The Rice-Wheat Consortium

An Institutional Innovation in International Agricultural Research on the Rice-Wheat Cropping Systems of the Indo-Gangetic Plains (IGP)

The Review Panel Report

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Abbreviations

ACIAR	Australian Center for International Agricultural Research
ADB	Asian Development Bank
ARI	Advanced Research Institute
ASA	American Society of Agronomy
C	Carbon
CABI	Center for Agriculture and Biology International
CDC	Center Directors Committee of the CGIAR
CGIAR	Consultative Group on International Agricultural Research
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo (International Maize and Wheat Improvement Center)
CIP	Centro Internacional de la Papa (International Potato Center)
CIRAD	Centre for International Co-operation in Agricultural Research for Development (France)
CSIRO	Commonwealth Scientific and Industrial Research Organization (Australia)
CU	Coordination Unit, RWC
CWA	Comprehensive Assessment of Water
DFID	Department for International Development (UK)
DG	Director General
DGIS	Netherlands Development Assistance (Formerly: Directorate General for International Cooperation, Netherlands)
EP	Ecoregional Program
FPR	Farmer Participatory Research
GIS	Geographic Information System
GM	Genetically Modified
IAEA	International Atomic Energy Agency
IARC	International Agricultural Research Center
IASRI	Indian Agricultural Statistics Research Institute
ICM	Integrated Crop Management
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IFAD	International Fund for Agricultural Development
IGP	Indo-Gangetic Plains
INM	Integrated Nutrient Management
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
ISC	Interim Science Council
IWMI	International Water Management Institute
K	Potassium

LCC	Leaf Color Chart
MTP	Medium-term Plan
N	Nitrogen
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NATP	National Agricultural Technology Project, India
NGO	Non-governmental Organization
NZODA	New Zealand Agency for International Development (formerly, New Zealand Official Development Assistance)
PT	Power Tiller
PTOS	Power Tiller Operated Seeder
R&D	Research and Development
RCT	Resource Conserving Technology
RRA	Rapid Rural Appraisal
RSC	Regional Steering Committee, RWC
RTCC	Regional Technical Coordination Committee, RWC
RW	Rice-wheat
RWC	Rice-Wheat Consortium for the Indo-Gangetic Plains
RWS	Rice-wheat System
SC	Science Council
SWI	System-wide Initiative
TAC	Technical Advisory Committee, CGIAR
TFP	Total Factor Productivity
USAID	United States Agency for International Development
USG	Urea Super Granules
WB	World Bank

Fig. 5. Estimated investment pattern of donor funded projects by thematic themes

Fig. 3A. Zero-till sown wheat after three weeks of seeding (This image shows the controlled traffic enabling movement of farm equipment in the (field)

Fig. 3B. A healthy wheat crop after five weeks of sowing. Stubbles can be clearly seen along side the crop

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Executive summary

1. The review of the Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC) was undertaken at the request of the Regional Steering Committee (RSC) of the RWC. The RSC at its 7th meeting (Dhaka, Feb. 17-18, 2001) outlined the purpose of the review. They sought greater clarity in the role and responsibilities of NARS, ARI and IARC members, and anticipated the need for broad-based partnerships, including those involving the private sector, to respond to changing needs. The RSC members were concerned that the work program of the RWC needed to be more explicit in its response to the revised assistance strategies of donors funding research to have greater impact on poverty alleviation, sustainability and the environment. The outcome of this review is outlined in this report.

2. Accordingly, the goal of the review was to determine the changes in research priorities, organization and methods that will be required for the RWC to continue to make a significant impact on the livelihoods of those employed in agriculture, especially the poor, on the sustainable management of natural resources in the IGP, and on regional food security.

3. The review process included the following activities:

i. A desk review of selected past work and outputs
ii. Field visits to partner countries and selected research sites
iii. Surveys of stakeholders (IARCs/ARIs, NARSs, farmers), including interviews of key personnel in the NARSs/IARCs/ARIs
iv. Country case studies to investigate on-farm changes undertaken by an external expert in each of the NARSs
v. Commissioned self-assessment of institutional impact of RWC undertaken by the RWC Coordination Unit (CU).

4. Findings of the review show that the RWC has emerged as an innovative model for regional and international collaboration, which is now beginning to develop a credible record of achievements. It is operating as an inter-institutional and inter-center, multidisciplinary network facilitating systems based farmer participatory research in the rice-wheat ecology of the IGP. The main source of strength of RWC is the commitment of its key stakeholders to the founding principles and ownership of its work program spanning strategic, applied, and adaptive research and knowledge dissemination activities. The key assets of the RWC are in its roles as:

- An innovator and supplier of new knowledge for the rice-wheat systems (RWSs)
- A 'clearing house' for new approaches, methods etc. for use by the NARSs in the region, and
- A facilitator and a catalyst of research for development among the NARSs.

5. The effectiveness of partnerships between CGIAR Centers and their NARS partners as well as within and between the four national systems is one of the most important achievements of the RWC. The RWC has provided a number of examples where the research from one member has contributed to all members based on experiences and expertise within the NARSs and their international partners. There is clearly room for further deepening of such mutually beneficial NARS and IARC partnerships, including NARS outside the region, e.g., Brazil and its work on resource conservation technologies (RCTs). ARIs have largely been involved as 'contractors' for donor-supported activities that have not always been programmed RWC projects

but potentially could make greater contributions in addressing the emerging strategic themes related to long-term sustainability and the environment. RWC has followed an 'open door' policy for new partners/members wishing to join the technical work and the technical committees of the Consortium. This has contributed to the free flow of new ideas/concepts, which has benefited the RWC. However, there are concerns by some that membership of the Regional Steering Committee (RSC) needs to reflect more the membership at the technical level. The Panel notes that the guiding principles for membership on the RSC and the Regional Technical Coordination Committee (RTCC) are neither widely known nor fully defined or understood. As the RWC changes and collaborates with more institutions (national and international, public and private) as well as deepens involvement of some of the existing partners, it is important to clarify as to who is eligible to be a partner/member, what are different types of memberships and what are the roles and responsibilities of partners/members in different categories.

6. While there is no need for fundamental change in the structure, the RWC must face several continuing design challenges relating to governance at various levels concerning national and international partners; scope and placement of programmatic work within national and state/provincial agencies, not to mention those with NGOs, private-sector entities, and advanced research institutions. Good judgment must be exercised in dealing with the dynamics of these decisions, such as judging when the RWC can best 'let go' of a theme that can be better handled by the national partners in the Consortium or beyond. The national coordination arrangements have not always been very effective and receive little budgetary support from the national systems. In some cases the National Steering Committee (NSC) has not met regularly, resulting in weak review and planning of activities at the national level, including linkages with the extension services. In addition, not all national research entities are fully integrated into the RWC network, especially those operating outside the agricultural research establishment.

7. The present RWC biological research is focusing on issues related to natural resource management (NRM). Its most notable success to-date has been the recent development of several RCTs due to the efforts championed by RWC's CU with its NARS partners, including the private-sector machinery manufacturers. There is evidence of a significant change in the tillage and crop establishment methods being used by farmers in the wheat-based system of the northwest IGP. This impact is a major achievement for the RWC of regional significance and contributes to the global application of RCTs into a new ecosystem. However, the success of the tillage practices raises a number of concerns as well as opportunities. The chief of these is the lack of farm-level impact studies that can guide the process of adaptation to other zones, and identify emerging issues that need to be addressed by the RWC partners. Although, some monitoring studies were launched a few years ago, e.g., on soil health, there is need for more holistic monitoring of long-term impacts on the productivity and sustainability of the RWSs in the context of RCTs. The scope, coverage and locations of such long-term work should be debated amongst members to develop a work plan with clearly agreed responsibilities of the national and international partners.

8. The focus on RCTs is important for reasons other than efficiency and sustainability per se. The new RCTs provide a novel 'platform' for land and water management approaches and to introduce new crops and varieties into the systems, which may also help to re-establish better ecological balance. However, the work to foster greater diversification of the RW systems lacks a comprehensive strategy, including policy and market analysis, to guide the research and development efforts in the region. Agreement on an overall

strategy would help to set more appropriate priorities for fostering systems diversification suited to needs of different transects of the IGP.

9. The biophysical and socio-economic heterogeneity in different IGP transects must be borne in mind in planning future programs. In the west, traditionally a wheat-based production system, introduction of intensive rice cultivation has raised concern about environmental sustainability due to antagonism between the current soil-water production requirements of the two crops**.** The challenge for RWC is to undertake research to determine what possibilities exist to grow rice in different ways to the benefit of the RWSs in terms of productivity, diversity and sustainability (particularly of water use) and determine under what circumstances (including national policies) such changes are appropriate. The RWC can make significant contributions both by improving water-use efficiencies at farm-level through new RCTs, including laser land leveling and bed planting, and by joining with the CGIAR's Challenge Program on Water and Food. In the east, where the production systems are traditionally rice-based, intensification and diversification in the winter (non-monsoon) season will need to be focused on enhancing economic viability, learning from farm-level experiences with diversification in Bangladesh.

10. The RWC has facilitated a change towards a systems approach and use of farmer participatory methods for location-specific multidisciplinary research. It has successfully linked NRM with production systems research. While these processes have been adopted in some institutes, especially in the context of RWS research, much greater effort is needed through the national research establishments to mainstream these processes as a regular feature of program planning and implementation. RWC can play a bigger role towards this goal by influencing national research policy, disseminating benefits and continued efforts to build capacity of the national partners.

11. There are opportunities for greater contributions from IARCs/ARIs in support of RWC's need for attention to policy analysis work and new knowledge about the system processes impacting on its long-term resilience and profitability in the context of full exploitation of RCTs and distinctly different needs of the western and the eastern transects of the IGP. These include strategic research themes of regional and global significance related to land, nutrient, water and crop component management and safeguarding the environment (global warming gas emissions and carbon balance). IARCs are well placed to assist by developing/introducing new tools and techniques and establishing new theme-based partnerships for pioneering research. Planning of future research should be backed up with a formal analysis of research priorities, and development of a Medium-Term Plan (MTP). It is not about tradeoffs, but about better targeting of limited resources available for research to both the national and the international partners of the RWC.

12. Knowledge sharing and capacity building is an important goal of RWC. It has done a good job in sponsoring training of scientists, organizing scientific interactions through national/international workshops, exchange of scientists and participation in annual RSC and RTCC meetings. It has been particularly successful in documenting and disseminating information emanating from RWC-supported/facilitated work. RWC is also playing a constructive role in generation and transfer of knowledge in non-traditional areas of agricultural research, such as those involving information technology and GIS tools. Cross-transect traveling seminars organized by the CU for scientists, extension workers, farmers, and private-sector participants from NARSs have proved to be popular and effective training tool for providing new ideas and opportunities for exchange of information between NARS personnel working on similar problems. This is helping to strengthen the systems approach to research by the NARS scientists and

their resolve to show greater farm-level impact of their work. Such benefits cannot be easily captured solely through the national and/or the private research and should continue as an important part of the RWC work program.

13. Policy analysis and work to understand the socio-economic circumstances of the IGP farming communities are a weak part of the RWC research program. This weakness has also been a handicap for setting priorities and in developing greater focus on poverty issues in the research programs. While inclusion of funding for socio-economic research in recently approved donor supported projects is a positive sign, development of a strong program that fully engages the national institutions would require pooling of resources and expertise of all the partners, wherever possible linking their on-going work with the RWC activities. The objective should be to develop a good understanding based on systems analysis, constraints, tradeoffs, equity, and institutional and policy issues, since each aspect has an important role in the IGP.

14. The impact assessment of the work under the RWC 'umbrella' has lagged behind, even though this is now routinely required as one of the products of research programs/projects. This work needs to be mainstreamed into all significant research and development activities of the RWC. This would mean designing in impact work routinely in all major project proposals to ensure adequate resources and attention to development of resource groups in the national teams with capacity to undertake such studies. Work to assess farm-level impact should include analysis of potential technical as well as socio-economic constraints to adoption of recommended technologies.

15. While the RWC in recent years has attracted good donor funding for small individual projects, harnessing of medium-term resources, especially for facilitation, coordination and support to national programs for system-based research and for human-resource development would require energetic efforts of all its members. There are gains to be made by developing more comprehensive program proposals of related projects covering biophysical, socioeconomic and communications aspects, which can then be presented to potential donors either as a whole or as individual projects. The needs for expansion of successful RCTs, for system diversification and for water management research present an attractive window of opportunity for adoption of such a strategy and for exploring different options for securing medium-term funding. At the same time, the RWC members should also examine a move towards a more equitable cost-sharing arrangement in line with their size, degree of involvement and capacity to bridge the gap in sustainable funding for the CU.

16. The review concludes that there are continuing focused roles for RWC in knowledge generation, co-ordination/ facilitation of research agendas and in exchange of knowledge and people among members and countries. It should stay NARS-driven, focused on new innovations for the RWSs and responsive to emerging needs and opportunities, be open to new committed members, including those from the private sector, promote greater collaboration between NARSs as well with IARCs/ ARIs, and support a time-bound and adaptable agenda that is modest in coordination and facilitation resources. The RWC can best contribute to impact for the beneficiaries by sharing of appropriate knowledge developed through participatory research, utilization of opportunities opened up by the new information technologies and facilitating the scaling up of its delivery by others to ensure sustainability of RWSs, which contribute some 80% of total cereal production and are the cornerstone of food security in the region.

1

Introduction: Recent developments in Rice-Wheat Consortium (RWC) and context of the review

1.1 The RWC in brief

The RWC for the Indo-Gangetic Plains (IGP) has its origins in many years of collaborative research between CIMMYT, IRRI and the National Agricultural Research Institutes (NARSs) dealing with rice and wheat in Bangladesh, India, Nepal and Pakistan (Fig. 1). In 1989 these parties signed an agreement for research collaboration in response to concerns about sustainability of the rice-wheat systems (RWSs) of the IGP occupying nearly 13.5 million ha and providing employment and livelihoods to tens of millions of rural families. Rice and wheat contribute 80% of total cereal production and are critical to food security in the region. Over the next 17 years, the demand for these two cereals in South Asia is expected to grow at 2.02 and 2.49% per year, respectively, (Rosegrant et al. 2001) requiring continuing efforts to increase production and productivity.

The RWC was formed in 1994 as an Ecoregional Program (EP) of the CGIAR with strong support from the national partners. As an EP, the Consortium is a special kind of research network, which addresses NRM issues, and problems of agricultural productivity and production within a geographically defined area. Its goals are given in Box 1. It provides a mechanism for the commodity-based international and national institutions working on

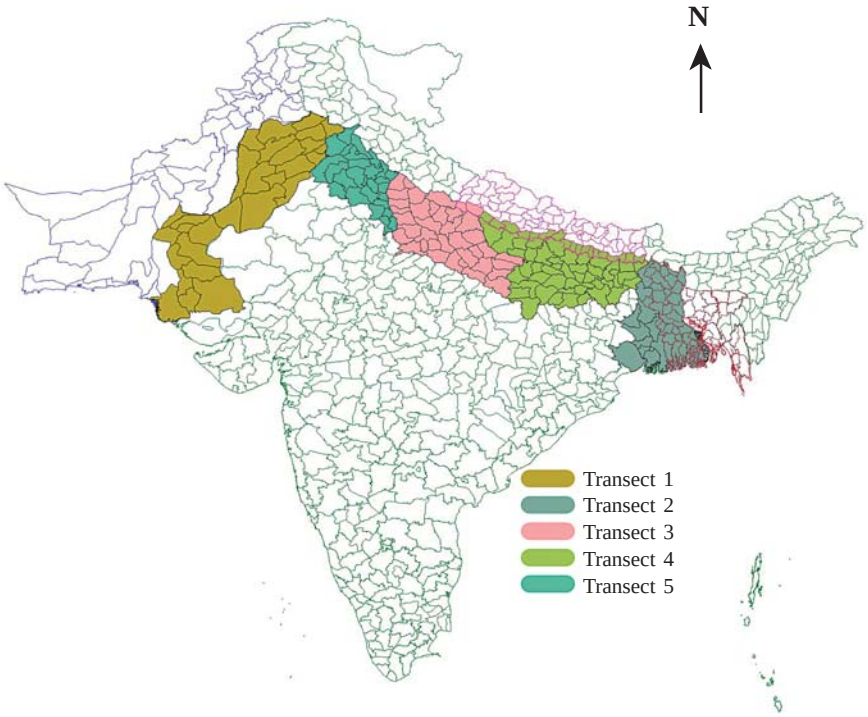

Fig. 1. Map showing the IGP transects according to RWC (*Source*: RWC, New Delhi).

Box 1. The Consortium objectives also serve the CGIAR goals

Strengthen existing linkages and partnerships with national research programs, other international centers, advanced institutions and the private sector working in the region to develop and deploy more efficient, productive and sustainable technologies for the diverse rice-wheat production systems of the Indo-Gangetic Plains so as to produce more food at less cost and improve livelihoods of those involved with agriculture and as a consequence to decrease poverty.

similar themes to engage in cropping systems research in collaboration with each other. It accords high priority to adaptation of new tools and techniques to regional needs and sharing of research findings amongst scientists in the region through workshops, meetings, seminars, newsletters and publications. The founding members of the RWC included the NARSs of Bangladesh, India, Nepal and Pakistan, and CIMMYT and IRRI. Three other Centers (ICRISAT, CIP and IWMI) collaborated closely from the beginning. ICRISAT was the first convening center and hosted the CU for a short time. This responsibility is now with CIMMYT. The Consortium also works with several advanced research institutions (ARIs) in more developed countries, mostly through donor-funded initiatives, including Cornell University (USA), CABI (UK), WIS International, Wageningen (Netherlands), IACR Rothamsted (UK), CIRAD (France), CSIRO (Australia), Massey University (New Zealand), University of Adelaide (Australia), Michigan and Ohio State Universities (USA), IAEA (Vienna), and development institutions/agencies (DFID, DGIS Netherlands, ADB, ACIAR, NZODA, IFAD, World Bank (WB), USAID). Funding for the Consortium activities largely comes through special projects financed by donors and from externally aided national projects as well as budgets of the participating NARSs.

1.2 Rationale for this review

A Panel appointed by the Technical Advisory Committee (TAC) of the CGIAR first reviewed the activities of RWC in 1999 as a part of a review of several EPs. The report of the TAC review Panel was positive. It assigned the success of the RWC to it being a NARS-driven initiative with other partners having defined roles with a commitment to make it successful. The report highlighted the fostering of improved system-based planning, and a sharpening of the focus on a systems perspective with crop establishment techniques providing a center stage for improving soil and crop management as its positive attributes. The Panel also noted its influence on how WB funding is used to strengthen national programs in the region.

Despite good progress, however, farm-level impact is still limited. A number of questions have surfaced that require a fresh look at the future role, strategy and priorities for the RWC work program. There is a need for greater clarity in the roles and responsibilities of NARSs, ARIs and IARCs. Donors have recently reframed their strategies for funding of research to have greater impact on poverty alleviation, sustainability and the environment. In addition, given the increasing strength of the private sector in the region, some objectives of the RWC can be best met through partnership and/or cooperation with the private sector. Given these wide-ranging considerations and an interval of three years since the TAC review, the 7th meeting (Dhaka, Feb. 17-18 2001) of the Regional Steering Committee (RSC) recommended a forward-looking review of the RWC.

1.3 Scope and coverage of the review

The review has the following goal:

"To determine changes in the research priorities, organization and methods that will be required for

the RWC to continue to make a significant impact on the livelihoods of those employed in agriculture, on the sustainable management of natural resources in the IGP, and on regional food security."

The review examines the RWC's past and present and assesses directions for future research, policy, organization and partnerships. The RWC is now in a mid-term transitional stage, raising the fundamental questions: Is there a case for maintaining the RWC at the regional level? If yes, what are the key assets of the RWC and should the RWC maintain focus or grow organically? What is the added value of IARCs and ARIs working in the RWC? The review addresses these questions in the final chapter (Chapter 5) – The Way Forward for the RWC, which includes the major recommendations.

The list of the Panel members who undertook this review and their Terms of Reference for the review are set out in Annexures 1 and 2 respectively.

1.4 How the review was conducted

The review began in first phase in October 2002, with a field visit of Seth, Jha and Anderson to the CU in Delhi and to several sites in northern India. Based on this early analysis the following was undertaken:

- A desk review of selected past work and outputs (Annexure 3)
- Field visits to partner countries and selected research sites (Annexure 4)
- Interviews of key stakeholders in the NARSs/ IARCs/ ARIs
- Commissioned self-assessment of institutional impact of RWC undertaken by the CU
- Country case studies on farm-level changes undertaken by an external expert in each of the NARSs
- Surveys of stakeholders (Annexure 5)

The second phase began in early March 2003 with the completion of the field visits by Fischer and Jha to India and Bangladesh, and by Seth to Nepal (The Panel was unable to visit Pakistan). During March 2003 RSC/RTCC meeting in Kathmandu, Nepal, the full Panel met individually with all members of the RSC, with the National Technical RW Coordinators as a group, with the Program Director of CIMMYT who is responsible for the CU, and with some donors and other stakeholders. The drafting of this report was commenced at the CU in Delhi in mid-March and finalized during April-May 2003.

2

The RWC: Past and present

2.1 Development of the approach

2.1.1 Historical and evolving rationale

The RWC evolved to address growing concerns that the rates of growth in yield of rice and wheat were slowing or had stagnated and in some cases were on decline (Flinn and Khokhar 1989). There was a growing awareness that the productivity of the system as a whole depended on the interaction of the two main commodities – rice and wheat – and that solutions could only be achieved by a farming-systems approach. In 1991, through an ADB grant, IRRI and CIMMYT, in partnership with the four South Asian NARSs, started a research program to respond to these concerns. This work, including the diagnostic surveys for setting up the initial research priorities (Harrington et al. 1993; Fujisaka et al. 1994), was coordinated by IRRI. Outcome of the early phase was reviewed in a workshop organized by FAO in 1994 (Paroda et al. 1994) and, with the World Bank help, led to establishment of the RWC as the ecoregional program of the CGIAR. The TAC review (1999) concluded that 'the RWC is truly a Consortium (a special kind of research network). It is not a research program in its own right in the sense that the word 'programme' is generally used in the CGIAR. Apart from any studies the Facilitation Unit might carry out on ecoregional methodologies, the RWC is not structured to conduct research in its own name'. The research approach for the RWSs that evolved over time had the following elements:

- The research would begin with multidisciplinary diagnostic surveys at key sites in the IGP. This was to identify the constraints to productivity at the farm level and to understand the complex chain of cause and effect that drove each constraint. Each member was to conduct a specific part of the agreed research agenda using their own core resources.
- The RWS research would feed back to the commodity programs the required changes in cultivar development.
- The research would monitor the long-term sustainability of the RWSs.
- Diagnostic surveys were to be conducted in all four countries and from them a set of research themes and responsibilities by the members of the consortium would be evolved.

The research themes included:

- Tillage and crop establishment (with a focus of providing a more favorable window for sowing wheat)
- Integrated nutrient management (with a focus on site-specific nutrient management, nutrient mining in long-term trials set up at the beginning of the Green Revolution (GR), and leguminous break crops in the rotation)
- Studies on water management at the field level
- IPM at the system level and need for break crops with a focus on *Phalaris minor* as a major emerging weed of the systems.

The RWC has since added the new themes of knowledge management systems, socio-economic analysis and human resource development, as well as capacity building in each of the themes. The present RWC activities are well founded in a farming system approach to research. A better understanding of the systems has evolved (as shown in Fig. 2) and most of the research is conducted at

the farm level with active participation and experimentation of farmers.

2.1.2 Institutional arrangements for coordination and implementation

The RWC is a multi-tiered organization (Fig. 3) with the RSC the pinnacle management group for endorsing the research themes, and approving work plans (developed by the RTCC) and budgets. It consists of the Directors General of the four participating NARSs, the Directors General of CIMMYT and IRRI and a donor representative. The Chairmanship of the RSC rotates annually between head of NARSs and is currently chaired by Dr. R.P. Sapkota, Executive Director, National Agricultural Research Council (NARC), Nepal. The Regional Coordinator acts as Secretary.

The activities of RWC are coordinated through the CU, (previously called the Facilitation Unit) headed by a Regional Coordinator (housed at New Delhi} and a Co-Coordinator (previously called Facilitator and Co-Facilitator), with the latter previously housed at Katmandu and now at Dhaka. CIMMYT is the current convening center and provides administrative support to the CU through its offices in India, Nepal and Bangladesh. The CU reports to RSC, liaises with IARCs/ARIs and the national partners, to facilitate implementation of agreed work programs, organizes annual RSC/ RTCC meetings, workshops and other HRD related activities, including traveling seminars and fosters partnerships. In addition, CU is also helping to develop a regional project information system and a regional GIS for cross-site synthesis of data. More information on the roles of CU is given in Annexure 6. A brief summary of the key functions of various bodies of RWC and the Panel's assessment of their relative strength and weaknesses is briefly summarized in Table 1.

2.1.3 Membership of the RWC

Over the years the RWC has engaged with over 80 partners in research and development activities, which are consistent with the RWC work plans.

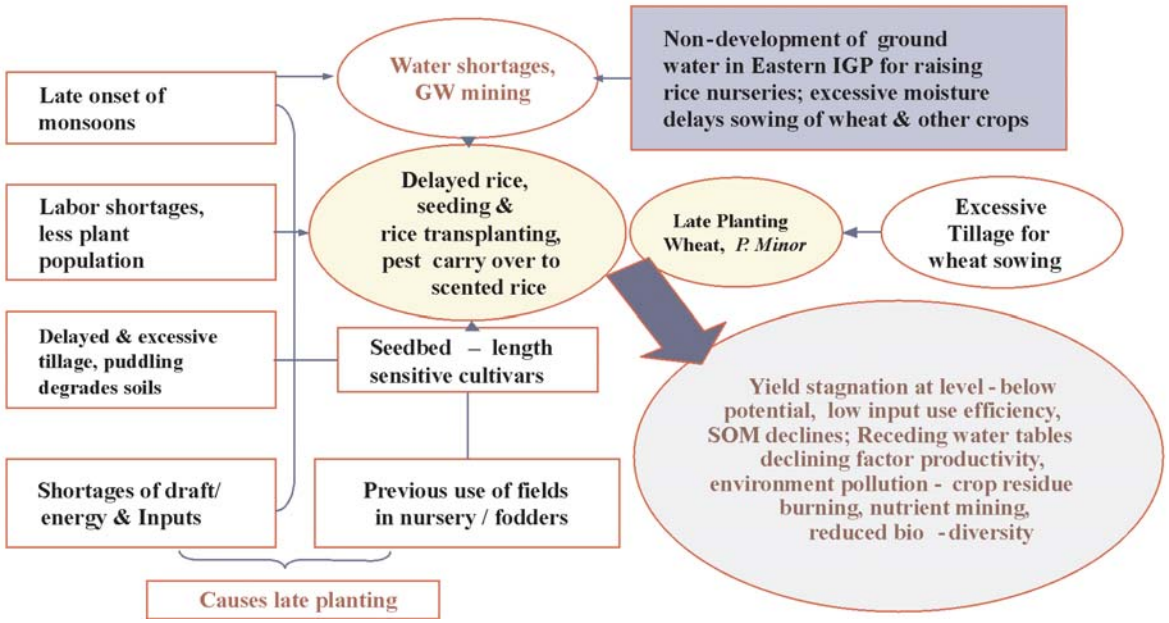

Fig. 2. Sustainability dimensions of rice-wheat systems

(*Source*: RWC. 2001. Vision paper for delivery of resource conserving technologies. Rice-Wheat Cosortium for the Indo-Gangetic Plains, New Delhi, India)

These have included institutions that are parts of NARSs, such as State Government agencies dealing with policy and extension, NGOs, IARCs, ARIs, UN agencies and the private sector. The level of involvement has varied between comprehensive on-going engagements with the core members (NARSs of India, Pakistan, Bangladesh and Nepal, IRRI and CIMMYT) to a short-term project-specific relationship. Many of the partners are self-funded while some receive funds from the special projects administered by the CU. A full listing of the partners by country is given in Annexure 7.

2.2 Achievements

In examining the achievements of the RWC, the Panel asked the following questions:

- Is there a systems approach to research by the RWC members?
- Is the research agenda appropriate to provide (international/regional) public-good research outputs?
- What is the impact at the farm level?
- How well it has contributed to capacity enhancement of NARI scientists?
- How robust and sustainable is the framework of the RWC?

In looking to answer these questions the Panel took note of the heterogeneity both in the natural resources of the RWSs in the IGP and in the research capacity of RWC members. It has given careful consideration to information contained in the RWC reports/publications, insight gained from responses to the questionnaires (Annexure 5) and personal interviews at several levels in IARCs and NARSs. The limited documentation of farm-level adoption and outcomes was largely from one zone of the RWSs (north western, wheat-based, irrigated) covering northwestern India and Pakistan (Punjab).

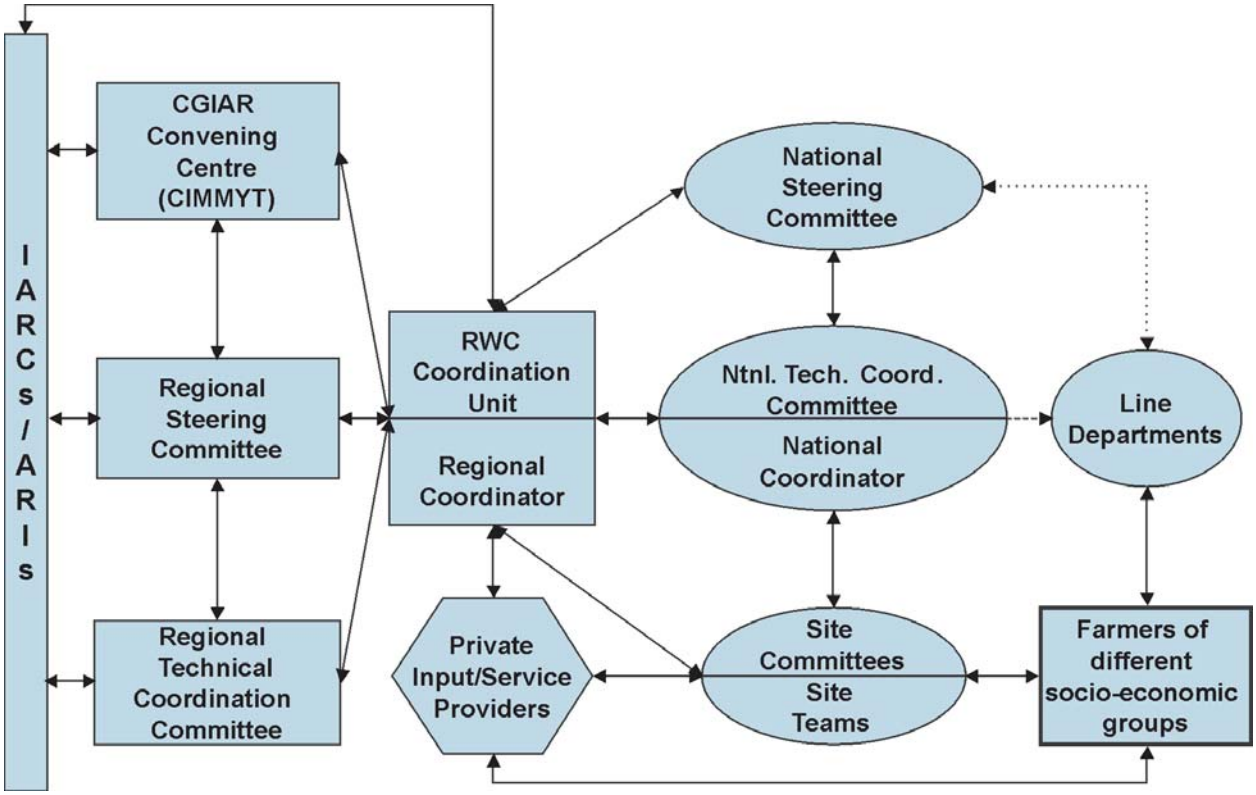

Fig. 3. The RWC operational structure

Table 1. Key functions of various bodies of RWC and the Panel's assessment of their strength and weaknesses

RWC body	Composition and function	Sources of funding	Strength and weaknesses
Regional Steering Committee (RSC)	Heads of NARSs, IARCs and a donor representative:Provides policy guidance, endorses priorities, resource allocations for agreed work plans and monitors progress	RSC meetings and other operational needs financed as a part of the CU budget	++++ Functions well and provides the needed policy guidance. Could play a stronger role in securing medium-term funding for RWC activities, including the CU
Regional Technical Coordination Committee (RTCC)	NARS, IARCs, ARIs RTCC meet annually in each of the member country by rotation. Develops work plan, identifies emerging issues and opportunities, promotes exchange of information and linkages between members and maintains technical oversight and provides quality assurance	Funding for regional technical meetings in the CU or special project budget	++++ Generally functions well. Can play a stronger role in technical oversight and quality assurance
Coordination Unit (CU)	Regional Facilitator full-time and Co-facilitator part-time CIMMYT staff; office and administrative staff engaged locally in India:Acts as secretariat to RSC and liaison with IARCs/ARIs and other stakeholders. Facilitates implementation of participatory research in each country under the agreed work plan; exchange of information within and outside the region; workshops, training and traveling semina	Donor funds, CGIAR contributions, CIMMYT contribution, Administrative support charges from special projects	+++++ Highly satisfactory performance, which is appreciated by all (Annexure 5). Of special importance has been its catalytic role in facilitating development of partnerships, adoption of participatory research processes and activities related to human resource development through knowledge sharing across countries, national and international institutions (also see section 2.1.2 and 5.3)
CIMMYT as the Convening Center	Part-time support from the Director, NRMManagement of CU; accountability of on-going projects; briefing of CGIAR about RWC; and development of project proposals for funding by donors	CIMMYT core budget, overheads from projects	++++ The arrangement is working reasonably well but an expanding and more complex program needs its own identity and greater managerial support from CIMMYT (also see section 4.3.1)

Contd...

Table 1. Contd...

RWC body	Composition and function	Sources of funding	Strength and weaknesses
National Steering Committee (NSC)	Head of NARSs, Chair; other senior staff members.Decides on research priorities; promotes multidisciplinary research; allocates resources for national research; and constitutes NTCC		+++ NSC not meeting regularly in all the countries leading to gaps in planning and oversight. There is a need for a more pro-active role, especially in monitoring and issues related to medium (also see section 4.3.3)
National Technical Coordination Committee (NTCC)	Heads of Units/Senior Scientists directly involved in RWSs research. Help plan activities undertaken by RWSs institutions; linkages between public-private institutions; identify emerging issues and propose research to address them; monitor progress	Limited operational funds from CU	+++ In some countries there seem to be slippage in regularity of NSC meetings leaving gaps in review and oversight. There is a need for pro-active involvement of NSC, especially in issues related to monitoring, priority setting and resource allocation/ mobilization (also see section 4.3.3)
National Coordination Units	Managed by mostly part-time National Coordinators (NCs) with some administrative support from host national institutions. Oversee implementation of national RWSs research programs; liaise with research sites and RWC CU, IARCs and other stakeholders; foster participation and facilitate government clearances	Member funds for staff position. Some projects funds through CU to cover operational costs	+++ There is room for further improvement; countries with a large program should either have a full-time Coordinator or provide effective coordination mechanism with some budget for operational support (also see section 4.3.3)
Site Coordination	Site specific multidisciplinary teams	Projects funds through CU. Some funds from special projects of IARCs and ARIs	++++ Generally working well. Receiving direct technical and financial input from the special projects

2.2.1 Is there a systems approach to research by the RWC?

2.2.1.1 Research processes

The impact pathway adopted by RWC (Fig. 4) emphasizes participatory needs assessment of farm-level constraints to determine priorities, joint planning of work programs with national partners and other stakeholders and participatory research and technology validation. The pathway also recognizes the importance of two-way flow of

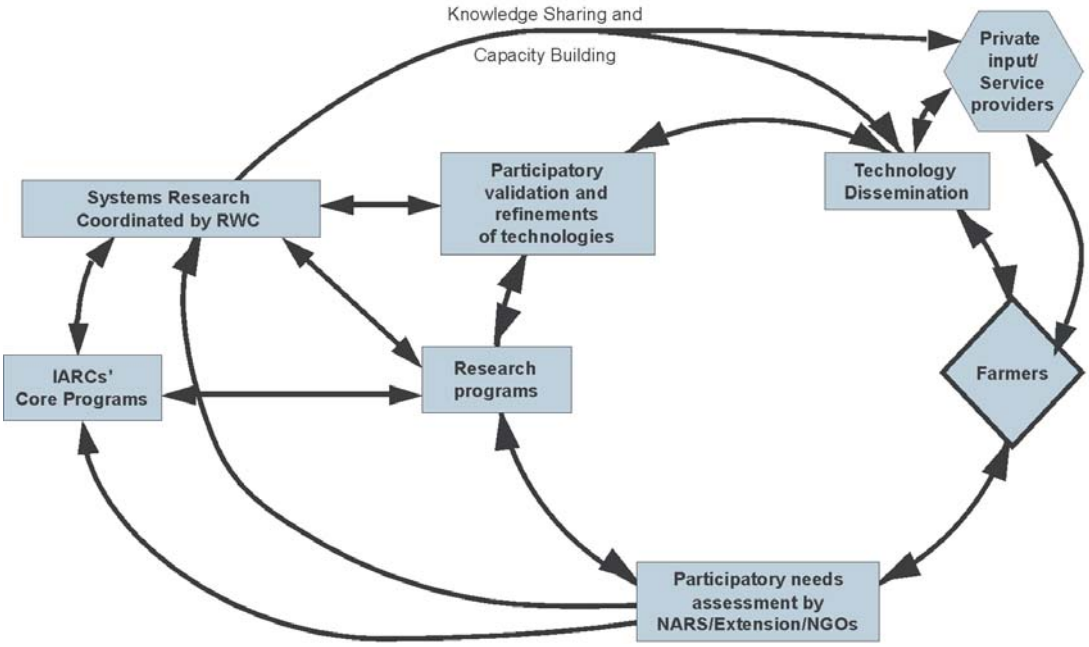

Fig. 4. The RWC impact pathways

information between the national and international partners, knowledge sharing and capacity building of national research and extension systems. It seeks to facilitate involvement of the private-sector input and service providers in technology development and dissemination processes. RWC considers that the adoption of this pathway has not only helped to instill a new paradigm for research-extension-farmer linkages but also accelerated the speed with which technologies are being transferred from research to farmers.

The Panel believes that the institutional processes adopted by RWC have been effective in the coordination of multidisciplinary and multi-institutional research, particularly at the field-site level. Here participants from different disciplines, including extension workers, NGOs, input suppliers, and farmers, are involved in all stages of the research process. However, while working well in the context of special projects, transfer of these approaches as a regular feature of national program planning and implementation is much less developed leaving considerable room for improvement.

The RWC has made good contributions in broadening the vision and perspective of participating scientists. In the past wheat and rice research was insulated in commodity-based programs. Now there are visible signs that these barriers are breaking down both in IARCs and in NARSs. Similarly, productivity enhancement was the primary criterion for assessing outputs of all research, but scientists are now starting to look at socio-economic factors, such as input-saving and cost-reduction strategies as legitimate goals of research. While there is room for further deepening of this process, the RWC has given hands-on experience for this change to take place and, as a consequence, scientists outside the RWC projects have started planning system-based experiments taking account of technical as well as socio-economic factors.

RWC is helping to promote concepts of farmer participatory research and much of its research is cast in this mode. During field visits, the Panel was struck by the enthusiasm and depth of interactions in many aspects of research where farmers are actively interacting with scientists and other partners in designing trials and in providing feedback, e.g.,

need for design changes to machinery manufacturers and options for crop diversification to scientists. Thus, this work is providing important lessons for a paradigm shift in agricultural R&D from the outdated linear research-extension-farmer model, to participatory approaches and extended networks where researchers, extension workers, NGOs, the private sector, and farmers are all involved in various stages of the process and many joint decisions are taken locally. The value of participatory approach and partnership with the private sector is well demonstrated by the effectiveness and speed with which the modified system involving the multi-crop no-till - *drill* - cum bed planter was developed and refined by private manufacturers working in close collaboration with researchers, extension personnel and farmers. Key features and reasons for success of this partnership are summarized in Annexure 8. The NARIs stand to gain a lot by decentralizing controls and by adopting more participatory approaches in research planning and implementation.

In many on-farm experiments undertaken in farmer participatory mode in South Asia, it is not possible to accommodate all treatments in the same field. As a result, the soil types, varieties and management regimes vary with each farmer adding to immense variability. To cater for such situations, there is a need to develop new statistical methods for analysis of farmer participatory research. RWC can facilitate such research in collaboration with IARC and specialized institutions in NARS, for example the Indian Agricultural Statistics Research Institute (IASRI).

To cope with the diversity of RWSs in different transects of the IGP, GIS-based knowledge systems are assisting in targeting the location-specific development and application of technologies for optimal use of the natural resource base. For example, at each research site under the ADB project[1], different options appropriate to the situation represented by that site are being tested. Scientists who met during field visits wanted to see greater use of this approach. However, access to GIS-based tools and techniques within NARSs is still limited and it would be some time before these become a routine feature of location-specific planning and implementation of research and development activities.

2.2.1.2 Human Resource Development

Knowledge sharing and capacity building is an important goal of RWC. It sponsors training of scientists, organizes scientific interactions through national/international workshops, exchange of scientists and participation in annual RSC and RTCC meetings. It has been particularly successful in documenting and disseminating information emanating from RWC-supported/facilitated work. RWC is also playing a constructive role in generation and transfer of knowledge in non-traditional areas of agricultural research, such as those involving Information Technology and GIS tools. Cross-transect traveling seminars organized by the CU for scientists, extension workers, farmers, and private-sector participants from NARSs have proved to be popular and effective training tools for providing new ideas and opportunities for exchange of information between national scientists working on similar problems in a number of important areas, including conservation technologies and crop establishment, nutrient management, pest profiling and management. This is helping to build capacity and strengthen the systems approach for research by the NARI scientists for greater field-level impact. Realizing these benefits, national programs are increasingly willing to meet local costs of these activities. The Panel concludes that the traveling seminars and other cross-transect activities to promote greater interactions and knowledge sharing between scientists working in the national systems

[1] A three-year ADB-financed project entitled 'Study on sustaining the Rice-Wheat Production Systems of Asia – RETA-5945 which commenced in 2001 at six different sites in India, Pakistan, Bangladesh and Nepal.

is an important achievement of the Consortium, which deserves continued emphasis and greater support in the future. Further, participation by IARC/ARI scientists in such activities adds depth to the scientific debate, helps in resolving issues through on-site exchanges and provides effective mechanisms for developing need-based programs/ partnerships to meet future challenges. Annexure 3 provides a list of selected publications on research facilitated by RWC, which has contributed to the advancement of knowledge. Annexure 8 and 9 describe the success of public-private partnerships and RCTs, provide examples of the RWC approach to capacity building of NARSs involving knowledge sharing participatory approaches, exposure visits, capacity building and technology transfer as mutually supportive activities.

2.2.2 Is the research agenda appropriate to provide (international/regional) public-good research outputs?

The RWC began its research agenda based on farmer participatory approaches (e.g., Fujisaka et al. 1994) and has evolved into a broader research agenda that now includes 26 activities in 8 themes, as shown in Annexure 7. In one theme, tillage and crop establishment, there has been remarkable success, while the success in other themes has been mixed, both in the implementation of the research agenda, and in research product (outputs) and impact at the farm level (outcome). The following is a summary of achievements in some of the themes of the ecosystem-based research agenda.

2.2.2.1 Tillage and crop establishment

There is evidence of a significant change in the tillage and crop establishment methods being used by farmers in the wheat-based system of the northwest IGP. This impact is a major achievement for the RWC of regional significance and contributes to the global application of RCTs into a new ecosystem. The Panel concludes that the drivers of this success are to be found in a timely congruence of technological interventions and the participatory operational approaches provided by the RWC, and the enabling environment created by the changing socio-economic circumstances, especially in the north-western India and eastern Pakistan. These factors are also becoming increasingly important in the Terai region of Nepal. These drivers, while unique to the adoption of zero and minimum tillage, are of generic interest for other technologies and are summarized in Box 2. The RWC is actively engaged in developing new tillage, land, crop, nutrient management and water use systems based on the principles of this success, yet adapting them to the different resources of the different transects. For example, in Bangladesh and Nepal, work is underway to develop/adapt tillage implements that can be used with the two-wheeled tractor which are now widely used in both the countries.

The focus on RCTs is important for reasons other than efficiency and sustainability per se. The new RCTs provide novel land and water management systems to introduce new crops and varieties into the system. The RWC has conducted a number of on-farm trials incorporating potatoes, lentils and other legumes into the systems at the local level but lacks a comprehensive strategy, including policy and market analysis, for research and development to foster greater diversification of the RW systems.

The success of the tillage practices raises a number of opportunities as well as concerns, the chief of which is the need for closer monitoring of areas rapidly adopting RCTs and greater understanding of bio-physical and socio-economic circumstances in the remaining areas to guide the adaptive research. The Panel understands that there will be a greater emphasis on socioeconomic work in the new research agenda of the RWC. Other needs and opportunities are discussed in sections 3.2 and 5.6.2.

2.2.2.2 Water management

Work initiated in Pakistan, later supported by the RWC, and has successfully adapted the technique

Box 2. Congruence of factors that drove rapid development and transfer of the resource conserving technologies (RCTs) in the western transect of IGP

Technical

- Yield increases from early planting of wheat, enabled by a time saving of 2-3 weeks that resulted from the adoption of zero tillage (direct drilling of wheat in rice fields).
- Development and modification of critical implements through on-farm testing, rapid feedback of farmer response to engineers and validation of prototypes with active involvement of the private sector machinery manufacturers, e.g., no-till drills (India), laser leveler (Pakistan), straw chopper (India).
- Increasing importance of *Phalaris minor* weed problem and development of resistance to the commonly used herbicide, isoproturon.

Operational

- Adoption of participatory approaches for on-farm trials with emphasis on allowing innovative farmers to experiment, e.g., with farm implements, planting techniques, rather than waiting until research and extension recommended the technology.
- Promotion of public-private partnerships through provision of prototype direct drills to machinery manufacturers and farmers for further development. Concurrent support to spread of contractual services for various farm operations, including direct drilling of wheat, which provided access to mechanical power to those without tractors of their own. A way for resource poor to obtain the technology (also see Annexure 8).
- Strong support from the national partners. In Pakistan this was mainly provided by the On-Farm Water Management Group.
- Rapid dissemination and exchange of research findings as well as field observations to all stakeholders within and between countries, including policy makers, scientists, extension workers and farmers.

Socio-economic

- Increasing cost of land preparation and other production activities, e.g., weed control due to increasing resistance of *Phalaris minor* to commonly used herbicide as well as shortage of labor at peak demand periods (land preparation, weeding and harvesting).
- Increased recognition by scientists and policy makers of the threat posed by stagnating/declining productivity of RWSs.
- Rapid mechanization of agriculture based on use of four-wheel tractor and availability of private contract service providers.

of laser land-leveling equipment in RWS improving water use efficiency by up to 25% (Box 3). This has involved laser technology development and innovation and the involvement of the private sector in developing appropriate earth-moving equipment and the engagement of new private suppliers of services to farmers. These concepts developed in Pakistan are in the process of being transferred to India with help from IRRI.

The RWC is developing other land-preparation/crop-establishment methods, including zero tillage and bed planting, that have the potential of reducing

Box 3. Laser land leveling for efficient use of water - A success story from Pakistan

LASER Leveling in progress

Key Constraints: Poor water application and water use efficiency and limited water resources.
Proposed Solution: Laser land levelling (also known as Precision Land Leveling) is a process of topographic modification, grading and smoothing of land to a precise and uniform plane surface (± 2 cm).
Local Adaptation. Imported rather expensive equipment was adapted to local conditions and manufactured locally with close support of scientists, agricultural engineers and farmers.
Benefits: It features the following benefits:

- Curtailment in irrigation application losses (25%)
- Reduction in labor requirements for irrigation (35%)
- Enhancement of the area irrigated (2%)
- Promotes the adoption of improved soil and crop management practices
- Increase in crop yields (20%)

(*Source*: Gill et al. 2002)

water use at the field/farm level. The RWC has just begun to measure the effect of these RCTs on water use at the farm and basin level. The Panel notes that, while this aspect of the work has been lagging (because of funds), the RWC is one of the partners for the CGIAR Challenge Program on Water and Food. It would be important to use this opportunity for a new partnership to add more capacity for analysis of water management issues at the basin level.

2.2.2.3 Nutrient management

The RWC has successfully developed new concepts for the management of nutrients based on the matching of site-specific capacities of the soil to supply nutrients and to the demand of the crop(s) in the system (Doberman and White, 1999). Farmers are learning these concepts through participatory research and the use of 'zero plots/ omission plot', and in the case of N, this 'knowledge' has been 'captured' in the leaf color chart (LCC). The LCC has been widely distributed to farmers in a number of countries to assess response.

The work on other nutrients is less advanced at the farm level although the careful examination of long-term experiments by the RWC is identifying nutrient mining (such as of K) and imbalances, along with the loss of C in some situations, as contributing to reduced yields (Ladha et al. 2003).

The RWC is adapting these nutrient management strategies to the new crop and tillage systems.

2.2.2.4 Crop improvement and management

The RWC has provided useful feedback from the systems research to the component commodity research programs of IARCs and NARIs; rice breeders have focused more on earlier maturity than on yield, so that wheat can be planted earlier; opportunities for short-season pulses, potatoes and other crops have been identified; and more recently commodity programs in wheat and rice are examining the genotype × planting-system interaction to decide if selection practices in the breeding program need to be modified.

As more farmers use the new RCTs there will be a need to adapt the inputs of crop, variety, fertilizer, water and pest management to the new system in the context of local requirements. The Panel noted a tendency for the RWC to engage in a diversity of such activities, raising the question of whether such work might be better done by the national commodity programs, leaving the RWC to focus on more strategic themes to develop new knowledge about systems to target the technological challenges more overtly.

2.2.2.5 Knowledge management

The RWC has begun a knowledge management system incorporating database management (on projects, experts, previous research, published information, institutions) by transects in GIS framework to develop methods that target the new agricultural technologies based on the natural resource base potential and crop characteristics at the local level. Sharing of database information with all scientists would significantly improve the ability to address location specific constraints of production systems. However, to date, outside of pilot projects there is no evidence of bringing the GIS-based tools to the agronomists/practitioners for their routine use in adaptation studies. The Panel recognizes that these tools are still in the early stages of use in research but also sees a need for greater coordination of efforts between IARCs and NARIs to ensure that as much effort goes to the validation of their use as to developing more sophisticated approaches by a small centralized unit in the CU of the RWC. The transfer, application and use of the knowledge tools by the national systems is a high priority in order to better target the adaptive studies for diversification, varietal selection, nutrient management and optimal use of natural resources, especially land and water, with or without the new RCTs.

In summary, the current research agenda of RWC is impact-oriented, as is highlighted through case studies on recent development of RCTs (Annexures 8 and 9). The agenda has produced research outputs that are appropriate public goods for the region and has encouraged involvement of the private sector where appropriate. The RWC has provided a number of examples where the research from one member has contributed to other members (Box 4).

The research outputs are effectively shared in a RWC Paper Series and in Research Briefs and there have been a number of Conference Proceedings. An ASA monograph (Ladha *et al.*, 2003) has recently been published covering a number of topics on productivity and sustainability of rice-wheat system. The Consortium has published a resource book on *Addressing Resource Conservation Issues of Rice-Wheat Systems of South Asia* in 2003. Thus, the RWC is generating a lot of knowledge about the systems and is communicating that knowledge to the members. However, the reporting of research in peer-reviewed journals, particularly on principles and processes, is variable among the research themes. There are a number of papers on nutrient dynamics, pest profiles and yield losses and on the sustainability (particularly in terms of nutrients) of the system. Also there are some papers from the early stages on understanding the importance of changes in productivity at the farm

Box 4. Examples of RWC-facilitated transfer of research information/technology from one member that has been of value to other members

Technology	Origin[1]	Primary destination	Linkage to biological research
Bed planter/Multi-crop bed planter	CIMMYT, Mexico/ India	India/Nepal, Bangladesh, Pakistan	Planting techniques in rice, wheat, and intercropping for improved system sustainability
Chisel type opener/Inverted T openers for ZT drill	New Zealand/India	Bangladesh, Nepal and Pakistan	Suitability for soil types, moisture conditions
Two-wheeled tractor attachments	Bangladesh	Nepal	Introduction of ZT/BP
Controlled traffic/paired row planting in zero tillage	Australia/China	India and other countries	Disease management and crop physiology
Coulter type double disk bed planter	Australia	India	Residue and nutrient management
Laser-aided land leveling	Pakistan	India	Water management for supply driven irrigation systems and crop-water-nutrient interactions
Leaf color charts	IRRI, Philippines	All IGP countries	Water-nutrient synchronization in wheat
Straw chopper	India	Pakistan environnemental	Residue management/
Parachute[2] planting of rice	China	Pakistan	Plant populations, labor saving
Star wheel type dibbler planter	Zimbabwe	India	Planting systems in loose crop residue

[1] Refers to the location from where the technology was picked up by the RWC for dissemination in the region

[2] Farmers in China grow rice seedlings in bubble sheets, a plastic sheet with cups holding ~200 g of soil enough to grow the seedlings for 20 days, and transplant the seedlings by broadcasting them in the puddled soil. The name 'parachute' came from the way the seedlings land on the soil while they are broadcasted along with the soil adhering to their roots.

level. The RWC is urged to maintain a balance in activities that will continue to generate new knowledge about the processes of the overall system that determine its long-term resilience and profitability. The Panel makes some suggestions in section 3.2 on how the RWC may better keep that balance.

2.2.3 What is the impact at the farm level?

As noted in section 1.4, one of the steps taken in planning this review was to commission studies of impact in each country. As of the main phase of the review in March 2003, only the India study was available as a full draft. The Nepal and Pakistan studies were unavailable. The full report on Bangladesh study was made available after completion of the review. Remarks that follow are thus largely drawn from the Indian case study.

In preparation of this review, economists at the National Center for Agricultural Economics and Policy Research (NCAP), New Delhi, were asked to conduct several rapid rural appraisals (RRAs) through the Indian RW zones. The scope of the work included other facets, such as review of aggregate data relevant to the zone, as well as some work on research prioritization. The draft made available to the Panel, Pal et al. (2003) assembled

much information pertaining to the RWSs of northern India as well as village-level observations in parts of the zone from Haryana to Bihar, where RWC has been active. The Panel has extracted from this draft the material on India that follows and looks forward to all four studies being published by the RWC in a single volume. Use is also made of information assembled by the CU of RWC.

Rapid rural appraisals using a relatively small sample were conducted in two production regions to capture some of the diversity of the system. The Kaithal district of Haryana, falls under the Trans-Gangetic Plains, where RW is intensively cultivated and a number of developments are taking place through market forces and technological intervention; and the Samastipur and Begusarai districts of Bihar, in the Middle-Gangetic Plains. This region is comparatively more humid, receives high rainfall, and use of modern inputs is comparatively low. Crop productivity is rising in the latter region, while it is plateauing in the former. Two villages were selected in each of the production regions where there was an adequate number of farmers exposed to or adopting the RCTs. The Panel concludes the following from these studies:

2.2.3.1 A positive and significant impact of zero/ minimum tillage

Among the RCTs, zero tillage technology has been adopted quickly and is spreading rapidly over a large area in both the regions.

It is estimated by RWC (RWC, personal communication, 2003) that in 2002-03 season zero-tilled wheat in rice-wheat system in India and Pakistan occupied nearly 500,000 ha (about 4% of total rice-wheat area in these two countries). The results of the survey established the superiority of zero-tillage technology over the conventional methods of crop establishment. It has enabled farmers to reduce the cost of wheat production (over Rs. 8000) and increased yields (by about 10-17% over conventional tillage) by facilitating the timely sowing of wheat (earlier planting by 1-2 weeks).

In zero tillage, wheat irrigation time and need for additional irrigations during crop growth was reduced due to the mulching effect of crop residue and increased soil water-holding capacity from higher organic matter content due to crop residue retention. Farmers also noted that with zero-till less time per irrigation was needed because the water flows more quickly over the surface and covers the whole field more rapidly.

A notable feature is that all categories of farmers are adopting zero tillage and its advantages are well understood by them. The advantages as told by the farmers are: (a) cost saving and thus higher profit, (b) saving of irrigation water, especially in the first irrigation, and (c) improvement in soil fertility due to decomposition of paddy stubbles in the soil. The date of sowing is also advanced by one to two weeks (Box 5).

The Panel can report other circumstantial evidence about zero tillage gained from their field visits with farmers. There appears to be a reduction in *Phalaris minor* weed population in wheat, which probably contributes to the higher yield reported by farmers. The Panel also heard of the initial resistance by farmers to zero tillage, as it was contrary to traditional beliefs that “the more you till the more the yield”. Such resistance was an obstacle to the early adoption and there may still be some concerns held by farmers of the long-term effects based on their perceptions of hardening of the soil as a result of continuous cultivation.

Based on the Bangladesh report by Hossain (2003) and the Panel’s own field visits it is concluded that there is considerable awareness of the potential of RCTs in wheat and other crops and some adoption is taking place in areas where research is being undertaken with somewhat similar benefits to those reported in the Indian study. However, more extensive adoption is being constrained by the limited availability of suitable implements. Further

Box 5. India: Reasons given by farmers for the adoption of zero tillage for wheat

Who are adopters?

All categories of farmers

Drivers of adoption:

(a) Reduction in cost of cultivation, including fuel savings

(b) Timely sowing of wheat

(c) Reduction in *P. minor* population

Other direct benefits:

Crop yield: A few farmers mention higher yield with zero tillage, but not sure about the long-term impact

Soil fertility: Positive due to mulching effect of crop residue and increased soil water-holding capacity from higher organic matter content due to crop residue retention

Irrigation water: Saves water in first irrigation; quicker spread of water in zero-tillage fields reduces pumping time from shallow tubewells

Major adoption facilitating factors:

(a) Refinement of the no-till drill

(b) Promotion of manufacturing of the drill by several private manufacturers

(c) Strong government support and provision of subsidies

(d) Integration of research efforts and large-scale demonstrations on farmers fields in a persistent manner

machinery development research is in progress to develop suitable attachments for two-wheeled tractors, which are widely available in Bangladesh. This should accelerate the pace of adoption of RCTs.

2.2.3.2 Other Impact Studies

Khan and Hashmi (2003) based on their research in Pakistan have reported similar benefits to those reported above from India (solving the problem of late wheat planting, reduction in cost of production, increased productivity, reduction in fuel consumption, less irrigation water use and improvement in environmental indicators). In their work they also identified areas for further improvement and research, including refinement of drill operation and manufacture and issues related to physical and biological properties of soil, fertility management under different types of soil, water management, varietal selection, etc. Despite these gaps, however, a significant number of farmers have now adopted some zero-tillage system for wheat planting, especially in Pakistan (Punjab). In addition, introduction of laser leveling in combination with zero-tillage has likely led to significant savings in water requirements (Box 3).

2.2.3.3 Summary

There are some important lessons for the RWC members from the experience of zero tillage. First, small refinements of technology, only evident with the interaction of farmer, and public and private agricultural engineers, remove important bottlenecks to large-scale adoption. These refinements may differ from area to area. In the case here, small modifications in the zero-till drill frame, tine and furrow opener blade based on farmer feedback, and close collaboration with the private sector, made the use of the drill more convenient for the farmers. Second, active participation of the manufacturers has improved the availability of the no-till drill and thus accelerating the adoption process. Training and

encouragement provided to the drill manufactures by the government and researchers encouraged their participation. This means that input suppliers, whether in the public or private sector, should be seen as key partners in the technology dissemination process—an aspect that was not given due attention until recently. Third, the provision of a (seemingly unnecessary) subsidy (Rs 3,000 per machine with a unit gross price of Rs 13,000) not only reduced the cost of new drills and hence possibly improved access by farmers, especially in Haryana but, along with persistent extension work, may have helped to convince farmers that the concept of zero tillage is beneficial and certainly has the endorsement of the government. Hopefully such arbitrary subsidies will not be sustained or re-introduced.

2.2.4 How robust and sustainable is the framework of the RWC?

The RWC has emerged as an innovative model for regional and international collaboration, which is now beginning to develop a credible record of achievements. The main source of strength of RWC is the commitment of its key stakeholders to the founding principles and ownership of its research and development program spanning strategic, applied, and adaptive research and support for technology-transfer activities. That these activities are demand driven and impact oriented is amply demonstrated by the success of RCTs, which are now generating research outputs of regional, and international public-good nature. In addition, its positive impact on research processes and contributions to human resource development contributes to sustainability of this partnership. Such benefits cannot be fully captured through only the national and/or the private research.

While there is no need for a fundamental change in the structure of RWC, the Panel concludes that there are some operational issues that require attention to enhance sustainability. These include greater inter-Center and inter-NARS collaboration, increased attention to the emerging strategic research themes related to land, nutrient, water, crop components and the environment (section 3.2 and 5.6) through explicit linkages between the RWC work program and the 'core' research of IARCs, human resource development support and rapid pass-through of research activities to the national systems. At the same time, the RWC members need to make greater efforts to overcome uncertainty about medium to long-term funding for research and for the CU, which affects sustainability (section 4.4).

2.2.5 What are the gaps in the research program as perceived by stakeholders?

A questionnaire was sent to all stakeholders with a goal of seeking forward-looking suggestions in several areas, including the gaps in the research agenda. In addition, the Panel also sought views of those met during personal interviews. The most common research gaps identified by these means is given in Annexure 5. A *summary* of responses highlighted the need for greater attention to the following areas:

- Socio-economic analysis at the farm levels
- Analysis of policies as they influence technology development and dissemination
- Formal methods of priority setting
- Diversification for sustainability and for income generation
- Inadequate understanding of the markets for diversification
- Changes to the soil ecosystem and to the soil pathosystem
- Water quality
- Technology uptake
- Move from IPM or IPNM to ICM models
- Crop modeling in the context of RWSs.

2.3 A summary of the achievements – what were the drivers for success?

The Panel concludes that the RWC has been successful in many of its activities. The Panel also notes that there are important gaps and some activities that were not successful. It encourages the RWC to carefully examine these outcomes and define its core strengths and unique assets. These must be strengthened in the next phase of the RWC. The Panel provides its assessment of the unique drivers for the success of the RWC (Box 6) as a guide for focusing the RWC in its next phase of activities.

Box 6. RWC drivers for success

- The research addressed constraints of a large, relatively homogenous, food system of global significance requiring the efforts of many stakeholders. *The need for a systems approach to research was clearly articulated and implemented with effective facilitation by the CU.*
- The formation of a partnership between the rice and wheat institutes at the national and international level to define the needs of the system through on-farm participatory diagnostics. *A multidisciplinary and bi-commodity team conducted diagnostic surveys at the farm level to identify the key research issues for the RWC. The research agenda explored innovations for the system with a strong focus on tillage and crop establishment research and provided the 'platform' for unifying all other major activities of the RWC.*
- The RWC welcomed all other self-funded stakeholders to contribute to the research agenda. The Consortium provided the entry point with teams of scientists at the local (site) and links with NARS, including the private sector. *A seamless participatory research system was made available at key sites in the IGP for some components of the research agenda.*
- The RWC had the commitment of the DGs of the members to decide policy and approve the research plan and budget. The NARIs defined the roles for the IARCs; identified the need for a CU to maximize interaction among the partners, and the commitment of national funds to the agreed research agenda.
- Some IARCs used core funds and dedicated full-time staff positions to the thematic research agenda approved by the RWS (IRRI and CIMMYT). Research in the thematic areas of tillage, nutrient management and knowledge management and sharing made significant progress; the gaps evolved in other thematic areas because of reduced core funding of a number of Centers.
- The CU was provided research funds for facilitating implementation of multi-stakeholder activities at the farm level and facilitated the flow of experiences among all members. *More on-farm participatory research by the members; rapid uptake of components of RCTs by farmers in the target sites; feedback to mainstream programs of the members.*
- The RCTs created new opportunities for increased productivity, possibilities to improve long-term sustainability (particularly through better water management) and a platform for diversification (including through bed planting for new crops). New opportunities for the system resilience and sustainability created through RCTs adapted to local needs.

3

Directions for the future: Policy and research

3.1 Policy issues

3.1.1 Validity of key issues: livelihoods/ growth, sustainable natural resource management

Rapid growth in rice and wheat production and productivity achieved during 1960s, 70s and 80s, supported by public investment in infrastructure, government policies designed to foster food self-sufficiency and GR technologies, has slowed or stagnated in recent years. This has raised concerns about future sustainability of the RWSs, and, in the context of increasing demand for wheat and rice at prices affordable to the poor, about regional food security. Since very little additional land can be brought under cultivation in the region to increase production, future rising demand for these cereals must be largely met through sustainable increases in productivity. The new challenge is that this must be done while conserving the natural resource base, especially land and water, and creating opportunities for diverting some land for diversification for greater income generation and enhanced sustainability. Attention to these concerns, therefore, must remain the central thrust of the RWC research agenda, technological innovations and analytical work for institutional and policy reforms.

3.1.2 Changing comparative advantage and strategic adjustment: Views concerning RWC roles

The production-oriented policies adopted in all the participating countries are changing. More liberal domestic and external trade, the (sometimes slow) shift from subsidy-oriented regimes, gradual withdrawal of state support for institutions and rural investment, and the focus on non-food commercial crops as a source of future growth, are some important pointers that will affect the IGP in profound ways. The RWSs and the RWC will also need to respond. In particular, as macro-economic circumstances change and influence the farming systems of the IGP, the RWC will need to adapt its priorities accordingly. In this process of change, it will be important to ensure that rural poverty concerns and ecological sustainability of production systems are not compromised.

The biophysical and socio-economic heterogeneity in different IGP transects must be borne in mind in planning future programs. In the west, traditionally a wheat-based production system, introduction of intensive rice cultivation has raised concern about environmental sustainability. Farm-level diversification would therefore likely re-establish better ecological balance. However, in the east, where the production systems are traditionally rice-based, intensification and diversification in the winter (non-monsoon) season will need to be focused on enhancing economic sustainability through optimal use of available natural resource base, especially water and the land left fallow after rice.

3.1.3 Productivity and policy

Pal et al. (2003), in the study cited in section 2.2.3, documented many aspects of the Indian situation including the rapid increase in both rice and wheat cultivation in recent decades through intensification of cropping and increased input use, the rising costs of labor, and the increasing use of mechanization. They cite the work of Kumar et al. (2002) who

documented changes in total factor productivity (TFP) in recent times (Table 2).

Kumar and his colleagues went on through further decomposition work to argue that most of the TFP growth was associated with investment in agricultural R&D. This is also in line with the wider findings of recent IFPRI studies for India and China (IFPRI, 2002). It should be noted that TFP, especially as imperfectly measured as it almost inevitably is, is not in itself a fully defining measure of trend in sustainability (e.g., Byerlee and Murgai, 2001).

By way of context setting, it should be noted that there has really been no new technology developed for the system until recently, with the exception of cultivars, which by and large have reduced the need for chemical pest control (through resistance breeding and IPM) but have done little for yield per se. As Pal et al. (2003) indicate, even with emerging technologies, a number of factors in the economic environment influence the choice of technology, for example in the RWSs of western and eastern regions of north India (weaker infrastructure, access to electricity and other services, including credit in the east as compared to west). They use their village data to describe several recent trends in the RWS including diversification into non-traditional crops, including maize, roots and tubers, and pulses, especially in Bihar, They stressed the significance of custom hiring of machines, particularly among small-scale farmers, and note the weakness in repair service facilities for machines in many parts of the zone. As noted in section 2.2.3, they focused on RCTs, in accord with their Terms of Reference. But noting these points for the Indian case serves to remind the reader that, while technological advance is critical for agricultural development, there are many other conditioning factors, which can be categorized broadly as policy matters. Of course, it is not just research (such as for crop improvement and biodiversity conservation and exploitation) and public infrastructure investments (such as for roads and telecommunications) that will be critical to progress. Policies that influence farmer investment in fixed improvements such as land leveling and irrigation will continue to be important as well as those pertaining to subsidies on inputs, most notably electricity and nitrogenous fertilizers.

It is reasonable to expect considerable progress on this broad policy front with the reforms emerging under globalization and trade liberalization, and changing perceptions of the importance of better management of natural resources in an expanded environmental policy agenda. Thus greater attention

Table 2. Annual growth (%) in input use, output, and TFP of the crop sector by agro-ecoregions during 1981-90 and 1990-96 in the IGP (Kumar et al., 2002).

Agro-eco region	Period	Trans-Gangetic Plain	Middle-Gangetic Plains		
		Plains of Punjab and Haryana	North-Bihar Plains	North–East Bihar Plains	South Bihar Plains
Input	1981-90	2.94	1.41	1.51	1.37
	1990-96	1.28	0.44	0.43	-0.63
Output	1981-90	4.47	2.23	2.40	2.08
	1990-96	1.60	1.11	-0.71	0.67
TFP	1981-90	1.53	0.82	0.90	0.71
	1990-96	0.32	0.67	-1.14	1.30
TFP % share	1981-90	34.25	36.71	37.35	34.31
in growth	1990-96	20.18	60.24	neg	194.08

in public policy to improved management of soil and water resources is doubtless to occur, and this accords well with the current and likely future focus of the RWC, with its strong emphasis on RCTs.

3.2 Implications for future research directions

3.2.1 Policy analysis and priority setting

The RWC has attempted to develop its research agenda and set its priorities in line with the constraints identified through diagnostic surveys at the field level. As indicated earlier, this process has lacked guidance from policy analysis and on knowledge about market-driven changes to diversify the system. There is clearly a need for more analytical procedures to set the priorities that bring in policy and market analysis. The analysis also needs to consider the balance between the sub-regions based on more detailed understanding of the biophysical and socio-economic situations. The priority-setting methods chosen need to combine close interactions involving farmers with analytical inputs from priority-setting models. A start in this direction has been made by Pal et al. (2003) that has revealed the likely returns to a variety of themes in the RWSs of India. This method can be validated and refined for use in the other RWSs too. Such an analysis would benefit the RWC in:

- developing the specific research agenda for different transects of IGP
- guiding the research of the NARS members (conducted outside the RWC), and
- seeking investor support for RWC activities.

3.2.1.1 What is the best use of the core assets of RWC?

Having identified the constraints and those research investments that will give the greatest benefits in the first stage, the second stage in this process should be an analysis of comparative advantage of the RWC as a supplier of that research and services. The Panel sees the RWC as a special institutional arrangement that provides added value to the NARS members who in turn are mandated to provide new knowledge to the national partners and farmers. The Panel considers the key assets of the RWC to be its roles as:

- An innovator and supplier of new knowledge for the RWSs, introduction of 'prototype' practices from other parts of the world, previously unknown in the Indo-Gangetic Plains
- A 'clearing house' for new approaches, methods etc. for use by the NARSs in the region
- A facilitator and a catalyst for research for development among the NARSs.
- It is important that: (a) a formal analysis of priority setting be conducted in line with the approach of Pal et al. (2003) after it has been further refined; (b) the RWC, through the RSC, define the role of the RWC/CU in implementing the agreed agenda; and (c) the RSC only endorses projects that are in line with the agreed priorities.

3.2.2 Directions for research

3.2.2.1 Environmental issues

Soil submergence is the dominant feature of present rice cultivation in the IGP and leads to unique biogeochemical processes that influence ecosystem sustainability and environmental services, such as carbon storage, nutrient cycling and water quality. For example the submergence of soils promotes the production of methane by anaerobic decomposition of organic matter. However, worries that such rice systems are a major contributor to global warming were allayed through a wide-scale study in the region (Wassman et al. 2001) Incorporation of straw can dramatically increase methane emissions under flooded conditions, but surface management of the straw under aerated conditions and temporary aeration of the soils can mitigate these effects. Thus the present direction of change in the RWS is likely to see a reduction of methane emissions from the system.

The water regime can strongly affect the

emission of nitrous oxide, another greenhouse gas, which increases under submergence, and is negligible under aeration. The trend of RCTs in the RWS would favor the decrease of this global warming gas.

The water, tillage and surface residue management influences the carbon stocks of the soil. Submerged rice fields maintain C content whereas soil C rapidly declines in frequently tilled aerated systems, particularly where residues are removed or burned, as is the case of much of the present RWS. The move to more aerated soils for rice will reduce C stocks whereas the move to no-till can slow respiration and accumulate more C in the soil. The no–till systems also use less energy for tillage and thereby reduce emissions.

In addition to these direct effects on global warming gases, the RCTs may have some indirect effects. Research findings show that zero-tillage on an average saves about 60 liters of fuel per hectare thus reducing emission of green house gases. The submergence of rice soils is known to promote N fixation with estimates of the indigenous and supplying capacity of the soils to be as much as 80 kg N per ha per year. The direction of change in the RCTs of the RWS, if not counteracted by residue retention, introduction of legume 'N catch crop' and higher nitrogen use efficiency through deeper placement, will reduce this inherent capacity with the likely need of more fertilizer N use (and the possible leaching of nitrates into the ground water). The production of N fertilizer has an indirect effect on global warming gases.

Thus, the changes in the RWS may influence all of these global warming gases. An agronomic activity that increased nitrous oxide emission by 1 kg/ha needs to be offset by sequestering 275 kg/ha of carbon, or reducing methane by 62 kg/ha (IPCC, 1996).

The Panel recommends that the RWC take in to account potential positive and negative impacts on the environment in planning future research and facilitate this work through partnerships of interested IARCs/ARIs/NARSs to measure and monitor these environmental services with the adoption of new RCTs.

3.2.2.2 Biophysical and socioeconomic research

The Panel is of the view that the RWC has and is developing an appropriate research agenda, as outlined in the Vision Paper for the Delivery of Resource Conserving Technologies by Gupta et al. (personal communication), in the comprehensive review of the RWSs by Timsina and Connor (2001) for the sustainable soil and water management of irrigated rice systems. The Panel suggests that the research agenda be developed as a medium-term plan (MTP) guided by the policy analysis and a balance between the 'core assets' of identified in the section above. At the same time the CU should develop its own Business Plan to complement the MTP and outline its core strengths in facilitating implementation of the MTP based on realistic availability of resources.

The Panel offers the following analysis of the main technological clusters with comments on activities that match the core strengths and focus for the RWC and the CU (Table 3). Specific recommendations are provided in Chapter 5.

3.3 Impact work in RWC

3.3.1 Role of impact assessment

Following a period when impact studies in agricultural research were undertaken only occasionally, these are now routinely required. But the topic is not one without many inherent problems, which must be recognized in any evangelical call for more attention to this matter, such as the Panel is attempting herein. The problems associated with attribution and with the cost of collecting 'impact' data are greatly compounded when assessments must be made of methods of, say, crop husbandry, that may be traceable to the research activities. Many agents are involved in advising farmers how

Table 3. A cluster of research activities and suggested core roles of the RWC for the two main transects of the RWS of the IGP

Activities for the western transect	Activities for the eastern transect
a) Effect of policy on the development and uptake of RCTs	
Provide research to: ● Understand the effect of policy at the state and national level that would guide new RCTs particularly those that influence sustainability and water quality and savings	Provide research to: ● Understand the effect of policy at the state and national level that would guide new RCTs particularly those that influence diversity for income generation.
b) Crop establishment, nutrient, IPM and residue management	
Provide research on: ● Socio-economic analysis of benefits and studies of constraints to adoption ● Measurement of the benefits of the new tillage systems to long-term sustainability including water at the basin level, and soil nutrient, physical and biological 'health'. Balance at the crop system level and soil physical and biological 'health' and microbial function ● Monitoring of second-order system constraints, particularly changing weed composition and biology with use of herbicides ● Understand the processes for conservation agriculture and develop a knowledge-based system that can target the extrapolation domains for the RCTs IPM and nutrient management.	Coordinate research on: ● Adaptation of RCTs to local environments including the development of new models (i.e. farmer field schools) for delivery and feedback. ● Farming system research to determine the adjustment of the component inputs of, variety, fertilizer and water based on the interaction of these with the new management (i.e., crop input by RCTs, IPM and nutrient management) ● The search for new 'break crops' to enhance sustainability and constraints ● Feedback of information to commodity programs to bring about change (if there is a large genotype by planting system interaction, changes will need to be made in the way in which early-generation nurseries are managed as well as in the selection of the end varieties) ● Understanding of other constraints to adoption
c) Changing the flooded rice culture in the RWS particularly in the irrigated West	
Provide research to: ● Explore the opportunity to reduce the antagonism between the current soil-water production requirements of the two crops with permanent raised bed plantings	Provide research to: ● Understand under what conditions, particularly soil texture, water availability in rainfed systems (where puddling of rice reduces the risk of drought) and weed management, new planting systems are appropriate
d) Maintaining the resilience and sustainability of the RWS under all tillage and planting systems	
Coordinate and strengthen the commitment of national systems to: ● Maintain and strengthen the long-term monitoring of the productivity and sustainability of the RWS as they undergo change, including nutrient balance studies at the system level ● Monitor at the farm level on nutrient mining with a focus on K and some macro nutrients	Same elements as for the East

Contd...

Table 3. Contd...

Activities for the western transect	Activities for the eastern transect
• Understand the patho-systems (including weeds) leading to better IPM practice • Understand the changes in the soil ecosystem and use the new knowledge to design appropriate intervention for sustainability	
e) Efficient use of water	
Provide research on water use efficiencies: • Measure the efficiencies of the new RCT practices including land leveling and bed formation, and though changes in cropping systems at the plot and farm level • Provide the entry point and framework for the collaboration of the RWC members with the CGIAR Water Challenge Program to measure effects at the basin level	Provide research on water use efficiencies: • Measure the efficiencies of the new RCT practices including land leveling and bed formation, and though changes in cropping systems at the plot and farm level • Coordinate the extended use of local irrigation systems • Provide research to monitor the specific case of arsenic poisoning
f*) Global gas emissions and carbon balance*	
Provide research to: • Understand the changes in physical properties, and supplies of indigenous and exogenous nutrients in the soil as the system moves from a repeated cycle of puddling to an aerobic system • Measure the fluxes in N gases and methane in the aerobic system • Measure C balances in the new systems, focused on surface tillage and stubble management and wetting and drying cycles	
Diversification and intensification	
a) Markets analysis for new crops: from field to plate – exploiting the new RCTs of the system	
Provide research on: • Analysis of policy at state and national level that will provide guiding principle for diversification in the region • A 'field-to-plate' system analysis that will set the appropriate research agenda for the component crops/varieties for a diversified system • As a coordinator and facilitator • Provide the feedback of this 'framework' analysis to appropriate crop-research-oriented members • Coordinate activities at the site level to facilitate the diversification of the system at the farm level	Provide research on: • Analysis of policy at state and national level that will provide guiding principle for diversification in the region • A 'field-to-plate' system analysis that will set the appropriate research agenda for the component crops/varieties for a diversified system • As a coordinator and facilitator • Provide the feedback of this 'framework' analysis to appropriate crop-research-oriented members • Coordinate activities at the site level to facilitate the diversification of the system at the farm level

Contd...

Table 3. Contd...

Activities for the western transect	Activities for the eastern transect
b) Adapting the crop components to the new land and water use systems	
Coordinate farming systems studies to investigate the benefits of the new RCTs for: ● reduced water use and more timely planting of new crops ● window for diversification (in line with state policies) ● window for 'break crops' for sustainability ● Facilitate the feedback of information on the crop management by tillage and water use system interaction, leaving the commodity programs to conduct the research for adjusting the components	Coordinate farming systems studies to: ● Understand benefits of RCTs and water harvesting to provide 'windows' for new crops particularly for the winter (non-monsoon) season for income generation ● Facilitate the feedback of information on the crop management by tillage and water use system interaction, leaving the commodity programs to conduct the research for adjusting the components

better to manage their farm resources, including new cultivars. The private sector, for one, is usually heavily engaged through its desire to sell inputs to farmers.

Perhaps these difficulties explain the rather limited documentation of the effectiveness of much crop-management research. This is not to say, however, that such work is unimportant. Indeed, given the importance of crop-management research as a major means of technological advance in the post-GR era, there is further imperative to intensify the effort to document successes.

The difficulties become even greater when estimating and assessing the effects of crop-management and soil- and water-management research on the productivity of the agricultural resource base. To see this, one has only to reflect, for example, on the technical difficulties of measuring soil loss under alternative crop-management and land-management practices, or the pollution of groundwater and downstream flows through inappropriate use of agricultural chemicals. Some of these difficulties should, in fact, be confronted in assessing the real impacts of any productivity-enhancing research, to the extent that some of the gains apparently made may be at the expense of reductions in the quality of the resource base.

Dealing with the equity issue presents substantial additional challenges. Many factors determine the extent to which the work of agricultural researchers benefits specific groups, and it is not easy to ascertain precisely whether the effects of research are equitably distributed. Observers need to be humble about the actual possibilities of assessing 'research impact' holistically. This is particularly the case in measuring the effects of research on poverty. Notwithstanding these challenges and difficulties, the Panel is convinced that the Consortium should do more to demonstrate the link between its work and poverty alleviation in the RWSs.

A guiding principle is that the purpose of any impact study must thus be well articulated to guide choices as to stage, product emphasis, geographic scope, precision of measurement, and other parameters, not to mention the extent of resource commitment made to such work. What all this might mean for the RWC is of immediate concern, especially as it struggles with questions of resource scarcity now common throughout the CGIAR and other public research enterprises. The approach to be taken will surely be strongly influenced by the dominant purpose that drives a particular effort, whether it be more for accountability, or more for

learning. Whichever, it is possible—but only possible—that the degree of impact and efficacy revealed will come at a relatively small social cost, yet with an impressively large social gain. Information of this kind, whatever the cost, will be helpful, and may be even decisive, in underpinning arguments in the halls of power for supporting natural resources research, which is the main focus of the work supported by the Consortium.

To go from these general guiding thoughts, just how should the RWC approach its impact challenges? It appeared to the Panel that there is a pervasive accountability reason for doing a much better job of impact accounting, given the diversity of stakeholders involved with the Consortium. This would be reason enough to invest a greater share of the scarce Consortium resources in such activity. But there is an even more compelling reason, namely, to support a stronger public- relations effort as discussed later in Chapter 4 (section 4.4.) in discussing the profile of the RWC. How then best to accomplish this?

It seems to the Panel that consideration of what is to be done about assessing impact needs to be mainstreamed into all significant R&D activities of the RWC. This would mean designing in impact work routinely in all major project proposals. Usually some baseline survey work will be necessary, so that there is a concrete comparator for assessing later claimed progress. Unless this is available from some prior activity, perhaps by an earlier project activity of a research institute or an NGO, fresh survey work will be needed. There will usually be other benefits to the research design that emerge from such more detailed description of the research domain, and it should be helpful to biophysical research workers to have an enhanced understanding of the socio-economic context in which their work is to proceed.

Critics will complain about added costs in an era of growing resource scarcity. But they need to reflect carefully on the benefits against which such costs should be considered, as well as the increasingly mandatory requirement that must eventually be confronted. In the Panel's view, mainstreaming such work at an early stage in the research cycle will constitute good practice, even if it is approached in a modest manner.

3.3.2 Better fostering of farm-level impact

The need for designing in impact work in the project proposals argued above (section 3.3.1) should include analysis of potential technical as well as socioe-conomic constraints to adoption. As discussed under achievements (sections 2.2.), the RWC work has been helpful in providing important lessons for better fostering of farm-level impact through adoption of participatory approaches, where researchers, extension workers, the private sector and farmers are all involved in various stages of the research and development processes. Amongst other things, such an approach has helped in early identification and resolution of potential constrain to large scale adoption, which sometimes can be small refinements of the technology nearly ready for dissemination. It seemed to have also shortened the time taken from discovery to farmer adoption. Commitment to and mainstreaming of similar approaches by the national partners clearly will be important to large scale success. RWC can play an important role in ensuring that this challenge is met through strategic partnerships, knowledge sharing, capacity building, input to design and planning of the national RWS research programs and in ex-ante analysis of potential technical and socio-economic constraints to adoption. A comparison of successful technology for zero-tillage planting of wheat with less successful nitrogen management technologies in rice given in Table 4 shows that, when insufficient attention is given to early understanding / addressing all potential constraints to adoption even a good technology can take a long time or even fail to get adopted by farmers.

Table 4. Understanding constraints to technology adoption – A comparative analysis of zero-tillage in wheat and nutrient management in rice

Potential constraint to adoption	No-till wheat	Use of LCC and USG in rice	Comments
Technical efficiency	High	High	See section 2.2.2
Ease of use	Medium	Medium	Better with LCC as compared to USG
Availability of implements for application:			Unlike collaboration with the private sector in the case of RCTs, which ensured availability of no-till drills, work with USG applicators made limited progress. More recent biological work is showing that single deep placement of prilled urea in wheat and rice may give similar results to those obtained with USG. If confirmed and fully developed, this would make USG work redundant.
Access	High	Low	
Affordability	High	Unknown	
Economic benefits	High	Medium	See sections 2.2
Incentive for the private sector to participate:			In countries with high subsidies on nitrogenous fertilizers there is low incentive for manufacturers and suppliers to promote USG technologies that reduce input use
Manufacturers	High	Low	
Input suppliers	High	Low	
Farmer response:			Early responses from farmers suggest that acceptance of LCC is likely to be good. However, there are indications that deep placement of single application of urea gives similar response to split application. If confirmed this would make use of LCC redundant
Priority attached to solving the problem	High	Medium	
Ease of use	Medium	Medium	
Perceived level of benefits	High	Low	
Level of adoption.	High	Low to Medium	
Potential overall impact	High	Low to Medium	

4

The future for the Consortium

4.1 Partnership issues

Establishment of need-based national and international partnerships has been the founding principle of RWC, which has stood the test of time and has been a significant contributor to its success. It has worked to foster sharing of experiences and expertise between NARSs and with IARC partners. However, as the scope and coverage of its work program is adjusted/expanded to address emerging issues and increased donor interest, it would be desirable to revisit the founding principles to ensure that these do not constrain the ability of the Consortium to fulfil its mandate. The Panel considers that these principles (Who is eligible to be a partner/ member? What are different categories of memberships? What are the roles and responsibilities of members under different categories? What are the funding options for members?) are neither widely known nor fully defined/understood. It is important, therefore, that, as decided by the March 2003 meeting of the RSC, the CU should develop a position paper on this aspect to clarify the situation to all those wishing to contribute by becoming partner/member of the RWC. The issues involved in expanding/changing national and international membership of the key RWC bodies are briefly discussed below.

4.1.1 Adding countries to membership of RWC

The political differences between Pakistan and India not withstanding, the collaboration between four NARS partners has been strong, driven largely by similarity of issues confronting the RWSs, relative ecological homogeneity and a desire to work together to benefit from strengths of each partner to overcome weaknesses. In view of the large unfinished research and development agenda and changing technical as well as socio-economic considerations, all senior staff of the four NARSs interviewed by the Panel emphasized the need for RWC research to stay focused on the IGP issues. The proposal to enlarge coverage of RWC to include large areas of RWS in different agro-ecological situations in the Peoples Republic of China apparently has been discussed by the RSC on several occasions with a unanimous view not to expand the full membership of the Consortium. Instead, the RSC has encouraged closer technical collaboration with scientists from China regularly participating in the RTCC meetings and other technical activities, which has helped in transfer of some technologies from China to South Asia (Box 4). These developments confirm the value of the open door policy adopted by the Consortium in promoting technical cooperation with other agencies/countries to address IGP issues. The Panel agrees with this position.

4.1.2 Adding/changing IARC engagement

The RWC is a NARS-driven initiative in which the Consortium decides the role of IARCs and other partners. The NARSs are the majority members of the RSC. As confirmed by the stakeholders it has been highly successful in building need-based partnerships between IARCs and their national partners without feeling the need to expand membership of the RSC. The Panel fully endorses the desirability of maintaining the NARS-driven nature of the consortium. However, increasing emphasis on newer issues, especially those related

to diversification and water-use efficiency have highlighted the need for deeper involvement of other IARCs, such as ICRISAT, IWMI and CIP. These Centers are members of the technical committee but not of the RSC. Only CIMMYT and IRRI support RWC activities through their unrestricted funds as well as from RWC project funds. Other centers depend on RWC special-project funds for their support (e.g., the ADB project). The Panel hopes that other centers would strengthen the scope and coverage of their involvement by allocating resources from their 'core' funds.

This has been suggested by some that membership of the Steering Committee needs to reflect more the membership at the technical level. The Panel believes that active engagement amongst the members takes place at the technical level (including decisions about funding of joint activities) than at the RSC level. The Panel suggests that just as membership at the national level is of the 'system' so too the IARC members develop a mechanism to be representing the 'system' and not individual components of it. One mechanism is for the current CGIAR member(s) of the RSC to actively canvass issues of the IARCs (perhaps in their DG meetings) for presentation and discussion at the annual RSC.

4.1.3 Public – private partnerships

Three areas of the private sector investments could have potential opportunities for developing public-private partnerships. These include seed, crop protection against weeds, pests and diseases, and farm implements. With the exception of growing interest in hybrid rice, at present there is little investment by the private seed companies in the two major crops of the RWS. The future growth would depend on the effectiveness of the PVP laws and the demand for genetically modified (GM) products. For example, IRRI, Rockefeller Foundation, Syngenta and others are working together to develop a GM rice (Golden Rice), which could in time create need for collaborative research through RWC, and integration with RCTs. Unlike for some other crops (e.g., hybrid maize), there is little incentive for the private sector to market cultivars of rice and wheat for which production in the region is largely undertaken by public institutions and farmers can save seed from season to season. However, the diversification of the system and the growing demand from new markets, e.g., animal feed grains, is an opportunity for the private sector. Integration of location specific hybrids, e.g., winter maize, into RWSs could provide opportunity to develop need-based models for such partnerships of value to the RWC members.

Perhaps it is in the area of integrated weed management that the RWC can play a major role with the private sector. The past experience of IPM (for insects) of rice shows quite a gap in the concepts (and outcomes) between the private and the public sector even though both parties genuinely favor IPM. For the public sector chemicals are matters of last resort; for the private sector, chemicals are to be used judiciously for 'protection'. These differences are real and need to be rationalized as the new pests and the higher costs of labor will bring increasing use of herbicides in the RWS for weed management outside the north-western transect. The major long-term concerns are shifts in weed species and emergence of resistant biotype. However, there is an opportunity for development of a genuine integrated weed management approach that is in the best interests of farmers, the public and the environment. This will also enable herbicide manufactures to prolong the effective life of the current, relatively environmentally benign herbicide molecules. In this changing scenario of the RWSs, the public and the private sector have a joint responsibility and a common interest to develop and design sustainable integrated weed management practices and *policies.* The RWC is in a strong position to take a lead in promoting public-private

partnerships to develop new models for NARSs to explore for mutually desirable outcome.

The private sector is becoming increasingly important supplier of other services. Two successful examples (highlighted in section 2.2. and Annexure 8) of such partnerships with RWC have involved adaptation and local manufacture of laser leveler in Pakistan and of no-till drills in India. These developments have also given a boost to growth of the private contract service providers for specialized work such as mechanized direct drilling, herbicide application, combine harvesting, involving expensive farm implements. This trend will continue to grow in the future.

4.2 Organizational issues

Over the years a number of institutions have become involved with RWC with somewhat diverse interests and this number is likely to grow in the future. This has some implications for the organization of RWC as discussed below.

4.2.1 The Convening Center

As indicated in section 2.1.2, CIMMYT is the convening Center, acting on behalf of CGIAR. It has played an important role in supporting RWC and in 'nursing' it through a difficult period following ICRISAT's decision to withdraw as the convening Center. In addition, CIMMYT also is a critical partner of RWC in its scientific work. Thus, the RWC activities both complement and supplement the mandate and core programs of CIMMYT, and unsurprisingly the Panel found strong support amongst the Consortium members for CIMMYT to continue as the convening Center. There is one further reason for CIMMYT to continue to play an important role in the management of RWC. In the four-member countries a high proportion of total wheat area is grown under RWSs. In the case of Pakistan 28%, in India 38%, in Nepal 78%, and in Bangladesh nearly 100% of wheat area is under RWSs. Thus, CIMMYT's ability to achieve its long-term goals for the wheat crop in South Asia is closely tied to the sustainability and profitability of RWSs.

Under current institutional arrangements CIMMYT's Director, NRM is the contact point for RWC. However, despite the importance of the RWSs, the RW program has no separate entity. As a result, boundaries between different RWC activities and the core programs tend to be somewhat blurred. While in past this has not been a major problem, increasing workload now makes it necessary to revisit the existing arrangements to define the roles and responsibilities of different units for coordination and implementation support to the RWC work program. This role clarity would be of help both to the RWC stakeholders and to the CIMMYT's Board to maintain an oversight on this increasingly important CIMMYT-RWC relationship.

4.2.2 The Coordination Unit

Since RWC is not mandated to conduct research in its own name, the most important function performed by the CU has been to coordinate and facilitate implementation of the research program by the NARS and IARC partners and to assist with activities related to human resource development. However, under the ADB project, the CU is also involved in overseeing implementation at some of the sites in India. Other important functions undertaken by the CU are summarized in Annexure 6. All the stakeholders surveyed thought the coordination arrangements to be effective (60%) or highly effective (40%). The leadership role played by the CU in catalyzing the institutional change and in raising the profile of RWSs research has been widely appreciated by the stakeholders. Annexure 5 gives more information on findings from the stakeholder survey. The funding issues related to the CU are discussed in section 4.4.1.

Looking ahead, the CU must continue to be a catalyst for change while maintaining the focus on its key facilitation role to ensure efficient and

effective implementation of the research agenda by the NARS and IARC/ARI partners and sharing knowledge on new approaches, techniques etc. for use by them. In performing these key functions the CU would need to reach out to all the NARSs, especially those with weaker national institutions, to make sure that they benefit fully from stronger NARSs and IARC/ARI partners. The CU must be actively engaged in capacity building activities and in strengthening old and new partnerships involving both the public and the private institutions to address the evolving work program of RWC.

4.2.3 National coordination arrangements

The most striking feature of RWC is the strong commitment to its activities at the highest leadership levels in NARSs. This commitment is also evident at working level amongst scientists and cooperating extension staff. However, despite this, the coordination arrangements at the national levels have not always been very effective. Until very recently, the national coordinators (NCs) have worked on a part-time basis in all the NARSs with little or no operational budget support from the national systems. In addition, they have not reached out to all national research entities as fully as may have been desirable, especially those operating outside the traditional agricultural research establishment. In some cases the National Steering Committee (NSC) has not been meeting regularly, weakening the national review and planning processes. Reduced time allocated in more recent RTCC meetings to the review of national research findings outside the donor-supported projects has further weakened this process.

The Panel is of the view that the NCs, especially in countries with large programs, should be full-time appointments with some operational and budgetary support. Perhaps there was a case for limiting the number of national research partners in the early stages, but with changing research agenda (discussed in section 5.6) new working links with specialized national (and international) agencies will be required.

4.3 Funding for the RWC

4.3.1 Coordination Unit

Like other systemwide programs of CGIAR stable funding for the CU operations has been a problem even though the resources required are not very large (Table 5) and the need for a strong capacity for management/governance to facilitate planning, collaboration and knowledge transfer has been widely recognized as critical to success. The current sources of funding for the CU (Table 6) include: direct grants from the DGIS, Netherlands, CGIAR, core budget of CIMMYT and administrative overheads contributions from on-going special projects. In the early years (1994-98), funding for the coordination function was made available through the systemwide Ecoregional Program. In 2002, on recommendations of the Center Directors Committee of the CGIAR (CDC), a sum of $150,000 was allocated from the $1.5 million strategic funds made available by the World Bank to CGIAR and this support may also be available during 2003. While in short-term funding situation looks comfortable, its continuity is not assured. The RWC/CU provides an effective mechanism through which IARCs and ARIs members can implement their research agendas. It is therefore reasonable to assume that, if the RWC did not exist, these external members would need an alternative arrangement, most likely financed from core funds. Clearly, a strong CU with assured funding is essential for effective implementation of the RWC program. The Panel considers that all the members of RWC need to work together to secure stable funding for the CU. As has been the case in the past, CIMMYT as the convening Center and IRRI as the core CGIAR partner, need to continue making a case for regular funding for the CU by the CGIAR and other donors. The practice of transferring a share of administrative

charges included in the recently approved projects to finance the CU activities is an important step in the right direction. In 2003 this mechanism is expected to contribute about $26,000 to the CU budget. The Panel considers that there may be opportunities for allocation of a greater proportion of available administrative charges to the CU budget. In addition, the Consortium needs to develop an equitable cost-sharing arrangement to bridge the funding gap with all members contributing (a 'membership' fee) in line with their size, degree of involvement and capacity.

4.3.2 Research funding

The research on RWSs is being undertaken under two streams. The first stream, which started before establishment of RWC, is being undertaken by NARSs outside of the RWC 'umbrella'. This work is financed under the national budgets, including some funding from the externally aided projects at the national level. The second stream is the RWC program, which is being funded under the special projects, financed by donors through IARCs/ARIs. Some of the staff costs of the RWC program are provided under the core budgets of CIMMYT and IRRI.

Since the NARS budgets do not include rice-wheat systems research as an expenditure head in financial reporting it was not possible to obtain information on current investment patterns of the NARS financed research. However, in the case of India, based on budgets of ICAR Cropping Systems Research Program and two World Bank funded projects (National Agricultural Technology Project and UP Diversified Agricultural Support Project), it is estimated that the total annual operational expenditure (excluding staff costs) over the past three to four years has been around US$1 to 1.3 million per annum. This is likely to exceed US$5 million per annum if all the staff

Table 5. Coordination Unit: Actual expenditure for 2000-2002 and proposed budget for 2003 (US$)

Budget Items	2000	2001	2002	2003
CU Core Budget				
Governance costs[1]	204,286	251,768	270,155	256,742
Capital Budget	0	22,069	30,709	22,300
Operational Travel[2]	26,618	36,950	26,966	35,000
RTCC/RSC Meetings	17,040	19,377	23,707	25,000
Web Page/PRISM/GIS	24,746	17,193	20,600	105,112
Publications/ Dissemination	10,389	8,607	21,502	32,429
HRD Support[3]	99,683	85,695	50,292	101,481
Sub Total (A)	382,762	441,659	443,931	578,064
RWC Special Projects[4]				
Special project expenses	56,277	347,832	704,217	628,081
Sub Total (B)				
Grand Total (A+B)	439,039	789,491	1,148,148	1,206,145

[1] Facilitator and Co-Facilitator salary & allowances, staff salary & allowances, CU office operational costs

[2] Operational travel of Facilitator/ Co-Facilitator/ Oversight Director.

[3] Traveling seminar/ study tours, support to national programs, prototype developments, trainings & workshops, contingencies & overheads.

[4] Special projects funds are passed through the CU to the national programs. Figure for 2003 does not include the impending projects.

Table 6. Sources of funding for the coordinating Unit, RWC

Source	Year 2000	Year 2001	Year 2002	Year 2003
Special project expenses	56,277	347,832	704,217	628,081
The Netherlands	111,707	245600	245,187	360,000
CGIAR Set Aside	145,833	104,167	0	0
CGIAR WB Special Grant	0	0	150,000	150,000*
Office Support from CIMMYT Programs	88,422	47,600	60,100	21,000
Others	0	14,000	33,352	28,700
Total for yr.	345,962	411,367	488,639	559,700

* proposed

costs are also included. While this may not be an accurate estimate, it does serve to indicate the high level of investment being made by India in RWSs research. It also points to a need to re-visit priorities by thematic thrusts to ensure that the program is addressing priority issues and is delivering 'value for money'. For the future, the Panel recommends that the CU should examine with NARSs the best way of estimating annual investments being made by the four NARSs to develop a more accurate picture of national investments by thematic themes. This information can then be used as an input to the priority-setting work and for tracking utilization of resources against agreed benchmarks.

CU was able to provide accurate information on investments being made through the donor-supported projects. Annexure 10 gives a list of projects approved between 1999 and 2003. The total investment over nine projects (financed by DFID, ADB, IFAD, WB, FAO, and NZODA) amounts to US$3.48 million with an estimated annual expenditure of US$1.27 million. Although the project expenditures are not being recorded by themes, an estimated breakdown is given in Annexure 10 and Fig. 5. This shows that the tillage, crop establishment, diversification and machinery development work now accounts for the largest investment at 29%. HRD and knowledge management follow at 21% and 19%, respectively. While the proportion allocated to nutrient management[1] work has stayed fairly stable at around 6%, more recent projects have expanded themes to include investment in water management (9%), crop management and improvement (9%) and socio-economic (7%) research. Thus, it would appear that a larger number of donors are now involved in funding research and the investment patterns are more balanced, covering the key themes, including the emerging issues.

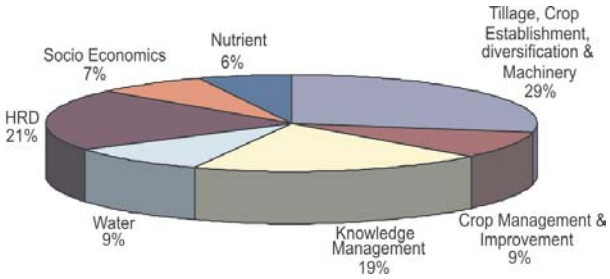

Fig. 5. Estimated investment pattern of donor funded projects by thematic themes

4.3.3 Future funding strategies

The expanding research program of RWC would require additional funds in future to support innovative projects. While the introduction of CPs by the CGIAR adds further complexity to the

[1] Figure does not include staff costs contributed by IRRI. If these costs are included the percentage investment on nutrient management will increase by 4-5%.

funding process, it also offers opportunity for forging new alliances. However, success in an environment with tightening resource availability for international agricultural research would require considerable effort from all members of the Consortium. The current improvement in funding situation notwithstanding, the Panel believes that the Consortium should make greater efforts to secure medium- to long-term funding to enhance effectiveness and impact. The Panel presents below some options for meeting future funding needs, taking into account the specific challenges identified above.

4.4 Increasing investor awareness and interest

4.4.1 Raising the RWC profile

Panel discussions on this theme led to a view that there was scope for the RWC to lift its profile, especially among the wider stakeholder community, including of course those investors concerned with poverty reduction and environmental sustainability. One such readily accessible community is the membership of CGIAR itself. Thus, focusing on that part of the profile might be a useful first step. Concurrently, the Consortium should also brief the plant science industry, the association representing the companies involved in production of crop protection chemicals and GMOs, and the fertilizer industry of its activities, especially the work on RCTs, which could be of particular interest to the member companies.

4.4.2 Develop a comprehensive medium-term plan

Since there is no coherent medium-term work plan for the Consortium, it makes it difficult to estimate and raise funds for key activities in a systematic manner. As discussed earlier in section 3.2.2, development of a MTP would facilitate fund-raising efforts.

4.4.3 Assess current returns to the early investors in the RWC

Since information on impact of research is now routinely required, documentation of ex-post impact of past research can be effectively used to bring stronger donor contributions and more sustained commitment, especially for the long term work that will be required in the future.

4.4.4 Increase commitment to funding issues by all members of the Consortium

To ensure stable funding for innovative research and for the CU the Panel recommends that the all the RWC members increase their commitment by:

- Developing a transparent allocation of the 'overheads' in the projects that support RWS research between Center headquarters administration and the CU, with the aim of allocating more funds to the CU;
- Moving to an equitable cost-sharing arrangement with all members of the Consortium contributing in line with their size, degree of involvement and capacity to the CU as a 'membership fee';
- Complimenting the considerable efforts of CIMMYT to actively explore new sources of funding for the RWC. The RWC members need to avoid a situation where they are individually seeking funds for activities for implementation in the RWSs using the framework of the RWC and the CU. The new CPs of the CGIAR highlights this point where individual members could be seeking support for their component programs and for and on behalf of the RWC. Such an approach does not strengthen the RWC or the CU;
- Developing more comprehensive program proposals of related projects covering biophysical socio-economic and communications aspects, which can then be presented to potential donors either as a whole or as individual projects. In this way, the donors

would be able to select projects that best meet their objectives while appreciating the linkage with the overall program and a project's expected contributions to the program's development objectives. The need for expansion of successful RCTs, potential for system diversification and water management research present an attractive window of opportunity for adoption of such a strategy and for exploring different options for medium-term funding for research;

- The role of the Consortium in knowledge sharing and human resource development, e.g., through traveling seminars, workshops and training, human resource enhancement has been widely appreciated by the NARS partners and this points to a need for increased funding of this activity. Since many donor-funded initiatives and loans to national systems for development projects include funds for capacity building, the NARS partners should pro-actively seek access to such untapped funds for supporting RWC-related HRD activities. An excellent example of this type of initiative has been in India where a sum of US$ 200,000 was allocated under a World Bank financed project (NATP) for the CU-coordinated HRD activities for the national teams involved with RWS research and development activities. In addition, there are often opportunities for competitive funds within the national systems. RWC can actively assist NARS members in project development as a component of a technical workshop.

5

The way forward for the RWC

The Panel concludes that the RWC has been a successful institutional innovation. Given this positive outlook, what should be the future of RWC? The Panel makes the following recommendations with the aim of sustaining that success as the RWC examines the scope, coverage and impact of its work and faces new challenges.

5.1 The RWC as an institutional innovation for regional/ international research

The RWC must face several continuing design challenges to be relevant in the future. Most of these could be described as 'boundary issues', relating to governance at various levels concerning national and international partners; scope and placement of programmatic work within national and state/ provincial agencies, not to mention those with NGOs, private sector entities, and advanced research institutions. Good judgment must be exercised in dealing with the dynamics of these decisions, such as judging when the RWC can best 'let go' of a theme that can be better handled by the national bodies within or outside the confines of the Consortium.

The Panel recommends that RWC should continue to play its central focused role, in knowledge generation, co-ordination of research agendas among members and countries, and in sharing and facilitating the exchange of knowledge and people. It should stay NARS-driven, focused on new innovations for the RWSs responsive to emerging needs and opportunities, open to new committed members, promoting greater collaboration between NARSs as well with IARCs and have a time-bound and adaptable agenda modest in coordination and facilitation resources. The RWC can best contribute to impact for the beneficiaries by sharing of appropriate knowledge developed through participatory research, utilization of opportunities opened up by the new information technologies and facilitating the scaling up of its delivery by others.

5.2 The partners of the Consortium

The Panel considers the effectiveness of partnerships between centers and their NARS partners as well as within and between the four national systems as one of the most important achievements of the RWC. It has worked towards a model where IARCs or other members can draw on experience and expertise within the NARSs to build capacity. RWC has followed an 'open door' policy for new partners/ members joining the Consortium to allow free flow of new ideas/concepts for the benefit of IGP but the guiding principles for membership are neither widely known nor fully defined.

As the RWC changes and collaborates with more institutions (national, international, public and private) as well as deepens involvement of some of the existing partners, **the Panel recommends** that:

(a) RSC/CU should clarify as to who is eligible to be a partner/member and what are different types of memberships; and

(b) what are the roles and responsibilities of partners/ members under different categories.

5.3 The role of the CU as the main business unit of the RWC

The RWC through the CU has successfully raised the profile of RWS research, catalyzed change in research processes towards a more demand-driven participatory approach to planning of research and development activities and contributed to human resource development. Despite these successes, however, there is room for a stronger role in exchange of information and personnel within NARSs, strengthening of the in-country coordination mechanisms and influencing resource allocation to agreed priorities in the national RWSs research programs.

The Panel, therefore, recommends that the CU should:

(a) focus on its important role in gathering and disseminating knowledge from all sources and for facilitating greater exchanges at different levels between IARCs/ARIs and NARS and between and within NARS;

(b) maintain a balance between its different roles by passing on themes that can be better handled by the national agencies within or outside the Consortium; and

(c) work with NARIs to develop an accurate assessment of national investments in RWSs research by thematic themes and influence future allocations in relation to agreed priorities and in tracking progress against agreed benchmarks.

5.4 Towards a systems approach based on participatory method and location-specific research for development

The RWC has facilitated a change toward systems approaches and use of farmer participatory methods for location-specific impact-oriented multidisciplinary research. It has successfully linked NRM with production systems research. While these research processes have been adopted in some institutes, especially in the context of RWSs research, much greater effort is needed by NARIs to mainstream these approaches as a regular feature of research and development program planning and implementation.

The Panel believes that RWC can play a bigger role in helping to institutionalize these concepts and **recommends** that a greater effort should be made through RSC and RTCC meetings and other opportunistic interventions to influence national research policy, encourage further research for methodology development, disseminate benefits and build capacity to facilitate broader adoption by the national systems.

5.5 Understanding the future biophysical and socio-economic environment of the IGP

The Panel (as well as many of the stakeholders) found that the RWC has made good progress in understanding the biophysical environment but has failed to link this work with appropriate policy analysis and understanding of the socio-economic circumstances of the farming communities. This has been a weakness for setting the research agenda and in developing a greater focus on the poverty issues. This need is particularly important to foster uptake of the RCTs and to diversify the farming enterprises. A holistic approach to understanding the environment of IGP will also be of help in developing the MTP and the business plan for the RWC.

The Panel is pleased to learn that some of the recently approved projects include work on socioeconomic issues and **recommends** that IARC and NARS members of the Consortium should make attempts to pool their resources and expertise to develop a stronger and holistic research program on socio-economic aspects, wherever possible linking their on-going work with the RWC activities. The objective should be to develop a good understanding based on systems analysis, constraints, tradeoffs,

equity, institutional and policy issues since each aspect has an important role in IGP.

5.6 The research agenda

5.6.1 Policy analysis and priority setting

The RWC has attempted to develop its research agenda and set its priorities in line with the constraints identified through diagnostic surveys at the field level. As indicated earlier that this process has lacked guidance from policy analysis and on market-driven changes as the RWC moves to undertake research on issues related to diversification of the system. There is a gap in policy analysis and clearly scope for using more refined methods of priority setting and resource allocation to guide the research agenda.

The Panel, therefore, recommends that the RTCC/CU should:

(a) initiate appropriate policy analysis work to guide the technical component of the research agenda,

(b) provide a formal analysis of priority setting in line with the approach of Pal et al. (2003) after it has been further refined,

(c) the RWC through the RSC define the role of the RWC/CU and NARS in implementing the agreed agenda and d) the RSC only endorses projects that are in line with the agreed priorities.

5.6.2 The research program for technology development

The constraints and opportunities for technology development for the RWSs have been outlined in several sources and gaps in the current system identified by the stakeholders are summarized in section 2.2.5. The critical need for more policy analysis to guide the technology development has been highlighted above. The Panel makes the following observations with respect to the main clusters of research activities for technology development in the context of the policy analysis work recommended above.

5.6.2.1 Development of resource conserving technologies

With regard to the RCTs, the Panel **recommends** that:

- The RWC continues RCT development recognizing:
  (a) the different pathways for impact between the West and the East transects of the IGP, and
  (b) the different roles of the RWC with more focus now by the RWC on the East, leaving country-member institutes to continue and expend the work in the West.
- The RWC undertakes research to determine the feasibility of changing the culture of rice to the benefit of the RWS in terms of productivity, diversity and sustainability (particularly regarding water use) and determine under what circumstances (including national policies) such changes are appropriate.
- The RWC continues the documentation of the change in water productivity at the field level. The Panel notes that the CGIAR Challenge Program on Water provides an opportunity to examine the water related issues at the basin level and therefore recommends that the RWC provide the entry point for the coordination and collaboration of the RWC members with the CGIAR water challenge program.

5.6.2.2 Diversifying the rice-wheat system

The RWC recognizes that additional demands for basic cereals must be met largely through increased yields, allowing some land (and other resources) for diversification for greater income generation. Clearly, market forces and national and state policies will drive the pace and form of the diversification. An additional factor influencing the diversification of RWSs would be the new 'platform' made possible by the RCTs, which presents the RWC with its most important strategic decision — how, as a limited supplier of research, can it best bring about

diversification of the RWS for income generation (particularly in the East) and for income and sustainability in the West?

The RWC has played an important role in feeding back information to commodity programs to develop components for the system, e.g., appropriate early maturing varieties. Now with the changes in tillage and land and water practice, and with an understanding of market driven diversification there is a need for adjusting all the component technology for the new systems. This will involve examination of such issues as to which rice based ecology to diversify, in which season and how best to address the multidimensional nature of poverty, including consideration of issues related to risk management, improved livelihoods, food security and nutrition. In the Panel's view this work needs to continue in all new tillage and water management systems but is best done by the component institutes. Thus, **the Panel recommends** that:

- The RCW:
  - provides an analysis of policy at state and national level that guide the diversification in the region learning from farm-level changes that have already taken place, especially in Bangladesh; and
  - a 'field-to-plate' market system analysis that will set the appropriate research agenda for the component crops/varieties for a diversified system;
- The RWC facilitates the feedback of information on the crop management by tillage and water use system interaction, leaving the commodity programs to conduct the research for adjusting the components.

5.6.2.3 Maintaining the resilience and sustainability of the RWS and monitoring the flux of global warming gases under all tillage and planting systems

The RWC has used results from the long-term trials, set up at the beginning of the GR, to understand nutrient mining in the system and to develop nutrient management strategies. Appropriate long-term monitoring must continue, and be relevant to the changes in tillage and water management. In addition, the benefits of changes in the tillage system and stubble management to the soil ecosystem need to be understood. The RWC has undertaken some work on IPM for the system with the main contribution in the control of *P. minor*. However, the new tillage system with a heavy reliance on herbicide will change the weed species and expose the system to more herbicide resistance. Gaps remain in the IPM agenda for the systems of today and there is a need for anticipatory IPM research (e.g., integrated weed management, the emerging role of nematodes in a more diversified and aerated system) in the context of the new RCT systems.

The changes in the RWS may change the balance in global warming gases. Reduced tillage increases carbon accumulation in the soil and reduces fuel-based emissions. Soil submergence is the dominant feature of present rice cultivation in the IGP and leads to unique biogeochemical processes that influence methane and nitrogen gas emissions and nutrient availability. Changes in rice culture to a more aerated system could change the balance of those gases for the better.

The Panel recommends that:

- The RWC responds to both its achievements as well as gaps and emerging issues in this cluster of research investment by:
  - co-coordinating and strengthening the commitment of national systems to maintain and strengthen the long-term monitoring (including appropriate farm monitoring) of the productivity and sustainability of the RWS as they undergo change;
  - coordinating research at the farm level on nutrient mining with a focus on K and some macro nutrients;

- initiating research to understand the patho-systems (including weeds) leading to better IPM practice; and
- initiating research to understand changes in the soil ecosystem and use new knowledge to design appropriate intervention for sustainability.

- The RWC seeks external partners with a capacity to measure and monitor the environmental services of the RWS, with a focus on understanding the effects of the new RCTs on the balance of global warming gases.

5.7 Attracting new (and maintaining old) investors

While the RWC in recent years has attracted donor support for small individual projects, harnessing of medium-term resources for system-based research for development would require energetic efforts by **all its members** while maintaining strategic focus of the research on agreed priorities.

The Panel recommends that all members of the Consortium should increase commitment to funding issues by:

(a) moving to an equitable cost-sharing arrangement in line with their size, degree of involvement and capacity to ensure sustainable funding for the CU as a 'membership' fee; and

(b) develop more comprehensive program proposals of related projects covering biophysical, socio-economic and communications aspects, which can then be presented to potential donors either as a whole or as individual projects. The need for expansion of successful RCTs, potential for system diversification and water management research present an attractive window of opportunity for adoption of such a strategy and for exploring different options for securing medium-term funding.

References

Byerlee, D., and R. Murgai. 2001. Sense and sustainability revisited: The limits of total factor productivity measures of sustainable agricultural systems. *Agricultural Economics* 26, 227-36.

CGIAR Secretariat. 2002. Recommendations for decisions by CDC on allocation of strategic funds to systemwide programs in 2002. CGIAR Secretariat, Washington DC.

Dobermann, A., and P. F. White. 1999. Strategies for nutrient management in irrigated and rainfed lowland rice systems. *Nutrient Cycling in Agroecosystems* 53, 1-18.

Flinn, J.C., and B.B. Khokhar. 1989. Temporal determinants of the productivity of rice-wheat cropping systems. *Agricultural Systems* 30, 217-233.

Fujisaka, S., L. W. Harrington, and P. R. Hobbs. 1994. Rice-wheat in South Asia: System and long-term priorities Established through diagnostic research. *Agricultural Systems* 46, 169-187.

Gill, M. A., M.A. Chaudhary, M. Ahmed, and A. Mujeeb-ur-Rehman. 2002. Water management, cultural practices and mechanization 10 pp. In M. S. Akhtar and G. Nabi (ed.), National Workshop on Rice-Wheat Cropping System Management, Islamabad, Dec. 11-12 2002. Pakistan Agricultural Research Council, Islamabad, Pakistan.

Harrington, L.W., P.R. Hobbs, D.B. Tamang, C. Adhikari, B.K. Gyawali, G. Pradhan, B.K. Batsa, J.D. Ranjit, M. Ruckstuhl, Y.G. Khadka, and M.L. Baidya. 1993. Wheat and rice in the hills: Farming systems, production techniques and research issues fro rice-wheat cropping pattern in the mid-hills of Nepal. Report on an exploratory survey conducted in Kabhre district. Nepal Agricultural Research Council, and CIMMYT.

Hossain, M.I. 2003. Farm-level changes of the resource conservation technologies in the rice-wheat system in Bangladesh. Tober Crop Research Center, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Study undertaken for the Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

IFPRI. 2002. Sound choices for development: The impact of public investments in rural India and China, International Food Policy Research Institute, Washington, DC.

IPCC. 1996. Climate Change 1995: The Science of Climate Change. Contribution to the Second Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge, Cambridge University Press.

Khan, M.A., and N.I. Hashmi. 2003. Impact of 'No-Till' farming on wheat production and resource conservation in the rice-wheat zone of Pakistan's Punjab. In R. Lal, P. Hobbs, N. Uphoff and D.O. Hansen (eds.). Sustainable Agriculture and the Rice-Wheat System. Ohio State University Columbus, Ohio, USA (To be published in 2003).

Kumar, P., D. Jha, A. Kumar, M.K. Chaudhary, R.K. Grover, R.K. Singh, R.K.P. Singh, A. Mitra, P.K. Joshi, A. Singh, P.S. Badal, S. Mittal, and J. Ali. 2002. Economic analysis of total factor productivity of crop sector in the Indo-Gangetic Plain of India by district and region. Agricultural Economics Research Report 2002 (2), National Agricultural Technology Project on Irrigated Agro-Ecosystem Production System Research. Indian Agricultural Research Institute, New Delhi, India.

Ladha, J.K., D. Dawe, H. Pathak, A.T. Padre, R.L. Yadav, Bijay Singh, Yadvinder Singh, Y. Singh, P. Singh, A.L. Kundu, R. Sakal, N. Rame, A.P. Regmi, S.K. Gami, A.L. Bhandari, R. Amin, C.R. Yadav, E.M. Bhattarai, S. Das, H.P. Aggarwal, R.K. Gupta, P. R. Hobbs. 2003. How extensive are yield declines in long-term rice-wheat experiments in Asia? *Field Crops Research* 81 (2-3): 159-180.

Ladha, J.K., J. Hill, J.M. Duxbury, R.K. Gupta, and R.J. Buresh (ed) 2003. Improving the productivity and sustainability of rice-wheat systems: issues and impacts. ASA Special Publication No. 65, ASA/CSSA/SSSA, Madison, Wis., USA. 211p.

Pal, S., A. K. Jha, R. Goel, and P.K. Gulia. 2003. Ploughing against traditional wisdom: Impact of

Resource Conservation Technologies for the Rice-wheat system. National Centre for Agricultural Economics and Policy Research, New Delhi, India.

Paroda, R.S., T. Woodhead, R.B. Singh (ed.) 1994. Sustainability of rice-wheat production systems in Asia. Rapa Publication 1994/11.

Rosegrant, M.W., M.S. Paisner, S. Meijer, and J. Witcover. 2001. Global food projections to 2020. Emerging trends and alternative futures. International Food Policy Research Institute, Washington DC, USA.

TAC Secretariat. 1999. First review of system wide programs with ecoregional approach. Available at http://www.inrm.cgiar.org/ documents/ecoregional/ER_document.htm (verified 31 May 2003).

TAC Secretariat. 2000. Review of the systemwide programmes with an ecoregional approach. TAC Secretariat of the CGIAR, FAO, Rome, June 2000.

Timsina, J. and D. J. Connor. 2001. Productivity and management of rice-wheat cropping systems: issues and challenges. *Field Crops Research* 69: 93-132.

Wassman, R., R.S. Lantin, and H.U. Neue (ed) 2001. Methane emissions from major rice ecosystems in Asia. *Developments in Plant and Soil Sciences*, Vol. 91. Dordrecht: Kluwer Academic Publishers. 416 pp.

Annexure 1

Members of the review team

The Panel members

- Dr Ashok Seth (Team Leader), Director, Agriculture and Rural Development Consultants Ltd., UK.
- Dr Jock Anderson, Consultant, Agriculture and Rural Development Department, World Bank, Washington DC, USA.
- Prof D Jha, Ex-IFPRI scientist and currently National Professor, National Center for Agricultural Economics and Policy Research, ICAR, New Delhi, India.
- Dr Ken Fischer, Adjunct Professor, School of Land and Food Sciences, University of Queensland, Australia.

Nominations from NARS country partners

- Dr Ismail Hossain, Chief Scientific Officer and Head, Economic Division, Bangladesh Agricultural Research Institute, Bangladesh.
- Dr M Ashraf, Senior Director (Crops), Pakistan Agricultural Research Council, P.O. Box 1031, Plot 20, G-5/1, Islamabad, Pakistan.
- Dr Ramesh Chand, Principal Scientist, Marketing and Policies. National Center for Agricultural Economics and Policy Research, Pusa, New Delhi, ICAR, India.
- Dr Suresh Pal, Senior Scientist, Priority Setting & Project Monitoring and Evaluations. National Center for Agricultural Economics and Policy Research, Pusa, New Delhi, ICAR, India.
- Mr Hari Krishna Shrestha, Scientist-3, Socio-Economist, National Rice Research Program, Nepal Agricultural Research Council, Hardinath, Dhanusa, Janakpur, Nepal or Mr Naresh Singh Thakur, Scientist-3, Socio-Economist, Outreach Division, Nepal Agricultural Research Council, Khumaltar, Kathmandu, Nepal.

Resource persons from the participating centers

- Dr JK Ladha, IRRI, Philippines.
- Dr Suresh Pande, ICRISAT, India.
- Dr S Ilangantileke, CIP, India.
- Dr Hammond Murray-Rust, IWMI, Pakistan.
- Dr Peter R Hobbs, Cornell University; Craig Meisner, CIMMYT, Bangladesh; and Scott Justice, CIMMYT, Nepal.

Annexure 2

Terms of reference for the review of RWC

Introduction

The Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC) was founded in 1994 as an Ecoregional program of the CGIAR in response to concerns about the sustainability of the RW systems of South Asia. These systems are the cornerstone of cereal food security in the region. The IGP occupies nearly one-sixth of the total geographical area of the South Asian sub-continent, produces more than 45% of the total food and holds nearly 42% of the total population of 1.3 billion. This region is also home to more than 400 million poor people. The population of this region is increasing at about 2.0% per year meaning that nearly 24 million more mouths need to be fed each year. The rice-wheat (RW) system is grown on nearly 13.5 million ha (Ladha et al. 2000) and provides food security and livelihoods for tens of millions of farmers and workers. Demand for rice and wheat will grow at 2.5% per year in the next 20 years. At the same time, the per capita RW growing area has shrunk from 1200 m^2 in 1961 to less than 700 m^2 in 2001. Future food production growth will require efficient utilization of natural resources through sustainable yield growth within the RW systems of the IGP.

The Rice-Wheat Consortium

As an ecoregional program, the Consortium addresses natural resource management issues and problems of agricultural productivity and production within geographically defined areas of the IGP. The Consortium performs its work within defined socio-economic and policy environments to develop technologies that enhance productivity and sustainability of the resources devoted to rice-wheat systems.

The present membership of the RWC consists of the four National Agricultural Research Systems in the IGP (Bangladesh, India, Nepal and Pakistan), five International Centers of the CGIAR (CIMMYT, CIP, ICRISAT, IRRI and IWMI), and various advanced researched institutions in developed countries, among them Cornell University (USA), CABI (UK), IAC Wageningen (Netherlands), IACR Rothamsted (UK), CIRAD (France), CSIRO (Australia), Massey University (New Zealand), University of Adelaide (Australia), Michigan and Ohio State Universities (USA), IAEA, (Vienna) and donor communities (DFID, Netherlands, ADB, ACIAR, IFAD, The World Bank, USAID).

The RWC is a multi-tiered organization with the RSC (Regional Steering Committee) the pinnacle management group for setting guidelines and approving work plans and budgets. It consists of the Directors General of the four participating NARS, the Directors General of CIMMYT and IRRI and a donor representative. Regional technical issues are deliberated at the RTCC (Regional Technical Coordination Committee) made up of senior partner scientists. Similar hierarchies are found at the national level and site levels. The activities of the Consortium are coordinated through the RWC Coordination Unit (previously called the Facilitation Unit) headed by a Regional Coordinator and a Co-coordinator (previously called Facilitator and Co-Facilitator) and housed at New Delhi.

TAC (Technical Advisory Committee of CGIAR) reviewed several CG Ecoregional Programs in April 1999. One of these was the RWC. The

Report of the TAC Review Panel was positive. It assigned the success of the RWC to:

- It being a NARS driven initiative with other partners having defined roles
- A commitment of partners to make it successful
- The fostering of improved system based planning
- Crop establishment techniques providing a center stage for improving soil and crop management
- A sharpening of the focus on a systems perspective, and
- Its influence on how WB funding is used to strengthen national programs.

Recent accomplishments include substantial adoption of RCTs by farmers in the IGP – especially zero and reduced tillage for wheat after rice. These innovations produce more food at less cost and provide substantial environmental benefits including immense savings in water and other resources and reduction in greenhouse gas emissions. For this success, the RWC was awarded in 2000 the CGIAR Chairman's Award for Best Partnership. Resource poor farmers and women farmers (who hire in tillage and establishment services) have been major beneficiaries of this "tillage revolution".

The goal of the Consortium is to:

"Strengthen existing linkages and partnerships with national research programs (NARSs), other international centers, advanced institutions and the private sector working in the region to develop and deploy more efficient, productive and sustainable technologies for the diverse RW production systems of the IGP so as to produce more food at less cost and improve livelihoods of those involved with agriculture and as a consequence decrease poverty."

Rationale for the review

Despite good progress, farm level impact is still limited. A number of questions have surfaced that point to a need for a fresh look at the future role, strategy and priorities for the work program of the RWC. There is a need for greater clarity in the role and responsibilities of NARS, ARIs and International Centers. Donors have reframed their strategies for funding research to have greater impact on poverty alleviation, sustainability and the environment. In addition, given the rapid advances in proprietary science, it is becoming increasingly clear that some objectives of the RWC can be best achieved through strategic partnership/cooperation with the private sector. Given these wide-ranging considerations and a gap of almost three years since the TAC review of Ecoregional Programs, the seventh meeting of the Regional Steering Committee (meeting in Dhaka on February 17-18, 2001) recommended a forward-looking review of the RWC.

Scope and coverage of the review

The review has the following goal:

"To determine the changes in research priorities, organization and methods that will be required for the RWC to continue to make a significant impact on the livelihoods of those employed in agriculture, on the sustainable management of natural resources in the IGP-Gangetic Plains, and on regional food security.

The expected outputs from the review include:

Research priorities

- Recommendations on the scope of the research agenda of the RWC (too broad? too narrow?)
- An examination of the relevance of the current research themes being pursued by the RWC
- An assessment of the extent to which equity issues, including gender issues, merit increased attention in the RWC research agenda
- A definition of important gaps in the research program for each of the five transects[1] within the IGP as identified by the RWC

[1] The RWC has delineated the IGP into five distinct transects based on physiographic, and bio-climatic factors to facilitate easier extrapolation of results within transects with similar problems (Fig. 1).

- A clear statement of what the NARS partners of RWC expect it to achieve in the short, medium and long-term and whether all stakeholders and partners have a similar vision
- A guide to suitable mechanisms for research priority setting that involve all parties and recognize the dynamic nature of the program

Research organization and partnership

- Guidelines for suitable involvement of China, Afghanistan, Iran or other countries in Consortium activities, and possible implications for levels of membership
- An assessment of the value-added role of the Coordination Unit for the efficient functioning of the Consortium
- An assessment of the funding strategy of the RWC and the Coordination Unit along with recommendations on how this can be improved. This assessment should take account of changing roles for partners and the on-going changes affecting the CGIAR system
- An examination of the role of the RWC and its partners – relative to other factors – in fostering farmer uptake and encouraging impact assessment of new technologies for increasing and sustaining system productivity and profitability
- Identification of those functions of its international partners that add value to NARS programs taking into account the diverse nature of the RWC partners

Research methods

- Recommendations on methods or approaches for assessing the interactions between the RW system and environmental issues such as global warming and plot- and basin-level water savings
- Recommendations on how the RWC can more systematically take account of the role of policy for enhancing the benefits of research in the ecoregion; this includes:
  - How policy decisions can be used to encourage adoption of new technology options while discouraging possible undesirable consequences
  - The importance of policy on environmental impacts and sustainability of the system
  - How policy decisions in the IGP affect the interests of the poor.
  - An examination of Farmer Participatory Research (FPR) and social science approaches for on-farm strategies of technology generation and validation currently pursued by the Consortium. Are they sufficient for technology diffusion on a large scale? Examination of strategies for scaling-out agricultural and natural resource innovations to provide quickly more equitable and quality benefits to more people.

Review methodology

It is proposed that this review be conducted in early October 2002 and finished over a period of four to six weeks. The final report should be available within two months of the completion of the review. The preliminary report should be circulated to stakeholders for comments before final publication.

Review team will finalize its own methodology to be followed. Preliminary suggestions on the review methodology are:

- A desk review of selected past work and outputs
- Interviews of key stakeholders in the NARS/ IARCs/ ARIs
- Field visits to each partner country and a few selected research sites by a member of the team to see activities on the ground
- Visits to selected donors and research oriented private industry to ascertain their feedback
- Meetings with the International partners to seek their inputs

- Selecting one or two case studies, maybe one in the west and one in the east, a clear time-table which shows the evolution of the system with changing roles for the partners, gradual reduction of the role of the CGIAR and targeted developmental and technical objectives. To highlight progress to date and understand what further improvements are needed

The Coordination Unit of the RWC will be responsible for arranging the logistics for the review. They will also inform partners about the schedule of the visit of the Review Team and help to assemble the materials needed for the desk and case studies. The Unit will provide secretarial assistance for preparation of drafts and the final report. Funds will be provided to the Unit to enable this support. The Unit will be responsible for the publication of the final report and distribution to RWC members, donors and other interested parties.

Reference:

Ladha, J.K., K.S. Fischer, M. Hossain, P.R. Hobbs, and B. Hardy. 2000. Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic Plains: A synthesis of NARS-IRRI partnership research. Discussion Paper No. 40. IRRI, Philippines.

Annexure 3

List of selected past work and outputs of RWC made available to the panel

RWC research paper series

Narang, R.S., and S.M. Virmani. 2001. Rice-wheat cropping systems of the Indo-Gangetic Plain of India. RWC Paper Series 11. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Pandey, S.P., S. Pande, C. Johansen, and S.M. Virmani. 2001. Rice-wheat cropping system of Nepal. RWC Paper Series 12. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Madan, P.P., B. Khadga, Shrestha, and N.H. Dhakal. 2001. Baseline study on agricultural mechanization needs in Nepal. RWC Paper Series 13. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Abrol, I.P., K.F. Bronson, J.M. Duxbury, and R.K. Gupta. 2000. Long-term soil fertility experiments in rice-wheat cropping systems. RWC Paper Series 6. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Sharma, S.B., Pankaj, S. Pande, and C. Johansen. 2000. Nematode pests in rice-wheat-legume cropping systems. Proc. of Review and Planning Meeting and Training Workshop. RWC Paper Series 7. RWC, New Delhi, India.

Mehla, R.S., J.K. Verma, R.K. Gupta, and P.R. Hobbs. 2000. Stagnation in the productivity of wheat in the Indo-Gangetic Plains: Zero-till-seed-cum-fertilizer drill as an integrated solution. RWC Paper Series 8. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Hobbs, P.R., and R.K. Gupta. 2000. Soil and crop management practices for enhanced productivity of the rice-wheat cropping system in the Sichuan province of China. RWC Paper Series 9. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Aggarwal, P.K., K.K. Talukdar, and R.K. Malik. 2000. Potential yields of rice-wheat system in the Indo-Gangetic Plains of India. RWC Paper Series 10. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Pingali, P.L. 1999. Sustaining rice-wheat production systems: Socio-economic and policy issues. RWC Paper Series 5. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Hobbs, P.R., G.S. Giri, and P. Grace. 1998. Reduced and zero tillage options for the establishment of wheat after rice in South Asia. RWC Paper Series 2. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Malik, R.K., G. Gill, and P.R. Hobbs. 1998. Herbicide resistance — A major issue for sustaining wheat productivity in rice-wheat cropping systems in the Indo-Gangetic Plains. RWC Paper Series 3. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Sharma. S.B., C. Johansen, and S.K. Midha. 1998. Nematode pests in rice-wheat-legume cropping systems. Proc. of a Regional Training Course. RWC Paper Series 4. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

RWC traveling seminar report series

Gupta, R.K., A.K. Shukla, M. Ashraf, Z.U. Ahmed, R.K.P. Sinha, and P.R. Hobbs. 2002. Options for establishment of rice and issues constraining its productivity and sustainability in Eastern Gangetic plains of Bihar, Nepal and Bangladesh. RWC

Traveling Seminar Report Series 4. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Gupta, R.K., and J. Rickman. 2002. Design improvements in existing zero-till machines for residue conditions. RWC Traveling Seminar Report Series 3. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Gupta, R.K., P.R. Hobbs, M. Salim, R.K. Malik, M.R. Varma, T.P. Pokharel, T.C. Thakur, and J. Tripathi. 2002. Research and extension issues for farm-level impact on the productivity of the rice-wheat systems in the Indo-Gangetic Plains of India and Pakistan. RWC Traveling Seminar Report Series 1. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Gupta, R.K., P.R. Hobbs, M. Salim, N.H. Chowdhary, and S.I. Bhuiyan. 2000. Study of research and extension issues in the Sichuan province of china for farm-level impact on the productivity of the rice-wheat system. RWC Traveling Seminar Report Series 2. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

RWC technical bulletin series

Ashok, Y., R.K. Malik, N.K. Bansal, R.K. Gupta, S. Singh, and P.R. Hobbs. 2002. Manual for using zero-till seed-cum-fertilizer drill and zero-till drill-cum-bed planter. RWC Technical Bulletin Series 1. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Rickman, J.F. 2002. Laser leveling training manual. RWC Technical Bulletin Series 2. RWC, New Delhi, India.

Miller, A., and R. Bellinder. 2001. Herbicide application using a knapsack sprayer. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Miller, A., and R. Bellinder. 2001. Herbicide application using a knapsack sprayer. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India (Hindi version).

RWC-PRISM. 2001. User manual for data entry & updating and focal point management. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Newsletters

RWC. 2002. Rice-Wheat Information Sheet. Vol. 43. Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi, India.

Other special publications and selected reports

RWC-CIMMYT. 2003. Addressing resource conservation issues in rice-wheat systems of south Asia: A resource book. Rice-Wheat Consortium for the Indo-Gangetic Plains and CIMMYT, New Delhi, India.

Ladha, J.K., J.E. Hill, J.M. Duxbury, R.K. Gupta, and R.J. Buresh (ed.) 2003. Improving the productivity and sustainability of rice-wheat systems: Issues and impacts. ASA Special Publication No. 65, ASA/CSSA/SSSA, Madison, WI, USA.

Kataki, P.K (ed.) 2001. The rice-wheat cropping systems of South Asia: Efficient production management. Food Products Press, New York.

Kataki, P.K (ed.) 2001. The rice-wheat cropping systems of South Asia: Trends, constraints, productivity and policy. Food Products Press, New York.

Ladha, J.K., K.S. Fischer, M. Hossain, P.R. Hobbs, and B. Hardy. 2000. Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic Plains: A synthesis of NARS-IRRI partnership research. Discussion Paper no. 40. IRRI, Philippines.

Hobbs, P.R., and M. Morris. 1996. Meeting south Asia's future food requirements from rice-wheat cropping systems: Priority issues facing researchers in the post-green revolution era. NRG Paper 96-01. CIMMYT, Mexico D.F.

Harrington, L.W., P.R. Hobbs, D.B. Tamang, C. Adhikari, B.K. Gyawali, G. Pradhan, B.K. Batsa, J.D. Ranjit, M. Ruckstuhl, Y.G. Khadka, and M.L. Baidya. 1993. Wheat and rice in the hills: Farming systems, production techniques and research issues fro rice-wheat cropping pattern in the mid-hills of Nepal. Report on an exploratory survey conducted in Kabhre district. Nepal Agricultural Research Council, and CIMMYT.

Harrington, L.W., S. Fujisaka, M.L. Morris, P.R. Hobbs, H.C. Sharma, R.P. Singh, M.K. Chaudhary, and S.D. Dhiman. 1992. Wheat and rice in Karnal and Kurukshetra districts, Haryana, India: Farmers' practices, problems and an agenda for action. Exploratory Surveys, CIMMYT, Haryana Agricultural University, Indian Council of Agricultural Research and IRRI.

Savary, S., F.A. Elazegui, H.O. Pinnschmidt, N.P. Castilla, P.S. Teng. 1997. A new approach to quantify crop losses due to rice pests in varying production situations. IRRI Discussion Paper Series No. 20. IRRI, Manila, Philippines. 53 p.

Savary, S., R.K. Srivastava, H.M. Singh, F.A. Elazegui. 1997. A characterization of rice pests and quantification of yield losses in the rice-wheat system of India. Crop Protect. 16: 387-398.

Woodhead, T., R. Huke, E. Huke, and L. Balababa. 1994. Rice-wheat atlas of India. IRRI/CIMMTY/ ICAR publication, Los Baños, Philippines. p 1-147.

Selected rice-wheat research works

Referred journal publications

Ladha, J.K., D. Dawe, H. Pathak, A.T. Padre, R.L. Yadav, B. Singh, Y. Singh, Y. Singh, P. Singh, A.L. Kundu, R. Sakal, N. Ram, A.P. Regmi, S.K. Gami, A.L. Bhandari, R. Amin, C.R. Yadav, E.M. Bhattarai, S. Das, H.P. Aggarwal, R.K. Gupta, and P.R. Hobbs. 2003. How extensive are yield declines in long-term rice-wheat experiments in Asia? *Field Crops Res.* 81:159-180.

Pathak, H., J.K. Ladha, P.K. Aggarwal, S. Peng, S. Das, Y. Singh, B. Singh, S.K. Kamra, B. Mishra, S.R.A.S. Asastri, H.P. Aggarwal, D.K. Das, R.K. Gupta. 2003. Trends of climatic potential and on-farm yield of rice and wheat in the Indo-Gangetic Plains. *Field Crops Res.* 80:223-234.

Sharma, P.K., J.K. Ladha, T.S. Verma, R.M. Bhagat, A.T. Padre. 2003. Rice-wheat productivity and nutrient status in a lantana (Lantana spp.) amended soil. *Biol. Fertil. Soils* 37: 108-114.

Bhandari, A.L., J.K. Ladha, H. Pathak, A.T. Padre, D. Dawe and R.K. Gupta. 2002. Yield and soil nutrient changes in a long-term rice-wheat rotation in the Indo-Gangetic Plains of India. *Soil Sci. Soc.Am. J.* 66:162-170.

Regmi, A.P., J.K. Ladha, E.M. Pasuquin, H. Pathak, P.R. Hobbs, L. Shrestha, D.B. Gharti, and E. Duveiller. 2002. The role of potassium in sustaining yields in a long-term rice-wheat experiment in the Indo-Gangetic Plains of Nepal. *Biol. Fertil. Soils* 36:240-247.

Regmi, A.P., J.K. Ladha, H. Pathak, E. Pasuquin, C. Bueno, D. Dawe, P.R. Hobbs, D. Joshy, S.L. Maskey, and S.P. Pandey. 2002. Yield and soil fertility trends in a 20-year rice-rice-wheat experiment in Nepal. *Soil Sci. Soc. Am. J.* 66:657-867.

Singh, B., Y. Singh, J.K. Ladha, K.F. Bronson, V. Balasubramanian, J. Singh, and C.S. Khind. 2002. Chlorophyll meter and leaf color chart-based nitrogen management for rice and wheat in Northwestern India. *Agron. J.* 94:821-829.

Gami, S.K., J.K. Ladha, H. Pathak, M.P. Shah, E. Pasuquin, S.P. Pandey, P.R. Hobbs, D. Joshy, and R. Mishra. 2001. Long-term changes in yield and soil fertility in a twenty-year rice-wheat experiment in Nepal. *Biol. Fertil. Soils* 34:73-78.

Timsina, J., and D.J. Connor. 2001. Productivity and management of rice-wheat cropping systems: issues and challenges. *Field Crop Res.* 69: 93-132.

Yadav R.L. 2001. On farm experiments on integrated nutrient management in rice-wheat cropping systems. *Expl. Agric.* 37: 99-113.

Gupta, R.K., and I. P. Abrol. 2000. Salinity build-up and changes in the rice-wheat system of the Indo-Gangetic Plains. *Exp. Agric.* 36: 273-284.

Selvarajan, S., P.K. Aggarwal, S. Pandey, F.P. Lansigan, and S.K. Bandyopadhyay. 1997. Systems approach for analyzing tradeoffs between income, risk and water production in Northern India. *Field Crop Res.* 51: 147-161.

Chapters in books/proceedings and presentations

Balasubramanian V, J.K. Ladha, R.K. Gupta, R.K. Naresh, R.S. Mehla, B. Singh, Y. Singh. 2003. Technology options for rice in rice-wheat systems in Asia. p. 115-148. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65, Madison, WI, USA.

Bronson, K.F., K.G. Cassman, R. Wassman, D.C. Olk, M. van Noorwijk, and D.P. Garrity. 1998. Soil carbon dynamics in different cropping systems in principal ecoregions of Asia. *In* Management of carbon sequestration in soil. R. Lal, J.M. Kimble, R.F. Follett and B. A. Stewart, eds. CRC Press, Boca Raton, FL. p 35-57.

Byerlee, D, M. Ali, and A. Siddiq. 2003. Sustainability of rice-wheat system in Pakistan Punjab: How large is the problem? p. 77-96. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65. Madison, WI, USA.

Gupta, R.K., R.K. Naresh, P.R. Hobbs, J. Jiaguo, and J.K. Ladha. 2003. Sustainability of Post-green Revolution agriculture: The rice-wheat cropping systems of the Indo-Gangetic Plains and China. p. 1-26. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65. Madison, WI, USA.

Gupta, R.K., R.K.Naresh, P.R. Hobbs, and J.K. Ladha. 2003. Adopting conservation agriculture in the rice-wheat system of the Indo-Gangetic Plains: New opportunities for saving water. p. 207-222. *In* B.A.M. Bouman, H. Hengsdijk, B. Hardy, P.S. Bindraban, T.P. Tuong, and J.K. Ladha (ed.) Water-wise rice production. International Rice Research Institute, Los Baños, Laguna, Philippines.

Hobbs,P.R. and R.K. Gupta. 2003. Resource conserving technologies for wheat in rice-wheat systems. p. 149-172. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65, Madison, WI, USA.

Ladha, J.K., H. Pathak, A.T. Padre, D. Dawe, and R.K. Gupta. 2003. Productivity trends in intensive rice-wheat cropping systems in Asia. p. 45-76. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65. Madison, WI, USA.

Samra, J.S., B. Singh, and K. Kumar. 2003. Managing rice residues in rice-wheat system of the Indo-Gangetic Plains. p. 173-196. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65. Madison, WI, USA.

Sharma, P.K., J.K. Ladha, and L. Bhushan. 2003. Soil physical effects of puddling in rice-wheat cropping system. p. 97-114. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65. Madison, WI, USA.

Gupta, R.K., R.K. Naresh, P.R. Hobbs, and J.K. Ladha. 2003. Adopting conservation agriculture in the rice-wheat system of the Indo-Gangetic Plains: new opportunities for saving water. p. 207-222. *In* B.A.M. Bouman, H. Hengsdijk, B. Hardy, P.S. Bindraban, T.P. Tuong, and J.K. Ladha (ed.) Water-wise rice production. International Rice Research Institute, Los Baños, Laguna, Philippines.

Sharma, P.K., L. Bhushan, J.K. Ladha, R.K. Naresh, R.K. Gupta, B.V. Balasubramanian, and B.A.M. Bouman. 2003. Crop-water relations in rice-wheat cropping under different tillage systems and water-management practices in a marginally sodic, medium-textured soil. *In.* B.A.M. Bouman, H. Hengsdijk, B. Hardy, P.S. Bindraban, T.P. Tuong, and J.K. Ladha (ed.) Water-wise rice production. International Rice Research Institute, Los Baños, Laguna, Philippines.

Hobbs, P.R., R.K. Gupta, and L. Harrington. 2001. Sustaining the Green Revolution by resource conserving technologies: The example set by the Rice-Wheat Consortium. ILEIA Newsletter Dec. 2000. p. 8-10.

Annexure 4

Field visits by the Panel members to partner countries and selected research sites

Date	Particulars	Panel
India		
3 October 2002	Visit villages in Karnal and meet farmers, Department of Agriculture, Govt. of Haryana and also meet HAU staff Reach PAU, Ludhiana and meet University functionaries	Dr. Jha Dr. Seth
4 October 2002	Visit manufacturers in Ludhiana. See experiment and diversification work	Dr. Jha
6 October 2002	Visit with APN workshop participants to village Dasna, Kaloogarhi, Matiala and Duhai to see farmer participatory work. Farmer interactions at Duhai and also visit Modipuram to see core experiment site	Dr. Jha
15 October 2002	Travel to Varanasi Visit BHU Experiment site and meet scientists	Dr. Seth Dr. Anderson Dr. Jha
16 October 2002	Visit Farmer fields in Pindhara, Kaitholi and Maritar in Balia district to Technology targeting work in different rice eco-systems and also have interaction with farmers at village Pindhara	Dr. Seth Dr. Anderson Dr. Jha
17 October 2002	Visit zero-till sites in Ghazipur Return to Delhi	Dr. Seth Dr. Anderson Dr. Jha
Bangladesh		
26 February 2003	Orientation at CIMMYT Bangladesh Meeting with Mr. Noel Magor, IRRI at his office	Dr. Fischer Dr. Jha
27 February 2003	Visit RARS Jessore and leave for ADB site at BRRI, Chuadanga	Dr. Fischer Dr. Jha
28 February 2003	Visit farmers' fields showing spread over activities of RWS other than Chuadanga and Dinajpur	Dr. Fischer Dr. Jha
1 March 2003	Discussion meeting on Rice-wheat activities at WRC, Dinajpur with: Site Coordinator, BRRI, Chuadanga Site Coordinator, BARI, Dinajpur PSO, BSPC, BARI, Debiganj	Dr. Fischer Dr. Jha
2 March 2003	Visit field activities at Birganj Meeting with Co-facilitator, RWC & NRG Agronomist CIMMYT and other scientists at CIMMYT office	Dr. Fischer Dr. Jha
3 March 2003	Meeting with Dr. H. Miah, Affiliate Liaison Scientist, IRRI at his office	Dr. Fischer Dr. Jha
Nepal		
6 March 2003	Travel to Bhairawan and visit fields and wheat research station	Dr. Seth
7 March 2003	Visit sites in Bhairawan and return to Kathmandu	Dr. Seth

Annexure 5

Stakeholder survey approach and summary of findings

Objectives

The objectives of the stakeholder consultation would be to seek views of the partner organizations on the current performance and future direction of RWC activities so that the research findings bring about significant improvements in the management of natural resources, livelihood of the farming communities and contribute to food security in the region.

The stakeholders

It is planned to consult a wide range of stakeholders who are either directly or indirectly involved in supporting RWC activities. These would include:

- NARS, IARCs/ARIs and donors undertaking/ supporting rice-wheat research
- CGIAR Secretariat and other CG bodies such as TAC (Research Council), CGIAR CDC Committee, CGIAR Private Sector Committee and interested individuals providing managerial and technical guidance and support
- Private Foundations and Associations related to life science industry interested in the rice-wheat research
- Farmers, who are the ultimate users of RWC supported technologies

The consultation process

The consultation process would involve a two-pronged strategy. First, the key stakeholders would be requested to complete questionnaires including question related to the RWC governance, research, funding and future strategies. Second, the information obtained through this process would be supplemented by face-to-face interviews of key stakeholders and field visits to all the four partners countries (India, Pakistan, Bangladesh and Nepal) of the Consortium. The consultation process with the farming communities would involve interviews of farmers (adopters and non-adopters) in villages participating in rice-wheat cropping systems research.

Given the differences in the role of stakeholders, it is intended to use slightly different questions for NARS, IARC/ARI and other stakeholders.

Feed back from the NARS partners

A total of 22 out of a possible 26 institutes responded to the questionnaire. The responses to the questions on satisfaction levels are specific and relevant to the question—they provide a useful assessment of the satisfaction level of the RWC and the CU.

The responses to questions on "suggested changes" in the 4 subject areas were not always relevant to the particular issue. The panel attempted to capture all comments and reassign them to relevant section of the questionnaire. In this process, the respondent number (n) sometimes exceeds or is less than the number of institutes that have responded to the questionnaire. The Panel has viewed the respondent number (n) as a measure of the importance of the particular issue and thus has provided this information in the summary.

The Panel has taken into consideration the information provided from the questionnaire, and explicitly, the information which is highlighted in blue in the following summary.

The summary of the questions and the responses

Governance

1. How satisfied are you with the current research partnerships in relation to the overall objectives and mandate of RWC?

Response	%*
Very satisfied	50
Satisfied	45
Not satisfied	5

No. of responses (n) = 20; * percentage based on the responses

2. What changes would you recommend for improvement?

Response	%*
Extend the research partnership to cover increased dimensions (socio-economics and biological components, impact assessment, etc.)	36
Add resources for training and physical facilities	29
Adopt a more comprehensive on-farm oriented system based research approach	21
Broaden the research agenda (to include other crops and untapped area) and new emerging issues	14

No. of respondents who addressed the question (n) = 14; * percentage based on the responses to the question

Facilitation/Coordination

1. In your view how effective are the current coordination arrangements for the RWC?

Response	%*
Effective	60
Very effective	40
Not effective	0

n= 20; * percentage based on the responses

2. Trans-boundary facilitation

Response	%*
Transboundary and overseas training, visit etc. should be organized.	67
Co-facilitators should be appointed to help augment co-ordination.	50
Quick flow of knowledge and other materials such as literature, spare parts, etc. should be facilitated	33

n = 6; * percentage based on the responses

3. What do you think are the main contributions of your institution that have added value to Consortium and its work program?

Response	%*
Facilitating the technology development, testing, dissemination and evaluation	29
Sharing information and experience through the travelling workshops	17
Promoting farmer participatory research	14
Overall co-ordination	14
Fostering the diagnostic and preliminary survey approaches	11
Supplying manpower	9
Facilitating the supply of physical facilities , travel etc across countries	6

n = 35; * percentage based on the responses to the question

4. What recommendations would you make for further improvement in coordination with regards to organizational arrangement?

Response	%*
Develop and co-ordinate multidisciplinary teams at each site as in the ADB project	33
Institutionalize the R-W system structure within NARS	33
Strengthening the linkage between national and site co-ordinators	11
Sustain the farmer participatory research approach in the RWC member Institutes.	11
Increase the staff to handle the increasing dimensions of the work plan.	11
Appoint co-facilitators to help augment co-ordination.(in some countries)	2

n = 9; * percentage based on the responses to the question

Research agenda

1. In your view which of RWC research themes provided important changes to your Institutes' programs?

Response	%*
The awareness and adoption of RCTs would not have taken place without the RWC	69
The integration and collaboration among the scientists and organizations would not have taken place without the RWC	31

n = 16; * percentage based on the responses to the question

2. In your view are there important gaps (biological, economic, environmental and social) in the research coverage of the RWC?

Response	%*
Yes	78
No	22

n = 18; * percentage based on the responses to the question

3. What are the gaps in research coverage?

Response	% *
Understanding technology uptake, dissemination and socio-economic impact.	24
Inadequate coverage of market issues	12
Consideration of allied activities such as livestock and agro-forestry, etc.	12
Consideration of hill/mountain farming system, and flood prone areas as special targets	12
Understanding of environmental issues	12
Understanding of soil health and water quality management	8
Inadequate work on insect pest and post harvest losses	8
Inadequate work on residue management	8
Inadequate work on RCT's and genotype interaction	4

n = 25; * percentage based on the responses to the question

4. How can these gaps be bridged?

Response	% *
Initiating research on socio-economic impacts of technology.	30
Sustaining a system based research approach at the Institute	45
Focusing on untapped areas like water logged and flood-prone areas, hill farming system, etc.	10
Focusing on location specific rather than area-general recommendations.	10
Developing small and cost effective equipment	5

n = 20; * percentage based on the responses to the question

5. What recommendations would you make for further improvement in the development and dissemination of new technologies/knowledge related to the rice-wheat systems?

Response	% *
Help document impact assessment and extrapolation of technology.	20
Use mass media such as video films, radio & TV programs, farmer feasts, literature in local languages	20
Promote more sharing and exchange of scientists and scientific materials among different centers and partner countries	15
Help influence the government policies towards new technology, loans to the manufacturers, subsidy to the farmers, custom duty, etc.	15
Promote and sustain farmers participatory approach to research	15
Increase training, visits seminars, conferences, etc	15

n = 20; * percentage based on the responses to the question

6. In your view what are the key attributes that make the RWC an effective eco-regional program and which of these are replicable in other situations?

Response	%*
Proactive role of RWC	28
Strong focus on importing and disseminating suitable RCTs.	17
The development of multidisciplinary teams including national and regional scientists.	14
The focus on scale neutral (commercial- non-commercial) technology adoption.	10
The consideration of regional and global environmental concerns (straw burning, fuel saving, etc)	10
The private sector participation in technology development	10
Farmer participatory approach to research	7
Facilitating the development of improved farm implement prototypes.	3

n = 29; * percentage based on the responses to the question

7. What mechanisms would you recommend to be used to prioritize RWC research to ensure effective involvement of all partners, and to adequately take account of the dynamic nature of the program?

Response	%*
Participatory needs assessment and priority setting by all partners	32
Integration of RWC themes with the national research and extension priorities	20
Closer interaction among all the stakeholders and stronger commitment on their own core resources to the RWC	20
More targeting of domains for the appropriate technology	16
Augment private and NGO partnerships	8
Transboundary facilitation	4

n = 25; *percentage based on the responses to the question

Funding

1. In your view how can the long-term funding for this ecoregional program and its Coordination Unit be made more stable and sustainable? Any quantification of contributions from your own or other sources (time or resources) you can attempt would be greatly appreciated.

Response	%*
More donation/aid from abroad, NGO's, INGO's, etc.	38
Increase the contribution of in kind manpower and physical facilities from member institutions	19
Initiate direct contributions from the participating countries/members	19
Create a revolving fund scheme	6
Tax the R-W industries	6
Match the goals with other NGO's and INGO's goals etc for new donor alliances	6
Create an endowment fund	6

n = 16; * percentage based on the responses to the question

Future Direction

1. How can the current review of RWC be made more useful to the national system?

Response	%*
Holding seminars, interaction sessions and review of the progress	28
Establishing linkages with national systems.	17
Updating and effective dissemination of the technologies	11
Allocating resources for extrapolation	11
Prioritizing the research based on the national interests.	11
Addressing the food security issues	11
Ensuring the participation of the policy makers and providing support at the policy level.	6
Close coordination and cooperation among all the stakeholders	6

n = 18; * percentage based on the responses to the question

2. Should RWC have a future? If so, what directions would you like to see it take?

2a. Should RWC have a future?

Response	%*
Yes	65
No	0
No comments	35

N=20

2b. What directions would you like to see it take?

Response	%*
Integrated farming system approach should be employed	38
Focus should be given on socio-economic impacts of technologies	25
Crop diversification should be taken into account	25
Effort should be put on evaluation of technologies	19
Aim at sustainability of the system	13
Inclusion of non-tapped areas like low land, hills etc.	6

n = 16; * percentage based on the responses

Any other comment/suggestion

Response	%*
Help proper dissemination and adoption of technologies	29
Give more emphasis to the diversification of the cropping systems	12
Validate and integrate the outcomes in the national systems	12
More effort on dissemination and adoption of the technologies (video films, literature in local language)	12
More opportunities for overseas training and studies	12
More resources (personnel, physical facilities, etc.)	6
More emphasis on the development of light equipment (animal drawn, 2 wheeled tractor)	6
More emphasis on sustainable management of natural resources	6
Try to incorporate the Farmers Field School	6

n = 17; * percentage based on the responses to the question

Feed back from the IARC

(No response was received from ARI partners). The following summarizes the feedback from written comments by four IARC (CIP, ICRISAT, IRRI AND IWMI), and from discussions with CIMMYT and AVRDC. The summary attempts to capture the main points made by the respondents. Because of the small sample size the Panel makes no attempt to assess the relative importance of the issues by the IARC partners.

Governance

- There is a divergence of view on membership for policy decisions (i.e. The Steering Committee) ranging from a desire to keep the numbers manageable and maintain a NARS majority on the steering committee to a need for more open and "participatory management' to engage more members.
- There is a need for a better priority -setting process for identifying RWC research and stronger governance in ensuring that special-project funding pursued by members for the RWC is in keeping with agreed priorities.
- More focus of the approved research agenda on generating new knowledge and international (regional) public goods.

Facilitation

- Maintain the strong facilitator/ coordinator role for NRM and RW system research.
- Explore means to sustain a system approach at the NARS level.
- Use the current ADB project as a model for an effective mechanism to engage more partners / diversity at the system operational level.
- Continue the traveling seminars and exchange of information as important activities of the FU.
- Use the RCW and the CU as an effective platform for the implement of IARC joint activities.
- Provide more staff and better coordination among centers.

Future research

- Conduct socio-economic analysis at farm and local levels to understand constraints to adoption of new RCT's.
- Conduct appropriate policy analysis at state – country level to better understand principles that influence adoption.
- Establish and support long-term studies on the sustainability of the system with the new emerging NRM / crop systems.
- Facilitate more involvement of other crops to diversify the system for income generation.
- Provide more attention to water use and quality at the basin level through the Water Challenge Program.

Financing

- All members to contribute to the FU (as investors of last resort!).
- More cohesion among centers in project development and approach to donors.
- Link the RWC to the appropriate CGIAR Challenge Programs.

Annexure 6

Roles and responsibilities of RWC Coordination Unit

The roles of the Coordination Unit of the Rice-Wheat Consortium for the Indo-Gangetic Plains (RWC) housed in the liaison office, CIMMYT-India can broadly be categorized into under RWC core activities and those related with special projects. CU performs roles in special projects that encompass technical, administrative, and finance matters.

S No.	RWC core programs	RW-special projects
1	Organize annual meetings of the Regional Steering Committee and Regional Technical Coordination Committee and work on the recommendations	Help NARS and Centers and other stakeholders conduct RW workshops, planning meetings, trainings, field visits, and seminars as stipulated in the project and participate in them
2.	Organize regional traveling seminars and facilitate in country traveling seminars for all stakeholders as a strategy for technology dissemination and adoption of RCTs	Help identify, nominate, and provide logistics support to NARS participants in various international training programs
3.	Interact with the donors, provide new leads and help develop project proposals for external funding. Do technical back-stopping by providing requisite information to national partners for internal funding	Help engaging personnel and organize project related field activities in India and work through regional CIMMYT and IWMI offices in other countries
4.	Gateway function for new partners to help them plan and invest in projects needed in IGP region	Manage and maintain special project budgets
5.	Organize and participate in RW seminars, workshops and conferences and encourage participation of national scientists in them	Collate, prepare and submit technical and financial reports to the donor agencies
6.	Provide need base logistic support to the National Coordinators (RW) and maintain active links with them and other national partners.	Organize field visits of the visitors and dignitaries as promotional activities
7.	Exchange information/ technical know-how, biological materials and equipments among member states	Coordinate between centers and NARs on project based activities
8.	Publish technical information of expert consultations in RWC Technical Paper/ TS / Manual / poster series / RWIS	Promote inter-center/ NARs collaborations
9	Manage the rice-wheat related information through PRISM, a sub-set of WISARD	Export and import of seeds, research materials and implements
10	Facilitate transfer of skills in knowledge management to NARS scientists and technicians, and acts as connecting link between NARS and IARCs	Provide inputs into annual technical program meetings and help in planning and implementing new initiatives
11.	Meet statutory requirements of the federal bank for RWC operations within India	

Annexure 7

List of RWC research partner national research systems

Bangladesh

- Bangladesh Agricultural Research Council
- Bangladesh Rice Research Institute, Gazipur
- Bangladesh Agricultural Research Institute
- Breeding and Seed Production Center, Debiganj, Panchagarh
- Wheat Research Center, Dinajpur
- Tuber Crop Research Center, Bangladesh

India

Indian Council of Agricultural Research, New Delhi

- Central Potato Research Institute, Patna
- Central Rice Research Institute, Cuttack
- Central Soil Salinity Research Institute, Karnal
- Directorate of Maize Research, New Delhi
- Directorate of Rice Research, Hyderabad
- Directorate of Wheat Research, Karnal
- ICAR Research Complex for Eastern Region, Walmi Complex, Patna
- Indian Agricultural Research Institute, New Delhi
- Indian Grassland and Fodder Research Institute, Jhansi
- National Bureau of Plant Genetic Resources, New Delhi
- National Bureau of Soil Survey and Land Use Planning, Nagpur
- National Research Center for Integrated Pest Management, New Delhi
- Project Directorate of Cropping Systems Research, Meerut
- VPKAS, Almorah, Uttranchal

State Government Agricultural Research System

- Chandra Shekar Azad University of Agriculture & Technology, Uttar Pradesh
- Chaudhary Charan Singh Haryana Agricultural University, Haryana
- Govind Ballabh Pant University of Agriculture and Technology (GBPUA&T), Uttranchal
- KVKs and State Agriculture Departments of: Punjab, Haryana, Uttar Pradesh, Bihar & West Bengal
- Narendra Deva University of Agriculture and Technology, Uttar Pradesh
- Punjab Agricultural University, Ludhiana, Punjab
- Rajendra Agricultural Research University, Bihar
- Sardar Vallab Bhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh
- Department of Agricultural Cooperation (DAC), GOI, New Delhi
- Banaras Hindu University, Varanasi, Uttar Pradesh
- Center for Advanced Technology (CAT), (Laser Technology), Indore, Madhya Pradesh
- Indian Institute of Technology, New Delhi
- Remote sensing Application Center, Lucknow, Uttar Pradesh

Independent/Department of Science and Technology/NGOs

- Centre for Advancement of Sustainable Agriculture (CASA), New Delhi
- Indian Institute of Technology, New Delhi

- Institute of Himalayan Environmental Research and Education, (INHERE) Uttaranchal
- Managal Innovation Center, Bhalonilodh, Jhansi Uttar Pradesh
- Tata Energy Research Institute, New Delhi
- VEETEE Rice mills, Sonepat, Haryana

Nepal

- Agricultural Implement Research Station, Ranighat
- Institute of Agriculture and Animal Science, Rampur
- National Wheat Research Program, Bhairhawa
- Nepal Agricultural Research Council (NARC), Kathmandu
- Regional Rice Research Station, Parwanipur

NGOs

- Local Initiatives for Biodiversity, Research and Development, LIBIRD Mahendrapool, Pokhara

Pakistan

- Land Resources Research Institute, Islamabad
- National Agricultural Research Center, and sister Institutions, Islamabad
- On-Farm Water Management, Directorate General of Water Management, OFWM , Lahore
- Pakistan Agricultural Research Council, Islamabad
- University of Agriculture, Faislabad

NGOs

- Farmers associations linked to RCTs in Pakistan

International research systems

- Asian Vegetable Research and Development Center, Taiwan
- Wis. International, Wageningen, Netherlands

CGIAR – Future Harvest Centers

- International Crops Research Institute for the Semi-Arid Tropics, India
- International Maize and Wheat Improvement Center, Mexico
- International Potato Center, Peru
- International Rice Research Institute, Philippines
- International Water Management Institute, Sri Lanka

Advanced Research Institutions and Networks

- Asia-Pacific Network on Climate Change, Japan
- Australian Center of International Agricultural Research, Australia
- Center for Agriculture and Biology International, UK
- Centre for International Co-operation in Agricultural Research for Development, France
- Commonwealth Scientific and Industrial Research Organization, Australia
- Cornell University, USA
- CSIRO, Australia
- Food and Agricultural Organization, Rome
- Global Change and Terrestrial Ecosystems, Australia
- Global Environmental Change and Food Systems, UK
- Institute of Arable Crops Research, Rothamsted, UK
- International Atomic Energy Research Institute, Vienna
- Long Ashton Research Station, UK
- Massey University, New Zealand
- Ohio State University, Columbus
- The University of Adelaide, Australia
- United Nations System of Organizations
- University of Melbourne, Australia

Private Industry

- Akza Nobel Chemicals Ltd. Mumbai, India & the Netherlands
- American Spray Equipment Company, Mumbai
- Kissan Beej, Patna
- Mayhico
- Monsanto
- Oswal Sugar Mills, Mukerian, Punjab, India
- Private entrepreneurs in agricultural Implements (Nepal, Bangladesh, Pakistan and India)
- Syngenta, New Delhi
- Uttam Sugar Mills, Roorkee, Uttranchal, India

Annexure 7 (continued). Existing organizational responsibilities for various thematic activities in the Consortium

Thematic areas and organizational responsibilities	Activities within thematic areas	NARS	CIMMYT	IRRI	IWMI	ICRISAT	CIP	IAC/Wis. Int.	Cornell Univ	IACR	IAEA	CABI	Massey Univ	ACIAR/CSIRO/ QU, MU	CIRAD/DMC	AVRDC	GCTE/ GECAFS/ APN
1. Tillage and crop establishment	1. Tillage and crop establishment	X	X	X						X			X	X	X		
	2. Residue management	X	X	X					X					X	X		
	3. Machinery development	X	X	X									X	X			
2. Crop improvement and management	4. Germplasm screening and GxE, GxT interactions, cultivar choices	X	X	X		X	X						X	X			
	5. Legumes in RW systems	X		X		X			X							X	
	6. System diversification and intensification	X	X				X										
	7. Modeling and climate change	X	X	X		X			X					X			X
	8. Seed quality, priming and storage			X					X								
3. Integrated pest & disease management	9. Crop protection – IPM, IDM	X	X			X			X			X					
	10. Weed management	X	X	X										X	X		
4. Nutrient management (IRRI)	11. Integrated nutrient management	X		X					X	X	X		X	X		X	
	12. SOM, long term fertilizer trials, nutrient enrichments	X		X					X	X	X						
5. Water management (IWMI)	13. Water use efficiency	X		X	X						X		X	X			
	14. Water (field , farm and system level)	X			X												
	15. Water quality, salinity/sodicity issues	X															
6. Knowledge management	16. GIS/ country almanacs	X	X	X		X		X	X	X							
	17. Database management- RWC-PRISM, RWIS and webpage	X	X					X							X		
	18. RWC paper series, other publications	X	X	X		X		X	X								
	19. Annual meetings in regional and International research fora	X	X	X	X	X	X	X	X	X	X	X	X	X			
	20. Multi-stake holder meeting events- traveling seminars, workshops and conferences	X	X	X		X				X		X		X			
	21. Technology dissemination./ adaptive research	X	x	X		X				X				X			
7. Social-Economics	22. Impact analysis	X	X		X	X							X	X			
	23. Policy issues	X	X														
	24. PR&GA	X											X				
	25. Community group working	X				X				X			X				
8. Human resources development and capacity building	26. Specialized trainings in advanced institutions for scientists and farmers	X	X	X		X	X	X	X	X		X	X	X			

Other organizations to include or integrate are Adelaide Univ. (weeds), Long Ashton (weeds), NGO's (eg. Libird in Nepal, Catalyst Management Services in India) and Monsanto.

Source: CU, RWC, New Delhi.

Annexure 8

Public-private partnership for accelerated development and manufacture of the multi-crop zero-till drill-cum-bed planter

Fig. 1. Newly developed zero-till drill which is capable of seeding into loose residues avoiding burning residues considerably (Inset: Manufacturers, scientists and farmers worked together in developing and testing the prototype of new zero-till drill)

What were the objectives of the partnership?

- Develop and refine no-till machine as a multi-utility drill to sow crops such wheat and pulses etc. after harvest of rice crop as an alternative to conventional tillage
- Add features to the machine for planting onto raised beds to serve as bed planter as well
- Be able to plant crops into loose residues with out burning / partial burning them in flats and /or the raised-bed system of planting

Who were the partners?

- Agricultural engineers and agricultural research scientists from IARCs (CIMMYT and IRRI), national research institutions and state agricultural universities in India, Bangladesh and Pakistan

- Private sector companies in India
- Cooperating farmers

What were the compelling circumstances that led to the formation of public-private partnership?

A common feature of the rice-wheat cropping systems is the short turn around time between harvest of rice and planting of wheat when using time consuming conventional tillage system. As a result late planting is common which after 14th November leads to reduction in wheat yield at the rate of about 35 kg/ha/day in northwest and more than 50 kg/ha/day in eastern Gangetic plains. Zero tillage was seen as a solution to this constraint but no-till drill suited to local conditions was needed to allow rapid turn around between two crops and to improve yields through timely planting. In addition, no-tillage combined with crop residue management was also seen as a possible solution to concerns related to declining soil organic carbon and environmental pollution from burning of rice straw. Farmers were also concerned about the increasing costs of cultivation and zero tillage provided opportunity for cost reduction. Increasing mechanization of agriculture in north-western part of IGP had created an important market for farm machinery for the private sector. Partnership with companies involved with manufacturing of farm implements was seen by both the public research institutions and the private sector as a mutually beneficial partnership to quickly develop and manufacture a suitable zero-till drill.

What were the key features of this partnership?

The work on development of zero-till seed-cum-fertilizer drill started in 1988 with import of an inverted T-Opener from New Zealand by CIMMYT.

After slow initial progress the first prototype was developed at the G.B. Pant University of Agriculture and Technology, Pantnagar, UP.

A collaborative program for further development and commercialisation of zero-till was initiated in 1992-93 with the small scale industries, primarily involving M/s National Agro-Industries, Ludhiana and M/s. A.S.S. Foundry, Jandialaguru, Amritsar, Punjab. Following consideration investment of resources and several considerable design changes this collaborative program within 12 months produced the first zero-till seed drill for field testing with nine tines openers and a side wheel drive.

By 1997, after further refinements based on feed-back received from scientists and farmers, these two manufacturers had supplied over 150 improved machines to state agricultural universities and ICAR institutions located in Haryana, Punjab, Uttar Pradesh, Bihar, and also to NAFED for use by farmers/contractors. During wheat sowing season the manufacturers spent a lot of their time in the fields with farmers and scientists to better understand the problems in machine operations which led to rapid improvement of subsequent models. At the same time the manufacturers felt encouraged to participate in International Trade Fair at New Delhi and Farm Festivals in different states to demonstrate their machines.

Jointly with farmers who had used the drill the manufacturers organized interactions with senior engineers of Dept. of Farm Power Machinery (PAU) and officials of the Dept. of Agriculture (Engineering), Government of Haryana and Punjab to share experiences and seek their support in promoting zero-till. All the officials were surprised to see such rapid progress and came back impressed by these interactions.

In year 2000, a team of 23 scientists, farmers and manufacturers comprising participants from Nepal. Bangladesh, China, Mexico, India and Pakistan visited North-west parts of IGP in India and Pakistan. This team met many farmers in village Panjouli Kalan, Patiala, and discussions provided us with many very useful tips for

improvement of the drill. Manmohan Singh in NAI workshop in Ludhiana incorporated all these suggestions. Further close interactions between the manufacturers, farmers and the University staff in Punjab and Hayana helped in overcoming "Not invented here (NIH)" syndrome and gave private sector lot of confidence to move forward with greater zeal.

The drill still needed lots of improvements to meet the international standards. To achieve this goal in 2001 National Agro-industries attended Farm Exhibitions in Italy and RWC / CIMMYT, IRRI and ACIAR sponsored a 15-day traveling seminar to Australia for bringing about improvement in the design of ZTD and bed planter. This visit provided many insights which led to several changes in the drill design and the workshop floor management arrangements.

Work for development of the bed planter was initiated immediately after Dr. SS Dhillon and scientists from Directorate of Wheat Research were trained with Dr. Ken Sayre in CIMMYT, Mexico. A.S.S. Foundry took the lead and provided prototypes developed with support from these scientists. Subsequently, with continuing support from the RWC scientists (Ken Sayre, Raj Gupta and Joseph Rickman), a multi-seeder metering device and shapers were attached to the existing zero-till drill to make it suitable for planting of rice, mustard and assorted sizes pf different seeds. M/s Beri Industries developed a zero-till seed–fertilizer drill-cum-cultivator in 2002 with vertical shock absorbing system.

What has been the farm-level impact of the multi-purpose drills developed as a result of this partnership?

To-date National Agro-Industries alone has produced and sold more than 3000 zero-till seed drill to farmers and many research organizations in India and abroad under the aegis of UNDP projects, CIMMYT /RWC in Nepal, Pakistan, Bangladesh and to IRRI Philippines, Burkina Faso. As a recognition of its efforts, National Agro-Industries was invited to serve on the committee for drill specifications constituted by Bureau of Indian Standards and was presented a Commendation Award by Punjab Chapter of the Indian Society of Agricultural Engineers.

Over the last three to four years, farmers in IGP countries have rapidly adopted zero tillage for planting wheat after rice. It is estimated (by RWC) that more than 14000 drills are in operation and during the 2002-2003 season in over 500,000 ha of land wheat was planted using the zero-till system. Survey shows that even resource poor small holders have started to benefit from this technology by using contractors to drill their fields

What were the main reasons for this rapid success?

- The initiative was responding to a strong farmer demand where the private sector could see substantial market opportunities for their products.
- RWC played a crucial catalytic role in promoting the public-private partnership, nurtured it through its formative stages and facilitated technology transfer from international and national sources. In addition, RWC established a small revolving fund to facilitate delivery of machines at districts points.
- Close linkages of scientists and farmers with the private manufacturers including placement of machines in villages for farmer experimentation allowed rapid feedback and refinement of implements.
- Involvement of several manufacturers ensured competitive prices, good quality, easy access to drills by farmers along with guarantee for repairs and servicing.
- Strong support from State and Local government officials helped with dissemination.

Annexure 9

A case study on changing tillage and crop establishment methods in IGP

The rice-wheat system in the northwestern part of the Indo-Gangetic Plains is highly mechanized; the eastern system is largely labor-intensive.

Expansion and intensification of the rice-wheat sys-tem in South Asia during the Green Revolution (GR) led to increased production of critical cereal crops. However, further intensification of GR technologies in recent years has resulted in lower marginal returns and, at times, salinization, overexploitation of groundwater, physical and chemical deterioration of the soil, and pest problems. This case study describes early results of a sustainable agriculture program that is showing higher yields, lower water consumption, and other key benefits.

Introduction

In South Asia, Bangladesh, India, Nepal, and Pakistan have devoted nearly half of their total land area of 401.72 million ha to feed and provide livelihoods for 1.8 billion people.[1] Rice and wheat are the staple food crops and contribute more than 80% of the total cereal production in these countries. This system is fundamental to employment, income, and livelihoods for hundreds of millions of rural and urban poor of South Asia.[3]

Suitable thermal regimes for rice and wheat cultivation, development of short-duration nitrogen-responsive cultivars, expansion of irrigation, and the ever-increasing demand for food from rising

Fig. 2. Zero-till drill sowing wheat in the untilled rice fields. Inset: A close-up of the seeder

population were the driving force for increased production through area expansion and intensification of the rice-wheat system during the Green Revolution (GR) period starting in early 1960s. In the last few decades, high growth rates for food grain production (wheat 3.0%, rice 2.3%) in Rice-Wheat Consortium (RWC) countries have kept pace with population growth.

Over the years the rice-wheat system in the northwestern part of the Indo-Gangetic Plains (IGP) has become largely mechanized, input-intensive, and dependent on the conjunctive use of surface and groundwater. In contrast, the rice-wheat system of the eastern IGP has remained largely labour-intensive and less mechanized. Farmers use low inputs because of socio-economic constraints and serious problems of drainage congestion along with rainwater management. In all parts of the IGP farmers rely on tube-well irrigation.

Evidence is now appearing that further intensification of input use since the adoption of GR technologies has provided lower marginal returns,[4] and the continued intensification of cropping has sometimes caused degradation of the resource base in the form of salinization, overexploitation of groundwater, physical and chemical deterioration of the soil, and pest problems.[5] Consequently, there is now great concern about the potential for productivity growth in irrigated rice-wheat systems of the IGP and their sustainability over the long-term. Thus, the major challenge for South Asia countries is to continue to look for technological innovations, socio-economic adjustments, and policy reforms for sustained increases in productivity and production of the rice-wheat systems.

Objectives

Since the inception of the RWC, member countries have been involved in a large research program with the following objectives:

- Develop technologies for sustainable intensification and diversification of the rice-wheat system, including tillage and crop establishment options for growing rice and wheat in sequence in a systems perspective
- Assist with capacity building of the national research organizations
- Disseminate promising technologies for scale-up among different regions of the IGP
- Agro-ecological conditions

The IGP is a relatively homogeneous ecological region. However, based on physiography, bioclimate, and social factors, the region can be subdivided into five broad transects. The trans-Gangetic plains

Fig. 3A. Zero-till sown wheat after three weeks of seeding (This image shows the controlled traffic enabling movement of farm equipment in the (field)

Fig. 3B. A healthy wheat crop after five weeks of sowing. Stubbles can be clearly seen along side the crop

(regions 1 and 2) occupy large areas of east Punjab (Pakistan) and west Punjab and Haryana (India). Tran-sects 3 and 4 comprise the areas of the upper and middle Gangetic plains in western-central and eastern Uttar Pradesh, Bihar, and the Terai of Uttaranchal in India and Nepal. The lower parts of the IGP in West Bengal, India, and parts of Bangladesh constitute transect 5.[6] The soils vary from sandy alluvial in the west to alluvial clay and some heavy clay in the east.

The IGP has a continental monsoonal climate. In the northwest trans-Gangetic plains, the average annual precipitation ranges from 400 to 750 mm/yr and increases toward the Bay of Bengal. In the warm and humid transect 5, comprising parts of the lower Gangetic plains of West Bengal and Bangladesh, annual rainfall is as high as 1800 mm/yr. Nearly 85% of the total precipitation is received during the monsoon season from June to September. In winter months, only a few showers are received from December to February. The weather is cool and dry during the wheat-growing season (November to March). Rice is grown during the warm humid/sub-humid monsoon season (June to October).

Description of treatments and Technologies

Work was undertaken both on research stations and on farmer's fields. On-farm trials were either scientist or farmer managed. Participatory approaches were extensively used where farmers were encouraged to decide on treatments and to undertake trials, e.g., various till-age options, mulch management, and nitrogen management. Key treatments and sustainable agriculture technologies included:

Substitution of conventional tillage with zero or minimal-tillage for wheat in rice-wheat system.

Conventional system for establishment of wheat crop includes repeated ploughing (4-7), cultivating, planking, and pulverizing of topsoil. This has been substituted with direct drilling of wheat without land preparation using direct drills with inverted T-openers to place seed and fertilizers into a narrow slot. Weeds, if present, can be controlled with herbicides prior to drilling.

Wheat planting on raised beds. Over the last decade the bed-planting system has become very popular in irrigated high-yielding wheat growing areas of north-western Mexico.[7] This system is now being evaluated for suitability in the Asian subcontinent where two to three rows of wheat per bed have given better results than conventional planting.

Weed management in rice-wheat systems. Re-peated use of isoproturon over the last 16 years in India for the control of *Phalaris minor* in wheat has resulted in development of resistance to this herbicide.[8] To overcome this problem, rotation of herbicides (clodinafop, fenoxaprop, sulfosulfuron, tralkoxydim) and crops has been recommended. In addition, the zero tillage system has led to reduced weed population pressure in the short-term and when practised in conjunction with one of the newer herbicides, effective weed control is achieved at a much lower rate, especially when closer row spacing (15 cm in place of 22.5 cm) is adopted.

Nitrogen management in rice-wheat system. Efficiency of N use in the rice-wheat system, especially in rice, is low. Based on IRRI's research, LCC have been developed to help farmers select right dose and time of application for optimum response. Recommendations have also been developed for deep placement (8-10 cm) of prilled urea or USG, which improves N uptake, reduces N loss, and saves on fertilizer application rates by over 30%. Availability of zero-till drill makes it possible to simultaneously deep-place urea and plant rice or wheat in dry or relatively moist soils.

Key benefits/impacts

Impact on Production and Productivity Changes in yield of key crops. In Pakistan, 34 zero tillage trials conducted in farmer's fields over three years in the rice-growing belt of Pakistan (Punjab)

Table 1. Effects on grain yield of zero-tillage and farm-ers' practice for establishment of wheat after rice, Punjab, Pakistan, 1985-88[1]

Year	Number of locations	Grain yield (kg/ha)	
		Zero tillage	Farmers' practice
1985-86	15	3600a[2]	3516a
1986-87	13	3791a	3509b
1987-88	6	4279a	3560b
Pooled data 3 years	34	3890a	3528b

[1] Source: Aslam, M, A. Majid, N.I. Hashmi, and P.R. Hobbs. 1993. Improving wheat yields in the rice-wheat cropping system of the Punjab through zero-tillage. Pakistan J. Agric. Res. 14:8-11.

[2] Means between zero-till and farmers' practice followed by the same letter do not differ significantly at $P < 0.05$ using DMRT.

gave higher yields with zero tillage because it enabled more timely (earlier) planting (Table 1).

In Haryana, India, yields from zero tillage plots esti-mated based either on farmer survey or crop-cutting experiments (in farmers' fields) averaged over districts and sowing time, were 270 kg/ha higher than conventional tillage (wheat yield of 5380 and 5110 kg/ha for zero-till and conventional tillage respectively). This is attributed to earlier planting, fewer weeds, better plant stands, and improved fertilizer efficiency because of deeper placement with the seed drill.[9] In zero-till bed-planting system in Punjab, India, two or three rows of wheat planted per bed were compared to flat bed planting using conventional tillage. The three-row planting system gave higher yields in all cases (see Table 2).

Use of new herbicides, which are effective against *Phalaris minor*, is delivering yield improvement of up to 1000 kg/ha over the yield

Table 2. Effects of bed size configuration on wheat yield, Punjab Agricultural University, Ludhiana, India, 1994-95[1]

Variety	Sowing methods					
	On the flat	75-cm beds		90-cm beds		Mean
	25-cm row	2 rows	2+1 rows[2]	3 rows	3+1 rows[2]	
PBW 226	5740	6170	6390	6160	6320	6160a
WH542	6290	5830	6360	6000	6040	6110a
CPAN 3004	6020	5530	6140	5630	5600	5780b
PBW 154	5460	5110	6000	5930	5880	5680b
HD 2329	5770	4660	6190	5580	5810	5600b
PBW 34	5650	5610	5800	5580	5630	5650b
Mean	5820b[3]	5490c	6150a	5810b	5880b	—

[1] Source: Dhillon, S.S., P.R. Hobbs, and J.S. Samra. 2000. Investigations on bed planting system as an alternative tillage and crop establishment practice for improving wheat yields sustainably. *In* Proc. 15th Conf. Int. Tillage Res. Org., Fort Worth, Texas, USA, 2-7 July 2000.

[2] 2 + 1 and 3 + 1 mean that an extra row of wheat was planted at the bottom of the furrow.

[3] Means of varieties and sowing method followed by the same letter do not differ significantly at $P < 0.05$ using DMRT.

where isoproturon was used.

Changes in productivity. While Murgai et al. (2001) have presented evidence to show that total factor productivity (TFP) both in India and Pakistan has been slowing/declining during the post-Green Revolution period (1986/85-94), it is too early to determine impact of conservation agriculture practices in restoring or arresting TFP decline.

Cost comparison with control/conventional prac-tices. Net benefits in India and Pakistan average around US$ 150/ha. Contributory factors to cost savings include higher yields and reduced cost of cultivation (about half of that for conventional tillage). More information on cost comparison of zero tillage over conventional cultivation based on a survey of farmer's perception and research findings is summarized in Table 3.

Extent of uptake of technologies tested/ recom-mended. Over the last 3 to 4 years, farmers in IGP countries have rapidly adopted zero tillage for planting wheat after rice. It is estimated (by RWC) that over 200,000 ha were planted in 2001 and more than 5000 direct drills were in operation. A survey shows that even resource-poor small holders have started to benefit from this technology by using contractors to plant their fields.

{Mexico: Raised bed planting of wheat in association with zero or minimal-tillage increased from 6% of farmers surveyed in 1981 to 75% in 1994. These data were based on a sub sample of 52 growers who were taken from a pool of growers that has been studied intensively by CIMMYT Economics Unit over 10 years.}

Impact on Environment

The intensification of rice-wheat rotations has resulted in a heavy reliance on irrigation, increased fertilizer usage, and crop residue burning, which all have a direct effect on the variable that most affects global cl-mate change—emissions of greenhouse

Table 3. Benefits of zero tillage over conventional tillage for planting of wheat after rice in Haryana, India[1]

Item	Farmers' perceptions	Researchers' findings
Sowing	Wheat sowing earlier by 5-8 days (small-to-, medium farms) to 2 weeks (large farms)	On average, wheat sowing can be advanced by 5-15 days
Fuel savings	Not available	On average 60 L diesel per ha
Cost of cultivation	US$ 42-92 per ha	US$ 37-62 per ha
Plant population	20-30% more plants in zero-till fields	13.5% more plants in zero tillage fields
Weed infestation	20% less and weaker weeds in zero-till fields	43% less weeds in zero-till fields
Irrigation	Saves 30-50% water in the first irrigation and 15-20% in subsequent irrigations	36% less water used, on average
Rice stem borer infestation	Less, because of less stubble sprouting	Winter coolness impairs sprouting and thus borer development. Beneficial insects in stubble help control borers
Rice stubbles	Decayed faster	Decayed faster
Fertilizer-use efficiency	High	Higher because of placement
Wheat yields	Higher than under conventional system depending on days planted earlier	420-530 kg more per ha

[1] *Source:* Hobbs, P.R. and R. K. Gupta. 2003. Resource conserving technologies for wheat in rice-wheat systems. p. 149-172. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65, Madison, WI, USA.

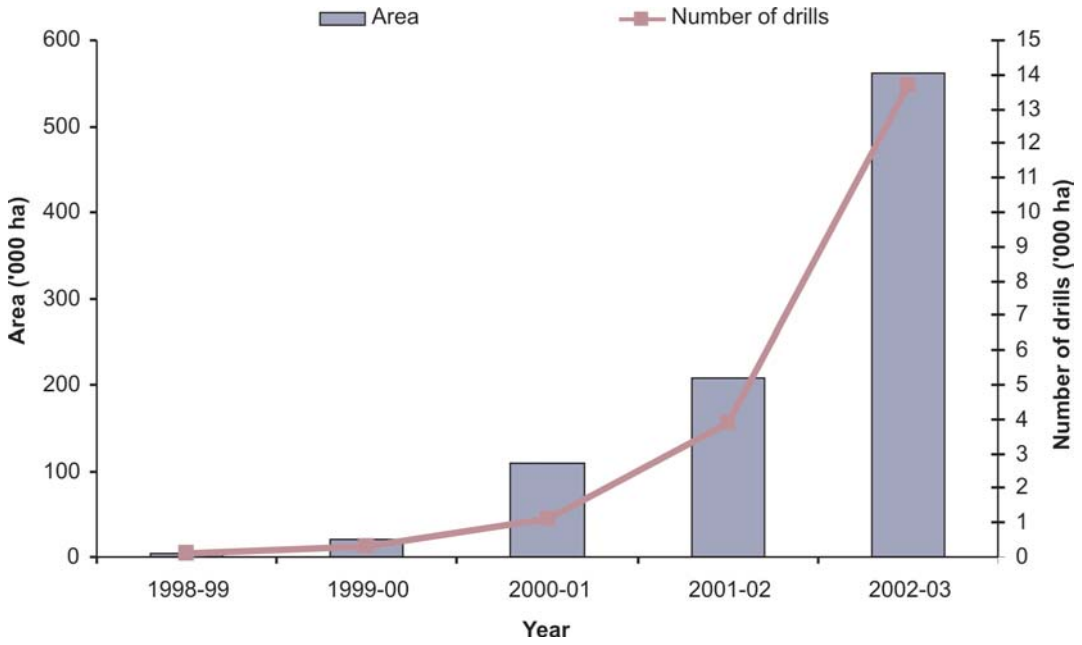

Fig. 4. Zero tillage wheat area in rice-wheat system: emerging trend in India and Pakistan.

(Source: Hobbs,P.R. and R.K. Gupta. 2003. Resource conserving technologies for wheat in rice-wheat systems. p. 149-172. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.) Improving the productivity and sustainability of rice-wheat systems: issues and impact. ASA Special Publication 65, Madison, WI, USA.)

gases. It has been estimated that the CO_2 equivalent emissions from a high-input conventionally tilled cropping system with residue burning and organic amendments would, equate to 8 Mg C or 29 Mg CO_2 per year if applied to 1 million ha of the Indo-Gangetic Plains. In a no-till/residue-retained system, with 50% of the recommended NPK application, the total emissions would equate to 3.7 Mg C, or 14 Mg CO_2 per year, an effective halving of emissions as we move from a high- to low-input system with improved nutrient use and environmental efficiency. The transition to intensified zero tillage systems, with recommended fertilizer levels, can be both productive and environmentally sound in a world that is rapidly becoming aware of the significant effects of global climate change in both the short and long term.

Early results indicate that 1 ha of wheat planted using zero tillage requires up to 1 million litre less irrigation water than the same crop grown under conventional tillage. Work is underway to determine the overall impact of farm-level savings on command level water demand.

Other key changes

One of the important areas of on-going research is the examination of genetic and management options to alleviate the major biotic and abiotic constraints for diversification of the rice-wheat system. Successful diversification would help to ameliorate the adverse effects of seasonality on family income and peak labour demands, reduce risk from fluctuating monsoonal patterns, save water trough planting of low-water demanding crops, and improve overall sustainability of the rice-wheat system. Early results have shown that harvest of short-duration rice provides opportunity for the diversification and intensification of the rice-wheat system with oilseeds, potato, peas, and other vegetables grown after rice harvest and before wheat planting. The raised-bed planting system with zero or minimal-tillage opens opportunities for

diversification of the rice-wheat system with pigeonpea, sugarcane, and maize. In addi-tion, in the eastern parts of the IGP where "rice fallows" cover an estimated area of 14.3 million ha, research had indicated that soil has enough soil moisture after harvest of rice to support legumes (lentil, chickpea, peas) and other crops with minimal-tillage/surface seeding.[11]

Sustainability and replicability would the economic and environmental changes brought about are sustainable? The shift to zero tillage and integrated approaches to pest and nutrient management results in more effective and efficient utili-zation of natural resources, especially land and water. Conservation/enhancement of the natural resource base is the key to sustainability of economic and environmental changes in the future.

What elements may be replicated elsewhere? Results show applicability of resource conservation and integrated technologies throughout the IGP countries and in other parts of the world with appropriate adjustments to suit the local conditions. The work on wheat planting on raised seedbed was first undertaken by CIMMYT in Mexico. This has now been successfully transferred to India and Pakistan. Similarly, Chinese scientists have adapted findings from work in South Asia to the rice-wheat system in China.

What would it take to scale up this experience?

- Adoption of participatory approaches and development of effective partnerships with national institutions, including those responsible for extension, NGOs, local governments, and farming communities, for location-specific research and technology transfer.
- Increased involvement of the private sector in de-velopment and transfer of input-based technologies (seeds, fertilizers, agro-chemicals, and machinery) that protect the natural resource base and respond to needs of farmers in all the socio-economic categories
- Greater attention by the public and the private institutions to stakeholder capacity-building and stewardship of sustainable crop and natural resource management practices
- Enabling policy environment for profitable farming, including access to national and international markets, and investment in rural infrastructure

Summary

Lessons Learned

It is important to focus on priority needs and timeliness of interventions. Solutions to complex problems threatening sustainability of the rice-wheat system ecology have to involve innovative technologies that are appropriate to the income endowments of farmers and meet the local bioclimatic and soil conditions. Development and dissemination of resource conservation technologies has been a timely intervention that addresses priority needs to reduce production costs, improve efficiency of natural resource management practices, benefit environment, and hold potential to improve livelihoods of farmers.

Strategic partnerships with all stakeholders in the agricultural system are necessary for success of new technologies. These include farmers, researchers (in International Agricultural Research Centres, Advance Research Institutes, and the National Research Systems), extension personnel, non-governmental agencies, and the private sector, including both the plant science industry and manufacturers of agricultural implements.

Wider adoption of conservation technologies would require concerted effort of all the stakeholders in the expanded partnership and participatory approaches in which farmers could experiment and provide rapid feedback. This would need to be supported by institutional changes that promote knowledge sharing, flexibility, and decentralized decision making for rapid adoption of technologies to maintain productivity, increase food production, and improve farmer livelihoods.

Most outstanding results/successes

- The most outstanding result has been the enthusiastic response of farming communities and rapid acceptance of these technologies, especially in the north-western transect.
- Another noteworthy success has been the close partnership with the private sector, especially with agricultural equipment manufacturers to modify/adapt direct drills in response to feedback provided by researchers and farmers. This was a significant contributing factor in the success of this program.

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Types of entities/stakeholders participating

- International Agricultural Research Centres (IRRI, CIMMYT)
- National Agricultural Research Organizations (NARS) of the Rice-Wheat Consortium (RWC)
- Farmers

Geographic location/country involved

India, Pakistan, Bangladesh and Nepal

Sources of funding

Donors, core budget of lARCs and NARS

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References

[1] FAO. 1999. FAO production book Vol. 53, FAO, Rome, Italy

[2] Timsina, J., and D.J. Connor .2001. The productivity and sustainability of rice-wheat production systems: Issues and challenges. Field Crops Res. J. 69: 93-132

[3] Gupta, R.K., A.K. Shukla, M. Ashraf, Z.U. Ahmed, R.K.P. Sinha, and P.R. Hobbs. 2002. Options for establishment of rice and issues constraining its productivity and sustainability in eastern Gangetic plains of Bihar, Nepal and Bangladesh. RWC Travelling Seminar Report Series 4, New Delhi, India

[4] Ladha, J.K., K.S. Fischer, M. Hossain, P.R. Hobbs, and B. Hardy (ed.) 2000. Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic plains: A synthesis of NARS-IRRI partnership research. IRRI Discussion Paper Series No. 40. IRRI, Los Banos, Philippines.

[5] Byerlee, D. 1992. Technical change, Productivity and Sustainability in Irrigated Cropping Systems of South Asia: Emerging issues in the post-green revolution era. J of Int. Dev. 4: 477-96; and Murgai, R, M. Ali and D Byerlee (2001). The World Bank Research Observer 16 (2):199-218.

[6] Fujisaka S., L. Harrington, and P. Hobbs. 1994. Rice-Wheat in South Asia: Systems and long-term priorities established through diagnostic research. Agricultural Systems 46:169-87.

[7] Meisner, C., E. Acevedo, D. Flores, K. Sayre, I. Oritz-Monaslerio, and D. Byerlee. 1992. Wheat production and grower practices in the Yaqui valley, Sonora, Mexico. Wheat Special Report No. 6, CIMMYT, Mexico; Sayre, KD and OH Moreno Ramos (1997). Application of raised bed planting systems to wheat. Wheat Program Special Report No. 31, CIMMYT, Mexico.

[8] Malik, R.K., G. Gill, and P.R. Hobbs. 1998. Herbicide resistance – a major issue for sustaining wheat productivity in rice-wheat cropping systems in the Indo-Gangetic Plains. RWC Paper Series 3, 36 pp., New Delhi, India.

[9] Singh S., A. Yadav, R.K. Malik, and H. Singh 2002. Long-term effects of zero tillage sowing technique on weed flora and productivity of wheat in rice-wheat cropping zones of Indo-gangetic plains. p. 155-157. *In* R.K. Malik (ed.) Herbicide resistance management and zero tillage in rice-wheat cropping system. Proc. Int. Workshop, Hissar, India, 4-6 March 2002, CCSHA, Hissar, India.

[10] Murgai, R., M. Ali, and D. Byerlee. 2001. Productivity growth and sustainability in post-green revolution agriculture: the case for the Indian and Pakistan Punjabs. World Bank Res. Observ. 16, 199-218.

[11] Grace P.R., M.C. Jain, L. Harrington, and G.P. Robertson. 2002. The long-term sustainability of the tropical and sub-tropical rice and wheat system: An environmental perspective. *In* J.K. Ladha, J. Hill, R.K. Gupta, J. Duxbury, and R.J. Buresh (ed.), Improving the productivity and sustainability of rice-wheat systems: Issues and impact. ASA Special Publication 65. Madison, WI, USA.

[12] Subbarao, G.V., J.D.V.K.K Rao, C. Johansen, U.K. Dev, I. Ahmed, M.V. Krishna Rao, L. Venkataraman, K.R. Hebber, M.V.S.R. Sai, and D. Harris. 2001. Spatial distribution and quantification of rice-fallows in South Asia: Potential for legumes. ICRISAT, Patancheru, India.

Annexure 10

Donor funding of special projects under rice-wheat cropping systems

Donor	Project Title	Countries participating	Duration of project	Total value of project ($)
1999				
DFID	Soil health and sustainability of the rice-wheat systems of the Indo Gangetic Plains	India, Nepal and Bangladesh	3 years (Apr 99-March 02)	465,600
DFID	Harnessing tillage by nutrient management interactions using participatory approaches to improve rice-wheat system productivity and sustainability	India, Nepal, Pakistan and Bangladesh	3 years (Apr 99-March 02)	479,200
2001				
ADB	Study on sustainability the rice-wheat production systems of Asia	India, Nepal, Pakistan and Bangladesh	3 years (Mar 01-Feb 04)	1,200,000
FAO	Database collection and development of concept note for funding RCTs	India, Nepal, Pakistan and Bangladesh	1 year	6,000
ACIAR	Drill modification for rice-wheat with straw retention	India	1 year	18,937
IFAD	Enhancing the rice-wheat system productivity in the more marginal areas of the Indo-Gangetic Plains: Building on a farmer innovation in water harvesting and efficient energy management	India and Nepal	1 year 8 months (Nov 01-July 03)	89,520
NZODA	Accelerating adoption of zero tillage in rice-wheat systems in the Indo-Gangetic Plains	Nepal and Pakistan	3 years (July 01-June 04)	300,000
NATP	Workshop and trainings for NATP sub research project: Accelerating the adoption of RCTs for farm level impact on sustainability of rice-wheat systems of IGP	India	2 years 8 months (April 01-Nov 03)	220,000
IACR-Rothamstead	ICM database	Bangladesh	2002-2003	14,400
2002				
APN	Climate variability and rice-wheat productivity in the Indo-Gangetic Plains		2002	40,000
2003				
DFID	Assessing the impact and facilitating the uptake of resource conserving technologies in the rice-wheat systems of the Indo-Gangetic Plains	India, Nepal, Pakistan and Bangladesh	3 years (Jan 03Sep 05)	480,000
IWMI	Assessing the impacts of wider adoption of zero tillage and other RCTs on farmer livelihoods in the irrigated plains of South Asia	India, Pakistan	2 years	165,000
TOTAL (1999-2004)				3,478,657

Annexure 10 continued.

Estimated investment pattern ($ 000) of donor funded projects by thematic themes

	Total fund	Tillage, crop establishment, diversification & machinery	Crop management & improvement	Knowledge management	Water management	HRD	Socio-economic research	Nutrient management
DFID Soil Health	465.60	395.00				70.00		
DFID GXT	479.20	200.00	135.00			144.00		
DFID-CABI	480.00			320.00		60.00	100.00	
ACIAR	18.94	12.44				6.50		
IFAD	89.50				89.50			
NATP	220.00					220.00		
IACR	14.40			14.40				
NZODA	300.00	200.00		79.00		21.00		
APN	40.00			40.00				
CWA	165.00						165.00	
ADB	1,200.00	185.30	185.30	234.50	240.00	208.00		146.30
IRRI (Excludes staff salaries)	71.00							71.00
TOTAL	3,543.64	992.74	320.30	687.90	329.50	729.50	265.00	217.30

Annexure 11

Matrix of RWC's current research activities along with priorities

Thematic areas	Activities within thematic areas	Priority		
		Low	Medium	High
1. Tillage and crop establishment	1. Technology targeting (surface seeding, zero tillage, reduced tillage, rotavator drill, bed planting system etc.)			H
	2. Residue management (Retention, incorporations, microbial decompositions, animal fodders)			H
	3. Machinery development & improvement (4-Wheel & 2-wheel tractors, animal drawn machine, sprayers/ Nozzles, Laser land leveling machines, hoes, attachments. USG machines, applicators, rotavator, multi-utility seeders, water pumps, clay pipe tubewells)			H
2. Crop improvement and management	4. Germplasm screening and GxE,GxT interactions, cultivar choices	M		
	5. Legumes in RW systems			H
	6. System diversification and intensification, intercrops			H
	7. Modeling and climate change		M	
	8. Seed quality, priming and storage	L		
3. Integrated weed, pest and disease management	9. Crop protection – IPM, IDM		M	
	10. Weed management,			H
4. Nutrient management	11. Site specific nutrient management			H
	12. SOM dynamics, C sequestration, long term fertilizer trials, nutrient enrichments,			H
5. Water management	13. Water use efficiency, land leveling, rainwater use			H
	14. Water productivity (field , farm and system level)		M	
	15. Water quality, salinity/sodicity issues, nitrate pollution monitoring	L		
6. Knowledge management	16. GIS/ country almanacs,		M	
	17. Database management- RWC-PRISM, RWIS and webpage			H
	18. RWC Paper Series and other publications			H
	19. RWC annual meetings in regional and international research fora		M	
	20. Multi-stake holder meeting- traveling seminars, workshops & conferences		M	
	21. Technology generation, adaptive and adoptive research in farmer participatory mode			H
7. Socio-economics	22. Impact analysis		M	
	23. Policy issues	L		
	24. PR&GA	L		
	25. Community group working/ farmer groups/ manufacturer groups		M	
8. Human resources development and capacity building	26. Specialized trainings in advanced institutions for scientists and farmers		M	