyond* (the 1989 Strategic Plan revised in 1993), in which IRRI affirmed its detailed strategic objectives:

- to increase rice production efficiency and sustainability in all major rice-growing environments through interdisciplinary research;
- to ensure the relevance of IRRI research and the complementarity of international and national research efforts through close collaboration with national programmes;
- to generate and disseminate rice-related knowledge and technology of short- and long-term environmental, social, and economic benefits; and
- to help enhance national rice research systems.

In meeting these objectives, IRRI's MTP of 1994-98 proposed a further evolution from a disciplinary, department-based approach to a multidisciplinary, programme-based approach to activities, implemented through a matrix management system. All activities were organized into projects, with explicit objectives, outputs, milestones, and budgeting for human, capital, and financial resources. A significant feature of *IRRI: Toward 2000 and Beyond,* and the MTPs of 1990-94 and 1994-98, was the re-organization of the Institute research into five ecosystem-based programmes (Irrigated, Rainfed Lowland, Rainfed Upland, Flood-prone, Cross-ecosystem), and five international service programmes (Germplasm Conservation, Dissemination and Evaluation, Information and Knowledge Exchange, Training, Crop and Resource Management Network, National Research Services).

The 1994-98 MTP was therefore designed to produce results that would help balance the need for ever-greater food production, at prices affordable to consumers and profitable to farmers, against some very real concerns about protecting natural resources and the environment for future generations. IRRI articulated these into its five Ps – *People, Permanency, Productivity, Protection, and Partnership.* The Institute's activities to meet its objectives were organized into 27 projects in research and 14 projects in international services. While most project activities were done at IRRI headquarters in Los Baños, The Philippines, this MTP saw a significant devolution of work through formalized collaboration such as consortia and networks to IRRI's NARS partners. IRRI's 1994-98 MTP was finalized after a strong consultative process and a formal research prioritization process, during which all stakeholder groups participated in reviewing the proposed activities and direction of the plan.

IRRI introduced the concepts of "mega projects" and "new frontier projects" in the 1994-98 MTP to, respectively, address the issues of impact by selected projects through scaling up in size whilst maintaining focus, and the issue of high-risk research with high payoff potential in science. An example of a mega project is to raise the irrigated rice yield plateau through approaches such as the "New Plant Type". New frontier research is exemplified by activities to exploit allelopathy for weed control and to assess opportunities for nitrogen fixation in rice.

IRRI continued to concentrate on its global commodity role in rice during this MTP, but devoted substantial resources to natural resource management research through its ecosystem-based programming. It responded to TAC's request for it to take leadership on ecoregional activities in Asia, and implemented an initiative with its NARS, ARO, and NGO partners to develop new models for natural resource management in the humid tropics where rice is a major component of landscapes. IRRI also responded to TAC-recommended shifts in its core activities by increasing its resources allocated to the conservation and management of natural resources (28% of budget in 1994), increasing its germplasm enhancement and breeding activities (34% in 1994), decreasing work on production systems development and management (15% in 1994), increasing work on socioeconomic, public policy, and public management research (8% in 1994), and decreasing institution building (16% in 1994). As a result of these shifts, the 1994-98 MTP featured significant increases in activities relating to prebreeding using biotechnology, biodiversity conservation and management of genetic and ecological resources, social aspects of crop and pest management, and devolution of training courses to NARS partners.

3.4 IRRI's Current MTP 1998-2000

IRRI's current MTP is based on its revised (1996) strategic plan *IRRI Toward 2020.* As a part of the planning process for the current MTP, national agricultural research leaders from major Asian rice-growing countries assessed the scenario of rice supply and demand balances over the next decade and prioritized their research needs and their expectations from IRRI.

For this MTP, IRRI proposes to implement the research and research-related activities through 31 projects under seven programmes. Besides continuing the five rice ecosystem-based research programmes, the international research activities and services are consolidated into two new programmes entitled 'Rice Genetic Resources: Conservation, Safe Delivery, and Use' and 'Accelerating the Impact of Rice Research'. These programmes will implement the CGIAR research-related undertakings of 'Saving biodiversity' and 'Strengthening national programmes'. The Plan discontinued a number of research activities and included four new projects entitled 'Increasing water-use efficiency in rice culture', 'Addressing gender concerns in rice research and technology development', 'Rice – a way of life for the next generation of rice farmers', and 'Implementing ecoregional approaches to improve natural resource management in Asia'. The project on water-use efficiency will integrate the efforts of breeders, water resource engineers, weed scientists, agronomists, and social scientists to address the growing labour scarcity and the looming global water crisis. Some of this work forms part of the Systemwide activities on water.

IRRI continues to have in its research portfolio a number of new frontier projects with low probability of success but a high pay-off, if successful. Examples are the hunt for an apomixis gene, assessing opportunities for nitrogen fixation, developing a perennial rice plant, and incorporating more micronutrients in rice. These new frontier projects require 3.3% of IRRI's internationally recruited staff time, and are financed from restricted funds. Almost all of the work is done in developed country ARI laboratories undertaking basic work not always related to rice. IRRI's programmes are implemented through a two-dimensional matrix to increase opportunities for interdisciplinary relevance and disciplinary excellence in the research, and to reflect the need to respond directly to the needs of IRRI's major partners (NARS).

IRRI plans to carry out its activities with 68 core and four non-agenda IRS by the year 2000. The allocation of resources by CGIAR activity is: 42% for Increasing Productivity; 26% for Protecting the Environment; 7% for Saving Biodiversity; 8% for Improving Policies; and 17% for Strengthening NARS. Of the total resources, 94% are allocated to Asia, and 6% to other regions. In Sub-Saharan Africa, IRRI focuses on the Eastern, Central, and Southern Africa region as WARDA has responsibility for West Africa. Building on 14 years of successful collaboration with Madagascar and over two decades of support to the region through INGER, IRRI is working with the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA) to establish a regional rice network. This network will draw on the knowledge and experience of IRRI and the Asian NARS, principally through the Rainfed Lowland and Upland Consortia. WARDA is also a partner in this initiative, sharing expertise and experience from West Africa. In addition, WARDA and IRRI have agreed to take joint responsibility for the management of INGER-Africa and to collaborate in strategic research and training for Sub-Saharan Africa.

IRRI is a convening centre for the 'ecoregional programme' called 'An Ecoregional Approach to Research and Development in the Humid/Subhumid Tropics and Subtropics of Asia; and has been requested to lead the Nutrient Management thrust of the Systemwide

Programme on Rice-Wheat Systems for the Indo-Gangetic Plains. In addition, IRRI participates in five other Systemwide programmes.

IRRI uses an interdisciplinary approach to address high-priority problems in all rice ecosystems. IRRI's matrix management system balances mission-oriented objectives with disciplinary depth. Because it contains the research consortia, the matrix enables the Institute to respond to the new agroecological zone concept of the CGIAR while maintaining its basic organizational structure and programmes. The projects outlined for the MTP have defined milestones and verifiable outputs to ensure quality and to monitor the impact of research. In addition, the divisions have developed a strong research capacity in specific areas (referred to as divisional thrusts). According to IRRI, these constitute the areas of scientific excellence of the Institute.

The research planning process, for both programmes and divisions, provides a framework for monitoring and evaluating progress. The progress indicators and the means of verification identified during the project formulation process provide the basis for ongoing internal review and evaluation of the research programmes. A programme of divisional excellence brings external peers to assist in the continued improvement of staff scientific skills and research quality.

3.5 International Research Partnerships - Strategy, History, Evolution

The Panel considers it appropriate that IRRI's unique role in partnerships is highlighted, for it is a story worth telling. We begin with an overview of the strategy (section 3.5.1), followed by a brief history (3.5.2), and a section (3.5.3) on IRRI's partnerships today. The history is very interesting, for it relates to the evolution of international agricultural research partnerships in general, since many such partnerships had their origin following IRRI's establishment and - along with CIMMYT's similar successes in wheat - IRRI's early successes with the new rices in Asia and Latin America.

3.5.1 Partnership Strategy

IRRI bases its partnership strategy on its capacities and strengths in rice research, its unique global and international research vision, its recognized record in rice science, its impact, its knowledge of Asian rice production systems, and its well established linkages with NARS, ARIs, and - increasingly - with private sector research. Within that context, in its own words, "IRRI invites the international community to forge a common, coherent, and focused research and technology development agenda within the international research continuum".

IRRI argues that its unique role in partnerships stems from its: (i) long relationships with rice-growing countries and familiarity with their rice culture and science; (ii) ability to move freely and build bridges with NARS in exchanging information, knowledge, and methodologies; (iii) ability to produce 'international public goods' that reach beyond national boundaries; (iv) tradition of science and scientific publication that gains the respect of ARIs; and (v) increasing capacity to link public and private research to obtain technology and to integrate rice knowledge for use by farmers.

Partnership mechanisms include bilateral arrangements with NARS (e.g., country programmes to strengthen NARS, bilateral collaboration with strong NARS) and ARIs (strategic and frontier research); networks for research, information exchange, and technology transfer; and research consortia. Networks and consortia are governed by steering committees and biennial work plans are framed within formal memoranda of agreement. IRRI is aided in partnerships with NARS by the Council of Rice Research in Asia (CORRA), which consists of the directors general of agricultural research institutions in the main rice-growing countries.

Research networks and consortia contain structured arrangements with NARS and ARIs, in which multidisciplinary and multilocational research can be prioritized, planned, executed, and evaluated. Consortium sites serve as centres of excellence for interdisciplinary research on key international problems, including those related to natural resource management and global change. Technology delivery networks include INGER and CREMNET.

At the international level, IRRI embraces the concept of gaining efficiency within the CGIAR through Systemwide activities. IRRI has carefully selected those Systemwide activities where it has significant skills and experience to contribute, or where its goals and those of its NARS and IARC partners can benefit from membership. It is a founding member of three Systemwide programmes: (i) genetic resources; (ii) water management; and (iii) participatory breeding, natural resource management, and gender analysis. It also participates in the Systemwide programme on integrated pest management where FAO is an essential partner linking IPMNet to regional technology delivery mechanisms. In addition to these, IRRI is the implementing centre for the ecoregional programme for the humid and subhumid tropics and subtropics of Asia and continues its role as a partner in the rice-wheat consortium for the Indo-Gangetic Plains.

The relationship with ARIs to capture and focus cutting-edge research is developed primarily through "shuttle research" programmes. These include short-term exchange of scientists, advanced degree research, sabbatical leaves, and reciprocal appointments as adjunct faculty/staff.

Two new partnership approaches are being adopted. The first is with the NGO community, where collaboration centres on priorities for research and "feedback" in evaluating new technology as well as the knowledge needs of farmers. The second is with the private sector, which has become important in producing new proprietary technologies and methods relating to rice improvement, and in developing and testing new materials, machines,or products. Both public and private sector R&D efforts have much to offer in partnerships to advance rice technologies.

3.5.2 A Brief History

IRRI has been a pioneer in forging partnerships in international research, first with public partners, including NARS, then increasingly with ARIs, and recently with the private sector. Since IRRI's inception in 1960, agricultural research has become international, and IRRI has been in the centre of many of these developments. A brief review of the situation in 1960 when IRRI was established is in order.

For most of human history, improvements in agriculture have come slowly and with difficulty. Before World War II, almost all increases in production came by expansion of cultivated land, while yield growth was slow and barely perceptible. After World War II, developed countries, with their own innovations and using materials and knowledge at hand, achieved faster yield improvement and eventually yield takeoff. Since 1945, profound agricultural change has resulted, so much so that during the past fifty years the greatest agricultural transformation in history has taken place. IRRI has contributed greatly to that transformation by matching developments achieved in temperate crops with similar developments in the major food crop of the tropics, rice.

When IRRI was founded, international collaboration was based on individual contact, even in developed countries. In the developing world, it was sporadic and lacking in critical mass, and not truly international in the sense of that term today.

IRRI's formation changed the picture dramatically, largely due to IR8 and IR5 varieties released in the 1960s. At that time, many persons doubted that a small research institute in The Philippines, no matter how well staffed, equipped, and funded, could make a difference in tropical rice. But two factors - high yield potential of the new semi-dwarf rices, and the almost-simultaneous arrival in Asia of high-yielding semi-dwarf wheats from Mexico's joint programme with the Rockefeller Foundation (parts of which were re-formed in 1966 as CIMMYT) - showed agriculture's potential to boost growth and development.

In the late 1960s, IRRI had gained an early reputation in Asia through its new high-yielding varieties. But, in particular, it needed to engage the outstanding rice scientists in Japan, Taiwan, China, and India in tropical *indica* rice research. IRRI also began with bilateral arrangements with individual countries, often funded by development agencies, to help improve national rice research capacity. Through its international staff, IRRI already had contacts with some national programme leaders, and through the NARS with Asian farmers. In this way, IRRI began to develop new ways to work with NARS.

In addition to sharing germplasm, IRRI introduced itself to NARS by holding production training courses and providing scholarships and fellowships for scholars from rice-growing countries to study at the University of the Philippines College of Agriculture (now UPLB) while doing their research work at IRRI. Workshops and conferences brought scientists and leaders to IRRI to see ongoing research, meet IRRI scientists, and form views on modes of collaboration. Germplasm distribution allowed NARS scientists to grow the new materials under their own conditions. Over time, former trainees, scholars, and other 'alumni' of IRRI formed a backbone of collaboration across Asia, and elsewhere.

In the meantime, IRRI's and CIMMYT's dramatic successes inspired national policy makers and scientists working in other crops to ask for other international centres to be established. Scientists and leaders sought ways to cooperate on global research problems. Plans were made and measures were taken to collect and preserve global collections of important crops. International donors, including bilateral development assistance agencies, private foundations, international development agencies, and international development banks came together to determine how international agricultural research could be placed on a firmer financial and institutional footing, resulting in 1971 in the formation of the Consultative Group on International Agricultural Research (CGIAR). Thus, just a little more than a decade after

IRRI was formed as the first international agricultural research centre (IARC), the CGIAR found itself supporting a growing global network of new IARCs modelled after IRRI. What began in 1960 as a foundation-supported, small research institute in the Philippines had inspired, in just over a decade, a global system of IARCs supported by the CGIAR, plus a number of other IARC look-alike institutions. Truly, IRRI represented a new paradigm in international agricultural research.

3.5.3 IRRI's Partnerships Today

IRRI as a Peer or Mentor. Like most other research institutions, IRRI would probably prefer to work in peer R & D relationships because they are more productive, direct, mostly scientist-to-scientist, and usually involve common scientific understanding of the problems faced and their possible solutions. Such collaboration between peers is especially important for IARC scientists who work in institutions that are thinly staffed in each discipline, and where an entire senior staff complement may not exceed that of a university department in industrialized countries.

So peer relationships are desirable and needed, and IRRI pursues them when it can. However, some national progammes with which IRRI works are as yet unable to engage in full peer relationships. Hence, IRRI often finds itself in a mentor position with some NARS, and may engage in bilateral efforts to improve the capacity of a NARS to identify and solve important problems. Some countries which IRRI has assisted in the past have now reached peer relationship status in a few areas of rice research, while others have become peers in many areas of research. However, there still are NARS that continue to need assistance. The unevenness in NARS capability affects IRRI's partnership strategies, and, further, can cause misunderstanding in cases where IRRI's operating modes or styles with different partner countries are compared.

Networks. Networks were an early means to link NARS with IRRI by using participatory planning, execution, and evaluation. Some began as information exchange or material exchange efforts, but with time, gradually evolved into research consultation or collaborative research networks. Networks have the difficulty that peer/non-peer institutions are often linked in the same network, thereby creating situations where the work pace may be set by the slowest member. IRRI has helped some of its networks to evolve to where NARS leadership and planning have become the norm. Networks can help ensure training of national scientists in new techniques of research and analysis and in their application. In this way, network-type training can help build national research capacities.

Research Consortia. Early in this decade, IRRI began to form research consortia to link NARS research capacity with that of IRRI to solve important regional problems through multi-country collaboration. Consortia provide ways to conduct strategic and applied research by sharing research responsibilities according to each partner's interests and capabilities, but it appears that to be effective, consortia require peer relationships among NARS and with IRRI. IRRI has three Rice Ecosystem Consortia, a new one for Irrigated Rice, plus one for Rainfed Lowland Rice and another for Upland Rice. The Panel commends IRRI for its consortium approach, and for the establishment of a network of consortium sites for strategic research to study matters affecting productivity and food security in Asia.

Advanced Research Institutes (ARIs). IRRI needs relationships with ARIs in industrialized countries and the NARS, and their means are varied and innovative. IRRI uses shuttle research and facilities sharing approaches with key NARS and ARI scientists who spend periods each year at IRRI in jointly planned collaborative research. Special research efforts with France and Japan have helped to stimulate shuttle research with ARIs in these countries, as has the network on rice biotechnology. IRRI also has effective shuttle research arrangements with NARS scientists in key areas, some from ARIs in the NARS.

The Panel considers shuttle research and facilities sharing to be innovative and effective ways for IRRI to gain needed scientific input and collaboration in critical research areas. NARS and ARI scientists also benefit by having access for periods of time to essential equipment, facilities, and expertise to carry out high-priority collaborative research. NARS scientists have high praise for such programmes that allow them to conduct research at IRRI that requires specialized facilities or equipment. Such collaboration means high-calibre field studies can be coupled with strategic laboratory and glasshouse research that can be done best on a shuttle basis between IRRI and NARS or ARI research facilities.

Council of Rice Research in Asia (CORRA). A recent development in partnerships has been the establishment of CORRA, the Council of Rice Research in Asia. This Council, made up of the directors general of rice research institutes in Asia, advises IRRI on its partnership strategy and arrangements. The Panel met with the CORRA leaders in September, 1997. CORRA leaders expressed their whole-hearted support for INGER and its work and the continuing need for rice research. One of the Directors stated that the Consortium approach has improved NARS collaboration, and that it fostered partnerships rather than "choosing from a menu". The Directors clearly appreciated IRRI's role in convening and sponsoring workshops and symposia on important topics, and timely publication of the results. They believe that globalization of research will depend on NARS scientists being able to attend scientific meetings. They were especially concerned that IRRI's capacity to provide strategic rice research may be less than is needed. A specific area mentioned was raising the yield frontier.

Bridging Role of IRRI. NARS often look to IRRI to help them identify new opportunities, tools, and methodologies in research. Biotechnology research has been one of those, as are methodologies such as GIS and modelling. Such a 'bridging' role is much appreciated by NARS.

'Lifeline' role for individual NARS scientists. IRRI's contacts with, and its help and support for, individual scientists are very important in their individual research careers and professional development. For scientists working in isolation, the chance to be linked in an international effort related to their research interest provides a kind of 'lifeline' for motivation and job satisfaction. Benefits include: receiving publications; attending scientific workshops and symposia; shuttle research, facilities sharing, participating in INGER (see Chapter 5.3.1), CREMNET (see Chapter 5.3.2), SysNet, or one of the Ecosystem Symposia; all of these are much appreciated by individual scientists. Network monitoring tours and other travel experiences provide opportunities for scientists to validate their own experience elsewhere, allowing comparisons to be made, and possibly needed corrections in their own research. Monitoring tours also provide a quality incentive and assurance system for the trials and individual researchers to be visited.

The enabling role of IRRI. Its ability to recognize new trends and to stimulate and energize collaboration is needed and appreciated by NARS. Also, IRRI has made it possible for NARS scientists with common interests to come together to prepare training materials, plan collaborative research, and other such efforts. The Panel commends the enabling role of IRRI as an essential part of its work.

Partnerships with the private sector. Private sector partnerships have come to the fore at IRRI, especially with the growth and developments in rice biotechnology. IRRI has issued a policy paper entitled, *Policy on Partnership with the Private Sector*, in which IRRI lists the benefits it can derive from such partnerships, all of them relating to access to: (i) technology and expertise; (ii) products; (iii) training; (iv) manufacturing or production capabilities; (v) economies of scale; and (vi) delivery systems for knowledge-intensive research (see Chapter 6.2).

The Panel was impressed with the range and scope of partnerships at IRRI. Partnerships are more than a slogan at the Institute, and it is serious about nurturing and improving them. The enabling and lifeline roles of IRRI are important, and probably under-appreciated. The Panel applauds IRRI's willingness to experiment and innovate in this regard. At first glance, the consortia may appear to be another name for networks, but it appears they are something more than that, in that they allow peer, multi-country collaboration within a strategic/applied/adaptive research continuum to work on important global problems of rice. The Panel commends IRRI for its long-time interest in partnerships in rice research, for its wide array of efforts, and for its willingness to adjust and find new ways to make partnerships more effective.

3.6 IRRI's Response to the Recommendations of the 1992 EPMR

The 1992 External Programme and Management Review made six programme-related recommendations, and five management-related recommendations. IRRI's response to these recommendations was initially reported to TAC. In 1994, IRRI reported on the implementation of these recommendations to the Programme Committee of the Board. The following is an assessment of the current status of those recommendations.

Of the six programme-related recommendations, IRRI has implemented three in full (4.1, 5.2, 5.3), and three partially (3.1, 3.2, 5.1). With respect to the five management-related recommendations, one was implemented in full (8.2) and four partially (7.1, 7.2, 7.3, 8.1). Appendix V provides a summary of the action taken, and the justification of the partial response where appropriate. The Panel comments on IRRI's actions in the relevant sections of this Report.

CHAPTER 4 - RESEARCH PROGRAMMES

IRRI's Research Programmes are organized by ecosystem (irrigated, rainfed lowland, upland, and flood-prone) plus a cross-ecosystems Programme which includes a diverse set of projects ranging from micro-molecular to macro-policy (see Chapter 7). The five Programmes are reviewed in terms of recent evolution and current focus, achievements and impact, and future strategy, followed by an assessment and any suggestions that have emerged. The chapter concludes with recommendations related to the organizational structure of IRRI's Research Programmes and the Panel's view on research staffing pattern and procedure.

In assessing the Programmes, the Panel defines an impact as something measurable that has favourably affected the livelihoods of people, such as the reduction in the real price of rice. An outcome is defined by the Panel as an effect or a consequence of research, such as the widespread adoption of a variety by farmers. Outputs are measures of scientific productivity (papers published, varieties released, etc.) which may, or may not, lead to a significant impact. In concluding that a Programme has had no impact, the Panel is not suggesting or implying anything about the quality of the science involved. We are simply saying that the Programme has not (yet) had an impact.

This review of Programmes posed difficulties for the Panel because of the near absence (only one) of Centre Commissioned External Reviews (CCERs) and the somewhat ad hoc nature of the documentation for some Research Programmes. The Panel also found difficulties in dealing with the same science appearing in several Ecosystem Programmes.

4.1 Irrigated Rice Ecosystem

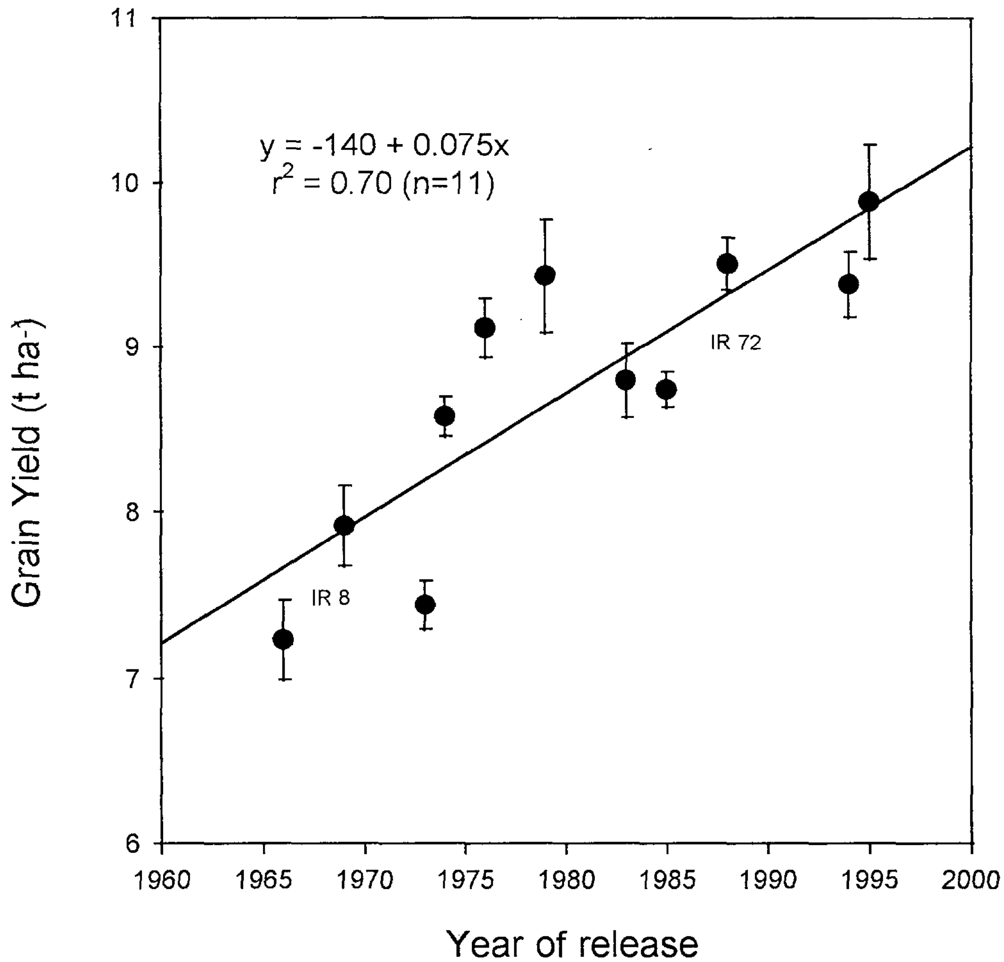
Irrigated rice covers 55% of the world's rice-growing area and provides 75% of the production. IRRI continues to make its greatest contribution to the world's food supply by the production of high-yielding irrigated *indica* rice germplasm. Pressure on the programme remains high as demand is expected to increase by at least 60% over the next 30 years, a period during which the available rice-growing land is likely to decrease. IRRI's 1998 irrigated rice research programme is planned to cost US$ 8.9M, or 33% of the research budget, although the total relevant investment including the cross-ecosystems components will be much higher.

4.1.1 Recent Evolution and Current Focus

The 14 projects of the 1994-98 MTP have been consolidated into seven in the 1998-2000 MTP: (i) Breeding to break yield ceilings: A systems approach; (ii) Sustaining soil quality in intensive rice systems; (iii) Improving productivity and sustainability of rice-wheat systems; (iv) Increasing water-use efficiency; (v) Improving pest management; (vi) Coping with global climate change; and (vii) Irrigated Rice Research Consortium.

Over the review period, the annual increase in yield potential due to genetic improvement has remained at around 1% (Figure 4.1). Alongside this continuing success by conventional pure-line breeding, which includes an effort to produce a new plant type (NPT),

Figure 4.1 Improvement in Yield Potential of Rice Cultivars, 1965 - 1995



Yield trend of cultivars and lines developed by IRRI since 1966. Eleven cultivars and lines were grown at the IRRI farm and the Philippine Rice Research Institute farm in the dry season of 1996 under optimum crop management. Each data point is a mean of the two sites. Vertical, capped lines represent standard error of mean. (Program Report for 1997, IRRI).

IRRI's F_1 hybrid breeding programme has come of age. As always, constraints to progress are apparent, which need to be contained or overcome. Among the former are concerns about declining productivity in intensive systems and potential effects of global warming. Among the latter are improving the efficiency of inputs such as fertilizers and water, as well as the looming dilemma of how to handle intellectual property issues while maintaining a free supply of germplasm to NARS partners.

Rice production must increase to meet growth in demand, yet the land and water resources are diminishing in both quantity and quality (see Chapter 1). Also, as food habits change, there is increasing pressure to diversify the cropping system, making even less land available for rice. Fear is increasing of possible future climatic instability and of potential problems that may arise with the continuing intensification of production on irrigated lands. The availability and management of water for irrigated rice will become even more important as competition for water increases and as environmental concerns grow. A related concern will be improving nutrient use efficiency, perhaps by development of nutrient-efficient varieties. Movement of labour from agricultural to non-agricultural sectors and increases in wages have become important problems for rice farmers in many countries.

Crop intensification may influence pest problems. Crop protection research at IRRI has broadened its scope from only resistance breeding to the improvement of pest management based on an understanding of the ecological and epidemiological background behind pest development and relation of the latter to actual crop losses. The interpretation of the term "Integrated Pest Management (IPM)" in rice evolved during recent years from biological control of one particular pest to a concept of crop protection against pest complexes including animals, diseases, and weeds. It is based on a blend of biological control with cultural methods, healthy seed, varietal resistance, adaptation of the genotype to the environment, and encouragement of beneficial organisms present in the field by judicious use of pesticides with low impact on these antagonists. Nevertheless, emotive perceptions, rather than rational economics, determine the pest management decisions of many farmers and this has led to misuse of pesticides. IRRI has promoted the adoption of IPM concepts by millions of rice farmers in Asia through innovative socio-economic and educational programmes. The IPM Net in eight countries has evolved into an efficient channel for the transfer, through extension services to the farmer, of innovations in IPM technology developed through multi-institutional and multidisciplinary research partnerships. In order to strengthen further the output of this partnership, IRRI has integrated the pest and nutrient management research linked to the IPM Net and the "mega" project (Reversing Trends of Declining Productivity) into the Irrigated Rice Research Consortium.

To meet growing socioeconomic and environmental changes that affect irrigated rice, improved management and new technologies including direct seeding of rice, effective weed control, and increased mechanization in rice farming are required. Weeds constitute a major production threat in direct seeded fields. The Weed Management Peer Review (an internally commissioned external review) in April 1996 expressed concern over the lack of strategic research on rice-weed systems. Strategic research on weed science in irrigated and rainfed lowland rice systems was therefore included in the research agenda to increase knowledge needed in formulating integrated weed management strategies.

Studies of rice fields in the USA and Europe with high organic matter, high N use (200 kg/ha or more), and high yields (7 t/ha) indicated that rice paddies were an important source of methane. However, these estimates did not apply to the conditions of Asia under which much of rice is grown, in soils with lower organic matter, lower fertilizer use (0 to 150 kg/ha), and lower yields. IRRI has initiated research on nutrient and water management to reduce methane emission from rice fields, and on the effects of global warming on rice productivity and rice production systems, in collaboration with NARS and advanced institutions.

4.1.2 Achievements and Impact

Despite a large increase in the global demand and production of rice, the price of rice in real terms has dropped by over 50% since the establishment of IRRI (Figure 4.2). This is the single best indicator of the long-term impact on the welfare of people. While the price decrease reflects an interaction with the price of other cereal grains, it does not reflect a lack of demand, and the contribution of IRRI's technology is clear and indisputable.

The analysis of long-term experiments (LTE) in rice monocropping systems at IRRI and some other experiment stations indicated yield stagnation or decline. Also, a decline in rice yield has been observed in rice-wheat rotations on some experiment stations in South Asia. In recognition of the threat posed by yield decline and decreasing factor productivity in intensively managed rice lands, the Fourth EPMR of IRRI in 1993 recommended a major research effort by IRRI to seek solutions for this complex of problems. To clarify the extent and possible causes for this, IRRI began a project on Reversing Trends of Declining Productivity (RTDP), usually called the "Mega project."

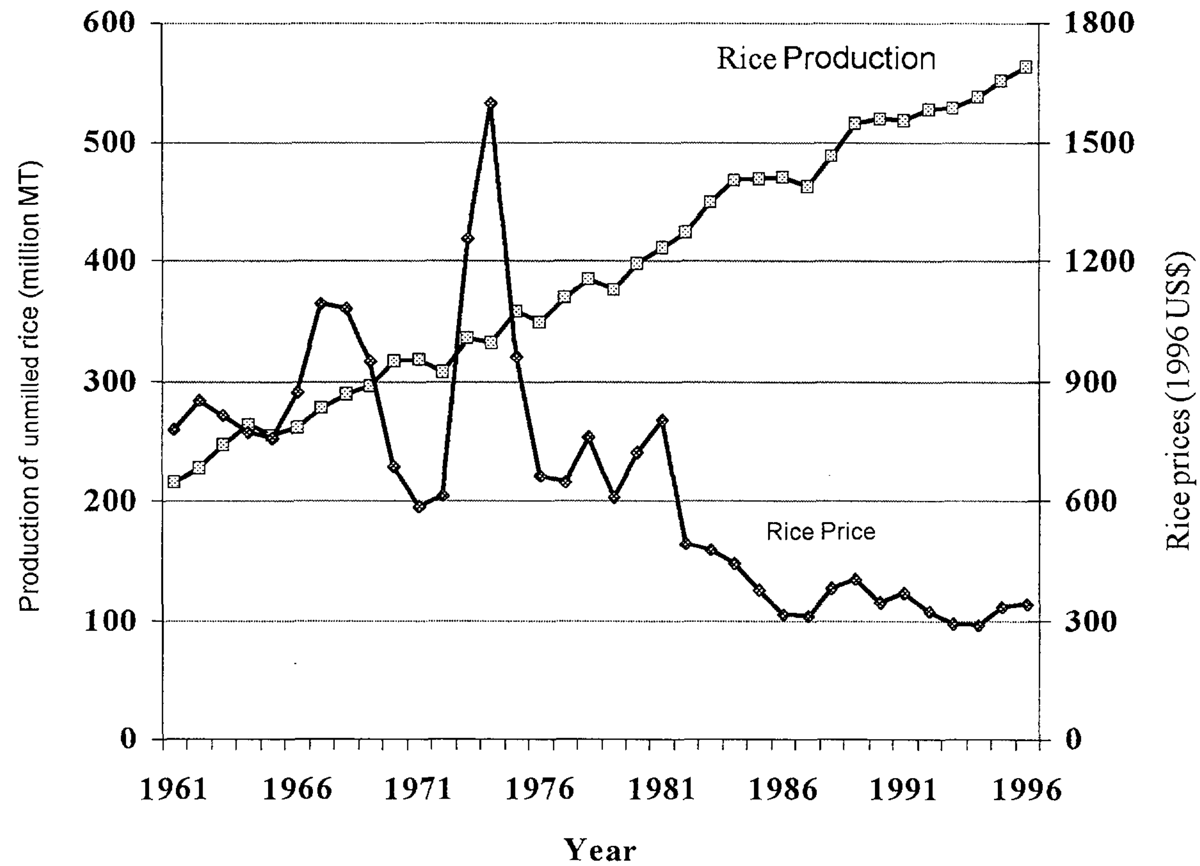
It is important to differentiate between the terms 'yield decline', 'decline in yield growth rate', and 'productivity decline'. Yield decline is defined by IRRI as "A decrease in grain yields per unit area over a period of at least several years". The IRRI definition would include both research stations and farmers' fields.

Decline in yield growth rate is defined by IRRI as "A slowdown in the (percentage) rate of increase of grain yield over time". IRRI gives the example of Indonesia where average national rice yield rose by 3.7% per year during 1967-81, by 1.6% per year during 1982-89, and by 0.5% per year during 1990-96. These figures indicate that Indonesia was experiencing a decline in yield growth rate during this time, but not a decline in yields per se. For example, although yield growth rate was 'only' 0.5% per year during 1990-96, rice yields increased from 4.25 t/ha in 1989 to 4.52 t/ha in 1996.

Productivity is defined as yield divided by the quantity of the factor affected, in appropriate units. The IRRI definition of productivity decline is "A decline in total factor productivity (TFP) over time, where TFP is the productivity of all inputs taken together". Productivity decline is not the same as a decline in production or a decline in yields.

With the three definitions stated above, some statements can be made about the current situation. First, it can be stated that there is no evidence for yield decline in farmers' fields in Asia. Secondly, there is evidence that, except for South East Asia and parts of India, most of Asia experienced lower yield growth rates during 1990-96 than during 1982-89. The South East Asian countries where increased yield growth rates occurred during 1990-96 were Vietnam, Myanmar, Cambodia, and Lao PDR. Third, there is little or no evidence of productivity decline in intensively cropped rice-rice-(rice) systems, primarily because of a lack

Figure 4.2 Trends in World Rice Production and Price, 1961-96.



Source: Production: FAOSTAT Electronic Database, 1997.
Rice Price: Relate to Thai rice 5%-broken deflated by G-5 MUV Index deflator
Source: World Bank Quarterly Review of Commodity Markets

of data. If total factor productivity was declining, this would be cause for concern. This is the reason why IRRI is collecting such data in its irrigated rice research through the Irrigated Rice Research Consortium. Two other statements relating to the third point can also be made: (i) CIMMYT scientists believe productivity may be declining in wheat in certain parts of Pakistan and (ii) IRRI does have circumstantial evidence that partial or total factor productivity decline is occurring on experimental plots at IRRI, where yields declined over time while inputs remained constant.

To ensure good measurements of the yield picture, IRRI has established more than 200 on-farm trials in 8 countries. Research results to date suggest: productivity decline observed in long-term trials at IRRI seems to be due to a decrease in the natural soil N supply and can be reversed by better N management; decreasing N supply from the soil is associated with changes in soil organic matter; depletion of soil K may be emerging as a factor; sheath blight may be involved in some cases; and micronutrients do not appear to be involved. Low fertilizer use efficiency is a continuing problem.

The IRRI breeding programme has continued to be remarkably effective. Some 750 new advanced lines are evaluated annually, and among the higher yielding lines advanced to multi-locational trials are genotypes with improved palatability and aroma and increased levels of resistance to green leafhopper. Pesticide use in many Asian countries has been reduced dramatically in recent years and it seems probable that IRRI's pest-resistant germplasm, combined with IPM, played a significant role in this outcome.

As a part of its conventional breeding programme, IRRI has been pursuing the development of a new plant type. Having developed a hypothesis about the factors limiting present day *indica* rice to around 10 t/ha, IRRI launched an initiative in 1989 to create a variety with fewer tillers to eliminate later unproductive growth, to increase grain number from 100 to 150 grains per panicle, to increase straw strength further to allow more height, and to incorporate thicker, more erect leaves for greater photosynthetic efficiency. NPT lines with 6-10, rather than the 25-27 productive tillers characteristic of, for example, IR72, have been produced. Potential grain number has been increased by a factor of 2-3. Some of these lines already have blast and bacterial leaf blight resistance incorporated.

The development of F_1 hybrid rice has long been an IRRI aim and real progress has been made over the last few years. This is particularly appropriate as only recently have some NARS come into a position to exploit the potential benefits. Hybrid rice requires a more sophisticated agricultural and commercial infrastructure for viability than the conventional inbred lines.

The initial strategy chosen was the conventional cytoplasmic male-sterile (CMS), maintainer, and restorer line approach, and these genetic stocks have now been developed by both the Irrigated and Rainfed Lowland Programmes. Yield advantages of 15-20% have been achieved together with technologies for seed production that can yield 1-2 tons per ha by commercial growers. A system of on-farm seed production has also been developed which may allow sustainability without the usual commercial infrastructure. India (where it has been shown that some farmers will pay up to 10 times the cost of inbred seed), Vietnam, and the Philippines are the initial target countries for major adoption of hybrids. About 120,000 ha were grown in India in 1997 and IRRI expects this to rise to 2 million ha by 2000. Bangladesh and Indonesia are expected to adopt IRRI hybrids before the millennium.

Studies on the population dynamics of brown planthopper (BPH), using several genotypes and insecticide treatments, demonstrated that natural biological control combined with partial BPH resistance provides satisfactory limitation of BPH populations on irrigated rice. Neither BPH-resistant varieties nor sprays with *Bacillus thuringiensis (Bt)* were deleterious to the biological control of BPH and other planthoppers. This suggests that *Bt*-transformed rice would not affect the natural beneficial arthropod populations in the field. However, field trials will be necessary to provide a definite answer.

A methodology for assessing pest, disease, and weed management practices of rice farmers was developed and used through partnership with NARS scientists for surveys in 10 Asian countries. Widespread pesticide misuse, due to an erroneous perception of the pest problem by the farmer, was observed among 80% of farmers surveyed in the Philippines. On the basis of previous research on insect population dynamics, physiological effects of insect damage, and socio-economic analysis of farmers' decision making, an attempt was made to convince farmers in various areas, through farmer field schools or other means, that insecticide application for leaf folder in the first 40 days after sowing is not necessary. The media reached 97% of the farmers in the study sites in Long An province, Vietnam, and within 3 years, farmers' mean insecticide sprays dropped significantly from 3.4 sprays per farmer to 1.6, with no yield loss. The farmers accepted the IPM concept and the information spread to other districts with the result that 77% of the farmers stopped early season spraying.[1]

Other achievements in the crop protection area included farmer-participatory research in The Philippines on tungro disease management which demonstrated the possibility to reduce disease losses by combining early planting of resistant varieties with crop sanitation to reduce inoculum carryover. Also, it was confirmed that rice yields may be improved up to 20% by cleaning rice seeds, which are often discoloured, unfilled, infected by pathogens and insects, and contaminated with weed seeds.

4.1.3 Future Strategy

While yields at farm level are not declining in any of the major rice areas of Asia, indications of slower rates of yield growth have suggested the importance of research on prediction and maintenance of soil N supply, depletion of soil K, nutrient-disease interactions, and diversity and efficacy of microbes in the soil. Also, IRRI has initiated new long-term experiments with rice-rice systems at six sites in China, India, Vietnam, Thailand, and Indonesia. Preliminary results do not allow assessment of any trends, but it is thought that through intensive monitoring at the selected sites, a system for site-specific nutrient evaluation and management might be developed. Assessment of aeration during crop development or fallow periods, crop residue management, and other soil/nutrient management factors may help to determine their effects on soil properties, soil N availability, and microbial diversity.

In the area of breeding, much more still has to be done to optimize the traits of the new plant type and to combine these with more of the necessary conventional disease and insect resistance and preferred grain quality traits. Grain filling in particular is a problem but suitable parents with bolder grains have been identified and incorporated into the NPT programme.

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1 Heong et al., 1998. Use of Communication Media in Changing Rice Farmers' Pest Management in South Vietnam. Crop Protection, submitted.

For hybrid rice, work will continue on thermosensitive genetic male sterility (TGMS) as an alternative to CMS, both by introduction and mutation breeding. Some TGMS lines have already been shared with NARS for evaluation of performance, stability, outcrossing, and combining ability. Seed production in adequate quantities remains a problem in the tropics, relative to that achieved in China, and selection continues on the tropical material to increase seed yields.

The main goal in pest management improvement is to ensure continued production capacity by protecting the rice-growing environment and the farmers themselves in the face of an intensifying cropping system. Yield is optimized by maximising knowledge input in order to decrease pesticide input and extend the durability of resistant varieties. Research will thus proceed on the understanding of the interactions among the pests, the crop, and biological control agents under intensive irrigated rice-cropping systems in order to develop systems for sustainable IPM at the farm level.

Management schemes for transgenic rice with the *Bt* gene will be developed and evaluated for their long-term sustainability and impact on arthropod environments. The prospects for durable resistance to insect pests and diseases will be enhanced through testing location-specific recommendations for the deployment of germplasm with appropriate resistance characteristics. Sheath blight resistance and control will become a major target.

The database on pest incidence and rice-cropping systems, combined with GIS, will be used to identify pest risk zones in selected countries. Predictive models will be incorporated into district-level risk-zoning. An integrated system for regional decision making to manage blast using early detection and forecasting in two blast hot-spot areas in humid Asia will be evaluated. Diagnostic kits for blast and sheath blight will be integrated into disease management decision-making at the field level.

Rice field habitat biodiversity will be studied to understand and generate habitat manipulation favouring biological control of pests. The main target is the impact of crop residue/nutrient management on natural biological control of pests. Snail ecology and weed ecology working groups will be established within IRRI. For minimizing herbicide input, the population biology of *Echinochloa* and of wild and weedy red rices, particularly the weedy form of *O. sativa*, will be researched. Work on the environmental hazards of herbicides and herbicide resistance in weed populations will be initiated. Transgenic rice with resistance to herbicide will be evaluated for its benefits and risks to contribute to developing policies on how this technology might best be used.

IPM training will be modified to include women as a target audience and to inform them of the risks of unsafe use of pesticides. Farmers' seed health pest management will also be a target for improvement. The IPM Network, integrated into the Irrigated Rice Research Consortium (IRRC), will continue to play a vital role in adapting and promoting IPM at the national level in collaboration with NARS, various NGOs, and the FAO Intercountry Programme on Rice IPM. An Integrated Crop Management approach will be adopted, linking nutrient status with pest development and promoting nutrient- and pesticide-efficient technologies across irrigated rice systems in the tropics and subtropics. Responsibility of various NARS partners in the Philippines, Vietnam, Thailand, India, China, Malaysia, Indonesia, and Lao PDR will increase with the end of funding in 2000.

4.1.4 Assessment

The hybrid programme has made impressive strides and adoption of hybrids is expected to expand, particularly in India. The partnerships forged with local seed companies will be important for the continued success of the programme. Work is planned to clarify the existence and nature of heterotic groups, possibly for the different ecosystems and environments within ecosystems, to facilitate the breeding of hybrid parents, rather than relying on the best products of the pure-line programme, seems appropriate and should be addressed in conjunction with molecular characterization of the germplasm collection (CE1). Application of QTL analysis to elucidate the genes involved in the heterotic response, specifically in IRRI hybrids, is also encouraged. The Panel is concerned that IRRI has allowed the press to quote the potential yield advantage of hybrids as 2 tons (which is achievable under only the most optimum experimental conditions), and that IRRI should encourage use of the 10-20% yield gain estimate, which would give farmers more reasonable expectations.

Apomixis research, which in theory will allow heterosis to be fixed, is continuing apace elsewhere and may become a realistic breeding adjunct in 10-20 years. In the Panel's view, IRRI should keep a close watching brief while not investing too heavily in this competitive area of fundamental research.

The Panel noted the continued progress with the development of the NPT. This strategy at present consumes about 30% of the resources of the irrigated rice breeding programme. Given the uncertainty that surrounds all plant breeding endeavours, it seems advisable to pursue the objectives of the NPT in the general context of the irrigated breeding programme. This effort was given too high a profile too soon and the Panel **suggests** that future references to this programme by Management should place it in an appropriate context, allowing the breeders the time and the options needed for the development of NPT cultivars.

The research investment of IRRI into understanding the relationship among pests, crops, and biological control agents has reached fruition in the development of improved pest management strategies transferred to farmers in 8 countries through the IPM Net. The combination of output from biological and socioeconomic research has proven very productive. The Panel commends IRRI for this achievement. The future programme builds on this successful strategy and will allow early identification of emerging problems and the initiation of research to provide the knowledge to manage them in an economically efficient and rational way. Priority setting, considering the lack of comparative advantage of IRRI for research on problems not occurring in the Philippines, will be a challenge. Further strengthening of NARS capacity and facilitation of international collaborations with ARIs in non rice-growing countries should be a part of the solution.

The responsiveness at the farmer level in relation to IPM should be most useful for channelling new information to farmers. This approach could also be valuable for other regions, but the very favourable conditions in the area chosen for the case studies should be kept in mind. Methods for efficient site-specific control of sheath blight, weeds, snails, and rats are in demand. A strategy to respond to these challenges should be developed. The sheath blight problem is also highlighted by the shift from insecticide to fungicide sprays by IPM farmers in Vietnam[2].

The Panel welcomes the integration of the IPM Net and the Mega project into one consortium. This synergy will increase the value of the heavy investment in long-term trials and provide solid data on nutrient status of the plant, crop management, and pest development.

Strategic research on weeds in irrigated and lowland rainfed rice ecosystems is important. Research on environmental hazards from herbicide use, and survey and biology of herbicide-resistant weeds should continue. Research on weed and rice competition under different environments and cropping systems is essential to formulate site-specific weed management.

Herbicide-resistant rice is a controversial issue. Although IRRI has been non-committal with regard to the development of herbicide-resistant rice, IRRI has a responsibility to evaluate available transgenic rice for its benefits and risks, and to assess the feasibility for potential use in certain rice-cropping systems.

Managing intensive irrigated rice production will continue to be more complex. Farmers want shorter duration varieties to save time in the field and to obtain better use of scarce land and water, by allowing double or triple cropping of rice or other rice + vegetable or legume crop systems. To this end, and to save labor, direct seeding is taking hold in many places. To be successful, direct seeding involves a complex of tillage, soil levelling, seeding methods, weed control, and water management. Strategic research is essential on the direct seeding/weed management/water management complex in almost all of the rice ecosystems, but it is especially needed in irrigated rice. Also, it can be expected that the higher-yielding hybrids and NPT lines will need to have strategic research on their management as well as the factors of production involved, e.g., soil, water, nutrient management, and pest management, including weeds. Such considerations were among the reasons the Panel was surprised to learn there was no general agronomist working in the irrigated rice programme.

Irrigated rice continues to be the IRRI flagship programme. The staff restructuring programme has bitten deeply into resources, particularly technical support for the breeders. Perpetuation of this situation can only be reflected in less spectacular outputs at the next review. The Panel also noted the need for more capacity in biotechnology to service the marker-assisted-selection needs of the breeders in the longer term. The Panel shared the breeders' concern about the continued diminution of resources for INGER.

4.2 Rainfed Lowland Rice Ecosystem

Rainfed lowland rice (RLR) is difficult to define precisely because of its central position in the continuum of rice ecosystems. In fact, it is usually defined by what it is not: (1) it is not irrigated; (2) it is not upland because it is flooded for part of the crop cycle; and (3) it is not deepwater (flood-prone) rice because the flooding depth is less than 50 cm. It is

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2 Do Kim Chung & Kim Thi Dung, 1996. Pest Management in Rice Production in Vietnam: A Socioeconomic Assessment.

usually transplanted, and is grown in levelled, bunded fields that are shallowly flooded with rainwater. According to IRRI, it is grown on about 25% of the world's rice area (about 48 million ha) and contributes about 18% of the global rice supply. One-third of South and South East Asian ricelands lie within this ecosystem, which dominates rice areas of Bangladesh, Cambodia, Myanmar, Nepal, and Thailand, and is important in India, Indonesia, Laos, and Vietnam. Madagascar and Brazil also have significant areas in this system, and it is estimated that several million ha in Africa could support cultivation of RLR. Because the crop is rainfed, the water supply is variable, and both drought and flooding may occur in the same season. Soil fertility is low and problem soils are common in this ecosystem. Most of the farmers are resource poor.

4.2.1 Recent Evolution and Current Focus

RLR can be divided into four subsystems: favourable, drought-prone, submergence-prone, and drought- and submergence-prone. Because the favourable rainfed lowlands can benefit from irrigated rice technology, IRRI has chosen to focus on the other three subsystems, with highest priority being given to the two with greatest potential for increased yield, the drought-prone and submergence-prone subsystems.

The RLR Programme comprises five projects across the locations of the Rainfed Lowland Rice Research Consortium (RLRRC), which was established in 1991 and operates at seven locations in five countries (Bangladesh, India, Indonesia, Philippines, and Thailand). The research has four programmatic objectives: (i) identifying rainfed lowland domains with similar abiotic/biotic stress complexes, (ii) developing varieties for these domains that tolerate the predominant abiotic stresses, yet respond to applied inputs, or favourable conditions; (iii) developing nutrient and water management strategies that maximize resource availability for crop output while maintaining the resource base; and (iv) identifying cropping system alternatives and decision-making criteria that allow a farmer to adjust systems to local requirements. Within these four objectives and five projects there are ten research areas: (i) agroecological characterization, (ii) germplasm improvement, (iii) drought tolerance and water supply, (iv) submergence tolerance, (v) nutrients, (vi) blast, (vii) weeds, (viii) dry seeding, (ix) gender concerns, and (x) risk analysis. In addition, seven research areas are listed for the Consortium: (i) physiology and genetics of submergence tolerance; (ii) germplasm improvement for South and South East Asia; (iii) physiology and genetics of drought; (iv) crop establishment and intensification, including direct (dry) seeding, weeds, and on-farm storage; (v) nutrient management/use efficiency and interaction with drought and crop establishment; (vi) risk analyses and management of technology generation and adoption; and (vii) large-scale definition of sub-ecosystems applying remotely sensed data.

4.2.2 Achievements and Impact

Steady progress has been made on characterizing the ecosystem utilizing leading-edge technologies. Members of the RLRRC have participated in this work and have gained skills in using the modern technologies. The germplasm improvement programme has been releasing cultivars through NARS, and developing or exploring new agricultural methods and techñiques. Genotype by environment (G x E) work will allow progress toward understanding the physiology of tolerance to drought and submergence and improving screening procedures for both stresses. Characterization of blast populations using molecular markers has provided evidence for the role of parasexual and sexual recombinations as mechanisms for generating genetic variation and structuring field populations. This provides useful information to increase the efficiency of breeding for blast resistance. Strategies have been devised for more effective management of nutrients in the fluctuating water environment characteristic of rainfed lowlands. Various weed control strategies have been investigated including the competitiveness of cultivars. The agronomic aspects of dry seeding have been investigated with useful results. Gender concerns have been investigated with some useful findings and there has been an attempt to quantify the nature and magnitude of risk in rainfed environments.

The RLRRC has proved to be an active partnership between IRRI and committed national programmes, with each member taking on responsibilities for one or more research problems. The first six years have seen progress in defining the problems, understanding key constraints, and developing solutions. It is recognized that RLR experiences sharp transitions in nutritional status due to the rapid changes between anaerobic and aerobic conditions, due to wetting and drying of the soil. New tools have been used to characterize rainfed lowland areas as an aid to planning and setting priorities for collaborative research. Earlier planting and direct seeding of better adapted varieties can help reduce exposure of the crop to late-season drought, and permit a short-duration, second crop to follow, thereby increasing crop diversification and using residual soil moisture. Weeds are a major constraint in RLR areas, and for direct seeding to be successful, weed control is essential. Cropping patterns gaining in use are rice-chickpea in Bangladesh and India, and rice-pigeon pea in India. From available data it appears that yield gain in RLR in Asia averaged only 11 kg/ha/yr over an 18-year period (1969-87). During that same period in The Philippines, RLR yield gains were 47 kg/ha/yr, indicating perhaps that some improvements were made in that country during that period, including perhaps adoption of modern varieties developed for irrigated conditions.

Failing a revolutionary achievement by IRRI and the RLRRC, the impact horizon of this programme will be very long. Rainfed lowland farmers are risk-averse, and changes in cultivars and practices are made slowly. Varieties released more than 40 years ago, such as Mahsuri, are probably still gaining acceptance. Impact from the additional research, in terms of improved welfare of people, will occur slowly and may, even then, be difficult to measure. Nonetheless, even modest gains in productivity in RLR will help improve the lot of many resource-poor farmers and poor rice consumers, thus helping meet equity goals while raising rice production in general.

4.2.3 Future Strategy

Programme scientists believe they have defined the issues that must be addressed during the next several years. They hope to determine the control of root growth and water extraction in the often alternating, difficult, anaerobic-aerobic conditions of rainfed lowlands, so that selection criteria for drought avoidance may be refined and molecular markers developed for this complex trait. They plan to continue marker-aided selection for submergence tolerance and hope to understand better the applicability of tolerance under different types of submergence. They see a need for research to improve the reliability of crop establishment in direct seeding, while at the same time ensuring that weed competition is effectively managed. They hope to devise a means, through early seeding, to capture the early flush of nitrate at the beginning of the wet season. They plan to investigate the role of nutrient management in enhanced seedling vigor and the role of nutrients in buffering the adverse effects of drought. Longer term studies related to gender issues are aimed at understanding inter- and intra-household strategies in sustaining food security in rainfed environments and their implications for technology adoption.

4.2.4 Assessment

It would be difficult to overstate the importance of achieving gains in productivity of RLR, not only because of the immense land area involved but also because millions of farmers in this environment face drought, floods, pests, weeds, and soil problems, often all present in the same field in a single season. Most farmers in the rainfed lowlands have few options. Even small gains in productivity of the system could affect many people. Some economic studies[3] have concluded that in Asian countries where RLR accounts for 40-50% of the area, research on this ecosystem would produce higher rates of return than research on the irrigated rice ecosystem. Indeed, production in the irrigated ecosystem is already at 70% of estimated yield potential while production in the RLR ecosystem is at only 45% of estimated potential.

The science in this programme is strong and the Panel commends the good work being done. But the time horizon is long and, at this point, the outputs of this programme are normal and measurable impacts and outcomes are minimal.

More knowledge of key adaptive traits for RLR would also be desirable in defining future strategy. The potential exists to assimilate genes from the extensive germplasm collection held by IRRI to produce cultivars that could represent a revolutionary advance in drought and submergence tolerance, as well as blast resistance. Incorporation of both major race-specific and minor blast resistance genes in adapted varieties by using marker-aided selection would increase survival ability against the extreme diversity and plasticity of blast populations. While it is important to sustain the increments achieved with conventional breeding approach, albeit aided by shuttle breeding and MAS and the associated studies in management, gender, and risk assessment, IRRI should be aiming more of its efforts toward a major breakthrough.

Because of the potential (and need) for impact in the rainfed lowland ecology; because molecular marker-assisted breeding has real and realizable potential for significant outcomes in the form of improved drought and submergence tolerance as well as blast resistance; because this work is labour-intensive; and because research support personnel is the major limiting factor, the Panel **suggests** that even higher priority be given to these objectives.

4.3 Rainfed Upland Rice Ecosystem

Upland rice is a staple crop for a large number of poor farmers in Asia, Africa, and Latin America. According to IRRI, it is grown on about 17 million ha, although the area used is larger because of rotation with fallow and other crops. It is reported to be grown on 9.2% of the rice area and accounts for about 3.8% of total rice production. It is almost always a subsistence crop with few purchased inputs. Yields are reported to have risen slowly over the

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[3] Barker, R., R.W. Herdt and B. Rose, 1985. The Rice Economy of Asia. Resources for the Future, Washington, DC, USA.
Fan, S. and P. Hazell, 1997. Should India Invest More in Less-favoured Areas. Environment and Production Technology Division Discussion Paper No. 25, IFPRI, Washington, DC, USA.

last 30 years from 0.3%/yr in India to 1.6% in Indonesia. The source of this increase is not known and it seems most probable that yields have been static. While the area devoted to upland rice has remained steady or increased slightly in some countries, the total area in Asia has dropped 16% in the past decade, most dramatically in Thailand (-90%) and the Philippines (-70%). This drop is attributed to the production of vegetables and other cash crops for urban areas and to economic policy issues, such as the relative rice to maize prices and subsidies for terracing.

4.3.1 Recent Evolution and Current Focus

The low yields of upland rice have been attributed to drought, weeds, soil nutritional imbalances, poor cultural practices, diseases, insects, and a lack of suitable varieties. The stated objectives of IRRI's programme are: to develop understanding and technology to maximize productivity and sustainability of upland rice where it is grown; to help maximize returns for farmer effort; and to reduce the area needed to satisfy demands for upland rice. The research areas identified are (i) germplasm improvement to overcome the major abiotic and biotic stresses, moving away from traditional breeding and selection and using new technologies to target, characterize, and incorporate desired genes (possibly including perennial rice and allelopathy); (ii) strategic understanding of nutrient availability in upland soils; (iii) biotic constraints with a focus on weeds, nematodes, and blast; and (iv) study of the socioeconomics of the uplands designed to understand the dynamics of the systems and the impact of new technologies and policies. New statistical procedures have shown (to no one's surprise) that the upland ecosystem is quite variable, which has led to a strong initiative to decentralize the conventional breeding efforts.

Presently, the focus is on the following specific research topics:

(i) **Germplasm improvement.** Improvement of productivity and stability of varieties is sought through incorporation of (1) drought tolerance through adapted duration, good root systems, and osmotic adjustment, (2) durable blast resistance, and (3) improved interference with weeds through improvement of allelopathic potential and rice competitiveness. Areas under investigation include root ultrastructure, vulnerability of the water transport pathway, and direct effects of water deficits on panicle sterility. The ultimate aims are to transform upland rice - still basically an aquatic plant - into a crop fully adapted to aerobic soil conditions; improve the value of the crop through good grain quality; develop a perennial upland rice to help reduce erosion in areas with steep slopes and high rainfall; and develop a participatory plant breeding programme in Eastern India to analyze adoption rates of improved rainfed germplasm and determine if farmer participation at any stage of the breeding process improves adoption rates.

(ii) **Resource and crop management improvement.** This research is concerned with the production potential of upland rice, long-term strategic studies on nutrients, nutrient x water interactions, weeds, and nematodes.

(iii) **Economic and policy analysis.** This research includes the examination of the livelihood strategies of upland farmers and changes in land use at the farm level, and the comparative analysis of the economics of upland rice systems over a range of biophysical and socioeconomic environments.

The Upland Rice Research Consortium (URRC), with collaborating institutions from Brazil, Germany, India, Indonesia, Laos, Philippines, Thailand, and Vietnam, provides a framework for much of this research. Numerous other countries and institutions are associated with the URRC.

4.3.2 Achievements and Impact

Molecular technologies have been used to map genes controlling root morphology, to characterize blast pathogen populations, and to analyze blast resistance genes. Strategies (yet unproven) have been developed to improve the durability of blast resistance, and a genepool aimed at improving partial resistance to blast has been assembled. Crosses have been made to perennial types and mapping populations are being developed. Nematode resistance has been reported in *O. longistaminata,* one source of perenniality. Allelopathy in rice has been demonstrated under laboratory conditions but cannot be separated in the field - if it is manifested there - from competitive effects. Work has been conducted and papers produced on the productive capacity of upland soils and the production potential of upland rice, phosphorus deficiency in low-input upland systems, soil spatial variation in the uplands, subsoil acidity amelioration, fertilizer formulation and placement, nutrient dynamics, nutrient x water interactions, weed competition, allelopathy, nematode dynamics, importance of market access, comparative analysis of upland systems, and the analysis of soil conservation strategies.

4.3.3 Future Strategy

Drought, weeds, nematodes, phosphorus deficiency, and blast are the dominant problems of the ecosystem. Genetic solutions will be pursued using marker-aided selection techniques resulting from recent advances in molecular biology. Research will be continued to expand the knowledge of genetic control of these traits using molecular markers. The feasibility of a perennial upland rice will be evaluated. Resource management work will focus on policy, nutrient management, dynamics of soil erosion, and integrated pest management (particularly weeds). The Upland Rice Research Consortium will provide a collaborative mechanism for work on (i) soil-plant-water relationships, (ii) socioeconomics, (iii) adapted germplasm, and (iv) human resources.

4.3.4 Assessment

IRRI began working on upland rice more than a quarter-century ago, and although numerous outputs (varieties released, publications, etc.) have emerged, it seems fair to say that impact has not been demonstrated.

The quality of science in this programme is good, but is not appropriately directed when opportunity costs are considered. That is, the resource expended in this programme would provide higher returns if expended on the rainfed lowland ecology. Upland rice has represented a dilemma for IRRI for more than 20 years. The first strategic plan, formulated in the late 1970s, stated that investments in upland rice research were not justified. Because it is an important crop for so many small farmers, many donors have pressed for IRRI's continuing involvement even though the problem appeared, and continues to appear, intractable and the area in upland rice is declining.

Resource management research in the highly variable upland rice ecology populated by resource-poor farmers is a clear demonstration of the difference between a need (which it is) and an opportunity (which it is not). This observation is supported by common sense and the lack of any impact. The major need in the resource management arena is a solution to the problem of phosphorus availability. Without a solution to the phosphorus problem, other interventions (including genetic and policy interventions) will have little impact in the upland ecosystem.

IRRI has continued to accept resources directed toward upland rice research. Currently, of the 8.1 scientist-equivalent positions in the programme, only 1.8 receive salary support from core funds. About 80% of the operating budget comes in the form of restricted funds from specific donors. The NARS need upland rice research by IRRI and the donors support the programme. The Panel considers this situation acceptable because of the valuable spin-off toward the solution of problems common to other ecologies (phosphorus availability, drought tolerance, and blast resistance, for instance) but **strongly suggests** that, where possible, IRRI direct attention to the most tractable ecosystems, where impact could be expected[4], or where, even in the absence of impact, the intermediate outputs of this programme could be substantial and useful in relation to other rainfed ecologies.

4.4 Flood-Prone Rice Ecosystem

Flood-prone rice is defined as that growing on inland areas where the sustained water depth exceeds 50 cm and tidal (coastal) wetland rices. Some flood-prone rice zones have undergone dramatic change with the availability of varieties and low-cost irrigation facilities that allow for the production of a high-yielding dry (boro) season crop. During the flooding period the land may be fallow or be used for alternative purposes, such as fish and shrimp farming. The traditional culture persists on about 70% of the original flood-prone area, covering approximately 12 million ha, mostly in Bangladesh, Cambodia, India, Myanmar, Thailand, and Vietnam and accounting for 4% of world rice production.

4.4.1 Recent Evolution and Current Focus

IRRI has adjusted its focus from emphasis on breeding deepwater rice varieties for flood-prone areas (work now devolved to NARS) to giving increased attention to strategic pre-breeding research and crop and resource management to improve productivity and sustainability of these lands. The objectives are to evaluate socioeconomic and biotic constraints to productivity of flood-prone rice, analyze the roles of mineral elements in flooding tolerance and productivity of rice cultivars, develop environmentally sound soil and water management strategies, and determine the potential effects of global warming and changing weather patterns on flood-prone ricelands. Coastal areas are the primary focus and there is an emphasis on partnerships between concerned NARS. Crop improvement activities now focus on semi-deep and coastal areas utilizing molecular marker-aided selection techniques for resistance/tolerance to soil-related stresses, submergence tolerance, novel genotypes for increasing yield and improving yield stability, and improving micronutrient content to enhance human nutrition.

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4 IRRI Upland Rice Ecosystem Programme. The Future of Upland Rice. EPMR briefing document, 22 pp.

4.4.2 Achievements and Impact

To the extent that IRRI has been responsible for the cultivation of high-yielding, short-duration boro rice in the flood-prone zones, achievements and impact have been dramatic. However, it seems clear that the varieties that are utilized originated from irrigated breeding programmes, including that of IRRI, rather than the flood-prone programme, and it appears that their cultivation in the zone was a result of farmer initiative and was not based on research by IRRI, but rather by partner NARS. Thailand has now assumed regional responsibility for South East Asia at its own expense and Thai varieties have been released in Cambodia and Vietnam. To date, varietal improvement or modified cultural practices have resulted in few achievements, and the impact has been negligible. However, IRRI now focuses on the semi-deep coastal areas for which a new plant type has been developed incorporating need-based elongation and high-yielding plant type characteristics above water. Achievements of potentially major impact are the tagging of major genes and QTL identification for submergence tolerance, elongation ability, salinity tolerance, and phosphorous efficiency. The pyramiding of genes controlling different physiological mechanisms for salt tolerance has been accomplished, but field verification is needed to prove the usefulness of this approach.

A significant development in which IRRI has been involved is the pioneering reclamation of acid sulfate soils in Vietnam that are annually subject to severe flooding. Here a management system worked out by scientists of Vietnam, IRRI, the International Mekong Committee, and the University of Wageningen contributed to the conversion of hundreds of thousands of hectares of low-productive deepwater ricelands, many of them in the Plain of Reeds, into highly productive rice fields. Here double and triple cropping with high yields (4-5 t/ha/crop), even in the first year after reclamation, are being achieved. Some off-site adverse effects of this conversion have also been quantified and corrective measures applied. This development is exciting and the experience in the proper use of acid sulfate soils in flood-prone areas is valuable.

4.4.3 Future Strategy

Using the approaches outlined in section 4.4.1 above, the strategy is to assist in the development of sustainable intensification/diversification systems to reduce poverty; to develop appropriate soil and water management techniques for acid, acid sulfate, and peaty soils that will prevent pollutants from leaching into waterways and affecting downstream flora and fauna; to produce novel genotypes tolerant of soil and water-related stresses and with improved nutritional properties; and to provide national policymakers with information on the socioeconomic and environmental impact of intensification as well as to increase the sustainable use of flood-prone ricelands.

4.4.4 Assessment

The acid sulfate soil land reclamation effort in Vietnam has led to the settlement and conversion of flood-prone lands into highly productive ricelands, and the Panel commends the innovative collaborative NARS/IRRI /ARI research that made this impact possible. Otherwise, this programme has shown limited direct impact. The changes in cropping pattern in the flood-prone ecosystem would have happened without this programme. The quality of the science in this programme is good and a number of commendable outputs have been noted. While a number of exciting new efforts in the programme, such as the improvement of human nutrition through the genetic manipulation of micronutrient content, and the combining of salt-tolerance genes, are very worthy of pursuit, they are relevant to all ecosystems and do not justify the retention of the flood-prone research activities as a separate research programme.

4.5 Cross Ecosystems Research Programme

The Cross Ecosystems (CE) Programme was established as a vehicle for research comparing the different systems or developing tools and methods applicable to all ecosystems. The five projects in the Programme are extremely diverse, ranging from macro policy to molecular biology. In this review the Panel has separately addressed those projects involving: (i) biotechnology tools and their application to breeding and germplasm assessment and exploitation, and the technology transfer to NARS (Projects CE-1,2 and 6); (ii) rice pest and disease biology (CE-3); (iii) quantification of different ecosystems (CE-4); (iv) nitrogen fixation in rice (CE-7); and (v) socioeconomic aspects of the different ecosystems (CE-5).

4.5.1 Germplasm Characterization, Biotechnology, and ARBN

4.5.1.1 Recent evolution and current focus

IRRI holds the world's largest collection of cultivated and wild rices. It has long been recognised that the value of, and ease of access to, the collections is enhanced by description and characterization in terms of traits of interest. Characterization of the individual accessions with the new generation of molecular diagnostics can now add efficiency by identifying near-duplicates among the 80,000 accessions, and by identifying manageable subsets of the material - 'core collections' - which will enable access to the widest ranges of variation. Similarly, the wild relatives of rice, a vast untapped resource of potentially beneficial genes, are more accessible when their cytogenetics, genome structures, crossabilities, and taxonomy are better understood.

DNA markers, which first became available to plant geneticists 10 years ago, offered the possibility of 'breeding on the laboratory bench' for adaptive genes which are difficult or expensive to recognise and select for in the field, and to assemble them in combinations that would be extremely difficult by conventional breeding techniques. The first molecular maps of rice became available eight years ago and IRRI scientists were quick to recognise the opportunities afforded and have since been at the forefront of their application in breeding. Molecular biology also offered the possibility of transferring isolated genes directly into rice. Genetic transformation could be used to introduce beneficial variants of natural genes back into rice more quickly than by crossing and selection or to introduce natural or synthetic genes not normally available to the breeder to produce enhanced or novel phenotypes. Since 1992, IRRI has built up capability in the various techniques of transformation and is already producing transgenics containing genes with potential for insect, disease, and stress tolerance.

4.5.1.2 Achievements and impact

Preliminary research has demonstrated the power of molecular classification to identify duplicates and establish relationships among germplasm bank accessions of both cultivated and wild rice. More than 100 accessions representing the eight putative species in the AA genome group, which includes *O. sativa,* have been investigated by intercrossing and cytological analysis of the hybrids. The work has resulted in the reclassification of *O. ridleyi* and *longiglumis* as conspecific and elucidated crossability and chromosome pairing relationships among these species, which represent the first port of call for breeders screening in the secondary genepool.

Aided by molecular technology, the wide-cross programme, which has now succeeded in producing interspecific hybrids between all wild *Oryza* species except one, continues to provide both novel materials for use by breeders and fundamental knowledge of importance to rice taxonomy and cytogenetics. Notable successes of importance to IRRI's breeding programme include the identification and introduction of new genes from wild species including blast resistance, BPH resistance, and the broad spectrum bacterial blight resistance gene, *Xa21*, which has since been cloned elsewhere and returned to IRRI for use in the transgenic programme.

Among the achievements gained through application of markers was the alignment of the cytological and genetic maps, by locating the rice chromosome centromeres on the genetic map using unique cytogenetic stocks produced at IRRI. This work was significant in bringing together and standardising the major international rice genome maps, which are now shown using the IRRI alignment. The IRRI group has made major contributions in the genetic mapping of many adaptive genes, including resistances to pests and diseases and traits relating to hybrid rice production. The same technologies have been exploited to produce novel resistance gene pyramids and transfers of beneficial genes discovered in wild relatives.

Progress has been made in developing transformation technology and, although efficiencies are still low, transformation is now possible with all rices, including the NPT. Potentially insect-resistant (*Bt*) and sheath blight-resistant transformants have been produced and many other constructs are in the process of being genetically engineered into rice.

Doubled haploids produced by tissue culture, an adjunct to transformation, have been used to accelerate breeding programmes, e.g., in the production of new salt-tolerant lines ready for release in the Philippines.

The Asian Rice Biotechnology Network was set up in 1993 with the aim of building biotechnology strengths in NARS institutes. An ARBN laboratory, overseen by IRRI staff, has been set up to receive trainees and collaborating researchers from the ten member countries. Some ten visiting scientists use the facility each year, and about five training courses, some lasting up to eight weeks, are run each year. Exciting collaborative research on bacterial blight and gall midge fingerprinting, and fine mapping and pyramiding of bacterial blight and blast resistance genes has been achieved.

4.5.1.3 Future strategy

Mass analysis of accessions with molecular markers is planned to move further towards establishing 'core' collections. The improved knowledge of the wild relatives of rice will be exploited to enhance methods of alien transfer from even more distant relatives, thus extending the available genepool in the search for novel genes, e.g., those controlling tungro, yellow stem borer, sheath blight resistance, and submergence and acid-soils tolerance. The mapping of wild-cultivated cross progenies has exposed unexpectedly small introgressed interstitial segments. The underlying mechanism will be further investigated.

The use of MAS will continue to be integrated as a common enabling technology for IRRI's breeding. Gene mapping activity will be directed increasingly at extended backcross analysis of the genes underlying quantitative traits (QTLs), such as yield, in both cultivated and wild rice.

Transformation research will continue, particularly to improve efficiencies from the current 0.1% and to enable the technology to work with all genotypes. Transformation targets include a host of newly isolated genes with potential to confer disease and pest resistance, submergence and drought tolerance, and grain size and quality obtained from collaborators, particularly in the RF Programme.

4.5.1.4 Assessment

Overall, most of IRRI's work in the biotechnology area, both as housed in PBGB and EPPD, is of the highest quality. Moreover, the Panel believes that the strategic sub-projects being carried out alongside the more applied activities are important as the channel through which IRRI has access to, and can take advantage of, the new developments in molecular biology and the products of the extensive network of rice biotechnologists around the world.

The Panel endorses the research on germplasm characterization and taxonomy, which can improve still further the key resource represented by the collections. Moreover, the Panel endorses the new research role of GRC which, in earlier times, was assigned only a service activity. However, some overlap was noted between former CE-1 and CE-2 in taxonomy and genome characterization research and the Panel believes that greater coordination would be valuable. Identification of potential heterotic groups to facilitate hybrid breeding parents will become important (IR-1) and the Panel hopes that these goals will be aligned with the more general germplasm characterization (CE-1) in the future.

The proposals to extend research to the identification of key QTLs were considered appropriate. The Panel noted that the role of the Biotechnology Group no longer provided a MAS service for breeders, but now provided laboratories for the breeders' use. In view of the staff shortages which constrain use of the laboratory, the Panel **suggests** that IRRI investigate the potential and cost-effectiveness of some developmental work on the application of automation and robotics in MAS.

The work and future plans in the tissue culture and transformation areas were judged to be appropriate and to be using external collaborations to best advantage. The Panel noted that a continued lack of a regulatory framework to enable field testing of transgenics in the Philippines would soon erode the advantages of IRRI over other partners as a potential collaborator, and suggests that senior management continue to do everything possible to hasten this process.

An area of science not addressed in the MTP is bioinformatics - the assembly, linkage, and manipulation of data relating to the collections, breeding, trials, genome studies, and DNA sequence data. In order to maximize utilization of the vast amount of information being generated at IRRI alongside that already collected in all the major cereals, the Panel suggests that IRRI establish a presence in this area while information exchange is still free (see Biometrics Unit in Chapter 5).

The Panel was impressed with both the concept and the operation of the ARBN. They noted a complementation between ARBN and the RF Network and saw the Project as an ideal means of partnership building and continuous technology transfer.

The excellence of IRRI's applied research and contributions notwithstanding, the recent radical developments in plant genomics, and rice genomics in particular, are good reason to revisit IRRI's future in the post-genomic age, which will begin as early as next year when the first rice genomic DNA sequence becomes available. IRRI should consider carefully how it can exploit its comparative advantages to maintain a central position and thereby continue to provide its NARS with the best advice, training, technology, and germplasm. The proposal presented to the Panel of establishing a major 'knockout' facility, using either transposons or deletion mutants, for application in gene function analysis may be extremely timely and should bear serious consideration (see Advances in Rice Genomics in Chapter 6).

4.5.2 Exploiting Biodiversity for Sustainable Pest Management

4.5.2.1 Recent evolution and current focus

This project evolved during the period under review from the previous Crop Ecology and Pest Science Sub-Programme. Its aim is understanding the key relationships between a spatial and temporal mix of organisms that maintain habitat diversity and that contribute toward the stability and resilience of rice ecosystems. This knowledge will assist in the development of strategies and on-farm practices that promote sustainable management of pests.

Many of the plant resistances incorporated in earlier years, especially those based on single genes, were not long lasting, when used on a large scale under certain pest pressures. Because durability of resistance to insect pests and diseases is a central issue in sustaining the productivity of rice across ecosystems, strategic research on the genetic diversity of pest populations as well as on the genetic bases for pathogenicity in the pest and for resistance in the host is required. This would allow the development of models for simulation of rice-pest coevolution and of strategies for improving and deploying resistance.

Predators and parasites of insect pests in the rice ecosystems are essential for containing harmful pest populations at a tolerable level. This has been demonstrated and utilised in developing IPM strategies. At the crop level, the diversity and dynamics of pathosystems and of pests' natural enemy communities must be analysed and linked to farming practices and the presence of habitats other than the rice crop within the rice ecosystems. These data will allow the development of biodiversity management strategies that ensure the resilience of the crop to pests.

Quantitative data on pest constraints, crop losses in varying production situations and environmental parameters at the plot and regional level are necessary for both systems analysis and simulation, and for a better understanding of the processes linking the pest genome, plant genome, crop, ecosystem, and the region. These simulations are used for predicting the durability of disease resistance genes, modelling pest development, assessing pest risk in emerging production systems, and developing location-specific pest control schemes.

4.5.2.2 Achievements and impact

Near isogenic lines and lines with gene pyramids were developed by IRRI to assay virulence of blast, bacterial blight, and tungro viruses, and for estimation of host resistance genes in germplasm. Mixed planting of rice varieties having different genes for resistance has demonstrated a positive effect on blast control in upland and irrigated rice.

Molecular tools have been developed and transferred through the ARBN to NARS for pathogen characterization and genetic diversity analysis of the blast, bacterial blight, and tungro pathogens. Effectiveness of *Pi-2/Pil* against blast and *Xa7* genes against bacterial blight has been demonstrated in the Philippines. RFLP analysis has been applied on gall midge from six countries, and the results have been used in the specification of the screening sites for resistance and for possible resistance deployment strategies.

The efficacy of *Bt* toxins from eight lines of *Bacillus thuringiensis* has been tested against stem borer and leaf folder populations. Yellow stem borer populations collected in China were found to be much less susceptible to tested *Bt* toxins than populations from the Philippines, with resistance factors reaching around 70 against *Cry*IIA and 160 against CryIC. This highlights the risk that plants with the gene for these toxins may not perform well for yellow stem borer control, as well as the need for undertaking in-depth studies of pest population susceptibility before embarking on rice transformation.

Pioneering studies have been undertaken on the importance of non-rice habitats for enhanced biological control of insect pests, identifying several predators and parasitoids from grassy areas. Biodiversity research tools have been developed and NARS partners trained in their use in various environments. Ecostatistical software has been written to elucidate the structure and dynamics of invertebrate communities across rice landscapes.

A crop-loss database has been developed by IRRI from surveys of more than 700 farmers' fields in South and South East Asia, and from experimental data from more than 400 plots. A survey portfolio has been produced for the characterization of rice pest constraints. Currently, the Experimental Rice Crop Loss Data cover a range of attainable yields from 1.7 to 11 tons/ha, and report damage in the range from 0 to 4.3 tons /ha (in absolute terms) or 80.6 % (in relative terms) in response to 11 different injuries alone or in various combinations. A simplified crop model has been developed to handle the database; and correspondence analysis techniques have been developed for improved pest profile characterization for IPM.

4.5.2.3 Future strategy

The project objective is to improve the use of and to develop new environment-friendly pest management tools. These tools will include deployment strategies, biocontrol agents, single- and multispecies models, and spatial designs of rice and non-rice habitats.

Gene deployment strategies will be developed according to both the type of resistance genes in rice germplasm characterized by rapid molecular diagnostic tools, and the durability of these resistance genes evaluated by predictive models taking into account possible fitness penalties associated with pathogen adaptation, through the frontier project *'Predicting durability of disease resistance: the gene to gene relationship'*. Further, new genes will be identified from rice germplasm and non-rice sources for durable resistance to insects and diseases. Sheath blight resistance and control will be the main target of research.

Ecological statistics are being used to develop software that will determine spatio-temporal patterns of vegetation and invertebrate populations across paddy landscapes. Habitat diversity strategies for improved biological control of pests will be distilled into "simple rules" for farmers' participatory research. NARS scientists will be trained at a "lighthouse site" for site characterization, landscape ecology, invertebrate and microbial taxonomy, and varietal improvement strategies.

The new simplified crop growth model developed for characterizing pest damage will be used to check results of risk analyses and to extrapolate results for future scenarios. Crop-loss surveys will be carried out in other areas, enhancing the value of the crop-loss database. The epidemiological model for sheath blight will be further improved for use in evaluating sheath blight management options.

4.5.2.4 Assessment

Very good innovative research on relevant topics for pest management improvement in various rice ecosystems is performed under this project. Some detailed portfolios for data collection and analysis have been prepared for use by trained NARS partners. The Panel commends the projects' scientists for these achievements.

The idea of combining the potentials of biotechnology for characterization of pathogen and host populations, with ecology and systems analysis of the rice ecosystems, in order to manage biodiversity for rice protection, is excellent. Cross-linkages between genome diversity and ecosystem diversity are identified in some of the research topics, and some staff members clearly articulated their views on ways to maximize these interactions. The project could increase its impact by focusing integrated team work with Ecosystems Programmes on carefully selected case studies.

The Panel is convinced that the assembly of quantitative information on crop losses due to pests under certain management practices and ecosystems and its use for systems analysis and modelling are vital to the development of sound plant protection management practices, as well as for making policy recommendations. The Panel was therefore pleased that a senior NRS scientist will assure the maintenance of the ecosystem database when the present projects' funding ends in 1999.

4.5.3 Systems Approaches to Quantify Performance of Rice Ecosystems

4.5.3.1 Recent evolution and current focus

IRRI is involved in systems analysis to investigate processes and their interactions using mathematical models to describe and quantify individual processes and critical factors that limit yield. Individual processes are linked to crop performance by integration of models. Models so developed are used in specific ecosystem research programmes by providing a physiological basis for germplasm selection for specific environments. The project was funded in 1997 at US$ 659,000.

This work is carried out under Project CE-4, which includes activities in three areas: (i) relationship of response of physiological and soil-related processes to quantified environmental factors; (ii) process-based models that simulate rice production in various ecosystems developed for use in quantifying constraints to rice production in agroecological zones, and resolving specific ecosystem problems related to yield potential and optimization of water, nutrient, and pest management; and (iii) continued support for national programme teams trained in use of systems techniques for generating and synthesizing research knowledge.

4.5.3.2 Achievements and impact

The basis for a 15 t/ha yield of Shanyou 63 grown in the Yunnan Plateau in China was determined to be: high production of biomass, high sink size, high leaf area index and leaf area duration leading to high radiation use efficiency and low night respiration rates. *Indica* rices were found to have higher photosynthetic and respiration rates and higher biomass production than tropical *japonica* rices.

A rice crop physiological model, ORYZA, was developed to simulate rice growth and development. A model for N management was applied to estimate yields under different scenarios, including climate change. Crop models and pest modules are being coupled to estimate pest-induced yield loss. A simplified rice model was developed and calibrated to simulate injury mechanisms in different production situations.

Uptake of soil N was limited by root uptake properties and N diffusion to root surfaces. Completed physiological research indicated the importance of lowering panicle height to increase yield of irrigated rice. In modelling, the BLASTSIM.2 model was validated and calibrated in Thailand. A simple model identified the process that governs efficiency of grain filling. Simulation models were validated for rice-wheat systems in Bangladesh, India, and China, that gave improved understanding of variety, moisture, and nitrogen interactions. A rice blast polyclonal kit tested in northern Thailand indicated agreement between kit reflectometer readings and severity and incidence of panicle blast.

Fourteen teams from seven NARS were trained and equipped for systems research. National networks were developed in selected NARS for applications in crop and pest management.

This work is aimed at developing knowledge and/or methodologies to improve research by IRRI scientists and national collaborators, and its impact will be difficult to measure except in terms of improved research methods or output.

4.5.3.3 Future strategy

IRRI plans to acquire knowledge and tools by developing systems approaches and models that integrate knowledge on favourable and unfavourable environments and predict ecosystem behaviour in different situations. IRRI will work with NARS to establish joint research priorities for agroecological zones and rice ecosystems.

In physiology studies, IRRI plans to study causes of poor grain filling in the wet season, and evaluate the hypothesis that poor grain filling in the new plant type may be due to lack of apical dominance of spikelets.

4.5.3.4 Assessment

IRRI has been involved in modelling work for more than a decade, and the work appears to be of good scientific quality. Developing tools and research methodologies, suggesting new approaches, improving the knowledge base concerning rice and its production, and helping NARS to improve research capacity are likely to be modelling's main contribution. The work on the physiological basis of very high yield in China is very interesting, as is the work on the physiological reasons for poor grain filling in NPT and in the wet season. Such work can provide essential information to help solve problems affecting rice productivity.

4.5.4 Assessing Opportunities for Nitrogen Fixation in Rice

4.5.4.1 Recent evolution and current focus

IRRI designated this effort as one of its new frontier projects in its 1994-98 MTP, and described it as follows: «Enabling rice plants to fix nitrogen to help reduce the dependence of farmers on chemical nitrogen and thereby achieve a more environmentally-friendly rice production system».

This work is done under Project CE-6, which includes research activities in four areas: (i) non-nodular associations, (ii) nodular associations, (iii) transfer of nif genes to rice, and (iv) CO_2 fixation and N use efficiency. The project also includes efforts related to the Biological Nitrogen Fixation Working Group, which has prepared a proposal for a Frontier Project on N_2 Fixation.

4.5.4.2 Achievements and impact

Methods have been developed to identify nitrogen-fixing bacteria in pure culture and their presence in plant tissue. This method is used to help screen putative endophytic bacteria isolated from field-grown rice. Methods to isolate rice root endophytes have been developed and the endophytes were marked with a gene so their colonization could be studied. N_2 fixing bacteria have been found to be associated with rice seeds. In studies of possible nodulation, some rice varieties were found to have the ability to induce gene expression in Rhizobia.

The future impact of this project will depend on a major, and in the Panel's view unlikely, breakthrough.

4.5.4.3 Future strategy

Work will continue in the four research areas listed in 4.5.4.1 above.

4.5.4.4 Assessment

This project is well-funded and was projected to receive US$ 0.869 M in 1997. In the absence of a CCER or peer review paper that had reviewed the project in depth as to focus, approach, and probability of success, it is difficult for the Panel to make judgments on its work. However, the possibility of success for nodulation in rice appears remote. The Panel is pleased that a peer review is scheduled to review the focus and approaches taken by the project on nitrogen fixation in rice. The Panel also **strongly suggests** that this review addresses the timeliness and likelihood of success of the project.

4.5.5 Constraints To Sustainable Development of Rice Ecosystems and Technology Impact and Policy Analysis

4.5.5.1 Evolution and current focus

In order to facilitate the transfer of technology to farmers across various cross-ecosystems to enable them to augment their farm production, it is important to understand the socioeconomic setting in which they are operating and to have information on the numerous socioeconomic and biophysical constraints they may be facing in adopting the new technology. The main objective of this programme is to collect information on socioeconomic indicators and on characteristics of agroregional and rice ecosystems with a view to the planning and prioritization of research. This involves undertaking interdisciplinary research and coordination with various scientific and social science departments. It also involves setting up priorities for research that could both evaluate the nature and extent of new technology absorption and its limitation and its ex-post impact on different socio-economic groups, income distribution, and poverty alleviation. The programme also aims at monitoring developments in the rice sector regarding changing patterns of production and consumption and the impact of trade liberalization, input use, and pricing policies and their implications for rice research. The other objectives are: to project medium- and long-term demand and supply balances for rice for major rice-growing economies in the context of changes in socio-economic conditions and macro-economic policies; to assess the importance of rice in the rural household economy and analyze the relationship between productivity growth in rice cultivation and expansion of the rural non-farm sector; and to contribute to the strengthening of NARS to undertake socioeconomic research studies on their own or in collaboration with IRRI.

The main priority research areas are: (i) to maintain and update the socioeconomic database on rice ecosystems, monitor levels in rice output and yield and draw implications for policy; (ii) to develop methodologies for delineating homogeneous regions on the basis of both biophysical and socioeconomic factors and develop approaches to addressing location-specific problems; (iii) to study the effect of rice and non rice production systems on food security; (iv) to evaluate the impact of new improved technology on income distribution, poverty, and women's welfare; (v) to analyze priority research problem areas and evaluate rice research capacity of NARS; and (vi) to identify strategies for improving farmers' income through commercialization of farming.

4.5.5.2 Achievements and impact

In the comparative analysis of rice ecologies, IRRI has built a rice statistics database, conducted rice sector analysis, and collected data on rice research capacity in different NARS. Also, IRRI has completed a study identifying constraints and factors contributing to yield gaps in partner countries.

Two publications (*World Rice Statistics, 1993-94;* and *Rice Almanac*, Second edition, 1997) are being brought out regularly. Another statistical publication is *Rice Area by Type of Cultivation*. These, and other publications dealing with rice supply and demand at the regional level, will help policymakers and research scientists in determining research priorities and planning.

IRRI has completed, and published the results of, a project on "Projections and Policy Implications for Medium- and Long-Term Rice Supply and Demand", in collaboration with IFPRI and National Policy Research Institutes in seven major countries. IRRI has also undertaken various projects on identifying socioeconomic constraints in different environments.

Research has improved understanding of farmers' decision-making processes in different ecological settings in relation to changes in the rural household economy. Impact studies include evaluation of the effects of new technologies on equity, poverty, and sustainability. This work includes a survey, initiated in 1996, of households to assess the differential impact of technology changes across various categories of farmers and households.

National policymakers, donor communities, and research managers have been informed of technological progress in the rice sector and the constraints to removing the yield gap at the national and subnational levels.

4.5.5.3 Future strategy

The strategy is, using the approaches outlined above, to assist in the development of appropriate technological packages in different ecological regimes with a view to augmenting the production of rice, the main crop, and other crops grown with it. Attempts will be made to look at the household economy by including allied farm and non-farm activities.

The new MTP proposes studies on assessment of rural conditions in Myanmar, Eastern India, Madhya Pradesh, Bihar, and eastern Uttar Pradesh.

On gender, the Project aims to generate information on involvement of men, women, and children in economic activities and the household decision-making process and their separate contribution to household income, and future work will assess the impact of improved technologies on the well-being of women and children. IRRI will also evaluate the impact of migration of men on women's' involvement in farming and effect on management of farms and input use efficiency

4.5.5.4 Assessment

Social science work at IRRI is quite strong. The creation of the Ricestat International and Country Sources database and its dissemination are an important development. The addition of GIS will also be a useful aid in delineating homogeneous regions. The numerous studies on demand - supply of rice, impact of new technology on poverty, and income distribution across different ecological regions are not only quite rich analytically but also provide useful guidelines for future planning and policy making.

However, the Panel observes some important gaps in the range of socioeconomic studies. Firstly, studies confined to rice only, without taking other crops into account, are only partially able to capture the impact of new technologies on household incomes and their living standards. Hence, there is a need to undertake studies of rice and other crops together with allied farm and off-farm activities. The second major limitation is that little information has been collected, and much less analyzed, on natural resource management and decisions taken by farmers. The Panel **suggests** that IRRI review its approaches regarding these areas.

4.6 Overall Assessment and Recommendations

The Panel was able to examine a considerable proportion of the IRRI research Programmes. It found that most of the work was scientifically exciting and of good quality.

Most of the important research objectives (drought tolerance, submergence tolerance, salt tolerance, improved human nutrition, etc.) cut across more than one of the three rainfed programmes and the breeding techniques needed to address these objectives are the same. A reduction in administrative effort and transaction costs is desirable and limited resources must be used in an efficient and flexible manner.

The Panel **recommends** that the Rainfed Lowland, Rainfed Upland, and Flood-prone Programmes be combined into a single Rainfed Rice Programme, in which related lines of work can be brought together, emphasizing those where prospects for success are greatest.

The Panel noted the fact that the Irrigated Rice Programme no longer has an agronomist. They also noted the need for more technical staff to support plant breeding, and in the longer term for more capacity in biotechnology to service the marker-assisted selection needs of the breeders. Molecular marker-assisted breeding promises important advances in the form of improved drought and submergence tolerance, improved pest resistance, and other important traits. This work is labour-intensive and research support personnel is the major limiting factor.

The Panel **recommends** that the research staffing in the Irrigated Rice Programme be reassessed with the aim of filling key positions, including an IRS agronomist with wide experience and certain skilled support staff in critical areas of work .

CHAPTER 5 - RESEARCH DIVISIONS AND SERVICES

5.1 Disciplinary-Based Divisions

IRRI established disciplinary-based divisions when it implemented its Research Matrix in 1992. The concept was to provide a mechanism by which each Programme could draw from a range of disciplines adjudged necessary to carry out its work. In IRRI's words, 'the programmes ensure the right research is done, while the divisions ensure the research is done right'. Within this concept, 'division leaders are responsible for maintaining and enhancing scientific quality and enriching the disciplinary knowledge base'. Division heads are responsible for implementing project activities within the division and helping in career development, recruitment, and performance evaluation of division scientists. Division heads also are expected to establish and maintain linkages with other research institutions, particularly those involved in basic research.

5.1.1 Plant Breeding, Genetics, and Biochemistry

The Plant Breeding, Genetics, and Biochemistry Division (PBGB) was formed in 1989, combining the plant breeding groups with biochemistry. In recent years the emphasis on biochemistry has declined in favour of the new biotechnology group. The eleven IRS staff and one affiliate scientist comprise eight plant breeders, three molecular biologists, and a cytogeneticist. In addition, the Division has seven project scientists, a visiting scientist, and 73 NRS. The plant breeders work with staff in EPPD and APPA in each of the four ecosystem programmes while the strategic research is carried out in the Cross Ecosystems Programme.

PBGB is the hub of the successful irrigated rice pure line and hybrid rice breeding programmes, as well as the inspiration for the 'new plant type' programme. Although selection for grain quality continues, this is mainly restricted to consideration of aroma, grain shape, and amylose content. Work on protein and other nutrition aspects has declined due to the lack of specialized staff. The wide-cross programme continues to be a valuable adjunct to the breeding by supplying a stream of valuable new genes. The biotechnology group, which introduced molecular marker-aided selection (MAS) technology to IRRI's breeding, initially provided a MAS service but now provides a well-equipped user laboratory where breeders can carry out their own molecular screening. Use of this facility is restricted somewhat by lack of trained support staff, attached to IRS breeders, and in some quarters, a lack of familiarity by the IRS with the potential of the technology. The Division also houses the ARBN laboratory, office area, and teaching space (although this is jointly overseen by PBGB and EPPD), which appears to operate very effectively. Four well-founded containment glasshouses were available for the initial multiplication and testing of transgenics. The Panel was pleased to note that these facilities were being shared by staff from UPLB.

Assessment

The Panel found the Division staff highly motivated and competent. The 12 IRS staff have published adequately in international journals (87 refereed and 55 conference and other professional publications) in addition to excellent breeding and training outputs. Divisional staff have a high international scientific standing and are sought as collaborators by rice scientists the world over. As a further measure of esteem, the Head of Division has, during the review period, been elected a fellow of the Royal Society in the UK, as well as being awarded the World Food Prize. Divisional staff have been awarded the Gold Medal for hybrid rice by ICAR and four honorary doctorates or professorships around the world.

In general, the Division was state-of-the-art equipped for cytogenetics and molecular biology. However, although the application of marker technology as a breeding aid was progressing at IRRI as rapidly as anywhere else in the public sector, the Panel did not see plans to scale up by employing automation or robotics. With the advent of PCR markers, automation is now becoming feasible, and indeed necessary, for routine large-scale, high through-put breeding applications.

The recent SRP appears to have bitten deeply into support staffing of the breeding programmes, and this will slow the flow of improved germplasm to the NARS and other outputs. The Panel also noted the continuing lack of a grain quality chemist or biochemist, an issue highlighted by the last EPMR.

5.1.2 Agronomy, Physiology, and Agroecology

The Agronomy, Physiology, and Agroecology Division (APPA) was formed in 1990 from the Department of Agronomy and Physiology and the Agroecology Unit, completing various organizational changes over the years that involved the Departments of Agronomy, Plant Physiology, and Multiple Cropping. The Division has 23 IRS in all (ten regular at Los Baños, four outreach, two affiliate, three project scientists, one visiting scientist, and three scientists seconded from other organizations), 44 NRS (research) and 48 NRS (research support).

In its early years, Agronomy emphasized maximum yield experiments, rotation crops and green manures, soil fertility and fertilizer management, land preparation, and influence of plant density in transplanted and direct-seeded rice. Later it added work on multiple cropping and intensification of irrigated and rainfed lowland systems. As part of that effort, a large network of experimental sites in different agroclimatic zones was established in tropical Asia; this work led to environmental characterization research. Between 1964 and 1968, long-term experiments were established at four sites in the Philippines; today, these experiments are invaluable in studying the sustainability of rice systems. Rice physiology research has a long history at IRRI. Physiologists have contributed to understanding plant growth and development, yield potential, mineral nutrition, photoperiodism, and tolerance of rice for flooding, drought, and temperature stresses.

Within the ecosystems programme structure, APPA operates under five research thrusts designed to underpin rice cropping in the 21st century; these are: (i) physiology of yield and stress tolerance, (ii) resource management, (iii) weed management, (iv) farming systems, and (v) systems analysis and simulation.

The Division is housed in modern facilities and is well equipped. Specialized equipment of note includes: an LI-6400 portable photosynthesis system with its own light source, PAM-2000 portable chlorophyll fluorometer, XL-100 ultracentrifuge, precision sprayer for herbicides, handheld HP computer for field data acquisition, setting for automatic data transfer from a weighing balance to a computer, and a time domain refractometer (TDR) for soil moisture measurement.

Assessment

The Division and its antecedent departments and units have a long history of scientific innovation and high-quality research. That record appears to have continued. During the review period 1993-97, APPA scientists published 120 articles in refereed journals and 129 conference papers, book chapters, and other professional publications, a record which the Panel considers satisfactory.

Physiology and agronomy at IRRI have enjoyed high international standing. At present, physiology research aimed at improving problems of grain filling and other productivity factors in NPT and hybrid rice is important, as is work with direct seeding involving tillage, and soil, water, and weed management. The systems analysis work is respected and gaining attention as sustainability concerns have raised interest in studies relating natural resource management with crop productivity and production efficiency.

The APPA Division has much to offer the research programmes. Studies of yield potential and of factors involved in this are important in view of an urgent need to increase rice production. Questions of yield performance and sustainability must be answered through relevant APPA research with partner institutions, using long-term experiments, and consortia sites in NARS research stations and farmers' fields, plus systems analysis and modelling to understand what is happening, and what might happen. The SysNet network is helping to train NARS scientists to apply new techniques in their work. Agroecological analysis and mapping help to delineate management domains ranging from mega to micro levels.

Recognition of Division staff during the review period include: the 1996 CGIAR Chairman's Excellence in Science Award (Promising Young Scientist); and the 1997 Special Award by the Japanese Society of Root Science for a paper, *"Root and Nitrogen in Cropping Systems for the Semi-Arid Tropics"*.

Concerning Division expertise, the weed science group has gained strength in several areas - weed ecology, weed management (including interactions with water management and tillage in direct seeding), and biological control. Physiology research shows continuing strength.

5.1.3 Entomology and Plant Pathology

The Entomology and Plant Pathology Division (EPPD) combines entomological and plant pathological research. EPPD comprises eight full-time IRRI IRS staff, (three entomologists, four plant pathologists, and one virologist), 40 NRS (research), and 41 NRS (research support). Collaboration with ORSTOM provides one full time scientist, a part-time nematology expert, and an affiliate scientist. EPPD has been successful in attracting additional research fellows for thesis research or on-the-job training, and by developing collaboration with NARS and ARI has substantially increased its research capacity. Three IRS (plant pathologists) have considerable research management responsibilities; two act as programme leaders and another is head of a service unit.

Major research efforts are directed to durable resistance, pest characterization and ecology, and formulation and verification of IPM. Biotechnology tools are used to develop novel resistances to pests, improve screening methodology to deploy host-plant resistance, and analyze diversity of pests and beneficial organisms. Research is focused largely on insect pests and diseases in irrigated rice, and on diseases in rainfed rice. EPPD coordinates the IPM Net and one component of the ARBN, and administers the SHU.

Since the founding of IRRI, systematics and biological studies of pests and beneficial organisms have been continued to identify key rice diseases, insect pests and their associated arthropods, and beneficial organisms in tropical rice ecosystems. These studies have become a great asset in new research aimed at understanding and utilizing the biodiversity of rice ecosystems for better pest management. In collaboration with NARS, a pest database management system is being developed through surveys and experiments, and the diversity of rice pests and related beneficial organisms such as parasites, predators, and microbial antagonists is studied to incorporate as many components of biodiversity as possible into IPM strategies. Farmers' perceptions of pest control measures are studied to promote the widespread adoption of IPM. In the Philippines and Vietnam, using an IPM strategy, insecticide applications were reduced significantly with no yield loss. Screening of rice germplasm and varietal lines examines resistance to key pests.

Assessment

The overall international standing of the division is high, thanks to the outstanding leadership and scientific creativity of several of its staff members. During the review period, EPPD scientists have been associated with 143 refereed publications, a high proportion of them in high standard journals which the Panel judges to be very good. Recognition received by the division or its scientists during 1993-97 included a fellow of the American Phytopathological Society (1994), an associate fellow of the Third World Academy of Science (1996), and the Medal for Agricultural Development in Vietnam (1996). One scientist serves as senior editor of the journal *Phytopathology*; another is a member of the editorial board of the *International Journal of Pest Management.*

The Panel considers the range of expertise covered by IRS and affiliated scientists and input from joint ventures and shuttle research to be appropriate for the proposed research agenda. Nevertheless, research on still unresolved pest problems such as snails and rats, traditionally not within the scope of entomology, is weak and is handled through working groups and inputs from ARIs.

The basic equipment and facilities are satisfactory. However, most of the equipment for biotechnology work was purchased ten years ago; with time, the risk of breakdown increases. Provision of funds in case of emergency replacement may be required.

5.1.4 Soil and Water Sciences

The Soil and Water Sciences Division (SWSD) was created in 1990 by bringing together soil and water scientists who formerly were administered independently. The Analytical Services Laboratory (ASL), which was formed in 1977 to provide plant, soil, and other analytical services, joined SWSD in 1997. Today, the Division consists of eight IRS, one outreach scientist (Cambodia), two visiting scientists, five postdoctoral fellows, 14 postgraduate scholars, and 34 NRS (research).

Expertise in the Division is grouped in six research thrusts which contribute to IRRI's research programmes, and in which the scientists aim to become recognized authorities. Soil chemists and soil fertility specialists in the Division's work on the effects of flooding on soil chemical properties and adverse soil conditions (e.g., iron toxicity, salinity, and zinc and phosphorus deficiencies), on nutrient management, and on the effects of rice production on the environment. Soil microbiologists work on the microbial ecology of flooded soils, biological nitrogen fixation, and the environmental effects of pesticides and herbicides. Water scientists work on the effects of water stress on rice production and on improving the productivity of water in rice systems. All staff are concerned with the effects of rice production on the environment, both local and global. The Division has research partnerships with various NARS and ARIs.

Strategic concerns include nutrient management, soil and water management relating to direct seeding, understanding the causes of greenhouse gas emissions, and the causes of productivity decline in long-term trials, and improving the efficiency of water and nutrients in crop growth.

Service functions of SWSD include the Analytical Service Laboratory, which includes radio-isotope and mass spectroscopy facilities, the Biofertilizer Germplasm Collection, and a section for screening germplasm for problem soils.

Assessment

SWSD appears to be well equipped and has good facilities to handle the research for which it is responsible. Its work appears to be of high quality. Over the review period, 1993-97, SWSD staff published 134 refereed journal articles and 68 conference papers, book chapters, and other professional articles, a good publication record for a Division which also includes a service laboratory (ASL).

Expertise in the Division includes several areas of soil science (e.g., soil fertility, chemistry, microbiology, soil management), and some of its research has attracted international attention. Soil science at IRRI has a long history, particularly in the chemistry of flooded soils, management of problem and toxic soils, and fertilizer management in submerged soils. The SWSD is well known for its research in water management; in particular it has received increasing recognition for its collaborative work with NARS in reclaiming and managing acid sulfate soils in Vietnam.

Recognition of Division scientists during 1993-97 included five scientists who were elected to the editorial boards of five international journals.

Because the Panel considers water availability and management to be one of the most pressing problems for IRRI and rice-growing countries in the next decade, the Panel **strongly suggests** that the vacant water management position be filled with a world-class scientist as soon as possible.

5.1.5 Agricultural Engineering

IRRI's Agricultural Engineering Division has a rich history in small-scale machinery development and manufacture suited for Asia's rice farmers. In its early work, it sought to support the rapid gains in productivity and agricultural development that were taking place during Asia's 'green revolution' in rice. In particular, it sought to reduce drudgery and raise productivity of labour in all phases of rice production and postproduction, and to that end prototype machines were designed and made available to small-scale, rural fabricators. Many small factories began in this way and continue to produce machines for small-scale farmers. Noteworthy machines designed and/or modified by the Division include: the axial flow thresher, a unique innovation which revolutionized rice threshing around the world; stripper-header; various low lift pumps; drum seeder; transplanters; and the rolling injection planter designed at IITA for sowing in mulched or stubble fields. The Division holds patents on its machines (39 in 1993), which were protected in the public interest for production by small manufacturers, without license.

There is one IRS position in the Division, currently occupied by the Acting Head. The SRP reduced NRS staff positions from 28 to 15. Plans for the future include hiring a project scientist and an affiliate scientist. The Division is now in the midst of a study and review process to determine what its future might be. At present, the scientific staff consists of a (half-time) Division Head, who is a soil scientist and is also Head of the IRRI Experiment Station, plus a half-time engineer. An outreach engineer works in Cambodia on matters relating to labour-intensive operations and machinery needs.

The Division has facilities and equipment sufficient for a much larger programme that once included design and fabrication of a wide range of machines and tools.

Assessment

During the review period, the Division published 18 articles in refereed journals and 22 conference papers and other professional articles, which the Panel considers outstanding for a small Division which has gone through significant downsizing and restructuring.

As mentioned, over the past two years the Division has studied what its future should be. In this process it developed the following mission statement: "Increase the efficiency of the production to consumption continuum; be a catalyst for system change". Several factors will influence the final decision, including a peer review at the end of February1998, by a panel of public and private engineers from national and international organizations and firms. The Panel was told the possible future focus may include key problems such as direct seeding, precision levelling of land, precision farming, systems analysis, and post-production problems. The Division aims to assess and modify machines produced by others rather than produce new designs itself. Feedback from CREMNET and NARS leaders might help to determine what demand might be for different research and development approaches for the Agricultural Engineering Division.

It is still too early to know what direction the Division will take; that will be decided after the peer review. The Division's future relationships with the private sector must be decided soon. The Panel believes such relationships are needed, especially in a proposed new operational mode in which existing machines from elsewhere are introduced for possible use in

Asian rice-farming systems. An example of this is the laser levelling machine which has been modified by the Division to suit land management needs in wet ricelands.

Whatever the focus will be in the future, the reorganized Division is likely to be small, with two engineers and a small support staff, and it will need to plan carefully what work is necessary, wanted, and possible.

5.1.6 Social Sciences

The Agricultural Economics Department (AED) was established in 1966 to undertake impact assessment of technological changes brought about by the introduction of IR8 and succeeding varieties, and to identify the constraints in the adoption of new technology in various regions and by various categories of farmers. In response to the research agenda which over time became multidisciplinary, the AED was converted into the Social Science Division (SSD) in 1990. The purpose was to put together economists, rural sociologists, anthropologists, gender specialists, and geographers to deal with processes and problems of technology transfer. In this regard, establishment of GIS capability has helped strengthen the database, and improved mapping and understanding of regional problems and developments.

The staff comprises four IRS, with an anthropologist to be recruited in 1998, three affiliate scientists, and two project scientists to be added, according to the MTP. The core staff consists of scholars from economics, anthropology, and geography. There are 21 NRS technical staff.

In addition to studying the constraints to the adoption of improved technologies, the Division's work focused on understanding socioeconomic characteristics of different agroecosystems including farmers' current practices, knowledge, and technology needs; their implications for research prioritization, and identification and evaluation of technologies. More recently, the Division has paid more attention to sustaining the natural resource base and the impact of rice technology on understanding the dynamics of the rural household economy; assuring the livelihood and risk management strategies of farmers in rainfed areas; analyzing the dynamic of land use changes in uplands; identifying factors influencing the sustainability of the natural resource base and evaluating the impact of rice technology on people, and other welfare issues including equity in distribution of gains; and gender issues and the participation of various groups, including women, in the decision-making process. Division scientists have also studied the differential impact of new varieties among different ecosystems; irrigated, rainfed lowland, upland, and flood-prone.

Assessment

SSD scientists are doing commendable research on the identification of constraints, the planning and prioritization of research, and studies on the impact of new technology on numerous socioeconomic areas including poverty, welfare of women, environment, and various ecosystems.

Over time, SSD research has become interdisciplinary, and the Division interacts with scientists in other divisions across the programmes and coordinates activities with them. The SSD also provides scientists and Management with statistical information on rice production, area, and yield in different parts of the world, classified by agroecological regions. GIS capability has further strengthened the database, including mapping and understanding of regional problems and developments and priority-setting. The database is available and used by all IRRI scientists. The database and SSD staff have also helped in formulating IRRI's strategies by preparing key documents (e.g., MTP) and resource prioritization. In the future, the Division may strengthen its work on gender issues, policy, and labour market conditions.

During 1993-97, the scientists in the Division published five books, 38 papers in refereed journals, 24 chapters in edited books, and 26 articles in conference proceedings.

The IRS in the Division are sometimes invited to write keynote papers for various international conferences and meetings and act as referees for contributed papers to international congresses. The Division Head was invited to address the first plenary session in the Rockefeller Biotechnology meeting in Bali, Indonesia in 1994, and the Third International Genetics Symposium held in Manila in 1995, and was appointed as Adviser to the National Agriculture Commission set up by the Prime Minister of Bangladesh. Eminent economists visit the Division frequently for collaborative research.

Recognition of Division scientists during the review period (1993-97) include: an NRS scientist received two awards: the 1996 CGIAR Excellence in Science Award (outstanding local professional) and the Medal of Recognition given by HRH Princess Maha Chakri Sirindhom of Thailand; the M.S. Swaminathan Award (social sciences) was given to the authors of the book *Pesticides, Productivity and Farmers' Health*; and a Division scientist with a co-author shared the Policy Article Prize of the University of Minnesota's International Center for Food and Agricultural Policy.

In addition to research, SSD is called upon by Management to prepare information for presentations to donors or other organizations. This can sometimes be a burden. The productivity of the IRS in the Division, compared to their social sciences colleagues elsewhere, is in part due to high-quality supporting NRS. The effect of the SRP caused the Division to lose some of its most skilled researchers, creating an incipient bottleneck in research. The impending addition of a sociologist and a gender specialist will round off the strength of the Division. However, the Division believes it needs an IRS policy economist, a post promised in the MTP.

5.2 Research Support Services

An international research institution such as IRRI depends on persons and units who support and help ensure research productivity and quality. Often under-recognized, such persons and units underpin the entire effort. This subsection of the chapter discusses seven such units and their work.

5.2.1 Genetic Resources

The Genetic Resources Centre (GRC) was established in 1989 to bring together two important components of IRRI's work - the long-term conservation of rice genetic resources, which IRRI began in 1962, and the international exchange and testing of elite germplasm (INGER), which began life as the International Rice Testing Programme (IRTP) in 1975. GRC has a staff of five IRS, including a vacant position for the INGER coordinator.

GRC is the world's main repository of rice germplasm, which complements and shares holdings with other CGIAR collections at IITA and WARDA and with major collections in India and China. In a recent initiative, to ensure its safety, the collection has been duplicated at the USDA's National Seed Storage Laboratory, Fort Collins, USA, where it is maintained in 'black box' storage. GRC's primary goal is to ensure the long-term preservation of the natural diversity harboured in the world's rice varieties, landraces, and wild relatives, and to make this diversity available to all users. Users include IRRI breeders and researchers, NARS and other public breeding operations, private sector breeders, NGOs, and scientists and farmers the world over. A related goal is to add value to the materials by further characterization through research.

The collection is still growing. Some 14,000 new accessions were added during the review period within the total of around 82,000. Some 84,000 samples have been dispatched individually; 32,000 to non-CGIAR researchers and breeders. Other GRC activities include the development and maintenance of the International Rice Genebank Collection Information System (IRGCIS), which was completed within the review period, and which facilitates day-to-day management of data from characterization and germplasm transactions.

As of January 1998, genetic conservation research - hitherto conducted within the CE Programme - will be carried out in a separate Genetic Resources Programme, including the conservation of rice and biofertilizer genetic resources. The new Programme will include 56% of GRC's budget, and includes collection, conservation and dissemination, and a new effort in plant genetic resources (PGR) research. Research in biosystematics and diversity of the wild rices will include molecular marker characterization, farmer-managed rice cultivation as a strategy for conservation, and methodologies of dynamic conservation of cultivated and wild rices. INGER, a concentrated attack on Genotype x Environment (GxE) interactions, and the development of IRIS, will all be in the new GC Programme.

The Genebank, built in 1977, has been well maintained, with major renovations taking place during 1993 and 1994, including the replacement of all the cooling compressors. During that time, the seed-drying room was added; also, the screenhouse facility for the wild rices has been upgraded. GRC holds some 82,000 accessions of wild and cultivated rice.

Assessment

In the Panel's view, GRC's conservation and characterization activities are carried out professionally and effectively. The Panel highly commends the continued acquisition of new accessions, the progress achieved in developing the wild rice collections, the 'black box storage' initiative, and the completion of the IRGCIS catalogue of the GRC holdings. The Panel also endorses the move towards a plant genetic resources research role for GRC, particularly that relating to the wild relatives and molecular germplasm characterization.

The five GRC senior staff have grasped the new research responsibilities, and have published well in international journals. GRC is well regarded internationally, not only for its well managed collections, but increasingly for innovations in the underlying theory and philosophy of *ex-* and *in-situ* plant germplasm conservation.

The Panel questioned the move to establish GRC as a separate programme as outlined in the 1998-2000 MTP. The Panel was concerned that this move would isolate GRC from ongoing science in the other programmes at a time when improved collaboration is needed, particularly with breeders in germplasm characterization. For example, such collaboration includes identification of heterotic groups to aid hybrid parent identification, and DNA marker-aided germplasm discrimination with molecular biologists. In addition, the new arrangement would further increase the administrative load on yet another key senior staff member. The Panel **suggests** that rather than being a programme, a solely divisional status would be preferable, allowing collection, maintenance, and PGR research to be carried out in the existing research programmes and in INGER in the new Impact Programme.

5.2.2 Seed Health

In 1986, the Seed Health Unit (SHU) was created as a service unit to assure that all rice seed sent from and coming to IRRI meets the high standards of international plant quarantine regulations. SHU comprises one Assistant Scientist (NRS), three other NRS (research) and five NRS (research support), and is administered by the Head of the Entomology and Plant Pathology Division. To some extent, the work is seasonal, using contract labour hired for peak periods. The Philippine Plant Quarantine Service (PPQS) supervises the analyses through a Plant Quarantine Officer based at the SHU.

Procedures for seed health include: macroscopic inspection of dry seed for assessment of physical condition and presence of contaminants; routine laboratory seed testing according to International Seed Testing Association rules to reveal any contamination by pathogens; seed cleaning and treatment by chemicals or hot water; and crop health inspection, especially of germplasm introductions and seed multiplication plots. ASEAN Plant Quarantine Regulations are enforced for incoming seed. On the basis of seed testing results provided by IRRI, the PPQS clears imported seed for post-entry and issues phytosanitary certificates for SHU seed lots shipped worldwide.

The activity levels of SHU are impressive. During the review period, SHU and PPQS received and cleared 349 shipments containing a total of 39,052 seed lots. Phytosanitary-certified seed lots shipped by the SHU totalled 458,291 in 2,482 shipments. The main sources of exported seed were INGER (54% of the seed lots in 1995), PBGB (33%), and IRG (12%). The results are stored in a database that allows statistical analyses of seed health trends. SHU has also developed new methods for rice seed health testing and is defining international standards as a member of the ISTA Plant Disease Committee. Training courses in rice seed health testing are offered, and at least two persons from each rice-growing country in Asia plus some in Africa have been trained. A spin-off of this service activity is research on antagonistic seed-borne bacteria, and on ways to improve farmer seed health management for IPM. Half of the activity is devoted to the theme of "saving biodiversity", a part of the CGIAR research agenda.

Assessment

SHU plays a key role in assuring the healthy and safe transfer of rice germplasm - a crucial component of IRRI's activities - and which in all cases must meet stringent standards. Rigorous testing minimizes the risk of introducing exotic organisms and the spread of rice pests through germplasm exchange, and strengthens confidence in partnerships with the NARS. The Panel believes that the quality of SHU's service is excellent.

Tests are performed according to international standards in well equipped facilities suited to presently used routine methods. Nevertheless, such routine methods allow detection mainly of fungal pathogens. Special laboratory tests to detect (rice) seed-borne, plant pathogenic bacteria are not yet required, despite demonstrated seed transmission risk for such bacteria. Serological or PCR-based detection tools are available or can be developed, but currently are not included in rules for routine testing for reasons of cost and difficulty of enforcement by most seed-testing laboratories. For research purposes, IRRI is developing such tools for pathogens. Such expertise could be used to develop more efficient, rapid methods for routine testing of seed health, especially for pathogens that otherwise would escape detection. The Panel commends SHU and advises IRRI to continue to stay ahead in this fast-moving field where it has a comparative advantage.

5.2.3. Analytical Service Laboratories

The ASLs provide analytical services to IRRI's programmes and projects, facilities for the use of radioactive tracers including the handling of radioactive waste, and advice on analytical techniques. They are part of the SWS Division. They standardize new techniques, and over recent years have worked on the analysis for acetaldehyde, stable isotope measurements, and the use of Near Infrared Reflectance (NIR) spectroscopy for analyses for N and starch in rice shoot tissue. N was determined with acceptable accuracy as compared to Kjeldahl and Dumas methods, but requires careful calibrations for different ages of plant tissue.

The Laboratories have several items of advanced analytical equipment, including the NIR spectrophotometer. A mass spectrometer is used for mass isotope analyses of C and N only. Simultaneous analyses of C and N, C and C^{13}, and N and N^{15} are available. The Laboratories' main routine analyses are on soils and plant materials, and they can offer all the normally expected techniques. They have an Inductively Coupled Plasma spectrometer, but this is a sequential machine that is not really suitable for mass analyses, and a simultaneous analysis instrument is now on order. With a flame atomic absorption spectrometer, autoanalyzers, a liquid scintillation counter and others, the laboratories are well equipped to offer an analytical service. Because N analyses are still done by the Kjeldahl method of nitrogen, this analysis is a bottleneck which slows high throughput.

The ASLs maintain contact with the Philippine Nuclear Research Institute, and via this arrange training, licensing, material inventory, waste monitoring, decontamination, leak testing, and commissioning or decommissioning of radioactive laboratories. Much of this work has related to the use of P^{32} in molecular biological work, and of C^{14} in methane studies.

There are in total 11 NRS staff, of whom four are graduates. The number of analyses has varied between 78,000 and 35,000 over the last four years. There is currently a small backlog of 1-2 weeks' work, and the unit is working at 90-100% of capacity. Several papers have been published on the analytical research studies, but these have been included in the SWS Division total, and are not considered further here. It is intended to convert the ASLs to the Modem Science Laboratory for tropical rice, according to the 1998-2000 MTP. The range of analyses will then be extended and much of the equipment upgraded.

Assessment

A modified internal market operates in the ASLs' operations, with a scale of standard charges for their work. The Panel supports such arrangements. However, the charges have not been revised since 1990, and on a rough calculation cover well under 50% of the true costs. Scientists with very large analytical programmes may set up their own analytical systems outside the ASL and not be subjected to charges, and this appears to inhibit the setting of economic prices.

The Unit appears to offer a useful and professional service, but management should re-assess the system of charging to see if efficiency and throughput can be raised to a point where it covers more of the total costs. Management should also consider whether it is cost-effective for alternative analytical centres to be set up elsewhere in IRRI.

5.2.4 Biometrics

The Biometrics Unit (BU) has evolved from the original Statistics Department, and was renamed in 1992. The Unit no longer provides computational services for scientists but provides consultation, training, software, and computer information and oversees IRRI's quality assurance (QA) activities. BU is staffed by one IRS supported by four Senior Research Assistants and three Research Assistants.

BU provides services and has a research function. The services include walk-in or on-line consultations on statistics and statistical interpretation, experimental design, data management, database development, appropriate software, and publication review. BU also provides information on, and customizes, available software for both IRRI staff and NARS collaborators. BU staff also work with other scientists in research projects which require significant statistical input and develop special biometrical software and analyses for IRRI data which require special treatment. Recently, BU has spearheaded a QA initiative to ensure maintenance of reliability, accuracy, and documentation of research data. The QA Taskforce, chaired by the Head of BU, coordinates and promotes QA activities, including study plans, data quality objectives, standard operating procedures, data ownership, storage, and access through the divisions, centres, and units. The Division, Centre, and Unit heads oversee quality issues within their units.

The Unit is well equipped, relying on the powerful PCSs available today. The Panel noted that the move to larger UNIX workstations had correctly been resisted because such machines were unlikely to be available to partner NARS.

Assessment

The Panel is convinced of the continued need for strong statistical support and training at IRRI, and found this small, well managed group to be very effective. At present, the Unit is well equipped; however, the shelf-life of PCs is probably shorter than that of any other scientific equipment, and machines may need replacing about every three years.

The publication rate was reasonable for the small group. However, the Panel encourages management to ensure, during internal publication review, that the statisticians receive recognition by authorship on research papers where their input warrants. IRRI-trained biomathematicians are highly sought after by industry and a valuable Institute resource, so career progression and motivation are particularly important for them.

The Panel noted that the biometrical emphasis at IRRI may change again as bioinformatics, the manipulation of rice genome data alongside the other 35 databases maintained at IRRI, begins to play a greater role in IRRI's science. This development is discussed at greater length below.

The first databases to emerge from the wave of molecular biology research contained DNA sequence information. Now there are many databases holding published genes, proteins, and both random and contiguous plant and animal genomic sequences. About eight years ago, USDA began to invest in several crop plant databases, including rice, to maintain and make accessible the vast bodies of information generated in, particularly, plant genome projects. Later, other national research funding bodies in Japan and the UK recognized the importance of bioinformatics as the key to future application of past research results. The recently discovered, remarkable conservation of genes and their organization in the genomes of related groups of plants, such as the cereals, have hastened international efforts to cross-link the individual species databases so that information gained in one crop may be used to predict gene location and function in another.

As yet, use of all such databases is free, although calls for means to recover infrastructure costs, such as charging for access, are increasingly raised on both sides of the Atlantic. IRRI scientists use these international facilities regularly. However, as yet IRRI has no plans to develop and distribute its own molecular information either through existing databases or through new databases maintained on-site.

IRRI has good reason to develop expertise in bioinformatics: (i) to make the best use of the information already available on trial results, pedigrees, germplasm accessions, DNA sequences, traits, genetic maps, and more; (ii) to facilitate and make future data collection and analysis more efficient; and (iii) to establish a position in the international bioinformatics community and establish some collateral against possible future moves to restrict access to other databases. The establishment of IRGCIS and the system-wide ICIS project are a significant start to this end, but cannot substitute for an active presence in the bioinformatics community. Discussions between the Panel and IRRI scientists in GRC, BU, EPPD, and PBGB during this review have indicated a clear appreciation of the position and a plan to build a limited capability in bioinformatics at IRRI.

The Panel **recommends** that IRRI evaluate carefully the developments in bioinformatics with a view to determining IRRI's future in this area.

5.2.5 Central Research Farm

The Central Research Farm (CRF) is administered by its Head, a soil scientist who is also Acting Head of the Agricultural Engineering Division. The CRF Head reports to the Deputy Director General for Research, as was suggested by the previous EPMR. The CRF manages all lands, roads, and farm irrigation systems, plus the phytotron, glass houses, screen houses, farm buildings and farm, and research plot equipment. Most of the farm operations are centralized, and CRF carries out tillage and land preparation and other routine non-experimental operations. Most specialized research operations within the plots are done by the researchers and their staff. Almost all farm operations have now been mechanized, and drainage systems have been improved. A new system of rat control has been introduced, with live trapping and other measures to reduce rat populations.

The CRF now has 95 staff members, down by more than half from the 225 positions before the SRP. Of the 95, 25 are assigned to work on the grounds, phytotron, greenhouses, screen houses, etc. The other 70 work on the farm in field activities.

The land area used for research during the dry season amounts to about 120 ha of the total 156 ha of paddy. Less land is planted in the wet season when solar radiation is low and typhoons are frequent. At present (i.e., January 1998), about 100 ha were in use. Of course, even when the fields are not planted to experiments, it is still necessary for the CRF staff to maintain fallow or closed season fields as part of the field management programme. This fallow rotation and management system is a cost-effective mechanism to (a) reduce unwanted volunteers of rice, and (b) to provide a cycle on non-flooded conditions (aerobic) for the longer term sustainability of high yields in the research plots.

The opportunity to begin to manage the farm with a fallow rotation is the result of less pressure on land because of the decentralization of research, particularly for the rainfed system which increasingly is conducted in partnership with NARS at the Consortia sites. The farm is also being used for breeder and certified seed production.

5.2.6 Information Centre

Since the last EPMR, the library has been transformed. Management followed up the Review recommendation that upon the retirement of the librarian a professional with demonstrated competence in library and information services management be appointed. At the same time, a capital grant enabled IRRI to renovate and refurbish the building. The library has now enhanced the usefulness of its collection of over 166,000 entries with computerized, state-of-the-art systems.

The library gives essential access to researchers through on-line catalogues, electronic journals, and leading agricultural and patent databases. Document delivery is speeded by scanning and electronic delivery as well as normal means. Delivery access is available through IRRI's World Wide Web site. The Panel found it surprising that while IRRI does have on-line, pay-as-you-go access to patent databases, these have not yet been accessed by IRRI scientists.

During the period of the review, the Communication and Publications Services (CPS) published 64 scientific books and 15 issues of the *International Rice Research Notes,* as well as other serials such as the IRRI Hotline and Rice Literature Update. The impact of IRRI publications is clearly seen in the libraries of many developing country institutions where IRRI books and journals are often the only published information on rice. In the past few years, the CPS has creatively used the World Wide Web and has received several distinctions for its Web site.

IRRI's public awareness materials are used for a growing number of stories in the international print and broadcast news media. The IRRI Riceworld museum has a steady stream of visitors, ranging from schoolchildren to visiting dignitaries. IRRI's public awareness programmes were judged to be excellent by the external committee auditing the CGIAR public awareness programme.

Assessment

The Panel finds the overall work of this unit to be excellent. The Panel was impressed by the facilities and their operation. The Information Centre at IRRI plays a crucial role in supporting IRRI's efforts in international research cooperation and in educating policymakers and the public about IRRI's activities.

5.2.7 Computer Services

The Computer Services Unit (CS) is currently part of Administration and Finance, but the policies, priorities, and work plans are discussed and approved by the Computer and Database Advisory Committee (CDAC), co-chaired by the DDG Research and the DDG for International Services. Computer Services operates and manages the central computers (IBM ES/9000 being decommissioned, two DEC VAX, and Five HP Netservers running Windows NT) and network infrastructure. A local area network of almost 600 nodes provides network connection throughout the IRRI campus. External access is through the 64kb IVDN direct leased line. CS provides desktop support, technical assistance and advice, and oversees database and application developments.

CS coordinates and approves the purchasing of new and replacement computer equipment, using three standard configurations which are updated regularly to keep pace with new developments in hardware technology. New computers are configured by CS with standard software packages before going to the users. CS negotiates for institutional discounts on all widely used software.

Assessment

The Panel was impressed with the service provided by the Computer Services function. Technology and computer equipment were reasonably up-to-date at IRRI, with a range of older equipment due for replacement through the latest models. No one seemed to mention computer equipment or computer services as an area for complaint - in computer services, this is high praise.

5.3 International Services

5.3.1 International Network for Genetic Evaluation of Rice (INGER)

INGER, formerly the International Rice Testing Programme (IRTP), has been in operation since 1975 and is acknowledged by IRRI, WARDA, CIAT, and NARS as being the single most effective pathway for sharing and distributing both IRRI and NARS breeders' lines worldwide. Today, a majority of the *indica* varieties grown in the world have been acquired through INGER directly or have been bred from parents obtained from INGER. The multi-locational trials, which now contain more NARS breeders' than IRRI breeders' lines, are coordinated by IRRI in Asia, in Africa by IRRI and WARDA (operations at IITA ceased in 1996), and in Latin America by CIAT, with support from IRRI.

Over the years, INGER has been remarkably successful and popular with NARS breeders. Of the 42,000 lines evaluated, 5,300 have been used as parents by NARS breeders and 429 have been released directly as 618 varieties in 66 countries. In the past, this success has enabled IRRI to attract external funding for INGER, initially by UNDP and latterly by BMZ. However, since 1985, the numbers of entries and the numbers of trials have declined (Figure 5.1) due both to funding constraints and attempts to streamline and make the operation more effective. Trials in Africa have almost ceased. The role of INGER in Latin America has been taken over to some extent by the *Fundación Latinoamericana para el Arroz de Riego* (FLAR). However, FLAR does not serve all ecosystems or countries in Latin America. Moreover, the position of INGER coordinator at IRRI remains vacant.

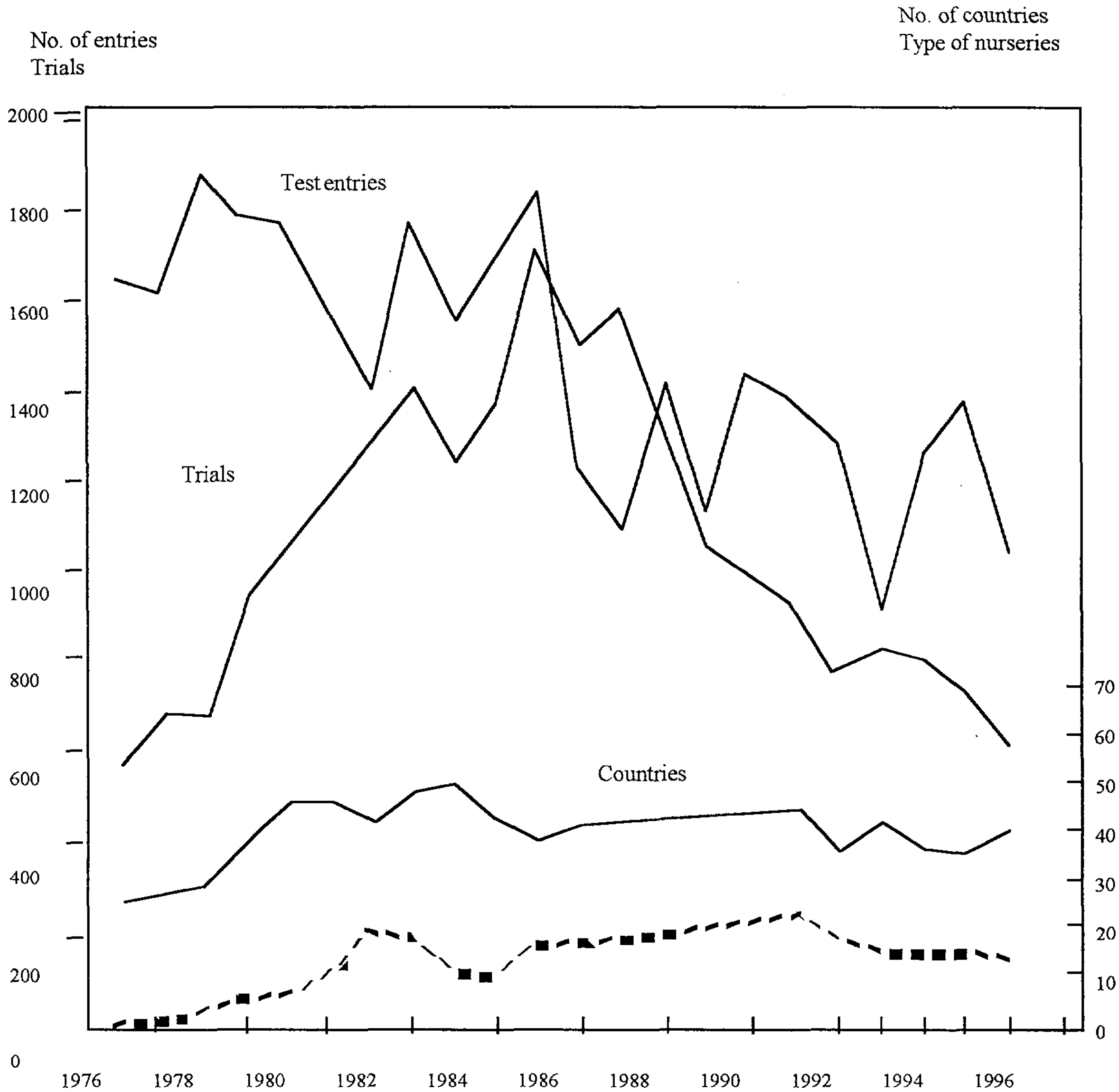
The 1992 EPMR, while commending INGER's 'sharper focus', noted the decline in the activities of INGER and encouraged IRRI to "mobilize required resources to protect the integrity and effectiveness of INGER". In response, IRRI has endeavoured to seek new donors for INGER. IRRI has provided some core support for INGER at the level of funding for one IRS and US$ 100,000 operational funds in 1998. In the last three years, IRRI has provided US$ 50,000 per year to FLAR, to support INGER activities in Latin America. However, this level of support from IRRI core does restrict INGER activities, particularly in the monitoring tours for young scientists from NARS and the steering committee meetings. IRRI has been encouraged, by discussions with members of the Council for Partnership in Rice Research in Asia (CORRA), to explore opportunities of cost sharing with NARS for the services provided by INGER, and to work toward a goal of the NARS assuming greater responsibility for in-country distribution and trials. Also, together with WARDA, IRRI has developed a proposal submitted to DFID, which is currently under consideration, to restart trials in Africa. However, in the meantime, nurseries, trials, and entries have continued to decrease in number.

Assessment

INGER is an emotional issue. The continued need for INGER is undisputed, but its current strategy and mode of operation are viewed very differently by IRRI and the NARS. The Panel agrees that IRRI's vision of INGER's future (i.e., new designs to facilitate GxE analysis, reductions in multiple site nurseries within countries, reduction in data needed from all trials, greater screening of entries to INGER by NARS and IRRI breeders, database restructuring and upgrading) is rational. However, the reduced role for the Steering Committee, which last met in 1995, and still fewer monitoring tours, which had already been reduced in recent years, appear to be an unfortunate consequence of funding constraints. It is clear to the Panel that the arguments for change have not been fully discussed with and accepted by administrators in the NARS whose opinions were sought by Panel members during field visits. These NARS see only a reduction in trials activity and a reduction in opportunities for young NARS breeders and assume this is driven by inappropriate funding considerations or is the result of an insufficiently responsive IRRI management.

The Panel **recommends** that: (a) a meeting of CORRA be convened with a specific agenda to design a high-quality INGER which meets NARS and IRRI's breeders' needs and achieves scientific ends of value to all; (b) IRRI give the highest priority to running INGER according to this agreed programme; and (c) the vacant position of INGER coordinator be filled as a matter of urgency with an energetic and respected rice scientist.

Figure 5.1 INGER Activities, 1975 to 1990



5.3.2 Crop and Resource Management Network (CREMNET)

CREMNET was begun in 1994 to bridge knowledge of scientists and farmers in optimizing crop and resource productivity. CREMNET was initiated to incorporate technology transfer aspects of two former IRRI networks, the Asian Rice Farming Systems Network (ARFSN) and the International Network on Soil Fertility and Sustainable Rice Farming (INSURF). The Fourth EPMR had recommended that IRRI study the future of these networks; the final result was that ARFSN and INSURF were phased out and CREMNET was begun.

The goal of CREMNET is 'to facilitate exchange, evaluation, and adaptation of emerging technologies, methods, and tools for higher and sustainable productivity of rice farming systems'. The network comprises eleven Asian NARS, plus IRRI, and aims to strengthen linkages between members, other IARCs, NGOs, and the cooperative and private sectors in implementing its activities. A senior IRRI scientist serves as CREMNET Coordinator, and each member country has a national coordinator. It has developed a comprehensive framework for R & D, including identification of constraints and opportunities, priority setting, technology/knowledge generation, synthesis, and distillation, product or process development, packaging and marketing, and impact assessment. By going through this process, network members can decide what to work on and how to bring new products or ideas from research to farmers.

CREMNET uses a farming systems perspective in its work, which includes three types of on-farm trials (farmer-participatory, on-farm testing and adaptation; researcher-managed trials for emerging technologies, and farmer-participatory technology adoption tests or demonstrations). Technologies tested include new machines (drum seeder, stripper harvester, dryers), new tools (leaf colour scale for N, chlorophyll meter for N), new practices (deep N placement), or novel technologies (rice micromill, rice hull stove).

Assessment

CREMNET appears to be a practical, focused network aimed at planning for, and achieving field production technology transfer for promising new ideas, tools, or machines. The relationships with NARS collaborators appear to be excellent, and NARS leaders appear to have a sense of ownership in the network. Training is a key part of the CREMNET programme and is planned to ensure transfer of the targeted technology.

5.3.3 Training

The mission of IRRI's training programme is to enhance NARS capability for rice and rice-related research through collaboration of IRRI with national research systems. The Training Centre is responsible for two regular courses produced and delivered by its own staff and assists in instructional design, preparing course materials and delivering training courses designed in collaboration with other divisions or programmes. The Centre's activities, previously classified as a programme under International Services, is now classified in the MTP as a project 'Human Capital Development (IM4)'. It has a complement of one IRS and 14 NRS.

5.3.3.1 Current programme and achievements

Since IRRI started its training and professional advancement programme in 1962, over 8,000 scientists and technicians from 96 countries have received training at IRRI. Almost 90 % of these trainees were from rice-growing countries in Asia and over 10% of them have attended more than one training course. In the last five-year period, 3,605 scientists and technicians have participated in the training at IRRI or in in-country training programmes (see Table 5.1).

IRRI's Training Programme has undergone considerable changes during the review period: (i) 17 new training courses related to strategic research areas were initiated. (ii) Many in-country training courses were launched for international and national audiences. IRRI has assisted the host countries in training material development and revision, and in logistics to set up the in-country training courses. Six regional (international) in-country training courses were held with 191 trainees - one in India, three in the Philippines, and two in Thailand. The courses were for irrigation water management; integrated pest management; gender analysis in agriculture, forestry, and natural resources; engineering for rice agriculture; and farming systems research. Also, in 1993-97, 1,990 scientists participated in national (in-country) training that involved 59 training courses in Bangladesh, Cambodia, China, India, Indonesia, Laos, Myanmar, the Philippines, Thailand, and Vietnam. Additionally, 440 scientists had training in country programmes through consortia/networks/ IARCs. The number of participants in these country training programmes increased from 949 in the period 1987-92 to 2,421 during 1993-97. The number of participants in group training courses at IRRI was therefore reduced. (iii) The core-funded MS scholarship was closed and the Ph.D programme was limited to thesis research only for students from Bangladesh, China, India, Korea, Malaysia, the Philippines, and Thailand, where higher education programmes have been well established. (iv) The proportion of Ph.D holders coming to IRRI for the group training has increased over the years, with a dramatic increase in 1993-97. (v) More women are receiving training, reflecting probably the increase of women scientists in national rice research programmes, as shown in Table 5.2.

Table 5.1 Trainees at IRRI: 1993-97

Category *	1993	1994	1995	1996	1997
Ph.D	64	68	62	51	43
MS	28	25	31	17	16
Non-degree	48	38	62	64	56
Hqs. Group Training	147	133	195	101	103
In-country Group Training	453	782	289	537	360

* These figures reflect the number of participants in these categories in each year. Thus the same trainees may be included in more than one year.

Table 5.2 Participation of Women in IRRI Training

Period	Hqs-Based Group Training	Non-Degree (On-the-job) Training	MS	Ph.D
1973-77	4%	14%	11%	7%
1978-82	11%	12%	13%	13%
1983-87	15%	26%	19%	16%
1988-92	19%	20%	25%	12%
1993-97	23%	26%	29%	23%

The in-country training for an international audience was conducted by expert scientists. However, some NARS found difficulty in continuously offering such courses, due to a shortage in funding. In addition, trainees themselves from neighbouring countries were not very enthusiastic about participating in these programmes. Strong support from the host countries or donors is required to support the NARS initiatives. This is also true for in-country training for national scientists.

5.3.3.2 Future direction

The opportunity for Ph.D candidates in the degree programme to work in on-site programmes will be expanded by accepting more thesis research at consortia sites or NARS institutions. Additionally, 150 NARS scientists will be trained annually in 8-10 training courses in strategic research areas. In collaboration with NARS, appropriate courseware will be developed for NARS to support in-country training for international or national audiences. The possibility of distance education using electronic communication systems is being explored to support NARS in-country training.

Assessment

The Panel commends the dedication of the scientists and staff in the Training Centre in developing the training courses and courseware, and in helping NARS to initiate in-country training. This has been done even though the Centre lost 12 NRS in the recent SRP.

The Panel recognizes the problems of decentralizing the training programme, developing specialized "upstream" programmes, and devolving basic production-oriented courses to NARS. It is crucial for IRRI to support NARS in increasing their capacity in rice and rice-based cropping systems research. This is especially needed for NARS whose capacity is still limited, and measures must be taken to make the in-country training more attractive.

The Panel has also been informed about difficulties faced by scholars and trainees with regard to access to the library and health insurance for family members. The Panel hopes that IRRI will carefully re-assess the facilities and terms of conditions of trainees to make their stay in The Philippines as productive as possible.

CHAPTER 6 - ISSUES

6.1 Developments in Rice Genomics

Over the past seven years, IRRI has made a commendable entry into the science of biotechnology, particularly in applications of marker technology and the use of genetic transformation as adjuncts to breeding. The present plans for the continuation of this work, both as described in, and transcending, the MTP and as presented to the EPMR, are evolving alongside developments elsewhere and, in the main, involve extensions of the present strategy by building on results and experience gained to date.

The Panel wishes to raise another issue that could affect IRRI's approach to biotechnology, i.e., the emergence of the new science of genomics. Over the past few years, the first effort to obtain the complete DNA sequence of a model plant has gained momentum and the 100 million or so DNA base pairs that make up the arabidopsis genome will be available to both public and private company researchers by the year 2003 or earlier. This will mean that the sequence of all 25,000 genes of one plant will be known, although only a handful will have been assigned functions. Alongside this public international initiative both public and private organizations, but particularly the latter, have begun to assemble databases of expressed sequence tags (ESTs), which are fragments of individual genes expressed in different plant tissues. Private databases already contain some 200,000 ESTs from maize, for example. This information will be used with the arabidopsis sequence and new 'chip' technology to assign functions to the maize genes as the information becomes available in the model plant. 'Expression chips', already being applied in human genome research, will allow researchers to screen through tens of thousands of genes simultaneously to find those associated with particular plant characteristics or responses to, for example, environmental stress or disease attack. It is not possible to patent an anonymous gene sequence, but it is possible to patent a gene for which a function and application can be defined.

Moreover, the focus of plant genomics has now moved on to rice itself. Of all the major cereal crop species, rice has the smallest genome at about 400 million DNA base pairs. Also, it has become clear over the past three or four years that the genes and their organization in the different grass genomes have remained remarkably conserved, even though they have diverged during 60 million years of evolution. An initiative, led by the Japanese group at Tsukuba, to sequence a *japonica* rice will begin this year. It is likely that the US and Europe will join this initiative, which may eventually cost US$ 200 million and take less than ten years to complete, because the results will be able to be extrapolated to maize and wheat. With its present plans, IRRI will have no part in this and will be on a par with the hundreds of laboratories in both developed and developing countries with capability in rice molecular biology. The advantages of those organizations with large EST databases are obvious.

When we know the DNA sequence of rice, we will know all of the genes of rice but still not their function. As the present patenting laws stand, there is likely to be an international functional genetics 'gold rush', a window of perhaps ten or twenty years, after which most of the significant genes with application for crop plant modification and improvement will have been discovered.

IRRI does have the required expertise and no doubt will use genomics and large-fragment transformation to approach those genes for which it already has a research lead. IRRI could still decide to collaborate in the international effort directly by scaling up its DNA sequencing capacity. On the other hand, as a collaborator for the mainstream sequencers and other laboratories focusing on the functional genetics of rice, IRRI does have a great deal to offer, particularly for laboratories in temperate countries where large-scale rice field trials are not possible or practical. Certainly IRRI should use the comparative advantage of its existing reservoir of knowledge and expertise in all aspects of rice agronomy and breeding to attract collaborators.

The Panel **suggests** that IRRI could go further and be proactive in assembling tools that will ensure that IRRI is the preferred collaborator for functional genetics research. Several ideas have already been formulated. The establishment of a deletion or transposon-based "gene-machine" is outlined in the CE review in Chapter 4. 'Core collections' developed with GRC's germplasm, an initiative already underway at IRRI, are likely to become vital resources for researchers seeking useful natural allelic variants of genes identified in the sequence of the *japonica* rice, Nipponbare. The Panel is sure that, if the question is addressed collectively by IRRI scientists, other proposals will emerge that will promote IRRI's advantages. The Panel suggests that incorporation of these ideas into IRRI's research plans will be vital if IRRI is not to become marginalized in this exciting new era of rice science.

6.2 Intellectual Property and Private Sector Linkages Policies

IRRI's present position regarding IP is clear. The Policy on IP Rights (PIPR), agreed upon by the Board in October 1994, clearly states that (i) information, inventions, and biological materials will be made freely available, (ii) material held in the germplasm collections and any genes derived from them will be made freely available, and (iii) all breeding materials, including hybrid parents, will be made freely available. The Policy on Partnerships with the Private Sector (PPPS) is equally clear. These policies are designed, in line with the CGIAR's present position, to ensure continued free access by IRRI's partner NARS to the very best germplasm, advanced lines, and technology.

The Panel argues below that, in the light of the changing international attitude toward IP rights, IRRI should re-examine both the PIPR and the PPPS. Indeed, some members of the Panel perceive dangers in continuing to follow the PIPR. The Panel also notes that two CGIAR panels have been convened to consider (i) IP issues (the CGIAR Proprietary Science and Technology Panel) and (ii) industry relationships (the CGIAR Biotechnology Panel), which are both due to report by the end of May 1998. The reports are likely to be most instructive in this respect.

Elsewhere, for example in the US, Europe, and Australia, public sector research organizations are today, in contrast with ten years ago, actively seeking IP protection on their discoveries. Today, these organizations attempt to retain their IP in-house, although, of course, they provide licences as are appropriate, usually depending on the source of funds with which the original research was undertaken. There are several reasons for their new approach: (i) to ensure more rapid transfer of the IP to collaborating industry; (ii) to ensure that the IP is used in the widest and most appropriate manner; (iii) to build up a portfolio which may be used as collateral when the organization needs to employ other already patented technology;

and (iv) last but not least, to attempt to build up a future income stream which will recover costs and supplement dwindling public support. Of these reasons, only (iii) may be relevant to IRRI and the NARS today, but, in the Panel's view, IRRI will soon need to examine all the reasons given above for considering IP.

Below we highlight scenarios in four areas of IRRI's science, identified in a meeting between IRRI staff and the EPMR in September 1997, where IP considerations may be relevant. The Panel hopes that these examples will be discussed in a wider context by IRRI, the NARS, and other interested bodies.

The need to protect IRRI's germplasm. DNA manipulation technology is now in expert hands in both the multinational breeding industry and developing country breeding organizations. Moreover, we are now entering into a new phase where the interests of the multinationals are no longer exclusively centred on the temperate crops. Indeed, at least one such company is targeting rice itself and is investing heavily in rice biotechnology research and rice-related IP. The significance of these developments is emphasized by the fact that the private sector now outspends the public sector worldwide in biotechnology R&D. Moreover, the increasing interest in genomics and the assembly of massive EST databases, taken together with the recent decision by the Japanese and others to completely sequence rice and make the data publicly available, is likely only to increase industrial capability and interest in the Asian rice market. The spectre of a top IRRI line being modified in a profitable and politically or ethically unacceptable way to produce a superior product is very real. Para. 4 of the PIPR attempts to prevent this, but IRRI does not produce registered 'varieties', only 'advanced lines' for the recipients to do with as they will. An IR72 derivative finished as a variety by a third party and converted to a protected herbicide-resistant variety for dry season planting, for which IRRI may be criticized by anti-GMO NGOs but receive none of the profits, is an ugly thought indeed. Trademarking the 'IR' prefix, as in "IR-Phil", "IR-India", etc., which IRRI plans to explore with CORRA, may control the use of the name but probably not the germplasm itself.

Genes isolated from materials held in trust in IRRI's genebank. Today, the situation is clear. IRRI has placed most of the collected germplasm under the auspices of FAO in accordance with the Convention on Biological Diversity and the Agreement between IRRI and FAO. Para. 2 of the PIPR states that IRRI will supply germplasm under a Materials Transfer Agreement (MTA) which is designed to ensure the continued free availability of the germplasm and any genes derived directly it.

If the clause in the FAO agreement, "...nor shall (IRRI) seek any IP rights over that germplasm or related information", does preclude, for all time, IP being taken on genes isolated from the germplasm, then IRRI and the NARS are at risk of being by-passed by potential research collaborators wishing to isolate genes directly or to 'mine' potentially useful alleles of genes identified from the DNA sequence information, because few will be willing to invest in work they cannot eventually protect.

On the other hand, assuming that it is legally possible, why should IRRI and the NARS not isolate and patent key genes from the materials IRRI holds in trust? Indeed, in other circumstances, and in the absence of any specific instructions to the contrary, trustees of others' property are obliged to manage, rather than simply hold, that property. IRRI might, for example, argue that the objective of such a patent is to ensure that a gene is used freely by rice partners but that the same clients benefit by control of the discovery for use in developed nation rice industries and, indeed, for use in other temperate crop species. *Xa21*, the leaf blight resistance gene discovered by IRRI in an *Oryza longistaminata* accession originally collected from Mali but held in the Genebank and now isolated and patented by a US university, is a case in point. When the situation arises again, should IRRI and the NARS block the research? Probably not. Should IRRI and the NARS collaborate with the ARI and take out a joint patent to ensure free delivery to the NARS breeders, and possibly an income stream from its use in industrialized nations' agriculture? Probably so. Such arrangements may, in fact, become the preferred route in the immediate future, because the partner is likely to be in a better position to licence and protect the IP.

Novel generic technologies. IRRI's present position is that it will place new inventions in the public domain. However, IRRI has now entered the field of DNA technology where discoveries are often generic. Increasingly, IRRI will wish to use technologies which have been patented by others. Increasingly, as commercial interest in the Asian rice market grows, IRRI may be required to honour those patents. Why, therefore, should not IRRI or the NARS attempt to recover the costs of their own discoveries , or offset the costs of using others' discoveries, by licensing applications in organisms other than rice? A move to protect such discoveries might again also more easily ensure their continued delivery to rice research partners.

Partnerships with industry. It is likely that partnerships with private and public sector organizations will become more common as more and more technology is already held under patent. Moreover, IRRI's present policy of buying IP outright, in a consortium with NARS under "one-off arm's-length" agreements, as with the first *Bt* constructs to produce insect resistance, may become untenable as the prices rise or where the source organizations are potential competitors with IRRI in rice breeding.

These developments probably mean that IRRI's future must include an even closer relationship with industry in order to have access to the best technologies and the best genetic materials, in order to maintain a supply of the very best germplasm and rice production technology to farmers. There are many reasons why industry will want to collaborate with IRRI, e.g., the expertise and experience of IRRI's scientists, IRRI's research facilities, particularly the field capability, IRRI's established international networks, and, of course, IRRI's international standing and reputation. Above all these is, however, access to IRRI's advanced germplasm. At present, this remains unregistered, unprotected, and freely available to all, NARS and industry alike.

Conclusions

Among the CGIAR-mandated crops, the case of rice in Asia is to some extent special and IRRI should have a clear understanding of the nature and timing of any possible changes in the laws concerning varietal protection (note that in Europe regulations are being put in place to ensure that even farmer-saved seed is liable to plant variety rights (PVR)) in its partner countries. Future laws relating to PVR will have a clear bearing on IRRI's future policies.

It is clear to the Panel that means of approaching these difficulties and opportunities must be identified soon. The issues already recognised by IRRI, i.e., conflicts of interest, arrangements involving exclusivity, public liability, endorsement of commercial products, equitable treatment of private companies, and equal access to research results by all, remain pertinent. The proposed mechanisms for dealing with new relationships individually, involving NARS wherever possible, and using an internal review process all appear apposite. However, the Panel believes that situations will soon arise where the only means of continuing to supply the best rice to NARS will require significant modifications to the present policies if IRRI is not to be marginalized while its research, its technology, and its germplasm are exploited by others to underpin the commercialization of the Asian rice industry.

The Panel recognizes, in the light of the situation elsewhere in the CGIAR System, the legal situation, and the current attitudes in private research organizations and other international public organizations, a need for urgency in re-examining IRRI's IP policy.

The Panel **recommends** that IRRI, the donors, and the NARS convene to address potential problems related to IRRI's current private sector and intellectual property policies, after the reports of the CGIAR Panels on Biotechnology and Proprietary Science are published.

6.3. The Sustainability of the Natural Resource Base

The advances in the biological sciences promise great increases in the ability of the rice crop to use the physical resources of the environment in generating yield and quality. The core NRM research on how the crop interacts with soils, water, and the atmosphere must therefore be maintained, and it is important to consider whether this resource base can be improved in terms of its ability to support the rice crop, or if it is fully sustainable.

6.3.1 Soils Characterization

The first requirement of NRM research is to identify the size and quality of the resources. IRRI is moving into studies on land use, especially in the major river deltas and the associated watersheds. It is important that this be done in a fully quantitative manner, to define the land and soil in relation to their exploitation for rice farming, and for mixed land use in which rice cultivation has a part. From the resulting databases it will be possible to predict yields under rice cultivation, extrapolate from site-specific experiments, and build up information on the likely sustainability of different land uses in different areas.

A particular issue is the loss of land from rice farming to urban, industrial, and commercial uses. Sometimes it is converted to other agricultural uses, such as high-value vegetables, but this appears to happen very largely on the rainfed uplands. We have not been given any data on the loss of high-quality irrigated land to rice cultivation, but such flat fields are attractive to developers, and we **suggest** that IRRI should ensure that it collects all the available statistics on this, as part of its Ecoregional studies. The ability to deploy crop modelling in predicting the best use of land is important, as it allows all the interacting factors in the environment to be included in the assessment. It is discussed at greater length below.

6.3.2 Soils and Yield Decline

Soil conditions have been brought into prominence by the term 'yield decline'. This subject was considered at length by the 4th IRRI EPMR, in 1992, which concluded that there were unexplained declines in yields of rice, especially at the highest levels of intensive cultivation, and that this was a critical problem for the future. This suggested that such high yields from intensive culture were not sustainable, and the hypotheses to explain this alarming possibility ranged over new diseases, loss of 'soil health' or soil structure, and changes in the microbial cycles in the soil. The Recommendation 3.1 included the statement that "... IRRI lead a major research effort, enlisting the best talents available in the world, to seek solutions for this complex of problems - a task that may take a decade or longer to complete".

The Panel has looked carefully at this subject. There is no doubt that the information available to the 4th EPMR indicated a serious problem, with declining yields on at least 3 of IRRI's flagship long-term field experiments (Cassmann *et al.* 1995)[1], for which a careful study of soil and crop properties provided no explanation. There was also anecdotal evidence from farmers that they were using more fertilizers to achieve the same yields as before (Cassman and Pingali 1995)[2]. However, there was insufficient evidence to reach any firm conclusions. The observations of yield decline were most convincing on the long-term experiment on the IRRI Research Farm, and least clear on rice-wheat experiments in India.

More information from the last five years is now available. Firstly, no evidence has been found that intensive farming yields are declining in general, so long as inputs are sufficient. Whereas the accuracy of the observation is clearly less in farmers' fields than on a long-term experiment, it seems unlikely that a widespread decline of the magnitude seen in the IRRI long-term experiment on the IRRI farm, of 33% over 25 years, could have gone unnoticed. Experiments were established by IRRI in 1993 in about 200 farmers' fields to obtain more accurate information about the use of inputs and the productivity that these maintained, but it is too early to draw conclusions from these yet. No evidence has been found that any single pest or disease is responsible. However, it has been found that the decline in yield from the previously high levels can often be reversed if the nitrogen supply is increased, and at the same time is managed more carefully in accordance with the increasing demand of the growing crop.

This suggests that the cause lies in a steadily decreasing rate of supply of natural nitrogen from the soil (Cassmann *et al.* 1995). With hindsight, this possibility could have been tested much more conclusively if the long-term experiments had been planned with more and larger rates of nitrogen and better timing of applications, and this needs to be borne in mind in the planning of the new generation of long-term experiments, which it is now essential to lay down. The more detailed studies made on the long-term continuous cropping experiment at IRRI suggest that there is a continuing decline in the annual rate of supply of natural nitrogen from the soil of some 60 kg/ha over a period of 22 years. There were also changes in the increase in grain yield per unit amount of

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1 Cassmann K.G., De Datta S.K., Olk D.C., Alcantara J., Samson M., Descalsota J. and Dizon M. (1995) Yield decline and the nitrogen economy of long-term experiments on continuous irrigated rice systems in the tropics. *Advances in Soil Science*, pp. 181-222.

2 Cassman K.G. and Pingali P.L. (1995) Extrapolating trends from long-term experiments to farmers' fields: the case of irrigated rice systems in Asia. In: *Agricultural sustainability in economic, environmental and statistical terms* (eds. V. Barnett, R. Payne, & R. Steiner) pp. 64-84. London: Wiley and Sons.

nitrogen, but it is not clear whether this was due to soil changes or to changes in the agronomic treatments. The soil scientists at IRRI have told the Panel that these changes in the natural soil nitrogen relationships, and possible changes in the efficiency of uptake of N by the rice plants, are the best current hypothesis for the cause of yield decline, and the Panel concurs in this view. If this occurs in farmers' fields, it could have been masked by the steady increase in the rates of nitrogen used over this period.

The decline in the rate of supply of natural nitrogen within long-term trials is not new. The usual cause is that the type of land use has changed when the experiment was laid down, and the soil nitrogen and carbon dynamics slowly adjust to the new situation - in temperate soils, this may take up to a century. This may be called a decline in the quality of the soil, but it is perfectly natural, and is compensated by supplying more fertilizer in appropriate ways. It can be interpreted as a reduction in 'factor productivity', but this economic concept has little relation to the biophysical processes. This general process in anaerobic soils appears to be different from that in drained soils, where it usually is linked to a simple decrease in soil organic matter. In this case, the total C and N levels remain constant, or even increase where high N fertilizer rates are applied.

It does, however, emphasize the point that increasing levels of nitrogen will be used for rice as the yield frontier expands, and that land use is likely to change more as new farming systems develop. Nitrogen is more difficult to manage in anaerobic soils than in aerobic ones, and the efficiency of use of nitrogen under wetland rice conditions is substantially lower than that of nitrogen for high-yielding cereal crops in aerobic temperate soils. The causes are probably known in general (e.g., hydrolysis of urea and loss of ammonia as the pH shifts with the bicarbonate level; denitrification; the formation of resistant nitrogen/carbon polymers under anaerobic conditions), but the integrated understanding of the carbon-nitrogen dynamics in flooded soils, as expressed in mathematical models of the microbial processes, is far behind that of the drained agricultural soils. This situation needs to be remedied urgently as the intensification of rice cultivation continues. Apart from the nitrogen supply, this impinges upon the phosphorus dynamics of the soil, the organic matter level and the soil structure, and the behaviour with agrochemicals. The Panel acknowledges the progress that IRRI has made in defining the factors required for yield sustainability in experiments and on the farm. It believes that IRRI should increase its efforts to improve the basic understanding of flooded soils and of the root systems of plants growing in them, thereby meeting the recommendation of the 4th EPMR, by improving the focus, strategic planning, and resources invested in current programmes.

The Panel **recommends** that a strategic programme on soil carbon and nitrogen dynamics in flooded soils should be designed and mounted in collaboration with appropriate centres of excellence.

6.3.3 Water

The water supply is fundamental to rice, as a wetland plant. The supply of water for rice is frequently stated to be declining, but the Panel is not sure what this means. The primary demand for industry and domestic use is obviously growing rapidly in the developing Asian economies, but a great deal of this water is recycled back into rivers or seeps down to the groundwater. If the quality of this water is maintained, the net loss is small, and this needs to be taken into account, rather than quoting the gross abstraction rate of water. The use that actually loses most water is clearly agriculture, because evapotranspired water cannot be used again. We **suggest** that IRRI should ensure that complete statistics on such real use of water are gathered within the Systemwide Initiative on Water Management.

Whatever the result of this, the supply of water will shrink rather than grow, and water economy is a very important aim of IRRI's AAPA and SWS Divisions. As stated in Chapter 4, the Panel is impressed with the work on water management in Vietnam, and such studies should be expanded to other countries. This also suggests added support for direct seeding, which makes great savings in irrigation water. The Panel believes that IRRI should look for innovative solutions in this topic, in an attempt to bring the transpiration ratio for rice closer to those of dryland crops.

6.3.4 The Climate and Atmosphere

It is well known that the 1990s are likely to be the warmest decade on record in global terms, and the Intergovernmental Panel on Climate Change has cautiously indicated that this change is probably due to anthropogenic causes. IRRI and others have produced several crop models on rice growth, whose predictions agree reasonably with each other. These suggest that the predicted increase in temperature over the next few decades will on average increase rice yields in the subtropical zone but decrease them in the tropical zone, where most poor rice farmers live. Crop modelling is becoming an essential integrating discipline in soils, water, and atmospheric research. IRRI needs to watch the situation carefully in relation to its plant breeding work, and the Panel encourages it to ensure that it remains part of the very active global crop-modelling community so as to retain the capability to model the response of rice to these and other changes.

As opposed to these still uncertain climatic predictions, the carbon dioxide in the atmosphere will almost certainly continue to increase; the current level is already about 70 ppm above that in pre-industrial times. The consequences for rice cultivation seem almost wholly benign. Work on field crops other than rice has shown a direct increase in rate of growth because of more rapid photosynthesis (at least in C3 plants), and a general increase in the ratio between net photosynthesis and loss of water by transpiration. This should therefore assist the general upward movement in yield levels caused by plant breeding and better agronomy and help to mitigate any shortage of water. This change must be borne in mind in the crop modelling studies.

6.4 Impact Assessment

6.4.1 Introduction

IRRI is a major research organization having numerous research programmes competing for resources and it has to allocate resources to each of these after their careful appraisal including an assessment of their likely impact. The given goals must be achieved in an economically efficient manner, and for public sector research organizations like IRRI, this means both ensuring that resources are used so as to minimize the cost of producing a given research output (cost efficiency) and ensuring that the research outputs are of maximum value to the organization's clientele (allocative efficiency).

Thirty-five years after its setting up, it is important for IRRI to build a system that attempts to assess its total contribution, along with that of its individual programmes, in relation to the costs incurred. More specifically, there is a need to develop more transparent priority-setting mechanisms through development of proper methodologies for impact assessment of its research programmes.

6.4.2 Evolution and Current Focus

IRRI has been concerned with impact assessment since its early days. There are two main types of impact assessment studies. The first group assesses *ex-post* the impact of new technologies on increase in output, on cost of production and prices of rice, and the extent to which the goal of improving food security and welfare of rice producers and consumers has been achieved.

Secondly, *ex-ante* impact studies are needed to help planning, through prioritization of objectives and allocation of research resources across programmes and projects. These studies attempt to assess the likely future impact of current or planned research activities on new technologies, on likely increases in yield and output, and on efficiency in the organization of rice production and the management of rural resources.

6.4.3 Methodology

IRRI scientists have for a long time worked to develop appropriate methodologies for undertaking *ex-post* and *ex-ante* research assessment at IRRI, keeping in view the main characteristic of IRRI, namely, its focus on single commodity research. These methodologies are briefly discussed below.

Ex-post studies. The methodology developed by IRRI scientists for undertaking *ex-post* impact assessment studies has changed over time. Initially, these studies used an economic surplus model that tried to define the market price effects of new technology on demand and supply and on income distribution. The methodology now being used in impact studies is based on process and outcome evaluation through in-depth household surveys. Since 1986, IRRI in collaboration with NARS has been engaged in generating household-level data on economic activities for process and outcome evaluation. Several major studies have been published based on this methodology, the latest being that by David and Otsuka (1994[3]) which contains the results of a Differential Impact Study (DIS) Project jointly conducted by IRRI and NARS colleagues in China, India, Bangladesh, Nepal, Thailand, Indonesia, and The Philippines, on the basis of agreed research methodology.

In 1994, IRRI launched a project to resurvey these villages with the same methodology to generate two point data for further assessment of impact of new technology at the household level. In addition, IRRI, as the participant in the CGIAR Impact Assessment and Evaluation Group (IAEG), is assessing *ex-post* the impact of mechanical technologies. Also in 1996, IRRI held an international workshop on *ex-post* impact of rice research, in collaboration with the Thailand Development Research Institute. The proceedings are being published as a book '*Impact of Rice Science and Production*'.

Ex-ante studies. IRRI scientists, in collaboration with the Rockefeller Foundation and Yale University, have developed a methodology for prioritization of research problem areas by

[3] David, C.C. and K. Otsuka (eds.), 1994, *Modern Rice Technology and Income Distribution in Asia*, Lyn Rienner Publishers, Boulder and London.

analyzing perceptions of knowledgeable rice farmers, extension workers, and researchers. Relevant data on yield gaps and yield losses due to various constraints are being generated in collaboration with NARS social scientists, with a view to prioritizing research problems and determining the need for further research on rice. IRRI has been regularly holding bilateral research planning workshops and dialogues in which findings of the *ex ante* evaluation studies are used. Over the last two years, IRRI and NARS have jointly organized India-IRRI, Bangladesh-IRRI, China-IRRI and Pakistan-IRRI research planning dialogues. In each, research managers and policymakers were invited to review the achievements of past collaboration and develop future research programmes. For future *ex-ante* impact assessment studies, it is proposed to include assessment of the capacity of NARS to undertake research in the priority areas, delineation of the comparative strengths of NARS and IRRI and identification of areas for research collaboration, and assessment of the training needs of NARS.

6.4.4 Designing *Ex-ante* Impact Assessment Methodology - Problems and Limitations

IRRI scientists in collaboration with other scholars[4] have been engaged in refining the methodology for impact assessment. Much of the methodology is derived from project evaluation in terms of benefits and costs. However, it has been modified to take into account numerous peculiarities of research output. Six steps are involved in this evaluation. These are: (i) specification of the project in terms of objectives, techniques, inputs, costs, and time; (ii) estimation of the *benefit stream* associated with the project over its life span; (iii) use of *ex-post* evidence of research impact for *ex-ante* priority setting; (iv) using subjective probability estimates of likely benefits and costs; (v) using modifiers to revise the estimates; and (vi) discounting the annual streams of benefits and costs by using an appropriate discount rate, or alternatively finding the internal rate of return (IRR) that makes the net value of annual streams of net benefits (benefits minus costs) equal to zero, and calculating the benefit-cost ratio or comparing the IRR with the prevailing rate of interest.

6.4.5 Limitations of Applying the Model to Research

There are serious problems of a generic nature, with respect to each of the above points when using this method to assess the impact of scientific research. Firstly, it is difficult to estimate with sufficient precision the time span to fruition of research and the duration of the flow of benefits from it. Secondly, for research projects, there are serious problems in measurement of both benefits and costs. Unlike many other projects, such as building a bridge, estimates of benefits are intangible and uncertain and cannot by definition be made on the basis of past *ex-post* experience. This is also because technologies do not stay constant themselves, but evolve over time, leading to qualitatively different outcomes, so that benefits and costs of earlier project may not be relevant. This is an obvious limitation of use of data from *ex-post* studies. However, the reliability of *ex-post* information improves as the unit of operation that is the research programme area becomes bigger, and the more aggregated it is, the more reliable is *ex-post* evidence. For some broad purposes such as comparing rice research priorities for broad ecoregions or with other research programme areas, *ex-post* evidence for research impacts from statistical studies may be the best guide. *Ex-post* studies

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4 See Evanson, R.E; R.W.Herdt and M. Hossain, (eds) 1996, *Rice Research in Asia: Progress and Priorities*, IRRI, CAB International, Wallingford.

clearly show that irrigated rice research programmes (in the aggregate) have had high impacts and few, if any, upland rice research programmes have shown impacts. There is every likelihood that unless better technologies (germplasm) for upland rice become available, the experience reflected in the *ex-post* evidence will continue.

The third problem is the need to clearly define and delineate research programme areas as basic units for priority setting. These areas should be consistent with currently perceived research problems. They should have clear and non-conflicting research objectives; have adequate economic and statistical data; an ecosystem dimension; and a technique (germplasm) or research tool dimension.

Fourthly, the research output is not at all certain. In many cases, it is possible to treat this as uncertainty, and some form of uncertainty can be treated as random elements and *expected values* can be based on past experience. But for most research projects, some form of subjective estimation and informed judgement about the benefits from the project is required. Moreover, for *ex-ante* assessment of new research projects, using past evidence is not generally possible because of the novelty of research.

Fifthly, because of the reasons discussed above, resort might have to be made to subjective estimates of benefits given by specialists. This method is called subjective probability estimates. The scientists working in the area are the best possible judges of, say, germplasm potential and they are in the best position to observe its performance in the field. There are four procedures to obtaining these probability estimates: (i) ranking techniques, (ii) scoring or scaling techniques, (iii) single point probability estimates, and (iv) subjective probability distribution.

Finally, even the subjective estimates suggested above may have to be supplemented through appropriate adjustment factors to take care of some important equity considerations such as: sustainability, unfavourable ecosystem properties, equity, weak NARS programmes, and environmental effects.

IRRI scientists are aware of these limitations and have been trying to improve the accuracy of estimates of benefits of research activities by quantifying yield gaps and yield losses due to various biotic and abiotic constraints and the probability of research success. Although initial estimates of benefits were based on studying perceptions of rice scientists, recent studies aim at generating the information by interviewing knowledgeable farmers and extension workers using rapid rural appraisal methods. An IRRI pathologist has been collaborating with NARS pest scientists to develop a database on pest losses, to further refine these estimates.

The subjective probability estimates for specific research problem areas and techniques are being built up by interviewing researchers from NARS and IRRI, and also scientists in advanced research institutions in developed countries engaged in biotechnology research. A questionnaire was administered to scientists participating in the Rockefeller Foundation's rice biotechnology meetings held in Bali, Indonesia in 1995 and in Malacca, Malaysia in 1997 to solicit this information. The above steps are in the right direction to improve the quality of *ex-ante* impact studies.

6.4.6 Conclusion

IRRI scientists are quite strong in undertaking *ex-post* impact assessment research studies. Most of the work done at IRRI is universally acknowledged as high quality in terms of methodology, analysis of data, and its interpretation. A beginning has been made in conceptualizing *ex-ante* impact assessment and a modified cost-benefit evaluation methodology has been developed. It is a correct strategy to involve NARS as collaborators in this type of research. However, though this has helped IRRI in its prioritization for research resource allocation, IRRI or the NARS have been able to provide only limited guidance to national governments for their planning and prioritization of research programmes. Further, there are three important gaps in the *ex-ante* research methodology which IRRI should address. These are the need: (i) to test the validity of *ex-ante* assessment of work projects by undertaking *ex-post* evaluation; (ii) to identify 'flag posts' representing intermediate targets in terms of achievements and expenditures during project implementation; and (iii) to identify impact pathways that are likely to operate in converting research outputs into desired outcomes and impact.

Ex-ante impact assessment research is extremely important, and the Panel **suggests** that IRRI should give high priority to this subject, including the refinement of existing methodology with a view to reducing subjectivity in assessments for priority setting, and identifying impact pathways.

CHAPTER 7 - ORGANIZATION AND MANAGEMENT

7.1 Governance and Leadership

7.1.1 Board of Trustees

Overall authority for IRRI's mandate and mission, embodied in IRRI's 1995 charter, is vested in a Board of Trustees composed of 15 members (12 members-at-large and 3 *ex-officio*: the Secretary of Agriculture, Republic of the Philippines; the President of the University of the Philippines; the Director General of the Institute). The membership of the Board since 1990 (Table 7.1) shows the nationality, specialization, gender, and terms of office of the respective members and the positions on the Board held by the current incumbents.

The current Board has a reasonable blend of complementary expertise, gender, and country representation. It is important to have sufficient members with science specializations, as IRRI's future research programme is expected to move rapidly into new strategic areas. The Panel realizes that balancing all the relevant factors - specialization, gender, national origins, ability to open doors to donors, and be representative of the rice-growing countries - is not easy. The Board appears to have given considerable weight to national origin and to political influence in the past. The Panel believes that when Trustee selection is based on eminence in their respective fields, be it science, finance, or management, Trustees' influence on donors should follow naturally, and that these factors should be preeminent in seeking nominees for the Board.

The Panel noted the availability of a concise handbook for Trustees, summarizing useful information. After comparing this document with the comprehensive set of reference guides to Centres and Boards of Trustees, published by the CGIAR Secretariat, the Panel suggests that the handbook be revised to include missing topics such as Board self-assessments, assessments of the DG, the selection process for choosing a DG, and the relationships between the Board and the DG.

The Board has five Standing Committees: Executive; Audit and Finance; Nominating; Programme; Goodwill and Resource Generation. The last Committee was newly constituted in April 1996. The Board meets annually, and Standing Committees hold meetings whenever the Board meets, and schedule other meetings as necessary. In a centre of the size and complexity of IRRI, the Board and Standing Committees have a difficult task in prioritizing their activities at meetings. The Panel feels that the creation of a fifth Standing Committee for Goodwill and Resource Generation may dilute members' contributions to the other committees and doubts the value of this Committee. Members' influence and credibility in their own environments combined with the DG's role in fund-raising and donor relations, and the Institute's demonstration of its accomplishments, should be sufficiently effective to influence donors and generate goodwill.

The Panel had limited opportunity to see the Standing Committees in action. However, Minutes of the Board and all Standing Committees were perused and the Panel was also able to obtain the personal opinions of some of the Trustees. The Programme Committee Minutes

Table 7.1 Board of Trustees from 1990 to 1998

Name	Nationality	Specialty	Gender	Nominated by:	90	91	92	93	94	95	96	97	Current	Board Position - Current Trustees
Howard A.Steppler	Canada	Agronomy	M	Board	x	x	x	x						
Dieter F.R. Bommer	Germany	Plant Science	M	Board	x	x	x	x						
Jose V. Abueva***	Philippines	Public Administrator	M	Ex-Officio	x	x	x	x						
Walter P. Falcon	USA	Agric. Economics	M	Board	x	x	x	x	x					
Kazutake Kyuma	Japan	Soil Science	M	Board	x									
Klaus J. Lampe [1]	Germany	Agronomy	M	Board	x	x	x	x	x	x				
Petcharat Wannapee	Thailand	Agronomy	M	Board	x	x	x							
Muhammad Yunus	Bangladesh	Economics	M	Board	x	x	x	x	x					
Senen C. Bacani**	Philippines	Financial Mgt.	M	Ex-Officio	x	x	x							
Rajendra S. Paroda	India	Plant Breeding	M	Board	x	x	x	x						
Vo-Tong Xuan	Vietnam	Agronomy	M	Board	x	x	x	x	x	x				
James R. McWilliam	Australia	Agronomy	M	Board	x	x	x	x	x	x				
Ibrahim Manwan	Indonesia	Entomology	M	Board	x	x	x	x	x	x				
Shinya Tsuru	Japan	Microbiology	M	Board			x	x	x	x	x	x		
Priscilla W. Kariuki	Kenya	Psychology	F	Board			x	x	x	x	x	x		
Roberto S. Sebastian**	Philippines	Agric. Economics	M	Ex-Officio			x	x	x	x	x			
Montri Rumakon	Thailand	Entomology	M	Board				x	x					
Sandra S. Batie	USA	Agric. Economics	F	Board				x	x	x				
Emil Q. Javier***	Philippines	Agronomy	M	Ex-Officio				x	x	x	x	x	x	Nom. Comm- Chairman/BOT - Vice Chairman
Michael H. Arnold	UK	Plant Breeding	M	Board					x	x				
Virendra L. Chopra	India	Genetics	M	Board					x	x	x	x	x	Prog. Comm.-Chairman/Exec/Nom. - Member
Samuel C. Shieh	Taiwan	Economics	M	Board						x	x	x	x	
Roelof Rabbinge	Netherlands	Entomology	M	Board						x	x	x	x	BOT/Exec. Comm. - Chairman
George H.L. Rothschild [2]	Australia	Entomology	M	Ex-Officio							x	x	x	
Mechai Viravaidya	Thailand	Agronomy	M	Board							x	x	x	GRGC* - Chairman/Exec. Comm.- Member
Sjurifudin Baharsjah	Indonesia	Agric. Economics	M	Board							x	x	x	Fin. & Admin. Comm. - Chairman
Makiko Arima Sakai	Japan	Communications	F	Board							x	x	x	Prog. Comm./Fin. & Admin - Member
Donald N. Duvick	USA	Plant Breeding	M	Board							x	x	x	Prog. Comm./Fin. & Admin. - Vice Chairman
Lene Lange	Denmark	Microbiology	F	Board							x	x	x	Nom. Comm./GRGC* - Vice Chairman
Sienc Saphangtong	LAO PDR	Agronomy	M	Board							x	x	x	Prog. Comm. - Member
Salvador H. Escudero III**	Philippines	Veterinary Medicine	M	Ex-Officio							x	x	x	GRGC* - Member

*Goodwill & Resource Generation Committee

[1]*Served as a Director General from 1988-1995*
[2]*Served as a Director General from 1995-1997*

***Phil. Secretary of Agric.*
****Pres. of the Univ. of the Phils.*

show that the Committee was fully involved in the whole research programming cycle, commencing April 1996. It first guided the revision of the strategic plan, *IRRI Towards 2020*, and endorsed, after detailed discussion, the new Medium Term Plan (MTP, 1998 - 2003). This process culminated in April 1997 with endorsement of the final draft of the MTP by the full Board. The Minutes also show that other important policy issues, such as the Staff Restructuring Programme, were brought to the Board by IRRI's management for endorsement.

The Panel is of the opinion that better oversight by the Board over the preparation for the EPMR, including the commissioning of CCERs in selected research and management areas, would have been desirable (and greatly facilitated the EPMR Panel's work). The Panel also believes that with the retirement of a finance specialist from the Finance and Audit Committee, it is essential to strengthen the financial expertise of the Committee.

Since the fourth EPMR in 1992, there have been two changes in Board Chair. The first change occurred when an *ex-officio* member was elected as Chair for 1995, when a nominee to the Board, who was expected to be elected as Chair, became unavailable. The Chair in 1995 was re-elected for 1996. The current Chair was elected in April 1996 (when the previous Chair wished to step down due to other commitments) and re-elected for each of the years 1997 and 1998. The Panel commends the Chairmen for creating a good climate for Trustees to contribute to IRRI's governance. The Panel, however, was not able to find if and when the Board conducted a formal, systematic self-assessment of its own performance, or assessments of the DG. It believes that such assessments are extremely useful to Trustees, and fully endorses the CGIAR guideline that this is an essential task for the Board if the Centre is to realize its goals in the most efficient and effective way. Such assessments will achieve several objectives: clarify expectations between the Board and the DG, provide insights into the strengths and limitations of the DG's performance and skills, and, most importantly, defuse points of contention before they become sources of major disagreement.

The Panel **recommends** that the Board undertake annual self-assessments, and annual assessments of the DG, and that records be kept.

7.1.2 Management

During the five years since the last EPMR, the DGs have been, successively, Dr. K. Lampe (to 1995) and Dr. G. Rothschild (to 1997). Both showed dedication to the purposes of the Institute, though through very different styles of management. During Dr. Lampe's period, his energetic leadership sustained a strong senior management team. He was also responsible for implementing a major programme of rehabilitation and refurbishment of IRRI facilities, for which he had successfully campaigned to raise the required capital. Under Dr. Rothschild, significant milestones were: updating of the long-term strategy, preparation of the current MTP, and the Staff Restructuring Programme (SRP). In the Panel's view, towards the end of this period the senior management staff did not function as an effective team and lines of authority were not clear, and this appears to have had a negative effect on staff morale generally. The Centre depended greatly upon the DDG Research at this stage. During 1997, three senior members of the management team, and the DG himself, resigned for varying reasons.

7.1.3 Assessment

The Board has a strong nucleus of members with experience and skills in conducting business, but it has also had several members who contributed less than would have been expected. It is essential that the Board avoids this in the future. During the recent turbulent period, the Board's oversight has not been wholly successful. The Panel **suggests** that greater involvement by members of the Board, or at least the Executive Committee, would be beneficial. The present Board Chair is dynamic and fully involved, and the Centre is fortunate that Dr. Robert Havener has agreed to serve as Interim DG till the appointment of a new DG. The Panel is pleased to note that IRRI is in the process of filling the other senior management vacancies. This will ensure that the good scientific work of the Centre can continue smoothly under the leadership of the DDG Research. The filling of vacant management positions is now a critical challenge for the Board.

7.2 Organizational Structure

IRRI's organizational structure has been modified several times since 1987, in response to changing circumstances and needs. The current formal structure (Figure 7.1) is similar to that reviewed at the previous EPMR in February 1992, except that activities under Strengthening International Partnership, and in the Genetic Resources Center and the International Rice Genebank, have been consolidated into two new programmes, and brought into the programme axis of research management. This is in accordance with the funding allocation and the programme description in the latest MTP (1998-2000). However, the Panel understands that this is a temporary operational move pending a thorough review of the organization. It has not been entirely easy for the Panel to determine exactly what the IRRI structure is at the present moment.

In September 1997, Management proposed a revised structure, and this proposal has now been further modified by a Task Force commissioned by the Board Chair. The objective was to achieve greater efficiency, responsiveness, and coherence. The Panel was asked to comment on this paper, though its current status is simply that of a proposal awaiting discussion by the Board. The Panel learned that the Task Force based the proposed re-configuration on the need for stronger linkage between research results from programmes, and their impact on IRRI's partners. While the Panel concurs with the Task Force that the linkage between Research Programmes and impact on IRRI's partners is of critical importance, and should be strengthened, it should not be at the cost of complexity and attendant transaction costs. The route proposed adds complexity which the Panel feels will be counter-productive at a time when the Institute is in need of organizational stability. However, the Task Force's proposal to combine the three Rainfed Programmes into one programme (Section 4.6), is a useful step in the right direction of reducing complexity. The Panel believes that after the new appointments of the DG and other senior managers have been made, the new team could reconsider the structures in due course.

In the meanwhile, the recent changes described above, including the consolidation of the Genetic Resource Centre and the International Rice Genebank as a "Division" under the DDG Research, could continue. The Panel believes that integrating the science of this division more seamlessly with that of the other disciplines is sensible. INGER will be housed in the new division appropriately close to the rest of the germplasm operation. The operational experience gathered with these temporary moves will provide additional input to any review undertaken of the organization.

On the Finance and Administration side of the IRRI organogram, the proposed elimination of the post of DDG for Finance and Administration, and replacement by two independent Heads - Finance; Administration and Human Resources - at the director level, appears to be a cost-effective move, and is workable if suitable candidates are appointed to these senior positions. Therefore, the Panel supports this move. The post of one new DDG is frozen, for the time being. For a number of years, an IRRI DDG has come from the host country, and the filling of this post will be a sensitive issue.

The Panel **recommends** that no major changes be made to the current organizational structure before the new DG has had time to consider whether changes are necessary.

It is important that management and staff shall not be diverted by the laborious tasks of introducing a new structure.

7.3 Planning and Review Processes

7.3.1 The Planning Process

The Panel noted that IRRI has a well designed process for development of its research programme (Figure 7.2). Preparation of the latest MTP (for 1998 - 2003) was undertaken and processed in a systematic way over a period of 20 months before finalization. The starting point was the revision of the long-term strategy - IRRI Toward 2020. This strategy paper was produced in 1994 as a backdrop for planning. Major inputs for the revision in 1995-96 included: the outcome of the Rio Conference on the environment and natural resource management; the CGIAR emphasis on poverty alleviation; and emphasis on unfavourable ecosystems. A variety of inputs were used in the process - reviews of ongoing research, scenarios of likely changes in the external environment, and inputs from NARS, the Board, and TAC. The significant difference between previous planning cycles and this one was the systematic integration of all inputs, and the close participation of NARS in this exercise. By explicitly taking into account the strengths of the NARS, some of IRRI's research activities could either be fully devolved or undertaken through partnerships and collaborative efforts, thereby releasing IRRI resources to shift into more strategic areas where IRRI has demonstrable comparative advantages.

The Panel believes that the planning and priority-setting process is sound. It contains, in the right sequence, all the essential inputs and parameters for the development of a good portfolio of projects through a practical methodology for priority setting. The Panel also commends the thoroughness with which the Task Force produced the MTP. It was pleased to note the high degree of involvement by NARS representatives (from ten major rice-growing countries, including China and India), and the Board.

IRRI now has a six-year perspective plan, from which it has extracted the parameters for the current three-year MTP. This approach, of extracting the parameters for preparing a resourcing plan from a longer term plan, is sensible. On a practical note, it should enable IRRI to keep rolling its MTP forward from year to year without excessive effort.

Figure 7.1 IRRI Organizational Structure (as of February 1998)

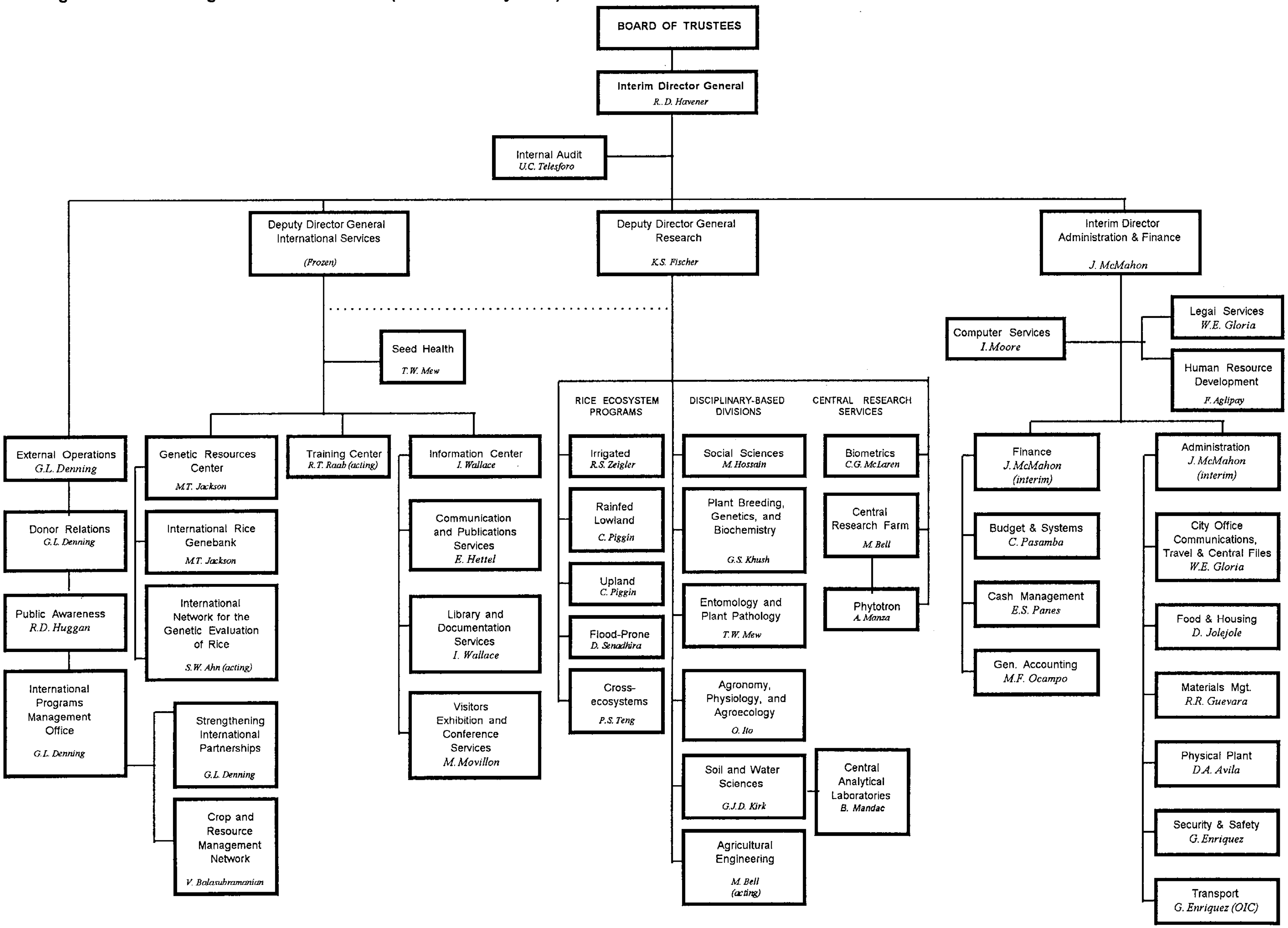
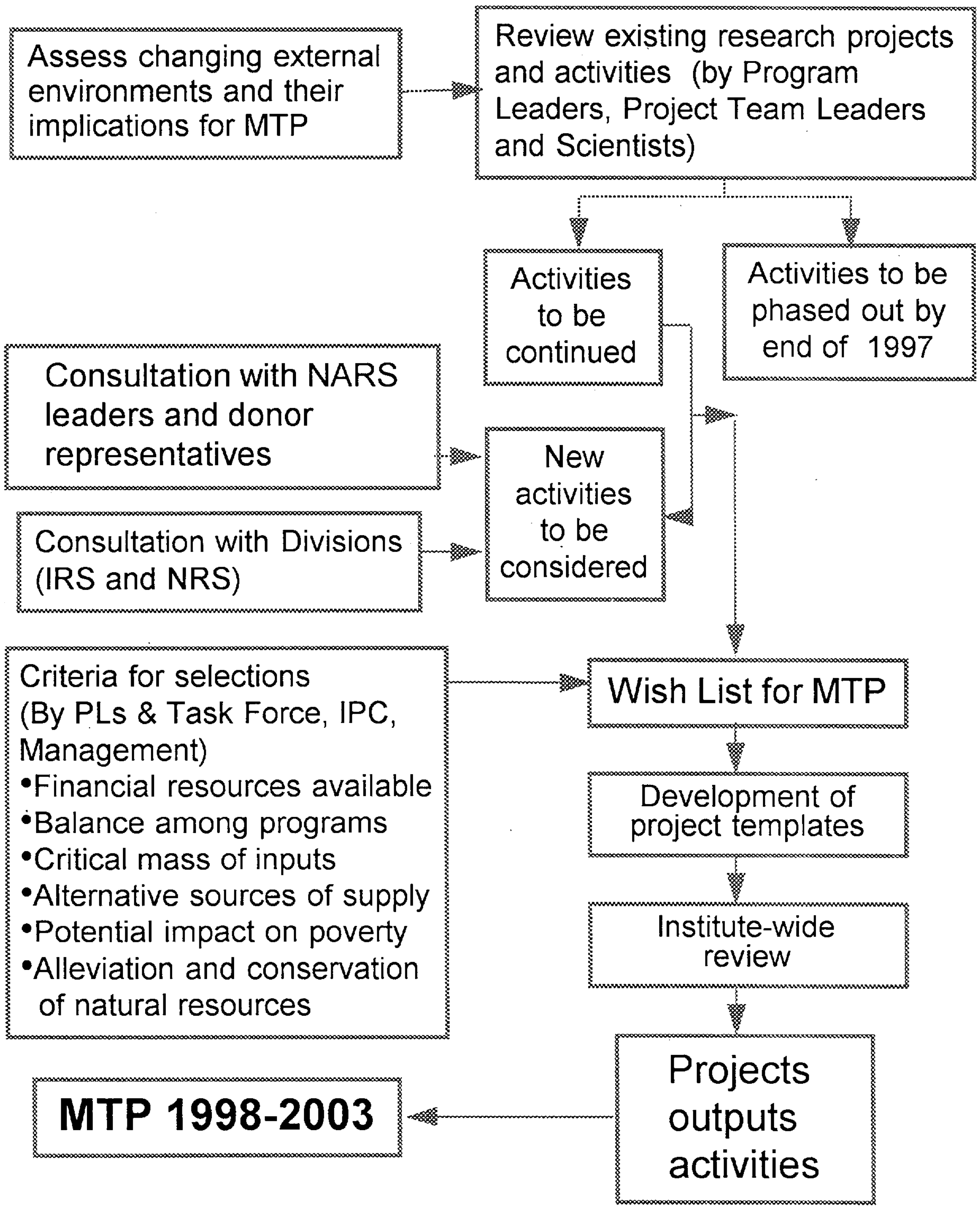


Figure 7.2 Process of MTP Development



Assessment

The Panel considers that overall, IRRI has a good Medium-Term Plan, with realistic, yet sufficiently challenging goals. This end product is also proof that the process for its generation is sound. However, given the highly staff-intensive effort needed to go through a full planning cycle, Management should ensure that with the CGIAR's new guidelines for rolling the MTP forward annually, each annual exercise does not become a major planning exercise in its own right.

7.3.2 The Review Process

IRRI has a hierarchy of reviews for monitoring progress on projects. The frequency of reviews is flexible and left to the discretion of the Project and Programme Leaders. At a project level these could be twice or thrice a year; at a programme level, annual or semi-annual. These reviews feed into a Management Information System (MIS) for an annual review by Management. This forms the database for the review of achievements made in a DG report to the full Board, and an achievements and constraints presentation to the Programme Committee of the Board. The preparation (or the annual update) of the MTP provides another opportunity for reviewing progress and adjusting future plans in the light of progress achieved. The MIS returns contain a description, by project, of the significant achievements, and bottlenecks to progress. They do not, however, contain the milestones - i.e., outputs expected, nor target dates - as described in the project templates. These templates contain, in a standard format, comprehensive data on all projects including milestones, resource allocation, outputs expected, and estimated time to completion.

IRRI is in the process of implementing a computerized Project Monitoring System (PMS) which is expected to be fully operational in 1998. This database will include all the data from the templates. Achievements will feed into the database annually, extracted principally from researchers' Performance Evaluation System (PES). The PES is an evaluation system for all Internationally Recruited Staff (IRS). These are agreed work plans within projects against which achievements by the individual are evaluated annually. Because of the workload for the MTP and the SRP in 1996 and 1997, this system for evaluation has not been used over the last two years. It has been restarted in January 1998.

At an institute level, IRRI uses the peer review process to guide and change the direction for research, and to monitor the quality of its science. Of the seven reviews conducted from 1993 through 1997, three were Internally Commissioned External Reviews (peer reviews) and four donor initiated. No reviews were conducted in 1996 and 1997 due to the workload from the MTP and the SRP. However, no Centre Commissioned External Reviews (CCERs), a review process available to the Board to assess the quality and effectiveness of particular areas of a centre's work, have taken place.

Assessment

The internal reviews made explicitly for preparation of the MTP appear to have been thorough. However, the absence of CCERs handicapped the EPMR. The Panel **strongly suggests** that the Board identify specific areas for CCERs and set a timetable for undertaking them.

The systems in place for internal progress and quality monitoring are appropriate but can be of value only when used rigorously and consistently over all research projects. The Panel believes that the introduction of indicators for progress into the MIS returns will introduce rigour into the monitoring process and assist management in critically reviewing projects; not only for noting achievements but also as a resource for managing resources. This is even more important when resource planning is on a rolling basis. The Panel, therefore, **suggests** that indicators and milestones be explicitly included in the internal review process for projects.

7.4 Research Management

IRRI revised its research organization from a discipline-oriented mode to a matrix management mode in 1990. The matrix was adopted as a means of ensuring the relevance of research programmes and projects to IRRI's goals, while maintaining scientific excellence. The current matrix, formally, has the five Ecosystems thematic Programmes - Irrigated Rice, Rainfed lowland Rice, Upland Rice, Flood-Prone Rice, Cross-Ecosystems, but operationally, already includes the two new programmes - Accelerating Impact; and Conservation of Rice and Biofertilizer Genetic Resources - on the output (relevance) axis. The discipline-based divisions along the input axis are formally Social Sciences, Plant Breeding, Genetics & Biochemistry, Agronomy, Physiology & Agroecology, Soil & Water Sciences, Entomology & Plant Pathology, but operationally include the Genetic Resources "Division". These operational changes have been discussed in Section 7.2.

The main actors in the matrix are the Programme Leaders, Division Heads, Project Team Leaders and Project Coordinators. Implementing research is a responsibility shared between Internationally Recruited Staff (IRS), Affiliate Scientists (AS), Project Scientists (PS), Nationally Recruited Staff (NRS), and partners. On average, each IRS and AP position has one additional PS and the support of ten research and field assistants, and 0.5 office staff to implement, in the current plan, 23 projects with 79 identifiable outputs.

IRRI recognizes that to maximize the benefits of working in the matrix mode it has to focus on setting practical targets, ensuring focus, acknowledging achievements (contributions to science, to impact, to team, to NARS), removing obstacles, and providing rewards. The Panel learned that some scientists were satisfied with the matrix system as it provided transparency, direct control of budgets, reduced paperwork, fostered participatory decisions and interdisciplinary team building. While by and large the matrix system is working, the Panel would have expected that given the gestation period of seven years, it would have been customized to IRRI's needs and working smoothly. This does not appear to be the case. Some of the criticisms made to the previous panel in 1992 were still repeated by other staff. Transaction time, management time at the expense of research, report-writing time, slow financial reporting, conflicts due to skills availability versus demand, and constraint on innovation, were among the criticisms.

These conflicting views are not unusual in matrix management where there are dual lines of authority and responsibility. The single, most important issue, in the Panel's opinion, is transaction time. To minimize transaction time, authority should be properly delegated down the line in a transparent manner. It should be clear where a given decision is to be made and Management, particularly, should adhere to this. It also means that chairs of all committees, task forces, and project teams, ensure that there is an agenda and timetable for meetings, with stated objectives, and make sure that these objectives are understood and attained. Where there is a premium on time, invitees to meetings should be limited to those who can contribute to attaining the objectives of the meeting, on a "need-to-know" versus a "nice-to-know" basis.

The staff of Finance and Administration can play their part in achieving greater administrative efficiency by understanding that they have a facilitating role (as opposed to a policing role) to enable the objectives of the Institute to be met; and they are as much a part of the research team as the scientists. The fostering of such an attitude may require the constituting of joint teams - research, finance and administration staff - to identify bottlenecks and find solutions with the theme that the business of IRRI is research.

The Panel was pleased to note that a Quality Assurance (QA) initiative, originating in 1993 as an integral part of an EPA project, is now being propagated as a requirement for all projects, driven by the enthusiasm of NRS (who find QA an excellent discipline for improving quality, morale, and continuity). IRS, on the other hand, have apparently been reluctant to adopt the QA discipline. They cite concerns over autonomy, privacy of data, and lack of funds earmarked for QA. The Panel understood that these concerns are being addressed, but wishes strongly to support the use of the QA discipline. The application of a QA discipline to research will prevent the "drift" of techniques when each scientist can alter them. Particularly in a matrix mode of operation, the Panel feels that the use of standard operating practices (SOPs), experimental designs, control charts, and quality reporting and publishing, will go a long way in eliminating inefficiencies.

Assessment

The Panel is of the opinion that the matrix system is still not functioning smoothly. This must be an impediment to the efficient conduct of research and its delivery. The Panel learned that many decisions require processing through several layers before decisions are taken. The DDG Research has been in a difficult situation - he has been handicapped because senior management did not function as an effective team, as lines of authority were not always respected; and overloaded, because of insufficient delegation to programme and project team leaders and division heads, who should be responsible for managing their staff, and budgets. The Panel believes that lines of authority should be made explicit to all staff in the matrix and that the additional managerial responsibilities (and accountabilities) carried by project team leaders should be appropriately rewarded.

The Panel **recommends** that a review be undertaken of management methods, including rewards for carrying managerial responsibility within the matrix; the efficient conduct of meetings; streamlining the interface between research, finance and administration; and appropriate delegation. This initiative must be seen to have the full commitment of the senior management team.

7.5 Institutional Relationships and External Operations

7.5.1 Overview

IRRI had three relevant units - International Programmes Management Office (IPMO); Liaison, Coordination, and Planning Unit (LCP); and Public Awareness (PA) - until 1997.

The IPMO coordinated international programmes under the DDG for International Services, and the LCP and PA units assisted the DG in fostering good institutional relationships, particularly with donors. The DDG International Services was more directly involved in maintaining good relationships with the host country and NARS.

With the retirement of the DDG for International Services and the Head of the LCP unit, the three units were brought under a new Directorate, External Operations, in early 1997, reporting directly to the DG. The only other change was to transfer, out of the LCP, the Board Secretariat responsibilities from the LCP to the legal office (under the attorney), and the programme planning activities to the DDG Research. The remaining liaison activities and activities associated with donor relations are now part of External Operations.

7.5.2 International Programmes Management Office

The IPMO's role is to coordinate and facilitate the planning and implementation of all cooperative and collaborative programmes, provide support to outposted staff and nationally recruited Liaison Scientists (LS) in regional and country programmes, assist NARS in the design, appraisal, and review of bilateral country projects (including fund sourcing from donors), and oversee the recruitment and outposting of scientists to country projects and liaison offices. Partnerships depend on the strength of the NARS, and are continuously evolving (see Section 3.5).

The IPMO oversees these partnerships through either LS located in a country, or IRS scientist(s) doing on-site research and institutional strengthening. LS are placed in strong NARS and outposted IRS are usually in the less developed NARS. At present, there are four LS (India, China, Indonesia, Myanmar), and 11 IRS in four other countries with an evolution towards the LS model.

Funding in IPMO is under the "Strengthening International Partnerships" Programme in the 1994-1998 MTP, and is now under "Accelerating Impact (IM 1)" in the new MTP. Country-specific projects, such as those in Cambodia, Laos, and Madagascar, are fully funded through special project funds with full overhead recovery.

Assessment

The IPMO is a pro-active node in the flow of research from and to IRRI, which links strategic to applied to adaptive. This pivotal unit helps fulfil the objective of institutional strengthening. Considering that NARS are the prime part of IRRI's institutional portfolio and its main partners, this office fulfils a key function. The Panel's assessment of NARS partnerships (Section 3.5.3), showed how well these partnerships are functioning and, therefore, the Panel finds the work in this office commendable.

7.5.3 Institutional Relationships

The main relationships are with: the host country; donor agencies; NGOs; and the Asia Rice Foundation. Host country relationships are principally with the Government, UPLB, Department of Science and Technology, PhilRice, Department of Agriculture, NGOs, the media, and the local community.

The Government. The Panel was informed by Management that IRRI enjoys full support from relevant agencies of the Government. In April 1996, a small labour group sought recognition through the Department of Labor and Employment (DOLE), the Senate, and the House of Representatives for its right to represent labour at IRRI. An earlier Supreme Court decision had supported and upheld IRRI's labour relations structures, i.e., the Council of IRRI Employees and Management (CIEM), to represent labour at IRRI. The Department of Foreign Affairs (DFA) which oversees all international organizations in the Philippines, as well as DOLE, have supported IRRI in the ongoing labour issue. However, the Panel has been told that in some parts of the Philippine Government there is a degree of support for the labour group at IRRI.

Department of Science and Technology (DOST); Department of Agriculture. The Panel found that IRRI has worked closely with DOST to update the guidelines for the release of transgenic material for field testing. This is a follow-up to the initiative taken in 1989, when in collaboration with UPLB and the Department of Agriculture, the current guidelines were formulated jointly and adopted by the authorities.

The University of the Philippines, Los Baños (UPLB). As landlord, neighbour, and academic institution, UPLB has many relationships with IRRI. Since 1961, UPLB has made lands available to IRRI for all its needs, including housing, on a long-term lease at nominal rates. UPLB has extended appointments to IRRI senior staff as affiliate members of the Graduate Faculty of UPLB, and accepted qualified graduate students nominated by IRRI. In turn, IRRI has provided IRRI senior staff members to serve as adjunct members of the faculty, and provided student assistantships to UPLB undergraduates and graduate students. IRRI has offered post-doctoral fellowships to UPLB faculty members. There is also a memorandum of understanding covering collaborative research and administrative affairs. A tripartite partnership involving PhilRice-UPLB-IRRI, for collaborative research and training, was launched in 1995. A joint UPLB-IRRI Committee on Administration meets regularly to discuss mutual assistance and cooperation. There is an annual sports day to foster contact between the staffs of IRRI and UPLB.

The above is an indication of the IRRI and UPLB interactions, and the Panel learned from UPLB that there are other promising areas where initiatives can be taken to strengthen the existing bonds.

PhilRice. PhilRice has excellent facilities for almost all aspects of rice research, and many of its staff have worked or were trained at IRRI. IRRI-PhilRice collaboration takes many forms. Phil Rice is a member of the Irrigated Rice Consortium, the Rainfed Lowland and Upland Rice Consortium, and the Ecoregional Initiative, and a key collaborating centre in the IPM network, the ARBN, INGER, and CREMNET. Other collaborative activities include technology transfer, communications, training, and seed production. PhilRice staff value peer relationships with IRRI staff and programmes and the opportunity to be part of wide research activities in rice both in and outside the Philippines, but suggested to the Panel some areas for improvement, including joint authorship of papers.

Donors. A key institutional relationship is with donors. Keeping them informed of the work and impact of IRRI helps to interest donors in funding future work. The two main CGIAR annual events, the Mid-Term Meeting and International Centres Week, are the main arenas for such efforts. Donor relations staff try to match donor interests and funding prospects to specific NARS needs. IRRI also maintains close contact with embassies in Manila and the ADB, and keeps them informed on a regular basis.

NGOs. There are two types of NGOs with which IRRI apparently must deal: advocacy and rural development groups. IRRI policy adopted for the former is to keep an open door for constructive dialogue. With rural development groups, IRRI considers that their interests can be complementary. A joint project with PhilRice and an NGO to introduce salt-tolerant material into coastal areas provided an example. Other promising avenues that IRRI plans to explore are linking its research to priority-setting processes of NGOs in partnerships to evaluate new technology.

Asia Rice Foundation. IRRI helped prepare the initial concepts and ideas for a foundation to support rice research. The Rockefeller Foundation was interested in exploring the feasibility of an Asia Rice Foundation and has a feasibility study underway. The Panel was informed that the aim is to create an endowment fund for rice research in Asia available to all rice and rice-related research organizations. The programme is in its infancy, and has attracted modest support from at least one ASEAN country at this time.

Local Community. Relationships with the local community are harmonious and IRRI's assistance in, e.g., fire-fighting and sponsorship of community events, keeps the relationship healthy.

Assessment

Government. The Panel believes that relations may have suffered from poor communication at an earlier stage, but the Panel has been assured that such problems will have been corrected.

Departments. The Panel was pleased to note the cooperative, proactive, and productive relationship with the Department of Science and Technology. The good relations that exist were confirmed by the Under Secretary in the Department of Agriculture, whom the Panel visited.

UPLB. The many channels for interaction with UPLB have produced mutually beneficial results, which were confirmed by the Chancellor, who suggested to the Panel more areas for fruitful collaboration.

PhilRice. The Panel considered the IRRI-PhilRice relationship strong and still evolving. The Panel strongly endorsed the annual tripartite planning meetings (with UPLB) as a forum to plan collaborative research and other activities and to resolve matters needing special attention.

Donors. The Panel believes that IRRI's donor relation efforts are essential and are reflected in the continuing support received. The Panel commends IRRI on its professional approach to fund raising.

NGOs. The Panel was pleased with the collaborative attitude adopted by IRRI towards NGOs and believes that this is conducive to productive partnerships.

The Media. IRRI makes special efforts to keep the media - local and international - informed of its work. This has resulted in published articles favourable to IRRI appearing in leading journals and newspapers, and IRRI believes that these provide a healthy balance to articles by advocacy groups who question the role of international agricultural research.

7.5.4 Public Awareness

The Public Awareness unit is the communications arm of the External Operations Office. Its mission is to ensure that IRRI stakeholders are kept informed; these include donors, potential donors, the host government, the public, client-country governments, NARS, and staff. The PA unit tailors information to the specific interests of these target groups through a broad range of high-quality publications. Close contact with the PA units of donor agencies, e.g., DANIDA, DFID, BMZ, helps to pinpoint donors' particular interests. Section 5.2.6 - Information Centre - summarizes the activities in the public awareness field.

Assessment

The Panel was pleased to note the attention paid to public awareness activities and the good response by the national and international media. The Panel understood that Management wished to assure itself that the current effort and direction were appropriate, and to this end a public awareness consultant will review this area in 1998. The Panel supports this initiative.

CHAPTER 8 - ADMINISTRATION AND OPERATIONS

8.1 Management of Human Resources

8.1.1 Staff Restructuring Programme

The management of human resources at IRRI took centre stage in late 1996, with the entire Institute becoming involved in a large Staff Restructuring Programme (SRP). The SRP eliminated 554 Nationally Recruited Staff (NRS) positions from a total of 1,311 positions before. The SRP was planned in late 1996, and the reductions took place in early 1997. The SRP has had short-term costs: financially, in employee morale, and in public relations within the host country.

The process followed is documented in detail in the report *1997 Staff Restructuring Programme (SRP): An Overview*. Management and staff at all levels were involved in evaluating the existing organizational structure and planning the new. The intent was to accomplish the reductions by eliminating overlap, increasing cross-training and multi-tasking, and outsourcing of services to local vendors. Management of each organizational area was actively engaged in the restructuring process with assistance from the Human Resources Department and grievance procedures were in place for appeals.

Any management faced with the necessity of large staff reductions must weigh the tradeoffs between rapid execution to avoid prolonged diversion of the organization's focus with a more deliberate approach, where successive layers are pared over several years to arrive at the correct staffing level through an iterative process of successive approximations. Given the anxiety and disruption which would have been caused by a prolonged SRP, the Panel can understand IRRI's choice of speed. However, the Panel believes that it is highly probable that the optimum staffing level was not obtained in every case, and that in some research programmes and divisions the ratio of NRS to IRS has been reduced below optimum, such that scarce IRS scientific talent is not appropriately supported by skilled NRS.

Post-SRP morale problems have been exacerbated by NRS concerns over compensation. A fairly large across-the-board salary increase was given to retained NRS in early 1997, but perceptions vary as to whether this increase was to compensate for increased workload, to catch up with competitive wage pressures, or both. In addition, NRS were promised that job evaluations and competitive salary surveys would be undertaken quickly. This has taken longer than planned, although now an outside consulting firm has been hired and has nearly completed the competitive salary surveys. The Panel applauds Management's recent communication to employees on these issues and endorses IRRI's policy that NRS should have competitively justifiable pay and benefits.

8.1.2 Performance Appraisal System

IRRI has well-documented procedures for performance appraisal of both IRS and NRS. However, the newly developed Performance Management System (PMS) for NRS has not been fully implemented. Regrettably, full implementation has slipped once again, and is not scheduled to be completed until the end of 1998. As presently designed, the PMS does not give an easily comparable quantitative measure of performance, leading the Panel to suggest that this should be added to make the system useful in linking pay to performance.

For IRS, especially those in scientific positions working within the research matrix, performance appraisal is of critical importance. If each scientist worked for only one supervisor, performance evaluation responsibilities would be clear and the performance evaluation process simple. In a matrix structure, the complexity of performance evaluation increases substantially, requiring inputs from several project leaders as well as the department head, greatly increasing possible disagreements in evaluation.

Conversations with various scientists led the Panel to conclude that all such difficult problems have not been solved. The Panel **suggests** that IRRI make this area a priority concern of the new Director of Administration and Human Resources, who should work closely with research management.

The Panel met with project scientists, who comprise a group of about 30 internationally recruited post-doctoral, or equivalent researchers. The Panel learned of some inconsistencies between the contractual benefits, particularly relating to education and health insurance, and the reality once the staff member arrived. This situation was confirmed by management. The Panel **suggests** that IRRI review the contracts for this group of staff and provide a handbook before arrival, which outlines living and working conditions at IRRI. Moreover, IRRI should provide all new staff with a comprehensive 'starter pack' for orientation.

8.1.3 Internationally Recruited Staff

Turnover figures for the 65 IRS averaged 14% for the last five years, amounting to an average stay of slightly over seven years. This statistic is about what one would expect for a project-based research institute, and does not imply major problems with staff retention. Additionally, a quick review of IRRI IRS salary levels, benefits, and conditions of service showed them in most respects to be in line with or above comparable CGIAR Centres. There are, of course, areas of concern to the staff, but none rises to the level of individual mention in this report.

8.2 Financial Management

IRRI's Finance Division is staffed with dedicated personnel possessing a high level of professional qualifications. They are supported in their efforts by modern computerized systems and have responded to the funding changes that require increasingly stringent identification of costs and their containment.

8.2.1 Financial Management Systems

IRRI has developed a project-based financial management system to support the matrix management of its research programmes. A key decision for matrix management is the proper level of detail to be used in capturing the cost data, especially the distribution of scientists' time to projects. IRRI does not attempt to do this by using time sheets; instead, allocation to projects is done *ex-ante* when the budget is prepared. The financial management system then allocates each scientist's time to the projects based on the budget percentages. The Panel believes that IRRI has the cost-benefit ratio of charging time to projects about right and was informed that project leaders and scientists review these allocations periodically and update the allocations as necessary. It would, of course, be unacceptable if the system were mechanically driven to match donor, TAC, or revenue goals, regardless of actual time expenditure.

IRRI is in the process of installing a new financial management system to run on networked PCs. As of January 1998, most of the new system was operational with only two of the old system modules still in operation. The changes to the new system will be almost unnoticeable at first to users since the report formats have not changed. However, the new system enables IRRI to discontinue using the IBM mainframe computer and improve the future flexibility of reporting. The Panel hopes that the reporting flexibility will improve responsiveness to scientists' needs for financial and purchasing information.

8.2.2 Revenue and Overhead Recovery

Table 8.1 shows the total grant and other revenues for the period. Total revenues have declined from the level achieved in 1993, a year which included large one-time grants for the capital renewal programme. In 1996, restricted funding increased sharply, while unrestricted grants decreased. While Systemwide CGIAR non-agenda funding declined 52% from 1995 to 1996, IRRI's non-agenda funding declined only 11%. IRRI's non-agenda funding in 1996 was 34% of the CGIAR total.

Table 8.1 Revenues

	1993	1994	1995	1996
Revenues	46,993	42,128	41,716	41,231
Agenda (Unrestricted)	22,060	23,808	23,020	18,764
Agenda (Restricted	4,853	3,310	4,206	10,095
Non-agenda (Restricted)	17,576	12,067	10,873	9,624
Other	2,504	2,943	3,617	2,748
Indirect Cost Recovery				
% Agenda Restricted	14.1	18	18	7.26
% Non-agenda	10.2	14.2	13.5	13.6

As the proportion of restricted funds increases, it becomes more important to recover indirect costs on those restricted projects. This maximizes the use of unrestricted funds to cover gaps in donor coverage of the agreed research agenda, rather than to pay for the indirect costs of projects funded by restricted funds. It is important that donors, to the maximum extent possible, agree to the charging of indirect costs to restricted grants. From the indirect cost recovery data shown in Table 8.2, it can be seen that the large shift in funds from unrestricted agenda to restricted agenda in 1996 did not carry with it much, if any, indirect cost recovery.

IRRI does an excellent job of minimizing indirect costs by maximizing direct charging. IRRI's General Administration and General Operations expenses were about 20% of total expenditures in 1996, which establishes a rough measure for evaluating the recovery of indirect costs. It can be seen that IRRI is far short of recovering full indirect costs on restricted grants, a situation not unique among centres in the CGIAR System.

To adjust to increasing donor restrictions on funding, it is important that within IRRI (and all other centres) there be no confusion regarding assumed linkages between sources of funding and research priorities. For example, IRRI's highest priority research could well be funded with restricted funds of limited duration.

8.2.3 Overall Financial Results

An EPMR is an opportune time to review the financial history of a centre since the last review. Centre financial reports are usually reviewed annually, using the previous year's result for comparison. However, two points do not reveal a trend, and such trends as may exist can be obscured in the short term by accounting changes, restatements, or the creation or the drawing down of reserves or provisions.

Table 8.2 Selected Financial Data (in US$ 000)

From Statement of Activities	1993	1994	1995	1996
Net Revenues	46,993	42,128	41,716	41,231
Operating Expenses	47,160	42,000	42,132	46,220
Surplus (Deficit)	(167)	128	(416)	(4,989)
Capital Acquisitions	9,404	2,328	4,234	2,164
Depreciation	1,261	1,714	2,211	2,334

The CGIAR adopted depreciation accounting in the early 1990s (codified in the *Accounting Policies & Reporting Practices Manual* issued by the CGIAR Secretariat in September 1993). This contrasts to the prior practice of including all capital expenditures in operating expenses in the year of acquisition and not depreciating the assets. IRRI has, however, continued to include capital acquisitions purchased with restricted funds in operating expenses. These capital assets are then added to the Fixed Asset Account.

The Balance Sheet is a correct statement of current accounts, but it is not readily apparent, even to a reasonably informed person who reads IRRI's financial statements, where funds in balance sheet accounts originated. Also, while the total equity accounts are unaffected, and certainly no cash is missing due to the accounting treatment, the distributions between the Capital Fund and the Operating Fund may not have been subject to sufficiently well-informed decision-making by the BoT.

To correct this, IRRI should prepare a current analysis of fixed assets, future capital expenditure requirements, and expected depreciation so that IRRI management and the BOT can carefully consider the appropriate level of the Capital Fund. If the fund is higher than needed, the surplus could be moved to the Operating Fund, eliminating the need for its replenishment.

The Panel **recommends** that IRRI prepare a current Capital Plan, and that IRRI management and the Board of Trustees decide the appropriate level of the Capital Fund, and that all future adjustments to the Operating Fund and Capital Fund be carefully and clearly documented.

8.2.4 Internal Audit

While the Internal Audit unit at IRRI has a direct reporting relationship to the Director General and the Audit Committee, it has been ineffective in improving internal controls. Effective internal auditors are perceived by the auditees as desirable collaborators in improving internal controls, not as informants or policemen. Indeed, there is a growing trend toward self-assessment of internal control, in which an organization's managers work with the internal auditor to prepare self-assessments of their own activities. It is clear to the Panel that internal auditing at IRRI has not augmented its effectiveness through collaborative self-assessment.

Internal Audit has shrunk, through turnover and the SRP, to only two auditors from as high as seven, and it is unclear just what path IRRI intends to follow. As internal auditing has evolved, a much broader range of skills is needed. Recognizing this, IRRI is considering the outsourcing of many internal audit functions, with supervision by the current Internal Audit Manager. However, at the time of the review, no budget for such outsourcing had been set, and no concrete plans for integrating such contracted work into a cohesive audit plan were presented.

Internal Audit tasks should be outsourced only if: (i) it is not cost-effective to maintain the skills required within IRRI, and (ii) the Internal Audit Manager has the necessary skills to plan the engagement of outside experts, coordinate their work with the auditees, and follow up on the recommendations made.

The Panel **recommends** that IRRI ensure that the internal audit function becomes fully effective in improving internal financial and operational controls, by reviewing the current level of skills available within IRRI for the Internal Audit function, deciding which skills it is necessary to have internally and which skills might be outsourced, and implementing the organizational and staffing changes required.

8.3 Administration and Operations

Administration and Operations as covered here consists of the Physical Plant, Transport Office, Food & Housing Services, Materials Management, Security and Safety Office, and City Office/Mail Room/Central Files. These units have 57% fewer staff positions than at the beginning of 1997. Therefore, for each of these units, 1997 was a year of innovation and restructuring to meet the needs of IRRI with fewer permanent personnel. It is also these units which are in the forefront of learning to meet the ongoing needs at IRRI with persons contracted from outside. Because these units provide a good understanding of the restructuring of activities required by the SRP, we will briefly explain how each unit reached its SRP staffing goal.

8.3.1 Physical Plant

The Physical Plant is responsible for all the engineering and service needs of IRRI. In addition to maintenance, repair, and fabrication activities, Physical Plant operates the power plant and water system. The staffing level has been reduced from 127 to 46, partly by contracting for many of the activities requiring electricians, painters, carpenters, plumbers, mechanics, and janitors.

8.3.2 Transport

Transport consists of the Motor Pool Dispatching Section and the Motor Vehicle Repair Shop. Transport oversees 411 operational vehicles consisting of buses, vans, cars, trucks, motorcycles, and even one ambulance. Staff has been reduced from 65 to 32 by making use of 14 hired drivers, contracting out some vehicle service activities, and improving the efficiency of other activities.

8.3.3 Food and Housing Services

Food and Housing Services is responsible for the operation and management of the food and housing needs of research fellows, scholars, trainees, nationally and internationally recruited staff, visiting scientists, and guests (including EPMR Panels such as this, which unanimously agreed it was exceptionally well cared for by the friendly and efficient employees of this unit). Staffing was reduced from 43 positions to 16. Nineteen of the reductions were achieved by contracting out the Cafeteria operations to a company formed by former employees, the rest from efficiencies in staffing of the other functions.

8.3.4 Materials Management

The materials management functions include purchasing, warehousing, shipping, inventory planning and control, and property disposal. Materials management reduced its staff from 30 to 14, using across-the-board reductions. For example, the purchasing department was reduced from 12 to 5 employees by consolidating foreign and domestic purchasing, using the Internet for sourcing and ordering where possible, delegating more petty cash purchases to the divisions/centres/units, using the computerized purchase order system in the new Platinum system, and increasing the use of blanket purchase orders for commonly ordered items.

8.3.5 Security and Safety

The Security and Safety office reduced permanent staff from 25 to 16 by increasing cross-training of security personnel for safety positions and increased reliance on the outside contracting of VSIA guards.

8.3.6 City Office, Mail Room, and Central Files

There was a marked reduction in the total number of personnel in these units from the former 13, including the Unit Head, to the current 5, excluding the Unit Head, who is concurrently the Legal Counsel. This unit provides a good example of some costs which may not have been saved but merely shifted. With the abolition of the messengers who provided a mail service within the institute, each organizational unit within IRRI must now send its own staff to send or retrieve mail for their respective offices at regular intervals.

8.3.7 Conclusion

The above survey was done with the purpose of informing the reader of the all-pervasive impact of the SRP on a cross section of the Units at IRRI. These are representative of reductions across IRRI, although in percentage terms they are somewhat higher, primarily due to more opportunities for contracting out services. IRRI staff at all levels seem to have responded magnificently to the challenges and are indeed to be commended.

However, such change does not come without costs. The Panel was often told by scientific staff that operational and administrative units including Finance and Human Resources, covered in a different section, were not responsive to the needs of the research personnel for financial reports, personnel matters, maintenance, and purchasing. While the Panel believes that some of these complaints may be short-term problems which are entirely understandable given changes of staffing and organization of these units, managers must be careful now to begin to regain their earlier reputation for good service.

CHAPTER 9 - CONCLUSIONS

It is undeniable that IRRI has been through a difficult period in the last few years. Several members of the most senior management staff have left, and their permanent replacements are mostly not in place yet. It is essential that the latter be of high calibre, and they should be allowed a reasonable period in which to settle into their new jobs before undertaking further change. The Staff Restructuring Programme, introduced in 1997 to balance staff needs with new responsibilities and to bring the budget into longer-term balance, is still clear in the memories of staff at all levels. However, this is now over, and we trust that IRRI can now provide salaries and other benefits that are competitive with other organizations. These administrative measures are an essential part of the re-stabilization of IRRI.

Rapid changes in science and in the science environment are becoming apparent, and the Panel believes that these present both opportunities and dangers for IRRI. The most prominent of these is that biotechnology, after a period of gestation, has quite suddenly come to fruition, and has started to produce extremely valuable outputs, both in new techniques that support conventional plant breeding and in the production of genetically modified crop varieties with radically new properties, including GMO rices produced at IRRI and elsewhere. This Report places great stress upon these developments because of their economic value and their potential to contribute to CGIAR goals. Not only the science, but also the organization of the science is changing extremely fast. There is a great explosion in the underlying information for molecular biology, and the organization and ownership of this are in a state of flux. The private sector is becoming a prime mover in the subject, and new styles of operation and alliances are developing fast. IRRI must position itself within this fast-changing scene to ensure that the interests of IRRI and its stakeholders are safeguarded for the future. Over the next few years, probably before the next EPMR, decisions must be taken and changes must be made that may affect IRRI's future for many years to come. These decisions must be taken by the Board and senior management, in the light of policies determined by the CGIAR, in consultation with the countries who are its partners, and with the interests of IRRI and its staff at heart.

There is much other new science at IRRI. In general, we have found that its science is appropriate and ranges from the acceptable to the excellent - nowhere have we found scientifically deficient work. Plant breeding, in which IRRI has such a distinguished history, continues to produce improved germplasm, and more radical achievements such as the hybrid rices that are now being used by three of IRRI's partners. Plant breeding links closely with the molecular techniques discussed above. The IPM Network has achieved a great reduction in the use of pesticides by farmers by an interdisciplinary research effort. Some science, such as the various aspects of NRM, requires organizing in ways that allow the interdisciplinary potential to be more fully realized in strategic programmes. For these to be successful, at least part of the staff have to invest the time to understand fully what their collaborators from other disciplines are doing. Modelling is an integrative discipline that can unify a joint approach, but the modelling must be truly grounded in real-life research, and tested by comprehensive validation. Another aspect of 'validation' that the Panel became interested in was the testing of *ex-ante* predictions of research outputs and impacts by *ex-post* analysis of the actual performance, which does not seem to have been done at IRRI. The Panel has recommended that the three 'Rainfed' ecosystem programmes should be combined into a single programme. This would allow the range of hydrological conditions to be considered together, and allow resources to be allocated where the prospects for success are greatest.

The relationships of IRRI and its partner countries and their NARS are also changing. Some Asian countries are virtually 'developed' now, and have agricultural sectors with strong research and extension, and sufficient capital available to farmers. There are other countries where subsistence farming is still the norm, together with all gradations between. The task of relating to all these different situations in the most helpful and efficient manner is obviously complex, and means that IRRI may be required to spread its interests more widely, and therefore more thinly, than before. This will need skilled and strategic management to prevent fragmentation, lack of focus, and a confused approach to these various problems. The new partnership approach that IRRI has explained to us does seem to embody innovative and useful features that will allow this to be done. The new consortia have impressed us, and the networks INGER and CREMNET are valued very highly by IRRI's partners, and IRRI should ensure that they are well supported. IRRI also enjoys a special relationship with its host country, the Philippines, that has been very supportive.

What then is needed to capitalize on this challenging, but essentially favourable, scientific situation? The funding of research is a basic necessity, and overall we have not been overly concerned by what we have found. There have undoubtedly been shocks over the last few years, but the net result is better than we had at first expected, and IRRI seems to be in no short-term danger on this front. The situation within the CGIAR will always be fluid and largely unpredictable, but the Centre has shown its ability to respond to changes. It knows full well that there are no long-term guarantees and no free lunches. If it can continue to stay at the forefront of scientific research in its various subjects, if it can continue to attract world-class scientists, if it can make the right decisions about molecular biology, and if it can continue to show clearly that its research is having impact, it has little to fear.

The other great need is institutional stability so that staff can give their undivided attention to their research and its application by their partner countries. Hopefully this stability includes funding, because research programmes cannot be managed efficiently in a climate of boom and bust. We have particularly focused on organizational and management structures, where we fear that IRRI is in danger of causing a self-inflicted wound. The matrix structure was introduced in 1989 to develop interdisciplinary research teams. The Panel judges that it is working well enough, though it makes IRRI science more difficult to survey and analyze, and few members of the staff or of the Panel seem wholly enthusiastic about it, though most see some benefits. However, no judgement of a mechanism is possible unless it is being properly operated, and the Panel believes that this is not yet happening at IRRI. The deficiencies are in quite simple matters that are outlined in the text of our Report, and are largely the consequence of the turbulence and problems of the recent past and the stress this has placed on managers. We recommend that IRRI should concentrate on putting these matters right, make only very limited changes to the current structure, and only consider changing this structure radically some time after the new DG and other senior staff are in post, and only if IRRI is certain that the new structure is significantly better. If this is done, one can hope that for a considerable period IRRI will enjoy a basic stability in its management, its organization, its partnerships, and its funding, so that the staff can concentrate on their research.

The task in front of IRRI is clear and well-documented. The population of the rice-eating countries is in total still growing fast, and their predicted population in 2025 is about four billion, a figure which equals that in the whole world as recently as 1975. Taken together with the predicted increase in incomes, this will increase the demand for rice by more than 60%, as we argue in Chapter 1. IRRI will be a main instrument in meeting this need, as shown by the award of three World Food Prizes to its staff over the last 20 years. It may be that at some time IRRI will have to ask if its total focus on a single main food grain in a world where eating habits are changing fast is still appropriate, but that is still some time in the future. At present, IRRI must concentrate on more and better rice grown in more sustainable ways, and no other organization is so well placed to do so. If IRRI did not exist, it would have to be invented. As it does exist, it should be supported.

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Dr. George Rothschild, Director General (until end November 1997), Dr. Bob Havener, Interim Director General (since 20 January 1998), Dr. Ken Fischer, Deputy Director General, Research, Mr. Michael Goon, Deputy Director General, Finance and Administration (until end September 1997), and Mr. Edward Sayegh, Director of Finance (until end December 1997), fully cooperated with the Panel as well as with the TAC and CGIAR Secretariats. They deserve our special thanks for ensuring that we were provided with a good working environment and effective secretarial and technical support. We also thank Dr. and Mrs. Havener for their kind hospitality.

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APPENDIX I

COMPOSITION OF THE PANEL AND BIOGRAPHICAL INFORMATION

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Name: TINKER, P. Bernard (UK)
Position: Senior Research Associate, Department of Plant Sciences, University of Oxford.
Expertise: Soil Science, Plant Nutrition, Natural Resources Management, Research Management.
Education: B.Sc. in Chemistry, Sheffield University (1951); Ph.D. in Organic Chemistry, Sheffield University (1955); M.A., University of Oxford (1965); D.Sc., University of Oxford (1983).
Experience: 1955-1962: Senior Scientific Officer, UK Overseas Research Service, Benin, Nigeria; 1962-65: Senior Scientific Officer, Rothamsted Experimental Station, Harpenden, UK; 1965-1971: Lecturer in Soil Science, Oxford University; 1971-77: Professor of Agricultural Botany, Leeds University; 1974-77: Head of Department of Plant Sciences, Leeds University; 1977-1983: Deputy Chief Scientific Officer and Head of Department of Soils and Plant Nutrition, Rothamsted Experimental Station; 1983-85: Deputy Director and Head of Soils Division, Rothamsted Experimental Station; 1985-1992: Director of Terrestrial and Freshwater Sciences, Natural Environment Research Council; Since 1993: present position.
Has membership of a number of societies such as the British Ecological Society, the Royal Society of Chemistry and the Society of Chemistry and Industry (Chairman Agriculture Group, and Member of Council 1981-1983). He has been a member of several review groups such as the NERC Terrestrial Life Sciences Grants Committee 1977-82, the Royal Society Group on Geochemistry and Environmental Health 1982, and the Rothamsted Visiting Group 1975. Member of 1977 QQR of IITA. Chairman of First ICRAF External Review (1993) and First IIMI External Review (1995). Member of Soil and Water Study 1996. Has published five books and some 170 papers.

Name: BHALLA, G.S. (India)
Position: Professor Emeritus, Centre for the Study of Regional Development, Jawaharlal Nehru University.
Expertise: Economics, agricultural economics.
Education: M.A. (Maths), University of Punjab (1951); M.A. in Economics, Univesity of Agra (1955); Ph.D. (Econ.), London School of Economics, London (1963).
Experience: 1956-1963: Lecturer and Reader in Economics, Rajasthan University, Jaipur: 1960-63: British Council Scholar at the London School of Economics; 1966-67: Associate Professor, Carleton University, Ottawa, Canada; 1967-69: Economist, Department of Regional Economic Expansion, Government of Canada, Ottawa; 1969-1975: Reader and Professor of Economics, Punjab University, Chandigarh; 1983-86: Chairman, Commission for Agricultural Costs and Prices, Ministry of Agriculture, Government of India, New Delhi; 1990-91: Member, Planning Commission, Government of India; 1975-1993: Professor of Economics, CSRD, Jawaharlal Nehru University and Dean, School of Social Sciences, JNU (September 1986 to April 1988); Since 1993: present position.
Prepared a research report for IFPRI, jointly with Dr. Peter Hazell of IFPRI, which is entitled *Prospects for Balancing Food Needs with Sustainable Resource Management in India to 2020.* Prepared a write-up on "Indian Agriculture" for the FAO publication, *The State of Food and Agriculture (SOFA)* for 1995.

Name: GALE, Michael Denis (UK)
Position: Associate Research Director, John Innes Centre, Colney, Norwich.
Expertise: Genetics, molecular mapping, plant breeding and germplasm.
Education: B.Sc. in Genetics (Hons), University of Birmingham (1965); PhD, University College of Wales, Aberystwyth (1969).
Experience: 1968-1984: Cytogenetics Department, Plant Breeding Institute, Cambridge; 1984-85: Study leave, Canberra; 1985-88: UG6 IM,Cytogenetics Department, Plant Breeding Institute, Cambridge; 1988-1992: Head, Cereals Research Department, Cambridge Laboratory; 1992-94: Acting Head of Cambridge Laboratory; Since 1994: present position.

Consultant, molecular mapping in Hevea, Rubber Research Institute of Malaysia (1987); Technical co-operation expert for International Atomic Energy Agency for wheat, barley and quinoa breeding programmes in Bolivia (1987); Ministry of Agriculture, Fisheries and Food, Novel Crops and Livestock Entreprise Review Group (1987-88); Scientific Advisory Committee for the Rockefeller Foundation Rice Biotechnology Programme (1989-); Overseas Development Administration, Plant Breeding and Physiology Management Advisory Panel (1990-); External review panel CIRAD, Montpellier, France (1992); Science Advisory Group, School of Biological Sciences, Reading University (1992-); Member of UK H&S Committee on Genetically Modified Organisms, representing BBSRC (1995-); Nuffield Bioethics Committee on Genetically Modified Plants (1997-).

Name: HIBINO, Hiroyuki (JAPAN)
Position: Director, Department of Environmental Biology, National Institute of Agro-Environmental Sciences, Tsukuba.
Expertise: Plant virology, plant pathology.
Education: B.Sc., Nagoya University (1961); Doctor of Agricultural Sciences, Nagoya University (1966).
Experience: 1966-1982: Technical Official, Institute for Plant Virus Research; 1969-70: Visiting Scientist, University of California; 1975-78: Japan-Indonesia Joint Food Crop Research Programme, JICA, Indonesia; 1982-88: Plant Virologist, International Rice Research Institute; 1988-95: Department of Plant Protection, National Agriculture Research Centre; 1995-97 National Chugoku Agricultural Experiment Station; Since 1997: present position.
Major research interests: virus characterisation, vector relations of plant virus, epidemiology of rice virus diseases, control of rice virus diseases, cytology of virus-infected cells, plant virus serology.

Name: PLUCKNETT, Donald L. (USA)
Position: President and Principal Scientist, Agricultural Research and Development International, Annandale, Virginia, USA
Expertise: Tropical crop and pasture management, weed control, farming systems, natural resource management
Education: B.Sc. General Agriculture, University of Nebraska (1953); M.Sc. Agronomy, University of Nebraska (1957); Ph.D. Tropical Soil Science, University of Hawaii (1961).
Experience: 1958-80: University of Hawaii - Lecturer and Assistant Professor of Agronomy (1958-65); Associate Professor of Agronomy (1965-70); Professor of Agronomy (1970-80).
1965 Consultant (Ford Foundation) and Senior Agricultural Advisor, Aswan Agricultural Development Centre, Egypt. 1968: Visiting Professor in Agriculture, University of Brisbane. 1968-69: Visiting Scientist, IRRI. 1971: Senior Fellow, East-West Food Institute. 1973-76: Chief, Soil and Water Management Division, USAID. 1978-80: Chief, Agriculture and Rural Development Division, Bureau for Asia, USAID. 1980-94: Senior Scientific Advisor to the CGIAR Secretariat. Since 1995: present position.
Panel Member of the Farming Systems Study (1977-78) and CGIAR Resource Person in the Reviews of CIAT (1977 and 1984), CIMMYT (1982 and 1987), CIP (1983 and 1989), IBPGR (1985), ICARDA (1983), IITA (1977 and 1983), ILCA (1981), ILRAD (1980 and 1986), IRRI (1982, 1987 and 1992), and WARDA (1986). Consultant to CIP Review (1995).
Member of several scientific societies and author of numerous publications.

Name: PAUL, Louis R.K. (The Netherlands)
Position: Private Consultant
Expertise: Strategic planning, technology management, R & D management (planning, co-ordinating, prioritising, evaluating).
Education: B.Eng. (Hons), Guindy Campus, Madras University, India (1953); Business Studies Programme for Senior Executives, Sloan School of Management, MIT, Boston, Mass., USA (1983).
Experience: 1954-1991: Positions of increasing responsibility with Royal-Dutch Shell, including, Field Mechanical Engineer (1955-1968), Project Economics and Project Management (1968-73), Strategic Planning Analyst (1973-76), Head, Planning and Economics, Refining Function (1976-1983), Marketing Policy Adviser (1983-87), Head, Planning and Coordination, Research (1987-1991). In this last position responsibilities covered the planning and coordination of Shell's research programme across a worldwide network of international research centres, with a research outlay of US$ 900 million and a scientific pool of 7,000 staff; key achievements included the introduction of rigorous research reporting coupled to business-impact review of research results. These positions required long-term assignments in Bombay, Trinidad, London and The Hague; trouble-shooting and other work-related visits to many other parts of the world. Since retirement from Shell, served as a consultant on R&D Management and Evaluation, to the European Commission (Brussels), the German Ministry for Research and Technology (Bonn), and the Advisory Council for Science and Technology (The Hague), the Science Office of the Prime Minister of Malaysia, the Commonwealth Partnership for Technology Management (London). Member of CIP EPMR in 1995.

Name: SMITH, Roger A. (USA)
Position: Consultant
Expertise: Finance
Education: B.Sc., Chemical Engineering, Rice University (1962); M.B.A., New York University (1972); Graduate study in Plant Physiology, New Mexico State University (1986).
Experience: 1962-1985: Atlantic Richfield Company - positions include:
1962-65: Petroleum refinery technical service and operations management; 1965-1970: Research and implementation of computerised process control systems and integrated refinery management systems; 1970-72: Manager of Refinery Coordination; 1972-76: Manager of Strategic Planning for Refining and Marketing Division; 1976-78: Controller of Refining and Marketing Division; 1978-1980: Manager of Planning and Analysis for the Refining and Marketing Division; 1980-82: Vice President and Chief Financial officer for Atlantic Richfield's Brazilian subsidiaries; 1982-85: Assistant Corporate Controller for company-wide accounting and controls; 1987-89: Chief Financial Officer, IITA; 1989-1997: Consultant - positions include: 1990: IFPRI EMR; Review of the plans for the computerisation of accounting and finance for CIMMYT; Special report on internal and external auditing in the CGIAR for the World Bank CGIAR Secretariat; Consulting on the World Bank CGIAR Secretariat Annual Financial Report; Consultant to the CGIAR Benefits Committee to evaluate and to set up a new Association (AIARC) to administer and manage the payroll and benefit plans for the 1200 expatriate scientists and administrators employed by the twenty international research centres; 1995: CIMMYT CCER; 1992-94: Executive Director/President, Association of International Agricultural Research Centres; 1994-97: Consultant to the AIARC Executive Director and Board of Directors; 1998: ICARDA CCER.

TERMS OF REFERENCE

FOR EXTERNAL PROGRAMME AND MANAGEMENT REVIEWS

OF CGIAR CENTRES

BACKGROUND

Context

1. The Consultative Group on International Agricultural Research (CGIAR) is an informal association of over 50 members that supports a network of 16 international research centres in agriculture, forestry and fisheries. The CGIAR aims, through its support to the Centres, to contribute to promoting sustainable agriculture for food security in developing countries. Because the Centres constitute the core of the CGIAR, the effectiveness of each Centre is crucial to the continued success of the CGIAR (as a System).

2. Each Centre is an autonomous institution operating within the mandate assigned to it by the CGIAR, and is governed by a legally constituted Board that has full fiduciary responsibility for managing the Centre. To ensure accountability in an essentially decentralized system, each Centre is expected to be responsive to the CGIAR, which provides financial support for its work.

3. The CGIAR has established a tradition of External Programme and Management Reviews (EPMRs) to provide a mechanism of transparency and accountability to the Members and other stakeholders of the CGIAR System. EPMRs are the joint responsibility of TAC and the CGIAR Secretariat, and are conducted for each Centre approximately every five years. As each Centre is autonomous, EPMRs provide a measure of central oversight and serve as an essential component of the CGIAR's accountability system.

Integrated System of Reviews of Each Centre

4. Besides the EPMRs, Centre Commissioned External Reviews (CCERs) are undertaken at each Centre. These CCERs are commissioned by the Centre Boards to periodically assess the quality and effectiveness of particular aspects of a Centre's work. The terms of reference (TORs) for each CCER are determined by the Centre, based on broad principles endorsed by the CGIAR at ICW95 (ref. document entitled *Improving the Quality and Consistency of CGIAR's External Centre Reviews*, dated October 24, 1995).

5. EPMRs complement the CCERs by providing a CGIAR-commissioned and comprehensive external assessment of the Centre's programme and management, especially its future directions and the quality and relevance of its research. The TORs for the

EPMRs (which update the "standard TORs" endorsed by the CGIAR at MTM95) are provided below. Guidelines for undertaking the reviews are issued separately.

TERMS OF REFERENCE

Objectives and Scope

6. EPMRs seek to inform CGIAR members that their investment is sound, or recommend measures to make it so. Members of the CGIAR and other stakeholders can be informed whether the Centre is doing its work effectively and efficiently. EPMRs are both retrospective and prospective; and help ensure the Centres' excellence, relevance and continued viability, and the CGIAR System's coherence. Each review is expected to be strategic in orientation and as comprehensive as the situation warrants.

7. The broad objectives of EPMRs are to: a) provide CGIAR members with an independent and rigorous assessment of the institutional health and contribution of a Centre they are supporting; and b) to provide the Centre and its collaborators with assessment information that complements or validates their own evaluation efforts, including the CCERs.

8. The EPMR panel is specifically charged to assess the following:

   a. The Centre 's mission, strategy and priorities in the context of the CGIAR's priorities and strategies;

   b. The quality and relevance of the science undertaken, including the effectiveness and potential impact of the Centre's completed and ongoing research;

   c. The effectiveness and efficiency of management, including the mechanisms and processes for ensuring quality; and

   d. The accomplishments and impact of the Centre's research and related activities.

9. The topics expected to be covered by the EPMRs are listed below.

TOPICS TO BE COVERED

A. Mission, Strategy and Priorities

- The continuing appropriateness of the Centre's mission in light of important changes in the Centre and its external environment since the previous external review.

- The policies, strategies, and priorities of the Centre, their coherence with the CGIAR's goals (of poverty alleviation, natural resources management, and sustainable food security), and relevance to beneficiaries, especially rural women.

- The appropriateness of the roles of relevant partners in the formulation and implementation of the Centre's strategy and priorities, considering alternative sources of supply and the benefits of partnerships with others.

B. Quality and Relevance

- The quality and relevance of the science practised at the Centre.

- The effectiveness of the Centre's processes for planning, priority setting, quality management (e.g., CCERs, peer reviews and other quality and relevance assurance mechanisms), and impact assessment.

C. Effectiveness and Efficiency of Management

- The performance of the Centre's Board in governing the Centre, the effectiveness of leadership throughout the Centre, and the suitability of the organization's culture to its mission.

- The adequacy of the Centre's organizational structure and the mechanisms in place to manage, coordinate and ensure the excellence of the research programmes and related activities.

- The adequacy of resources (financial, human, physical and information) available and the effectiveness and efficiency of their management.

- The effectiveness of the Centre's relationships with relevant research partners and other stakeholders of the CGIAR System.

D. Accomplishments and Impact

- Recent achievements of the Centre in research and other areas.

- The effectiveness of the Centre's programmes in terms of their impact and contribution to the achievement of the mission and goals of the CGIAR.

ITINERARY OF THE EPMR PANEL

The Panel Chair attended the IRRI Board meeting from 7 to 12 April 1997. The Chair, together with the Panel Chairs of IFPRI and CIMMYT External Review Panels, attended a two-day briefing and discussion meeting in London on 10 and 11 May 1997, with the TAC Chair and staff from the TAC and CGIAR Secretariats. The purpose of the meeting was to brief the Panel Chairs on the review process and to initiate discussion of the key issues to be considered by the respective Panels.

The whole Panel visited IRRI Headquarters from 9 to 17 September 1997 for the initial phase to familiarize itself with the Institute. The visit was timed to coincide with the IRRI Board's Executive Committee and Programme Committee meetings. The Panel members interacted with the Board members, Management, and staff, including representatives of the various staff associations and the spouse employment committee. The Panel also met with directors of national programmes from the Philippines, Myanmar, Laos, and Bangladesh, who had been attending a workshop at IRRI, and with the Director of PCARRD and the Chancellor of the University of the Philippines at Los Baños. On 17 and 18 September, a subpanel visited the national rice programme, Philrice, in Munoz.

In November 1997, two Panel members met with the ICAR Director General, the Director of the national rice programme in India, and some leading rice scientists in India. From 4 to 16 January 1998, one subpanel visited India and another subpanel visited Vietnam where they met with IRRI field staff, national programme scientists, and government officials. Prior to the main phase, the Panel Chair and a Panel member communicated with the Board Chair and Board members.

The whole Panel returned to IRRI Headquarters on 26 January 1998 for the main phase of the Review. Panel members interacted with management and scientific staff, individually and in small groups, and also met with the nationally recruited staff and IRRI trainees. Two Panel members met with the external auditors, and the Panel Chair and a Panel member met the Philippines Under Secretary of Agriculture.

The drafts of the report were shared with the Interim Director General for comments. On 13 February 1998, the final Report of the Panel was presented by the Panel Chair to the Board's Executive Committee and IRRI Management, and subsequently to the staff.

APPENDIX IV

DOCUMENTS PROVIDED TO THE REVIEW PANEL

A. Documents Provided by the TAC and CGIAR Secretariats

1. Review Processes in the CGIAR, 1988.

2. CGIAR Priorities and Strategies for Resource Allocation During 1998-2000.

3. Report of the Fourth External Programme and Management Review of the International Rice Research Institute (IRRI).

4. Report of the Fourth External Programme and Management Review of the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

5. Investment in Rice Research in the CGIAR: A Global Perspective - Report of the Inter-Centre Review of Rice.

6. Priorities and Strategies for Soil and Water Aspects of Natural Resources Management Research in the CGIAR (and two background documents):
   (a) A Synthesis of Current Activities in Soil and Water Research in the CGIAR;
   (b) A Strategic Review of Natural Resources Management Research on Soil and Water.

7. Harvest and Postharvest Problems in Agriculture, Forestry and Fisheries - The CGIAR Contribution to Research.

8. Priorities and Strategies for Policy, Public Management and Institution Strengthening Research and Service in the CGIAR (and two background documents):
   (a) Perspectives on Policy and Management Research;
   (b) The Future Role of the CGIAR in Development of National Agricultural Research Systems: A Strategic Study of Institution Strengthening Research and Services.

9. Extracts from the Reports of the 66th and 69th Meetings of the Technical Advisory Committee (TAC)

10. Medium Term Resource Allocation 1998-2000: Centre Proposals and TAC Recommendations.

To All Panel Members:

11. Lucerne Declaration and Action Programme (February 9-10, 1995 - 2 Vols.)

12. Most recent CGIAR Annual Report.

13. Most recent CGIAR Brochure and Directory.

14. (a) Financial Requirements of the 1998 CGIAR Research Agenda (Agenda Item: 8, Doc. No: MTM/97/14, May 6, 1997);
    (b) Financial Requirements of the 1997 CGIAR Research Agenda (Doc. No: MTM/96/10, April 26, 1996.

15. Organization and Management of the CGIAR System: A Review, 1993. (S. Ozgediz, Public Administration and Development, Vol. 13, 217-231 (1993); copyright 1993 by John Wiley & sons, Ltd.).

16. Reference Guides for CGIAR International Agricultural Research Centres and their Boards of Trustees, August 1997.

To Relevant Panel Members:

17. Governance and Management of the CGIAR Centres, 1991 (S. Ozgediz, Study Paper No. 27, copyright 1991, first printing October 1991).

18. Most recent volume of the CGIAR Board of Trustees Directory (October 1996).

19. Some Thoughts Toward Ensuring the Successful Performance of Boards in the CGIAR System, 1987 (John L. Dillon, August 1987).

20. CGIAR 1995 Financial Report (August 1996).

21. Committees and Units of the CGIAR: Roles, Responsibilities, and Procedures (April 3, 1996).

22. Most recent CGIAR financial guidelines and manuals relating to:
    (a) Financial Management Guidelines, Series No. 1 (January 1988);
    (b) Accounting Policies and Reporting Practices Manual (October 1993);
    (c) Financial Guidelines - Audit Manual (July 7, 1995).

23. CGIAR Research Agenda: 1999-2001 Medium Term Plans (MTP).

B. Documents Provided by IRRI

To all Panel Members:

24. IRRI 1995-1996 Listening to the Farmers (Corporate Report).

25. IRRI's Programme Report for 1995 (Annual Report).

26. IRRI Toward 2020.

27. Sustaining Food Security Beyond the Year 2000 - A Global Partnership for Rice Research (Medium-Term Plan 1998-2000).

28. Rice Research in a Time of Change:
    (a) IRRI's Medium-Term Plan for 1994-1998.
    (b) 1997 Programme Plans and Funding Requirements.

29. IRRI Financing Plan 1997 -(Supplement to 1997 Programme Plans and Funding Requirements).

30. IRRI Administration and Operations 1993-1997.

31. IRRI Financial Management 1993-1997.

32. IRRI Programmes 1993-1997.

33. Major Issues Confronting IRRI's Research and Research Support Programmes.

34. IRRI Organizational Structure - July 1997 (with major Institute Committees).

35. IRRI's IRS and NRS Directory

36. List of Reports of Major Planning Conferences, Internal Reviews, Internally-commissioned External Reviews, Expert Meetings.

37. Summary of Actions taken in Response to the last External Programme and Management Review.

38. IRRI Publications 1993-1997.

39. Memorandum of Agreement (MOA)/Memorandum of Understanding (MOU).

40. List of Ongoing Special Funded Projects as of 4 July 1997, Grouped by Donor.

To Relevant Panel Members:

41. Articles of Incorporation and By-Laws 1990.

42. Agreement Recognizing the International Legal Personality of the International Rice Research Institute (IRRI) at Malacañang Palace, Manila, Philippines, 19 May 1995.

43. Current Members of the IRRI Board of Trustees.

44. Composition of the IRRI Board of Trustees over the last 5 years.

45. Board of Trustees Handbook, March 1997.

46. Table of salary ranges, allowances and benefits - Nationally Recruited Staff (NRS).

47. Table showing Personal Data on Internationally-recruited Staff by Programme

48. List of Internationally Recruited Staff Turnover by Category (Arrival and Resignation 1993-1997).

49. List of Nationally Recruited Staff.

50. List of Internationally Recruited Staff Unfilled Positions.

51. Information Management Systems and Procedures.
Available at the Centre:

52. Set of Minutes Covering Board and Board Committee Meetings since the last External Review (and reports of Board Committees to the full Board if not included in the minutes).

53. Staff Manual or a Description of Current Personnel Procedures for International and Locally-recruited Staff.

54. Local Compensation Surveys Used by the Centre.

55. Reports of External Auditors, including Management Letters, and Financial Officer's Reports to the Board since the last External Review.

56. Most Recent Internal Audit Reports.

Additional Papers Provided Upon Request By The EPMR Panel After The Initial Phase:

57. Natural Resources Management Research at IRRI.

58. Some Definitions Relating to Productivity and Yield

59. Upland Rice Ecosystem Programme.

60. Rainfed Lowland Rice Ecosystem Programme.

61. IRRI's Role in the International Rice Research Community and Its Partnership Strategy:
    (a) Partnership in Rice Research: Rationale, Experience, and Implications;
    (b) Bangladesh-IRRI Dialogue, 24-27 February 1997;
    (c) Institution Strengthening: Toward Accelerating the Impact of Rice Research;
    (d) IRRI 1996-1997, PARTNERS - Making A Difference (Corporate Report);
    (e) Policy on Partnership with the Private Sector.

62. Rice Research Consortia: Partnership in Strategic Research for Rice-based Ecosystems:
    (a) International Rice Research Consortia: A New Initiative for Sharing Resources and Responsibilities;
    (b) Research Approaches for Variable Rainfed Systems - Thinking Globally, Acting Locally;
    (c) Operating Procedures;
    (d) Rainfed Lowland Rice Research Consortium: Workplan 1997-1998 - Rajabari, Rajshahi, Bangladesh - Bangladesh Rice Research Institute - Regional Station, Shyampur Rajshahi - 6212;
    (e) Scientific Monitoring of the Rice Research Consortia.

Provided to the EPMR Sub-panel for Visits to India and Vietnam:

For Visit to India:

63. Briefing Document for IRRI-EPMR Visit to India 4-10 January 1998

64. IRRI Rice Facts

65. Fact about Cooperation - India and IRRI

66. Vision of India's Rice Trade

67. Physiology of Stress Tolerance in Rice

68. Partners make hybrid rice a reality in India

69. Agroclimatic Atlas of Eastern India

70. Training Resource Book for Agroecosystem Mapping

71. Training Resource Book for Farming Systems Diagnosis

72. Training Resource Book for Participatory Experimental Design

73. Technologies for the improvement of rainfed rice production in Eastern India.

For Visit to Vietnam:

74. Briefing Document for IRRI-EPMR Visit to Vietnam 11-16 January 1998

75. Facts of Co-operation—Vietnam & IRRI (Oct. 1997)

76. Vietnam and IRRI: A Partnership in Rice Research

Evaluation of IRRI's Progress in Implementing the Recommendations of the 1992 External Programme and Management Review (EPMR)

Recommendation(s)	Implementation *	Comments
Chapter 3 - Research Programmes **Recommendation 3.1.** *The Panel, recognizing the threat posed to food supplies by yield decline and decreasing factor productivity in intensively managed riceland, recommends that IRRI lead a major research effort, enlisting the best talents available in the world, to seek solution for this complex of problems--a task that may take a decade or longer to complete.*	Partial	**Response:** We have recognized the importance of maintaining or increasing productivity in intensive systems but not at the level of concern as suggested by the EPMR. The Mega Project on Reversing Trends of Declining Productivity in Intensive Rice Systems was initiated in the second quarter of 1994 to quantify and monitor indices of soil quality and economic performance of farmers' rice production systems in domains of intensive rice cropping near and conceptually linked to existing long-term fertility experiments at several locations in tropical Asia. The expected outputs are: 1. productivity decline quantified and extrapolated; 2. indicators of cropping system performance and production efficiency; 3. indicators of soil quality and sustainability; 4. key constraints and research priorities identified; and 5. models of soil quality and crop productivity validated and refined. The project involves five NARS research stations in the Philippines, Indonesia, India, Vietnam, and Thailand. The project sites are located in intensive rice systems that are most representative of the irrigated ecosystem in each country. At each site, the project team consists of an agronomist, a soil scientist, and an agricultural economist. Teams have now been formed for all sites except Indonesia. Time frames, major activities, and standardized research and crop management protocols on farm monitoring (total factor productivity, biophysical) and long-term fertility experiments were finalized and research activities have been initiated at four sites. Funding for the first 3 years of the project (1994-96) was provided by the Swiss Development Cooperation. Yield decline has only been observed in long-term on-station experiments. We do not have sufficient evidence for a yield decline at the farm level. Available data suggest, however, stagnating or declining productivity from applied inputs, such as nitrogen or other inorganic fertilizer, as a general concern to sustainability of intensively managed riceland. Although we can reject several hypotheses for the observed yield and/or productivity decline, we have not fully unraveled the complex phenomenon. Major areas for research will focus on 1) better understanding of nutrient x disease interactions and their involvement in yield gaps and 2) assessing whether diversification of intensive rice systems would lead to greater sustainability.

* Full/Partial/No

Recommendation(s)	Implementation *	Comments
Recommendation 3.1 (cont'd.)		Despite substantial donor support for research in rice monoculture (IR9) and rice-wheat (IR9) systems, international efforts have remained below the levels suggested in the 1992 EPR. One of our major achievements in the last 5 years has been to understand yield decline and recover those yields in the intensive on-station trials. Our ability to link on-station results with what is happening at the farm level, however, has lagged -- partly because the issues are more complex and site-specific, and partly because of economics staff changes and the difficulty of establishing NARS teams of economists for such studies. Most of the rice research systems still have minimal socioeconomics staff, increasing the difficulties of this type of work at a regional level. The outlook for the next 5 years for real impact at the farm level is positive. We have assembled competent NARS teams in the Mega Project (on productivity decline), and a new economist is on duty. **Panel's comments:** The Panel agrees that the implementation of the recommendation has been partial because of the complexity of the problem and the need to first describe it clearly. The link with IPM Net in the IR Consortium is a positive development.
Recommendation 3.2. *The Panel recommends that IRRI explore the feasibility of combining with cultivated rice the ability of some wild species to grow under low solar radiation, in order to increase wet-season productivity.*	Partial	**Response:** We recognize the need to understand and manipulate processes related to raising the yield ceiling. However, we have not focused on increased light use efficiency at low light as the only and main component. We suggest that other factors particularly associated with N metabolism will have greater payoff for research. Crop management as well as crop improvement could play an important role in increasing wet-season rice yield. The key steps in our physiological understanding of yield, outlined in the actions taken in 1994, remain part of the IR-1 Project. Only from these studies can we ascertain the opportunity for enhanced photosynthesis under reduced radiation levels. One of the key steps is determining the genetic variation in quantum use efficiency. This work will be extended to wild rice materials. Our most important target in photosynthesis remains the matching of N supply to demand and reducing the rapid rate of N decline after anthesis. The yield potential in the wet season has been closely examined using ORYZA 1. At present, the model estimates are significantly higher than the actual yield, indicating the presence of unknown constraints (physiological, environmental, or managerial), even under the best possible conditions. For more detailed analysis on the yield limitation in the wet season, the model should be modified, or the new type of model should be adopted, that considers physiological processes more closely. Such work is now underway. In actual field situations, rice yield in the wet season is limited not only by solar radiation but also by lodging, insects/diseases, or by their combinations. Manipulation of photosynthetic systems is the most difficult part of conventional breeding and molecular genetics. Thus, as we address this issue, we emphasize other attributes, such as lodging and disease resistance (sheath blight), which will open up new technologies for crop and fertilizer management and may lead to a higher probability of success for increasing yield in the wet season. A

Recommendation(s)	Implementation *	Comments
		New Plant Type (NPT) now being developed has a higher lodging resistance and a canopy environment that reduces sheath blight. This NPT may be suited to wet-season cultivation if the proper management option is developed. **Panel's comments:** There is a danger in humid environments of increase in panicle and seed health problems with the New Plant Type, which has its panicle under the upper canopy.
Chapter 4 - Research Management **Recommendation 4.1.** *The Panel recommends that IRRI adjust the matrix management system to provide the Divisions more authority and means to strengthen disciplinary capabilities and rigour, and to ensure that the emphasis on ecosystem research Programmes does not lead to an erosion of disciplinary expertise.*	Full	**Response:** Given the key role of projects as the unit of Medium Term Plan (MTP) implementation within the Matrix, both the Programme Leader and the concerned Division Head(s) should "sign off" on the project design (i.e., work plan, staff time allocations, budget). Project on Strengthening Division Excellence. In 1994, this concept -- of a few limited projects that evolve "outside" the programmes, and strengthen disciplinary capacity -- was initiated and has been implemented since 1995. The terms of reference of the project are: • Improving and strengthening division staff interactions and communications with concerned professionals on the cutting edge of science. • Bringing leading scientists into research areas not adequately covered by the Programmes. • Strengthening divisional Nationally Recruited Staff (NRS) by providing training opportunities in the use of new techniques or concepts when other funds are not available from the Institute. • Creating division databases and guiding a Quality Assurance Team to assure research quality. • Organizing a division retreat annually to set the division research targets and focus, and to motivate division staff. **Panel's comments:** The divisions are an equal partner in the matrix structure, and disciplinary capabilities have been strengthened. Maintaining the balance between programmes and disciplines needs to remain a high priority for IRRI Management. Divisions should also favour linking the needs of the rice ecosystems programmes to the response capacity of the cross-ecosystems projects with greater divisional responsibility.
Chapter 5 - International Programmes **Recommendation 5.1.** *The Panel recommends that IRRI make every effort to mobilize required resources to protect the integrity and the worldwide effectiveness of the International Network for Genetic Evaluation of Rice (INGER), and to maintain the high level of management capability required for INGER's success.*	Partial	**Response:** We have made large efforts to mobilize more donors but to date that has been partially successful. Our approach has been to review the way INGER operates to streamline its activities and target the NARS as co-owner and supplier of the Network. The reorganization of IRGC and INGER in the GRC is providing the necessary management support for all activities under IRGC and INGER. The rationalization of common activities within the GRC for IRGC and INGER has led to greater efficiency and reduction of duplicate efforts without compromising any of the high standards necessary for germplasm conservation and exchange. IRRI had received funding from UNDP, but this was terminated in June 1996. In October 1994, we were successful in obtaining funding support from the SDC (Switzerland) and BMZ

Recommendation(s)	Implementation *	Comments
		(Germany). The SDC funds were awarded for a single year only and the BMZ funding support terminates at the end of 1997. We have been unable to secure additional funding support for INGER and, beginning in January 1998, the project will be supported from IRRI's core budget. Recent changes to the structure and organization of the GRC have been aimed at achieving greater rationalization of resources and achieving efficiency in their use. We will use IRRI core funding for the maintenance of international exchange of germplasm, and we are working toward the goal of NARS assuming more responsibility for within-country distribution. This emphasis will mean fewer trial sites for the uniform INGER nurseries, but the same level of breeder access to germplasm at the national level. We aim to provide a better analysis and interpretation of INGER trials that will permit breeders to make reasonable choices for testing lines selected from the uniform INGER trials. IRRI and WARDA have jointly developed a proposal to fund INGER activities in Africa, and that proposal is currently being evaluated by UNDP. The Council for Partnership on Rice Research in Asia (CORRA) has agreed to the concept that members, in addition to the indirect costs of INGER, pay for the indirect costs for the multiplication, clearing and safe delivery of INGER materials. We are exploring in 1998 NARS capacity to 'purchase' the INGER trials at a cost that pays for added value costs while maintaining INGER germplasm. **Panel's comments:** INGER provides a much-valued service to IRRI and the NARS in the region, and deserves to receive increased funding from the donor community. The Panel regrets that funding for INGER is not adequate at present.
Recommendation 5.2. *The Panel recommends that, in replacing its retiring librarian, IRRI employ a professional who has demonstrated competency as an international leader in the diverse areas of library and information services management.*	Full	**Response:** In May 1993, Ian Wallace was recruited from Agriculture Canada to carry on the fine work of Mrs. L.M. Vergara, IRRI's first and only librarian. During the 4 years that followed, good progress was made: a) the library facility was completely remodelled, with improved space, lighting, and fire protection; b) training of IRRI librarians in the new technologies was emphasized; c) the main international bibliographies on CD-ROM were acquired and made available on the local computer network; d) a library automation system was launched; e) international access was enhanced by setting up a World Wide Web site; and f) contacts with NARS clients were broadened. The IRRI Library is now adding links to electronic journals and other Internet-based sources of information. As the most modern library in the Philippines and the CGIAR, it is ideally situated to deliver rice information to scientists worldwide. **Panel's comments:** IRRI's Library remains world-class.
Recommendation 5.3. *The Panel recommends that IRRI, together with colleagues from national research systems, seriously consider the future of and IRRI's participation in the two Networks: Asian Rice Farming Systems Network (ARFSN) and International Network on Soil Fertility and Sustainable Rice Farming (INSURF).*	Full	**Response:** Cognizant of the rapidly changing research and information environment within which the two networks operate, the establishment of the ecosystem-based research consortia places a different perspective on the role of these networks. In line with an IRRI Management-initiated Peer Review on Networks, Management has begun in early 1992 discussions on the reorganization of existing networks. IRRI discussed with NARS the changing environment, technology, and information needs of modern rice farming in Asia. The NARS partners emphasized that the twin objectives of intensifying rice production systems to meet the growing food demand and preserving the resource base and the environment will require

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		the development and dissemination of innovative technologies. They advocated that sharing of crop and resource management information, knowledge, and technologies--not only between IRRI and NARS, but also among NARS--is vital to improve rice productivity, and similar to the exchange of rice germplasm by INGER. IRRI strongly believes that the establishment of a resource management network will exert pressure on researchers to develop technologies that will increase productivity in rice farms and improve the relevance of rice research to field problems, based on clients' feedback. After much intensive in-house discussion, and consultation with NARS, in 1994 IRRI established the Crop and Resource Management Network (CREMNET) to facilitate the sharing, evaluation, and adaptation of rice research outputs from IRRI and NARS. During the past 3 years of operation, the network has made significant progress, and NARS partners appreciate very much the catalytic role of CREMNET in promoting evaluation and adaptation of emerging research findings and technologies. **Panel's comments:** IRRI and its partners are active in CREMNET, and are committed to fully utilizing the benefits of this network, which are already considerable.
Chapter 7 - Organization and Management **Recommendation 7.1.** *The Panel recommends that the Board further improve the way it selects and orients its new trustees.*	Partial	**Response:** As a matter of policy, the Nominating Committee of the Board follows accepted procedures for CGIAR centers where prospective trustees are identified through an interactive process involving IRRI Board Members, Management, CGIAR Secretariat staff, databases, and other contacts. The search process has been expanded by encouraging nominations from IRRI staff. A continuing process of identifying and compiling a list of nominees was established. Nominations must include specific information on the candidates' possible contributions to the Board. IRRI has responded accordingly to global changes in the technological and economic frontiers by expanding the composition of the Board. The former practice of giving preference only to eminent experts in agricultural research has changed. Nominees with high personal and political profiles from the private sector or non-governmental organizations receive special consideration. Steps were taken to revise the old practice of "automatic" re-election of Trustees for another term. According to recent guidelines, at least 1 year prior to the termination of a Trustee's term, the Nominating Committee Chair must inquire officially about his/her interest in accepting re-election, if nominated. If a Trustee indicates willingness to be re-elected, the Nominating Committee includes the name in a list of two to three candidates and presents this list to the Board in a closed session. The concerned Trustee will not attend the closed session. Through secret balloting, the choice is made and becomes the official Board action on the matter. This process broadens the choice of candidates for a vacant post. The number of female Trustees has increased from one in 1992 to three in 1997. A handbook on Orientation Programme for New Trustees has been updated. New Trustees are requested to come at least a day before the Board meeting to get acquainted with IRRI programmes, staff and facilities on-site. The Programme Committee Chairperson assumes the task of orienting the new Trustee to IRRI and the CGIAR System Special orientation sessions are also held as requested by the Board. In 1995, an orientation for Trustees on the planning, budgeting, accounting systems, and procedures at IRRI was conducted. A manual was also prepared

Recommendation(s)	Implementation *	Comments
		to help the Board Members in understanding and interpreting financial reports. **Panel's comments:** Although some improvements have been made, the composition of the Board remains a matter of concern. Increased attention is needed to further strengthen the scientific and finance/management expertise on the Board.
Recommendation 7.2. *The Panel recommends that future peer reviews include a critical assessment of scientific quality.*	Partial	**Response:** Scientific quality and relevance have been and are key concerns of IRRI. The introduction of management-initiated external peer reviews is one of the tools to ensure high quality. Further, we have strengthened the independence of our Peer Reviews by: • Canvassing the names and CVs of potential panel members from a broad audience including TAC and donor members. • The IRRI Steering Committee selecting the panel members based on their objectivity and experience. We have continued to undertake Peer Review using the guidelines developed at IRRI for independent reviews. However, in 1996 and 1997 we did not conduct peer review during the year of (a) extensive planning for MTP in 1996 and (b) large staff reduction in 1997. **Panel' comments:** Peer reviews and CCERs are useful mechanisms for ensuring scientific excellence and management effectiveness. IRRI Management and Board need to give increased attention to the Centre's mechanisms for quality assurance.
Recommendation 7.3. *The Panel recommends that IRRI continue to conduct impact assessment studies.*	Partial	**Response:** We appreciate the Panel's confirmation of the importance of impact analysis. We interpret this recommendation as supportive of both *ex-ante* and *ex-post* assessments. We have focused more analysis on *ex-ante* impact to guide our research with limited *ex-post.* We place high importance on *ex-ante* impact assessment as a component in setting priorities, assessing equity and environmental impacts, and planning better use of scarce resources. We conducted a workshop on impact assessment in 1996; the output is a book publication to be released soon. We are conducting some limited *ex-post* assessment in the IAEG Programme of the CGIAR. **Panel's comments**: The development of an impact culture is a continuing task. Both *ex-ante* and *ex-post* impact studies need to be carried out. The Panel is pleased that IRRI intends to further strengthen its impact assessment work.
Chapter 8 - Administration and Operations **Recommendation 8.1.** *The Panel recommends that, in reality, the HRD Manager report directly to the DDG for Finance and Administration and that human resource management responsibilities be consolidated.*	Partial	**Response:** The position of the HRD Manager, vacant at the time of the 1992 External Review, was filled in February 1993. This Manager has done an exemplary job of strengthening the human resource management function, particularly for the Nationally Recruited Staff (NRS). IRS personnel matters, on the other hand, continued to be handled by a Director for Administration until early 1996. Both officers reported directly to the DDG for Finance and Administration. With the retirement of the then incumbent Director for Administration on January 31, 1996, this position was not filled in line with the streamlining measures at IRRI. IRS personnel matters in IRRI continue to be under

Recommendation(s)	Implementation *	Comments
		the supervision of a single senior IRRI official. Although consolidation of both the IRS and NRS human resource management functions as envisioned by the 1992 EPMR Panel has not yet been possible, IRRI is actively recruiting to fill a newly established IRS position (Director of Administration and Human Resources), which puts renewed emphasis on the human resource management function. We expect that consolidation will occur once this position has been filled within the next few months. **Panel's comments:** The human resource management function, both for IRS and NRS, needs to be under the charge of well qualified and experienced professionals. The Panel expects that the new Director of Administration and HR and the new HR Manager will bring the needed expertise.
Recommendation 8.2. *The Panel recommends that the Chief Security Officer position be filled by a person from outside IRRI present staff and that IRRI increase the proportion of contract security officers among its security staff.*	Full	**Response:** We appreciate the importance the Panel has placed on the security issue at IRRI. We have, for several years, initiated steps to improve security, and we will continue to do so with the Panel's suggestions duly noted and with the special care needed in the local environment. The Chief Security Officer position was filled on May 16, 1994, with an experienced officer from the Philippine Army. This Officer resigned after a year and was replaced with a certified security professional whose qualifications include some years of military training at the Philippine Military Academy, a Management degree, and graduate course work in Public Administration. Between 1992 and 1997, the number of contract security officers has increased by 38%. Changes in the composition of security personnel since the 1992 External Review follow: Contract / Core Before the Staff Adjustment Programme in 1993: 45 / 47 As of July 1994: 60 / 21 As of March 1997: 62 / 14 **Panel's comments:** Security of IRRI's campus appears to be good. However, continued attention would be useful as the function is increasingly contracted out.

GLOSSARY OF ACRONYMS

AED	Agricultural Engineering Division
AFRSN	Asian Rice Farming Systems Network
APPA	Agronomy, Plant Physiology, and Agroecology
ARBN	Asian Rice Biotechnology Network
ARI	Advanced Research Institution
ARO	Agricultural Research Organization
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ASEAN	Association of South-East Asian Nations
ASL	Analytical Service Laboratories
BB	Bacterial Blight
BOT	Board of Trustees
BPH	Brown plant hopper
Bt	*Bacillus thuringiensis*
BU	Biometrics Unit
CCER	Centre Commissioned External Review
CDAC	Computer and Database Advisory Committee
CE	Cross Ecosystem
CGIAR	Consultative Group on International Agricultural Research
CIAT	Centro Internacional de Agricultura Tropical
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo
CMS	Cytoplasmic Male-Sterile
CORRA	Council of Rice Research in Asia
CPS	Communication and Publications Services
CREMNET	Crop and Resource Management Network
CRF	Central Research Farm
CS	Computer Services Unit
DDG	Deputy Director General
DFID	Department for International Development
DG	Director General
DIS	Differential Impact Study
DNA	Deoxyribonucleic Acid
EPMR	External Programme and Management Review
EPPD	Entomology and Plant Pathology
EST	Express Sequence Tags
FAO	Food and Agricultural Organization
FLAR	Fundación Latinoamericana para el Arroz de Riego
GC	Genetic Conservation (programme)
GIS	Geographic Information Systems
GMO	Genetically Modified Organism
GRC	Genetic Resources Center
GxE	Genotype x Environment
IAEG	Impact Assessment and Evaluation Group

IARC	International Agricultural Research Centre
IFPRI	International Food Policy Research Institute
IITA	International Institute of Tropical Agriculture
IM	Accelerating the Impact of Rice Research
INGER	International Network for Genetic Evaluation of Rice
INSURF	International Network on Soil Fertility and Sustainable Rice Farming
IP	Intellectual Property
IPM	Integrated Pest Management
IRGC	International Rice Genebank Collection
IRGCIS	International Rice Genebank Collection Information System
IRIS	International Rice Information System
IRRC	Irrigated Rice Research Consortium
IRRI	International Rice Research Institute
IRS	Internationally Recruited Staff
IRTP	International Rice Testing Programme
ISTA	International Seed Testing Association, Switzerland
IVDN	Integrated Voice and Data Network
LTE	Long-Term Experiments
MAS	Marker-Aided Selection
MTA	Materials Transfer Agreement
MTP	Medium-Term Plan
NARS	National Agricultural Research System
NGO	Non-Governmental Organization
NPT	New Plant Type
NRI	National Resources Institute, UK
NRM	Natural Resource Management
NRS	Nationally Recruited Staff
ORSTOM	Institut français de recherche scientifique pour le développement en coopération, France
PBGB	Plant Breeding, Genetics, and Biochemistry
PC	Personal Computer
PCR	Polymerase Chain Reaction
PCS	Personal Computer Systems
PDR	People's Democratic Republic
PGR	Plant Genetic Resources
PIPR	Policy on Intellectual Property Rights
PMS	Performance Management System
PPPS	Policy on Partnerships with the Private Sector
PPQS	Philippine Plant Quarantine Service
PVR	Plant Variety Rights
QA	Quality Assurance
QTL	Quantitative Trait Loci
RF	Rainfed
RF	Rockefeller Foundation
RLR	Rainfed Lowland Rice
RLRRC	Rainfed Lowland Rice Research Consortium
RTDP	Reversing Trends of Declining Productivity
SHU	Seed Health Unit
SRP	Staff Restructuring Programme

SSD	Social Sciences Division
SWSD	Soil and Water Sciences Division
SysNet	Systems Research Network for Ecoregional Land Use Planning in Tropical Asia
TAC	Technical Advisory Committee
TDR	Time Domain Refractometer
TFP	Total Factor Productivity
TGMS	Thermosensitive Genetic Male Sterility
UNDP	United Nations Development Programme
UPLB	University of the Philippines at Los Baños
URRC	Upland Rice Research Consortium
VSAI	Veterans Security Agency Incorporated
WARDA	West Africa Rice Development Association

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