Rice research in the DFID RNRRS programmes

Lessons learnt and implications for future research

February 2006

Barbara Adolph and Tim Chancellor

Natural Resources Institute, University of Greenwich, Central Avenue, Chatham Maritime, Kent ME4 4TB, United Kingdom

Contents

Table of Annexes

Acronyms

BRKB	Bangladesh Rice Knowledge Bank
BRRI	Bangladesh Rice Research Institute
CGIAR	Consultative Group on International Agricultural Research
CPP	Crop Protection Programme (of DFID)
CPHP	Crop Post-harvest Programme (of DFID)
CRIDA	Central Research Institute for Dryland Agriculture
DEFRA	Department of Environment, Food and Rural Affairs
DFID	Department for International Development
DNA	Deoxyribonucleic acid
DONATA	Dissemination of New Agricultural Technologies for Africa
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária
ICAR	Indian Council for Agricultural Research
ICT	Information and Communications Technology
IPM	Integrated Pest Management
IRRI	International Rice Research Institute
NARES	National Agricultural Research and Extension Systems
NERICA	New Rice for Africa
NGO	Non-government Organisation
NRSP	Natural Resources Systems Programme (of DFID)
PETRRA	Poverty Elimination Through Rice Research Assistance
PPB	Participatory Plant Breeding
PSP	Plant Sciences Programme (of DFID)
PVS	Participatory Variety Selection
RNRRS	Renewable Natural Resources Research Strategy (of DFID)
ROCARIZ	West and Central Africa Rice Research and Development Network
WARDA	Africa Rice Centre

Executive summary

This study documents lessons from research on rice-based production systems that was funded by the United Kingdom's Department for International Development (DFID) through its Renewable Natural Resources Research Strategy (RNRRS) which spanned an eleven year period from 1995-2006. The report considers both the research process and the development and uptake of research outputs and discusses the implications of the findings for future research programmes. It highlights the importance of rice as a food crop and for income and employment generation in developing countries. The global demand for rice continues to increase rapidly, especially in sub-Saharan Africa (SSA) which imports a large proportion of its rice from the United States of America and Asia.

Continuing increases in both production and productivity will be needed to meet this growing demand. The main constraints to increased production in the rice sector are a shortage of water and arable land; pests, diseases, and weeds; the availability of suitable varieties for diverse environments (including low potential areas); rising production costs, low quality of locally processed rice in SSA, and inefficient markets for inputs and produce.

This study focuses on research conducted since 2001 by the Crop Post-Harvest, Crop Protection, Natural Resources Systems and Plant Sciences programmes. Following the 1997 UK government White Paper on Development and the adoption of the Millennium Development Goals in 2000, the RNRRS placed more emphasis on the promotion and uptake of new knowledge to improve the livelihoods of poor people. The research Programmes responded to this change by allocating a greater share of their resources to the promotion of technologies and to influencing policies, albeit with reductions in their overall budgets. The Programmes also adopted more participatory demand-led approaches to identify and prioritise production and post-harvest constraints. However, there was little coordination between the research Programmes, either in the identification of research priorities or in the promotion of research outputs. As a result, the potential to generate synergies from cross-programme activities was not fully exploited. Future research Programmes should include mechanisms to better integrate rice-related research initiatives and to explore opportunities for links with non-agricultural sectors; particularly, with the health sector on issues such as nutrition and vector-borne diseases.

Individual Programmes adopted different approaches to partnerships. Whilst some worked primarily through research centres in the Consultative Group on International Agricultural Research (CGIAR) and the National Agricultural Research and Extension Systems (NARES), others preferred to develop their own networks and coalitions. Each of these has advantages and disadvantages, and choices need to be tailored to the specific requirements of the research area. However, some generic factors supporting and hindering partnerships can be identified and are discussed in this report.

Research outputs produced by the research Programmes were categorised as follows:

- technologies and approaches to reduce the 'yield gap' between actual and potential production, such as

    - improved water and nutrient management combined with weed control;
    - improved support services to farmers (advice, credit, inputs, farmer organisations);
    - breeding for increased yield and for resistance to biotic and abiotic constraints, using transgenic methods, Participatory Plant Breeding and Participatory Varietal Selection, aided by pathogen characterisation;
    - managing risk and enhancing food security (for example, through control of the rice hispa beetle);
- ways of increasing income earning opportunities through
    - increase in total system productivity (short duration varieties, direct seeding, chickpea seed priming);
    - rodent management (community action);
- addressing rice quality constraints (improved parboiling and milling processes);
- enhanced environmental benefits (soil fertility management, Integrated Pest Management, safe use of herbicides, biodiversity in rice-based cropping systems);
- capacity development (human and physical resources, but also development of organisational systems / attitudes)
- resulting from all the above, published and unpublished research reports, journal articles, conference contributions and extension materials.

The potential for several new technologies to have impact at the farmer level was convincingly demonstrated in on-farm trials. However, the scope for uptake was constrained by the fact that research outputs were generally promoted by individual projects, in the absence of programme-wide or cross-programme uptake strategies. As fewer funds were available during the uptake phase, there was little scope to commission impact assessment studies, or research that would explore strategic opportunities for uptake. DFID country programmes provided few opportunities for uptake, possibly because of a lack of awareness of the potential of some of the research outputs. Linkages to CGIAR centres such as the International Rice Research Institute (IRRI) and the Africa Rice Centre, and to national research organisations such as the Indian Council for Agricultural Research and the Bangladesh Rice Research Institute (BRRI) were useful, but had to rely on the quality of networks, partnerships and demand assessment mechanisms available to these. In some cases research programmes were able to have an impact on NARS strategies and induce institutional changes. For example, the Plant Sciences Research Programme (PSP) that promoted client-oriented breeding (COB) and participatory variety selection (PVS).

Working with private sector organisations enabled some projects to scale up and reach a large number of potential users of the technology; the most prominent example being the participation by Syngenta-Bangladesh in the rice stem borer pheromone project in Bangladesh. Such partnerships make it possible to utilise relatively small amounts of funding to leverage significantly larger resources available to private companies to jointly develop and promote new technologies. In the case of the rice stemborer research, Syngenta-Bangladesh benefited from the specialist technical inputs of the other research partners in areas which it lacked expertise.

Few projects assessed their impact on farmers directly, as the project duration was generally too short to expect large scale adoption of technologies. Most projects did not have Monitoring and Evaluation frameworks to assess impact on intermediate or end users of knowledge and technologies, but there is evidence that some of the earlier projects achieved impact 5-10 years after the original work was done; for example, research on soil organic matter indicators and rice tungro disease management. Impact on the capacity or approaches of organisations, in particular of NARES, is an important intangible outcome of research projects that is rarely documented and should be addressed in future research programmes. There are examples from the RNRRS rice research in which such impact was achieved and these are discussed in the report. Promotion of outputs through knowledge repositories such as the 'Knowledge banks' maintained by the International Rice Research Institute and BRRI could well be a useful strategy, but currently few RNRRS projects are included in these.

There are several research areas in rice-based systems where future DFID research can make an impact on poverty reduction and in stimulating economic growth. There is good potential to scale up promising outputs from the RNRRS and to add value to other initiatives such as Dissemination of New Agricultural Technologies for Africa project of the New Partnership for African Development. There are also emerging research areas where DFID research can make a distinctive contribution, but it will be important to ensure that the relatively limited funds available are used to add value and to leverage additional resources most effectively.

Introduction

This study has been commissioned to synthesise lessons learnt from rice research funded by relevant research programmes under the Renewable Natural Resources Research Strategy (RNRRS) of the Department for International Development (DFID). It focuses on research undertaken from 2001 onwards, but reference is also made to earlier research where this is considered to contribute to a fuller understanding of the issues discussed; for example, where project teams have built on work done by earlier projects.

The main purpose of the study is to document lessons from the research process, and from the development and uptake of research outputs, and to relate these to the needs of future DFID research. This reflection should be used to provide evidence-based recommendations of further researchable constraints which will lead to poverty elimination. The Terms of Reference (ToR) for this study are shown in Annex 1.

Two methods were used to gather the information for this report:

(1) a review of project and programme documents, and of relevant publications, and discussions with programme managers and advisers and

(2) consultations in West Africa, South Asia and the United Kingdom with scientists and other stakeholders involved in the research. These consultations included stakeholder workshops in Benin, Bangladesh and the United Kingdom and summaries of the workshop findings are provided in Annexes 3-5. In addition, separate discussions were held in Bangladesh, India and Benin with representatives of national agricultural research institutes (NARIs); non-government organisations (NGOs); private companies; national agricultural extension services and other government agencies; rice farmers[1].

The study was commissioned by DFID through the Crop Protection Programme (CPP) and, in accordance with the ToR focuses on rice research managed by the Plant Sciences (PSP), Crop Protection and Crop Post-Harvest (CPHP) programmes and, where appropriate, examines linkages between these programmes. Although not specified in the ToR, the study also reviews relevant research commissioned through the Natural Resources Systems programme (NRSP). A list of research projects with a focus on rice is shown in Annex 2). In view of the time constraints it was not possible to examine each of these projects in detail. Guidance was provided by research programme managers and advisors on projects that were likely to be of particular interest for the study.

This study is one of a series of cross-programme lesson-learning studies commissioned by DFID through the RNRRS programmes and is one of only two with a specific commodity focus[2]. Rice has a number of important and particular characteristics. The crop provides the staple diet for the majority of the world's poorest people (Cantrell & Hettel 2004: 76) and much of it grows in a specialised ecological environment in which it dominates the agricultural production system. There is a renewed awareness of the potential for rice and other major staple crops to

[1] Interaction with rice farmers was through field visits to RNRRS project sites in Uttaranchal state in India and Bogra district in Bangladesh.

[2] A lesson learning study on roots and tubers was also commissioned by DFID.

have a major impact on poverty and to help achieve the Millennium Development Goals, particularly in Sub-Saharan Africa (ASARECA, 2005). Furthermore, the importance of rice as a world trade commodity means that rice production and consumption are influenced by world trade patterns and trends. The unique role played by rice for food security and poverty alleviation was acknowledged by the United Nations when it designated 2004 as the International Year of Rice. This follows an earlier designation in 1966 and rice remains the only food crop to have been recognised in this way. Rice research has a significant contribution to make towards achieving food security and poverty reduction.

Much of the internationally-funded research on rice for developing countries has focussed on varietal improvement. A recent study on the impacts of such research in India and China shows that it accounted for 14% to 24% of the total production value over the last two decades in each of these countries (Fan *et al*., 2005). In the same study, an analysis of the returns on investment in rice research at the International Rice Research Institute (IRRI) indicated that for every US$1 invested more than 800 and 15,000 rural poor were lifted above the poverty line in China and India, respectively.

This paper first outlines the livelihood context of rice-producing farmers in South Asia and sub-Saharan Africa (these being the focus areas of RNRRS), and then summarises the main constraints in rice-based farming systems. This is followed by an analysis of the research process – including the identification of research priorities and the development of partnerships. The subsequent section analyses the main outcomes emerging from the research programmes, and their promotion and uptake. The final section summarises emerging research priorities and recommendations.

Livelihood context

Rice and food security

Rice is the staple food for more than half of the world's population and is the main food source for seventeen countries in Asia and the Pacific and for eight in Africa (FAO, 2005). Within individual countries, there are key rice production areas which make a crucial contribution to national food security. For example, in India 40% of grain production comes from the rice-wheat system which occupies 13.5 million ha of the Indo-Gangetic Plains. In Africa, a large proportion of the rice production is in Nigeria and Madagascar, who produce together over 50% of the rice produced in sub-Saharan Africa in 2004 (WARDA 2005: 15).

The total area of rice cultivated, and the overall production of harvested grain is much higher in South Asia than in sub-Saharan Africa (Figures 1 and 2). However, the amount of rice consumed is increasing more rapidly in sub-Saharan Africa and, unlike in Asia, the area harvested has also continued to increase during the past decade. A key issue for countries in sub-Saharan Africa is their extremely low productivity. The large difference in average yields between South Asia and sub-Saharan Africa is illustrated in Figure 3. Africa has not yet achieved the rapid growth in productivity seen in South Asia from the mid-1970's following the introduction of high-yielding varieties grown with inorganic fertiliser under irrigation. The bulk of rice produced in

sub-Saharan Africa is grown under rainfed conditions, where average yields range from 1 to 2 t ha^{-1}. By contrast, mean yields in irrigated rice production ranges from 3 to 9 t ha^{-1}.

Only 4-6% of global rice production is traded on the world market and the total volume of exports has reduced each year between 2001 and 2004 (FAO, 2005). However, as already noted the demand for rice is increasing globally, especially in Africa which imports almost as much as it produces. In 2002, for example, countries in West Africa produced on average only 39% of their requirements forcing them to spend a substantial proportion of their foreign exchange on rice imports. Rice markets are still heavily protected in many countries but there has been a trend towards increased liberalisation during the past decade. This provides opportunities for countries with low production costs but poses a challenge for small developing countries with relatively inefficient rice sectors. In Africa, the availability of imported rice has not led to cheaper rice for consumers. By contrast, in much of Asia, rice is now cheaper to buy in real terms than it was in the early 1980's. At that time, one day's wages for an agricultural worker in Bangladesh bought 2.3 kg of rice. By the early 2000's this figure had risen to 4.5 kg. This has brought tremendous benefits to poor people, who tend to spend about half of their income on food.

Rice and nutrition

In Asia, it has been estimated that 2 billion people receive 60-70% of the calories in their daily diet from rice. In Sub-Saharan Africa, less rice is consumed, but still provided on average 8% of the total calorie intake in 2002 (WARDA 2005: 32). The proportion is much higher in some countries – for example Madagascar (49%), Guinea Bissau (41%) and Sierra Leone (37%). Despite increases in rice prices, consumption continues to increase in most African countries, in particular in urban areas.[3] Some rice varieties contain relatively high amounts of micro-nutrients such as iron and zinc and these are now being utilized in rice breeding programmes. However, the standard process of milling removes a large amount of the available nutrients.

Rice and income generation

Employment in rice production and associated post-harvest activities is provided for *c*. 1 billion people worldwide. Although much of the production of rice is done using family labour, seasonal labour is very important for key operations such as transplanting, weeding and harvesting. In addition, post-harvest operations employ a large number of people in both rural and urban areas – often women. In many African countries rice is mostly a cash crop, grown to supply a household with the income

[3] While consumer prices for rice have remained relatively stable in South Asia, there has been an increase in Africa. The consumer price index (CPI) for most West African countries (see WARDA 2000: 16) has increased substantially over the past 5 years – an indicator for increased rice prices, as the official price of rice contributes to determining the CPI.

required to pay school and medical fees, while family members consume other food crops such as cassava, millet or sweet potato.

Figure 1 Rice production, consumption, and area harvested Sub-Saharan Africa

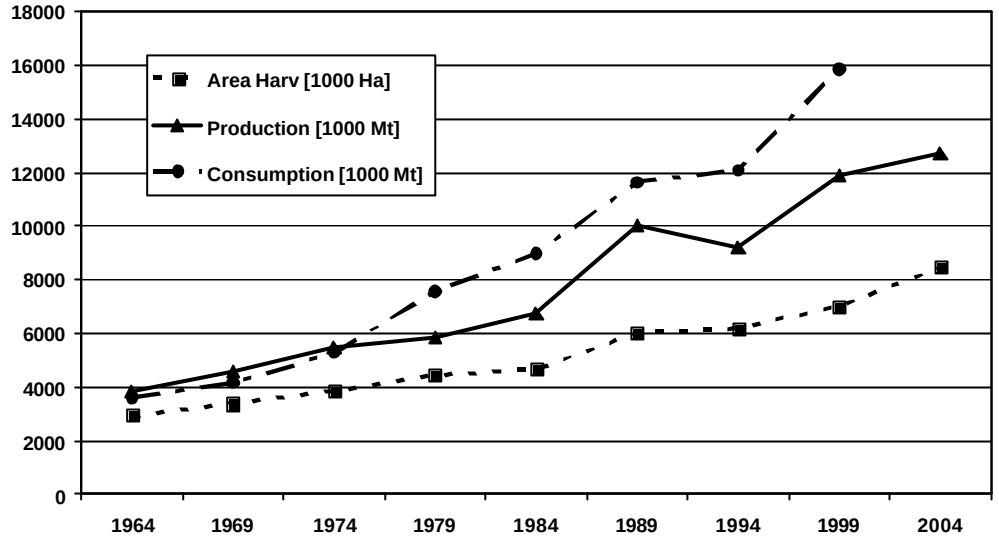


Figure 2 Rice production, consumption, and area harvested, South Asia

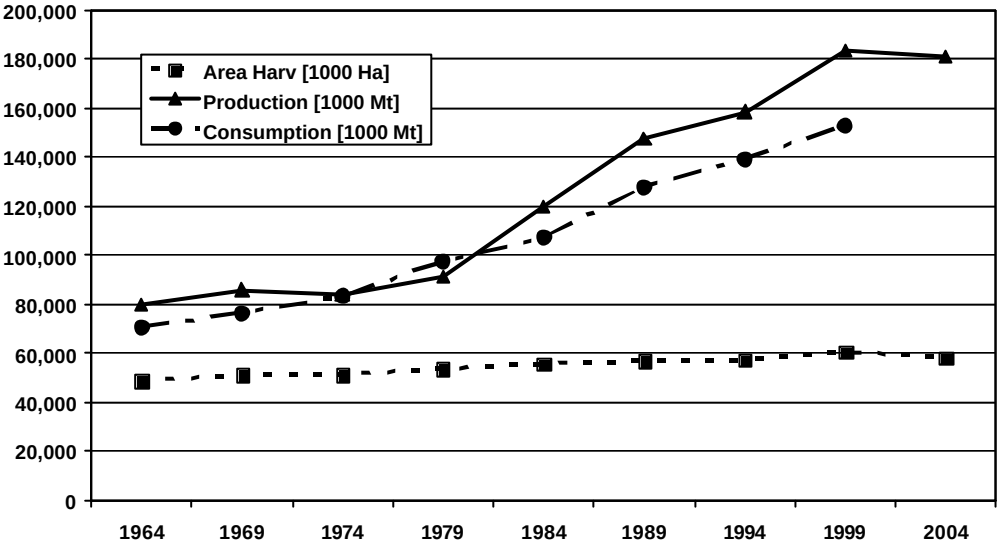
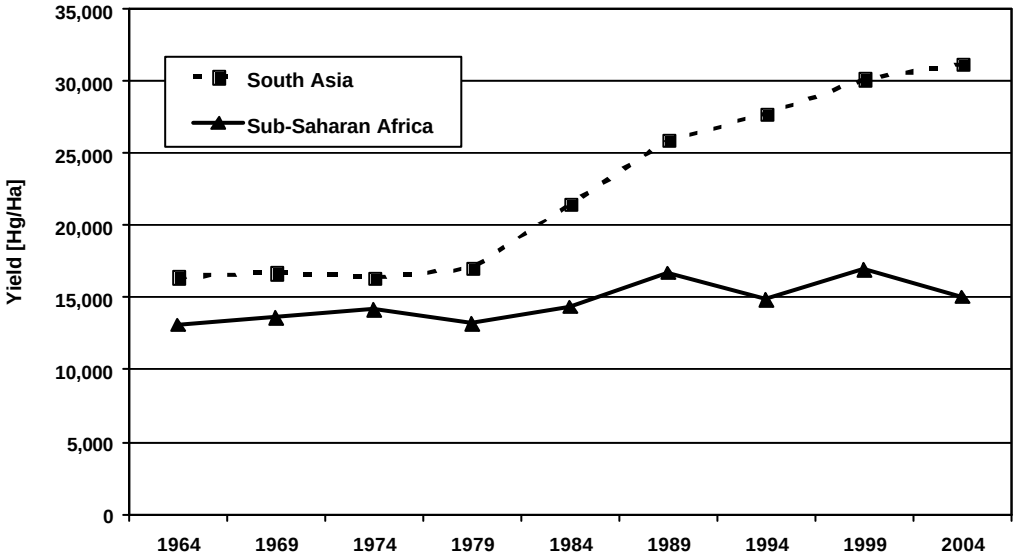


Figure 3 Rice yield, South Asia and Sub-Saharan Africa



Source of data: FAOSTAT 2005

Rice and biodiversity

Rice–based systems include much of the biodiversity of plants, insects and other organisms in large areas of Asia. Insect pest management depends to a large extent on predation and parasitism by natural enemies that are present in these ecosystems. By-products of rice-based ecosystems are particularly important in Asia (Settle *et al*., 1996). Landless people can supplement their diet, and gain additional income, from fish, snails, frogs and other aquatic organisms. Rice straw is an important source of fodder for livestock in some Asian countries; for example, in India. Rice straw is also used for thatching and for fuel, although it is usually burned in many areas.

Constraints in rice-based farming systems

Rice production, processing and marketing in the context of smallholder farming in South Asia and Sub-Saharan Africa faces a multitude of constraints. The following is intended to provide an overview of the major constraints, rather than a comprehensive analysis of the sector.

Soil and water management

Rice can be grown on a wide range of soil types, although water retention is better on heavier soils (De Datta, 1981). The key bio-physical constraints are the availability of water and nutrients and, in some lowland areas, lack of adequate drainage is also a major problem. In order to fulfil their potential, high-yielding modern rice varieties need good water management and an adequate supply of nutrients, particularly nitrogen. In less favourable production environments, which are solely dependent on rainfall, adequate moisture is especially important at crop establishment and during grain-fill. In these systems, water cannot be used to aid weed suppression and weeds must be managed by other means. In rainfed areas there is considerable scope to intensify system productivity by cultivating a short duration crop on residual moisture following rice. This would result in considerably enhanced incomes for resource-poor farmers. Overall the scarcity of water and land is perhaps the biggest challenge to increasing rice production worldwide.

Pests, diseases and weeds

Pests and diseases can cause significant yield loss in rice crops and successful control is crucial to farmers' ability to produce rice profitably. Pest and disease incidence and damage vary widely according to location and season so that knowledge of pest ecology and disease dynamics is therefore necessary to allow farmers to take appropriate action to manage their rice crops effectively. Communicating such knowledge to rice farmers has formed the basis for successful integrated pest management (IPM) programmes implemented in countries such as Indonesia (Matteson, 1996). However, to date IPM has only reached a small minority of rice farmers in developing countries. Moreover, the control of diseases such as rice blast and sheath blight remains difficult to achieve and the management of diseases and other pests such as rodents has not been integrated into IPM programmes. In Africa,

it is anticipated that intensification of rice production will lead to an increase in the significance of diseases, particularly the fungal disease rice blast, as production constraints (Defoer *et al*., 2004). Fungicide application is almost non-existent in most of the African rice-based farming systems, and therefore varietal resistance is considered to be the most effective way of combating the disease.

Most insect pests or diseases cause damage and yield loss in fairly specific environments. By contrast, if they are not controlled weeds cause significant losses in all rice-growing environments although these are particularly severe in rainfed and upland systems (Johnson, 1997). Weeding is often delayed or inadequate due to seasonal labour shortages, while women's responsibility and involvement in weeding imposes an additional burden. With the exception of the high potential irrigated lowland rice systems in Asia, smallholder crop producers have not benefited from the revolution in weed control provided by herbicides to high-input systems around the world (Moody, 1993).

Availability of suitable varieties and associated technologies

Developing varieties that meet farmers' quality requirements, are resistant to pests, diseases, and can tolerate abiotic stresses is a major challenge. Tremendous advances have been made in rice varietal improvement in recent decades and the yield potential of the crop in irrigated systems has increased by an average of 1% per year since the first improved variety (IR8) was developed in the mid 1960's (Peng *et al*., 2000). Nevertheless, it remains true that most of the yield gains have been achieved in the high potential systems. New varieties are needed that perform under constantly changing farming systems and environments; for example, in drought-prone environments. Furthermore, new improved varieties need to reach the smallholder farmers – a process that can take years. Inefficient and under-resourced agricultural extension services and an underdeveloped private sector for seed multiplication and sale are in many countries preventing farmers from benefiting from improved varieties and associated technologies such as soil and water management, control of pests and diseases, and improved processing and marketing.

Rising production costs

Many improved production technologies require additional inputs such as labour, agro-chemicals or improved seed. Whilst in Asia, the price for rice has remained low over the past decades, production costs have increased. This is partly due to the removal of input subsidies, but also to competing demands for labour, especially in peri-urban areas where industries such as brick-making and garment-making attract rural workers. This forces up the price of agricultural labour and shortages exists at key points in the production cycle; for example, harvesting and transplanting.

Rice quality and marketing

Rice quality is a key factor in determining returns to producers. Consumers often prefer imported rice because locally produced and processed rice is of variable quality and not competitive with imported milled rice. For example, in Ghana the local parboiling process is time-consuming, laborious and utilises large quantities of firewood and water. Milling technology is another bottleneck, with poor quality mills resulting in a large proportion of broken grain. In the past it has been argued that research into rice processing in West Africa should have priority over production-

related research, because there was no market for low quality rice. However, considering the steep increase in demand for rice in the region, a balanced approach to research that addresses both production and post-harvest constraints appears most appropriate.

Analysis of the research process

Identification of research priorities under the RNRRS

During the life span of the RNRRS, the focus of the strategy shifted, triggering a shift in the types of partnerships and approaches used by research programmes. During the initial phase of the RNRRS, there was a particular focus on characterising researchable constraints and in conducting strategic research to gain a clearer understanding of the problems being addressed. The resulting knowledge was designed to lay the basis for the development of more applied research that would evaluate potential solutions to these problems. Finally, there was a move towards a promotional phase, in which outputs from successful projects were actively disseminated through a variety of mechanisms, including the use of a wide range of media tools. Thus, the RNRRS followed a somewhat linear approach, with little basic or strategic research being undertaken by most research Programmes during the second half of the strategy[4]. This tendency was reinforced by the increased pressure placed on programmes to demonstrate impact at the farmer level, while at the same time operating with decreasing financial resources. The expectations of what the programmes would deliver in terms of impact on the end user of the research changed significantly during the strategy. This probably reflected the more overt poverty focus adopted by DFID following the publication of the 1997 government White Paper on Eliminating World Poverty.

Priority setting by individual programmes had to be carried out within the overall framework provided by the RNRRS; or 'yellow brick' as it came to be known, due to the size of the document and the colour of its cover. The 'yellow brick' provided guidance on researchable areas on which to focus and defined programme goals and purposes. A hierarchical logical framework system was used to create a unified structure for planning and management and to attempt to ensure that the research was demand-led. Whilst this approach had advantages in ensuring that programmatic purposes and outputs were aligned with those of the RNRRS, the system was quite rigid and there was no formal mechanism for reviewing it. Contributions to the on-line consultation for DFID's Science and Innovation Strategy in 2005 (http://www.dfid.gov.uk/consultations/summary-sis-3.pdf) suggested that one-off priority setting exercises such as that used in the RNRRS should be replaced by continuous assessment of the needs of the poor, identifying gaps in present knowledge.

In practice, RNRRS programmes were able to develop more flexible approaches to identifying research priorities in response to emerging needs. Initially, all programmes were encouraged to use a framework based on production systems in order to identify

[4] An exception was the Plant Sciences Programme which continued to manage a portfolio of strategic and applied research projects.

researchable constraints. Some programmes, such as the PSP, subsequently moved away from this framework because it was not considered to be the most appropriate for their needs. The PSP adopted a theme-based system of research management in which the themes were defined by the technical approach utilised; for example, molecular marker technology or participatory technology development (Stirling *et al*., 2006). PSP research was focused on West Africa and South Asia and was primarily designed to increase productivity for resource-poor farmers in marginal upland environments. The Programme commissioned a series of studies to assess demand for research on several crops, including rice. This rice study identified drought tolerance as a key researchable constraint (Craufurd, 1997).

Other programmes, including the NRSP and the CPP, retained a production systems focus. However, they placed their research within the wider context of rice-based farming systems rather than taking a narrower commodity-based approach. In the case of the CPP, programme development studies revealed that the researchable constraints for rice in Asia were actually greater in the high potential system than in the land-water interface which was the research focus identified in the 'yellow brick'. Consequently, the research effort was re-directed to address the problems in the high potential production system. Research on rice-based cropping systems funded through the CPP was conducted predominantly in South Asia and West Africa, with a small number of projects located in East Africa. Researchable constraints that were identified through programme development studies in the target countries were validated through workshops or meetings with scientists from the respective regions and from the UK. Thus, a workshop was held in Bangladesh in 1999 at which representation was particularly strong from the government-funded Bangladesh Rice Research Institute. In this way it was anticipated that researchable issues that emerged would be aligned with national priorities.

The Crop Post-Harvest Programme (CPHP) initially developed research priorities in relation to production systems and commodities. Participatory needs assessments were undertaken and priority research areas were assessed against national agricultural research strategies. Five livelihood themes were addressed, namely market access, processing, storage, food safety, and institutional arrangements for technical innovation. However, in 2002 the CPHP adopted a new strategy that focuses on supporting national and international crop-post harvest innovation systems to respond more effectively to the needs of the poor. The strategy uses a "coalition approach" to project design and management, which is implemented via four Regional Offices that have a considerable autonomy in deciding on funding priorities in their respective region. The focus of the programme also shifted from technology development to uptake, with the aim of maximising returns to research investments, and with an emphasis on joint ownership, flexibility and institutional learning. As a result of the decentralised nature of the programme, priorities were increasingly determined regionally.

In the case of research conducted in Bangladesh, there was an interesting contrast between the approaches taken by RNRRS programmes and those used by a DFID-funded bilateral project entitled Poverty Elimination Through Rice Research Assistance (PETRRA). Researchable issues commissioned by PETRRA were identified through stakeholder exercises conducted at the local level in target zones. Thus the priorities which emerged did not necessarily accord with those identified at a

national level. Whilst there were advantages to this approach, in that research efforts were focussed on local issues identified primarily by farmers, there was less scope for scaling up the research outputs over larger areas.

Some programmes focused on only a small number of research topics and commissioned several projects or larger projects on these topics. For example, the CPP addressed a wide range of constraints through a series of separate projects. There were few formal linkages among projects, although rice 'cluster' meetings were held periodically which involved project leaders and other key project staff. By contrast, the PSP focussed on a more specific set of issues and channelled resources to linked groups of projects. A disadvantage of the distinctive approaches developed by individual programmes was the absence of mechanisms to capture synergies among them. In some instances there was a degree of coordination among programmes in identifying priority areas of research; for example, the NRSP and CPP conducted a joint programme development study in Bangladesh which led to linked projects on soil fertility and insect pest management. However, there were few other examples of cross-programme collaboration and this meant that the potential for promoting the uptake of certain technologies was not fully realised. As programmes worked with different research partners and sometimes operated in different countries, it was difficult to develop packages of crop management options that could be promoted in particular locations.

In conclusion, whilst RNRRS programmes used participatory approaches to identify and prioritise production and post-harvest constraints these processes involved mostly researchers from national research organisations. However, there has been a visible trend towards wider partnerships and a more participatory, demand-led approach, including stakeholder workshops. Considering the limited time and resources available for programme development, the process used might well be the best value for money. However, inter-programme coordination could have been improved to arrive at a portfolio of complementary outputs.

Stakeholder involvement and partnerships

Looking at the type and range of stakeholders involved during the different stages of a research project can give valuable insights into decision-making processes and prioritisation. Partnerships exist between those immediately involved in the project as project partners, but can also extend to linkages with a wider range of organisations that influence project outcomes.

Types of stakeholder involvement and partnerships

Research projects involve and affect stakeholders in multiple ways. Consultations take place with stakeholders at the project design stage to incorporate their views, suggestions and needs. Stakeholders are then involved in the conduct of the research itself and in the promotion and dissemination of the research outputs. It is often difficult in retrospect to assess how widely consultations with stakeholders were held before the start of the project, and how effective communication was during the project implementation, as these aspects are generally not documented. Project documents usually only report on the roles and responsibilities of research partners.

However, some indication of how partnerships operated in RNRRS rice projects was gained from discussions with project staff.

Most project teams were to some extent interdisciplinary, including both biophysical and socioeconomic researchers. Whilst generally project teams were self-selected as a result of negotiations during the project proposal development, in some instances partnerships were imposed directly or indirectly. In the former case, programme management sometimes required organisations submitting competing proposals to combine their proposals into one. Indirect selection resulted from the central role played by particular organisations in the region or country. For example, the Bangladesh Rice Research Institute was regarded as an essential partner for several research issues addressed. Imposed partnerships can be very successful, but require goodwill and willingness to compromise from all sides.

As the RNRRS progressed, partnerships moved from involving mostly or exclusively research organisations to include "non-traditional research partners" such as NGOs, civil society organisations and the private sector. For example, the CPHP projects R7531 and R8263 on milling quality in Ghana involved not only researchers, but millers and manufacturers of mills, as well as small scale traders. PSP and CPP research projects increasingly involved NGOs and agricultural extension services to promote the adoption and uptake of research findings. In India and Bangladesh, research to introduce and develop new technologies such as seed priming, insect pheromones and improved weed management practices was conducted with national and international agricultural research institutes and with non-government organisations (NGOs).

Partnerships were also developed with private sector organisations which, working in tandem with government agricultural extension systems and NGOs, have played a significant role in promoting the adoption of research outputs (see the section "Taking forward research outputs" for details). In Africa, research was conducted in partnerships involving UK institutions, national agricultural research institutes in West and East Africa and the West Africa Rice Development Association (WARDA). The validation and dissemination of improved IPM practices has been through regional rice networks led by WARDA. The Plant Sciences Programme worked through "informal networks", which included a range of different stakeholders, and which were involved during all stages of the research process, from the design stage through to dissemination and uptake. The advantages and disadvantages of these institutional arrangements, in particular in relation to uptake of outputs, are discussed in the section "Taking forward research outputs".

The delivery of agreed outputs can sometimes become a source of conflict between project partners. Generally it is difficult to change partners once the project has started, but in some instances additional partners were brought on board after the project inception. In terms of commitment, PhD students are a very useful resource to a project and, if recruited from within a partner organisation, can help develop long-term linkages between organisations. This approach was used successfully for research on rice blast disease in West Africa (R6738) and on rice yellow mottle disease in Tanzania (R6763).

Exploiting synergies with other research programmes

No formal mechanisms existed between RNRRS programmes to coordinate their research strategy on rice. While informal consultations took place, the absence of a communication strategy (included at times in individual projects towards the end; for example, the last NRSP call) for programme clusters to explore synergies and joint uptake strategies was a missed opportunity. However, the scale and scope of research projects would most likely have had to be reduced to cover the transaction costs of closer inter-programme collaboration.

In Bangladesh, there was considerable scope for synergy between research commissioned through the RNRRS programmes and the PETRRA project. This was partially realised through linked activities on weed management and on rodent ecology and management. Similarly, the NRSP developed collaborative activities with PETRRA in the areas of pro-poor knowledge management and information services for natural resources related information. RNRRS projects participated in research 'fairs' organised by PETRRA to communicate research findings to NGOs, farmers, policy makers, researchers and other stakeholders. However, the potential for collaboration between RNRRS programmes and PETRRA was never fully exploited. One constraint was that PETRRA did not generally fund inputs from international researchers. In the case of a project on rodent management that was initiated by PETRRA (R8184), there was a clear requirement for international expertise as there was little specialist capacity available within Bangladesh on rodent ecology and taxonomy. Although the CPP had not identified rodent management as a priority area for research, it collaborated with PETRRA on the project and funded a significant proportion of the total costs; including the costs of UK and Australian research organisations. RNRRS programmes generally engaged with PETRRA on an individual basis and the partnerships might have been more productive if a more coordinated approach had been taken. A longer timeframe for PETRRA and a more flexible structure within the project to address emerging partnership needs was needed to help both PETRRA and the RNRRS programmes achieve their objectives most effectively.

Motivation and incentives for partnerships

Partnerships appear to work best when goals and objectives are jointly developed and negotiated, and all parties perceive a fair distribution of costs / inputs and benefits from the project. Often no one partner has the capabilities and resources to undertake all aspects of the research alone – especially as research moved towards the adaptation and validation of technologies with farmers, requiring the contacts and experiences of NGOs and farmer organisations.

An interesting example is seen in the partnership arrangements in the CPP project on rice stemborer pheromones in Bangladesh. What has been termed the "common interest space" of the research partners was clearly identified at the outset, driven by the shared need to develop more environmentally sound technologies. Bangladesh has adopted integrated pest management (IPM) as an official policy and insect pheromones have a potential role to play in IPM programmes. The interest of the Bangladesh Rice Research Institute and the Department of Agricultural Extension in exploring the potential of insect pheromones was therefore very clear. In the case of Syngenta Bangladesh, its evolving marketing strategy was influenced by a recognition

that hazardous insecticides (categories 1 and 2) were likely to be banned in the future and there was a commercial imperative to develop safer new products. Partnership with research providers would allow it access to knowledge and materials that would help it to develop new products. As a result, Syngenta Bangladesh would quickly be able to establish itself as the market leader in pheromone products.

In West Africa, the motivation to work together on weed management, rice blast, yellow mottle virus and rice processing (milling and parboiling) was based on the interest of collaborating NARS in these topics, which were identified by the ROCARIZ IPM task force. ROCARIZ, the West and Central Africa Rice Research and Development Network, aims to link rice stakeholders in West and Central Africa in order to generate improved and relevant rice technologies, and facilitate their rapid transfer to users by enhancing the capacity of NARES for participatory rice research planning, technology generation, evaluation, and transfer. Incentives for collaboration also included professional development opportunities, for example staff visits to the UK, and the purchase of technical equipment such as computers and laboratory equipment with project funds. Some of the main points arising from discussions with project leaders on factors influencing partnership arrangements are shown in Box 1.

Farmer involvement in research

The degree and type of farmer involvement depends largely on the objectives of the research project. While the differentiation between 'basic' and 'adaptive' research might not always be useful, it is generally understood that farmers will play a less active role in basic research that aims at developing new models and methods. However, as research becomes more applied and problem-oriented, farmers' inputs become more crucial. In DFID RNRRS rice projects, farmers have been involved in the following ways:

- Passively, in surveys and field assessments, including impact assessment.
- Actively, but indirectly, by representation in key fora, such as the ROCARIZ task force on technology transfer (which also includes NGOs) in West Africa, or in NGO networks in Bangladesh.
- Actively and directly, through involvement in the testing of technologies, such as participatory variety selection (PVS), participatory plant breeding (PPB) and farmer field schools.

It is difficult to assess whether the level and type of farmer involvement was always adequate or optimal – this would require in-depth analysis of each project. However, it appears that there was some farmer involvement in most projects, especially as the RNRRS was drawing to a close. In some projects, such as PPB work in Nepal and Bangladesh farmers were integral to the research process. These breeding efforts were specifically designed to meet local needs and the process has recently been described by its practitioners as 'Highly client-oriented plant breeding' (Witcombe *et al.*, 2005; Joshi *et al.*, 2006). NRSP research on participatory technology development in Eastern India was very much geared towards placing farmers at the centre of the research and development process (R7830 and R7839). In some RNRRS projects, though, farmers might have been brought into the research process at an earlier stage and a greater effort could have been made to characterise them by resource endowment. In West Africa, for example, there was a tendency amongst project scientists to view all farmers as poor and lacking in resources. A more

realistic approach was adopted by the Sahelian Irrigated Rice Research Project in which crop management options for different types of farmers were developed.

Box 1 Factors supporting and hindering effective partnerships

Discussions with project leaders and partners revealed the following supporting and hindering factors, which can at least partly be influenced by donor policies and procedures:

Supporting

- Provision of resources for joint proposal development, especially face-to-face meetings of key partners, results in more ownership of Southern partners and genuine partnership.
- Inception workshops are a useful tool to develop partnerships early on in the project.
- In order to increase farmer participation in research partnerships, it is useful to hold meetings at the beginning of the season with farmers to discuss important constraints and opportunities. This could be done by NARS and extension in each country.
- Flexible project design enables the inclusion of new partners during the project, if they are identified as important stakeholders. In longer term projects, it is not always possible to identify all emerging stakeholders at the outset. Sometimes projects funded by other donors can be useful partners in research. Again, if the project design is flexible, synergies can be better exploited; for example a French-funded lowland rice development project also worked on rice milling in Ghana.
- Exchange visits are a useful tool to develop partnerships between individual scientists and organisations, but they need to be well targeted and integrated into project design.

Hindering

- Short time span between call for proposals and submission date sometimes results in proposals being driven by Northern partners, with Southern partners being consulted, but not fully involved.
- Effective partnerships involve transaction costs, in particular for communication as time and resources are needed; for example, for Internet access. These are generally not budgeted for, resulting in poor communication and delays in project progress.
- Similarly, involvement of extension staff in research projects will not be possible unless resources for per diems are included in the budget, as most extension systems are under-funded.
- Partnerships require time to be established. The short time horizon of some projects hinders effective partnership development – a minimum of 3 years is required.
- Competition between NARS and universities for funds can be counterproductive. Donors should explicitly encourage them to collaborate, and perhaps specify such partnerships as a requirement for certain calls.
- If follow-up projects take too long to be approved, continuity is lost and NARS scientists move on to working on other issues.

Work with existing networks or build new ones?

The RNRRS programmes differed in the extent to which they worked through existing networks and partnerships, which emerged in-country and had the backing of the NARES, or by developing new networks specifically to support programme goals. There are clear trade-offs between these options, as shown in the table below.

Table 1 Trade-offs between different partnership arrangements

Partnership arrangements	Advantage	Disadvantage
Working through IRRI and WARDA / ROCARIZ (CPP)	• Enables leveraging of research capacity (human and physical resources) of partner organisations • Use of existing uptake pathways / networks of partners • Potentially sustainable (assuming funding to these organisations continues from other sources)	• Relies on demand assessment processes used by these, which might not be sufficiently inclusive of non-research stakeholders – e.g. ROCARIZ includes mostly research organisations • Has to deal with shortcomings in capacity of these partners • Often RNRRS projects compete for (human) resources with other programmes
Working through NARS (NRSP – ICAR, CPP – BRRI, PSP: LI-BIRD/CAZS-NR/NRRP)	• Helps build capacity of national systems • Can contribute to changing attitudes and perceptions of national researchers • Sustainable • Politically most acceptable to host countries	• As above • DFID priorities might not be the same as national priorities (e.g. poverty focus vs. production increase through development of high potential areas), leading to tensions • Danger for projects to get caught up in national politics • Can exclude key stakeholders (e.g. civil society organisations) • Can be restricted by bureaucratic / technocratic way of operation
Working through informal networks (PSP)	• Can be very inclusive (civil society, private sector, farmer associations etc.) • Enables a more innovative approach, not restricted by bureaucracy • Enables pursuing DFID priorities (MDGs)	• Not sustainable, if dependent on project support • Might not be acceptable to NARS – can lead to alienation

There is clearly no "best practice" that should be uniformly promoted, because each of these partnerships produced interesting and valuable outputs; rather, there is a need for a contingency approach that develops partnerships that are able to meet the short and longer term objectives of the programme.

Research outputs and their promotion

Types of outputs

Outputs from RNRRS rice research have taken a variety of forms, reflecting the diverse range of researchable constraints and the specific requirements of individual problems addressed. In some cases the technology developed involved a product such as an insect or rodent trap, and associated knowledge related to the use of the product. Other outputs were new practices, tools and methods, sometimes packaged in an interactive database or a decision support system. For some projects, more intangible

outputs such as changes in the way that institutions conducted research were important outcomes of the research.

The approach we have taken is to consider research outputs in relation to the objectives and the main anticipated impacts of the research. Many of the outputs are oriented towards increases in production and productivity and this reflects the overall aim of the RNRRS as it was originally conceived. However, as the livelihoods approach assumed greater importance in DFID thinking, the research programmes began to focus more on targeting research to enhance the income of the rural poor and to reduce food insecurity. Reducing drudgery, especially for women, became a key objective for some research areas and prominence was given to environmental impacts, both on human health and on rice ecosystems. This is not to say that individual research projects necessarily produced outputs directed at only one of these categories. Most of the research addressed more than one category and gender and environmental concerns were generally regarded as cross-cutting issues to be considered by all projects.

Research impacts can be felt by different target groups. In most of the research the ultimate beneficiaries were farmers and rural and urban consumers of rice and other crops in the system. For many projects, though, the immediate users of the research outputs were researchers or staff at NGOs or agricultural extension services. Some research outputs were directed at policy makers. These may have been aimed at removing a policy constraint or helping to create an enabling environment for the adoption of a technology. In the later stages of the RNRRS DFID became increasingly concerned with demonstrating impact of the research at the farm level and identifying areas where research has brought about policy changes. We examine examples of farm level and policy impacts but also consider cases where impacts on intermediate users of the outputs were the most important outcome of the research.

Main output areas

Reducing yield gaps

A primary objective of much of the research on rice-based cropping systems carried out under the RNRRS was to develop and promote improved technologies that would close the gap between actual and attainable crop yields. This was designed to result in greater economic returns to farmers and lead to an increased supply of rice and associated crops. Further, the increased harvest would be available to rural and urban consumers at more affordable prices. There is evidence that RNRRS research has demonstrated the potential for closing this yield gap in several areas. It should be noted that some of the more recent projects may ultimately contribute to reducing the yield gap, but that insufficient evidence is currently available to demonstrate this. This reflects the inevitable lag between the development of technologies and their widespread adoption by farmers.

As outlined earlier, there is tremendous scope to increase productivity in rice-based systems through improved water and nutrient management and the potential for this was clearly demonstrated in early RNRRS research. Research in West Africa has shown that significant yield gains can be achieved through optimising crop

management interventions (Box 2). Similar responses to improved water, nutrient and weed management have been shown in south Asia. For example, in Bangladesh research in rainfed rice-fallow systems in the High Barind Tract and in intensive irrigated rice systems showed that losses of between 0.5 and 1.5 t ha^{-1} were attributable to sub-optimal weed control (R7471).

Box 2 Improved crop management in rainfed and irrigated systems in West Africa

Improved water control in lowland rainfed areas in Côte d'Ivoire, achieved through the construction of simple bunds, increased rice grain yield by 40% (Becker & Johnson, 2001). Part of this yield gain resulted from improved weed control, with a reduction in weed biomass of 25%. Application of mineral nitrogen increased rice yields by 18%, but only in bunded fields where water could be managed efficiently. Improved fertiliser management also led to large yield responses in irrigated rice areas in Senegal and Mauritania, where gains of 0.9 t ha^{-1} were recorded in farmers' fields (Haefele *et al.*, 2000). In these same areas, more timely application of the post-emergence herbicide propanil at the recommended rates produced a yield increase of 1.0 t ha^{-1}. The effects of the recommended fertiliser and weed management practices were additive, so that mean yield increases of 1.8 t ha^{-1} were recorded. This led to an increase in net revenue of up to 85% compared with standard farmer practice and subsequent work helped to further refine the recommendations for weed management practices (Johnson *et al.*, 2004).

Increased rice production in Africa will need to come from intensifying production in irrigated areas and in expanding and intensifying production in rainfed systems. The results from the research carried out in West Africa clearly indicate that large production increases are technically feasible and the key issue is how best to support the more widespread adoption of the recommended practices. This has to be addressed as part of broad policy initiatives at the national level to facilitate farmer access to credit and to inputs such as seed and fertiliser. The encouragement of effective farmer organisations is also an important part of this process but experience with previous initiatives has not been encouraging. Lessons need to be drawn from more successful schemes such as the Office du Niger scheme in Mali where farmers are producing rice at efficiency levels that can compete with foreign imports (Diarra, 2004).

Breeding for increased yield, or for resistance to biotic or abiotic constraints, has been fundamental to the large production increases achieved in favourable environments in recent decades. However, in spite of the undoubted successes improved rice varieties have not been widely taken up by farmers in some areas. The low adoption of improved rice varieties developed and released in conventional national breeding programmes has led to increasing interest in involving farmers more directly in the selection process. PPB approaches promoted through the PSP enable farmers to choose lines at the early stages of generation segregation. Thus, farmers are able to consider criteria such as aroma, milling recovery and cooking and eating quality before such traits become fixed in advanced breeding lines. As a result, the rice varieties produced are more likely to meet local preferences and market needs (Box 3).

Box 3 Participatory Plant Breeding in Nepal

Participatory Plant Breeding approaches conducted in high potential production systems in Nepal have led to the production of several advanced breeding lines that match the diverse biophysical and socio-economic environments that exist (R7122). Most lines have good levels of resistance to leaf and neck blast, caused by the fungal pathogen *Pyricularia grisea*. Many lines also have some degree of resistance to bacterial leaf blight, caused by *Xanthomonas oryzae*. The most widely grown rice varieties, CH-45 and Masuli, are susceptible to these two diseases and so the new advanced lines confer a significant advantage. In view of the high yields, good agronomic characteristics and favourable quality traits of the new lines the potential for widespread adoption by farmers is excellent. An additional benefit is that the genetic diversity of rice grown in the target areas will be enhanced (Witcombe *et al.*, 2001). The PPB activities have been shown to be cost-effective as widely adapted genotypes have been generated from a small number of crosses. This was made possible through knowledge of farmers' preferences which increased the efficiency of targeting new germplasm.

RNRRS research has also provided support to rice breeding programmes through participatory varietal selection (R7552), the development of transgenic rice crops and pathogen characterisation work (R7778). Research on transgenic crops received 26% of the PSP budget from 1990 to 2003 and led to several novel outputs (Stirling *et al*., 2006). These outputs included transgenic rice lines with resistance to rice yellow mottle virus (RYMV) (Pinto *et al*., 1999) and lines with resistance to nematodes (Atkinson *et al*., 2003). PSP research also developed a 'clean gene' transformation system for rice which does not involve the use of a detectable marker gene (Vain *et al*., 2003). It uses a binary system of transformation that allows subsequent genetic recombination between the marker gene and the transgene. Segregants which only have the transgene are selected to produce a reporter-gene-free crop. Much attention was paid to producing biosafe transgenic crops by using a gene from a cereal crop (rice) that expresses cystatin (an inhibitor of protease), a protein which is present in grain and which therefore already forms part of the human diet. The use of promoters which allow cystatin to be expressed in the roots confers high levels of resistance to nematodes as the protease prevents efficient digestion of proteins. This strategy has been shown to be effective in potatoes in field trials in the UK (Urwin *et al*., 2001). However, as with the RYMV resistance, it has not been possible to test the strategy for rice due to the absence of biosafety regulatory structures in countries in Africa where the constraint is present. Thus, although the quality of the science was high and effective products were generated, the impact of the transgenic research has been limited to date. Without appropriate legislation in place, the allocation of significant resources to transgenic research might be questioned. On the other hand, technical advances can lead to changes in the policy environment and the development of a biosafe rice transformation system is a significant contribution in this direction and the development of a biosafe rice transformation system and biosafe transgenic strategies to control nematodes are significant contributions in this direction.

.

Managing risk and contributing to enhanced food security

For some researchable constraints there was a particularly strong focus on assisting farmers to manage risk in order to enhance food security. A project on developing improved management strategies for rice hispa in Bangladesh is one example (R7891). Rice hispa, *Dicladispa armigera*, is a beetle which feeds on rice leaves and which can cause total crop loss when insect numbers are high. In most seasons, the beetle is present in very low numbers and causes little or no damage to rice. However, periodically there are large-scale outbreaks of the pest which can be devastating for subsistence farmers largely dependent on credit to purchase needed inputs. Research into the ecology of rice hispa provided new information on how outbreaks develop and on the conditions that favour insect population increase. A key issue for the research was how best to use this information to reduce the risk for farmers. A benefit: cost analysis identified the most appropriate control measures for farmers to use. The research helped to refine existing recommendations by identifying control measures which provided low economic returns or which were not acceptable to farmers for other reasons. At a different level, the research led to a re-evaluation of the way in which the Department of Agricultural Extension uses pest survey data to forecast pest outbreaks. Information is now computerised and available in a form in which it can be readily accessed and used to guide strategic management of rice hispa when the need arises.

Enhancing income earning opportunities

As already indicated, as the RNRRS progressed greater attention was given to research that could lead to improved livelihoods for the rural and urban poor. Consequently the need to identify opportunities for farmers to generate additional income came into sharper focus. One way in which this can be achieved is through increasing total system productivity, especially where there are options to grow crops on land that has traditionally been left fallow. In rainfed areas of Bangladesh, and in large tracts of eastern India, rice is grown in the monsoon season but the absence of irrigation prevents a second crop being cultivated. Research conducted by national agricultural research institutes in each of these countries identified the potential for growing a short duration crop on residual moisture after the cultivation of a short duration rice variety. However, there are certain technical and socio-economic constraints which have prevented the double cropping system from being widely adopted. A suite of RNRRS projects has attempted to address these constraints and considerable progress has been made to overcome them.

An important component of the system is to identify high-yielding short duration rice varieties that have a high degree of marketability. PVS activities conducted in Bangladesh have identified suitable varieties and these are being actively promoted through a local NGO, PROVA. Another approach is to use direct seeding to ensure earlier establishment of the rice crop (Box 4).

Box 4 Direct seeding in Bangladesh and Eastern India

In Bangladesh, the use of direct seeding has advanced the harvest date of rice crops by up to twelve days allowing the earlier sowing of chickpea or other short duration crops. In Eastern India, farmers are experimenting with direct-seeded rice in response to the need to reduce input costs and to shortages of labour and water at key times in the cropping cycle. Where good weed control was achieved through the use of recommended practices, net returns of 13,350 Indian Rupees ha^{-1} were achieved for wet-seeded rice (R8233). This compares with net returns of 10, 343 Indian Rupees ha^{-1} for transplanted rice. Net labour savings of 27 days ha^{-1} resulted from using direct seeding in place of transplanting and considerable savings in water also resulted. Farmers have also seen the benefits of earlier harvesting of the rice crop which enables them to plant succeeding crops in a timely manner. For example, in parts of Uttaranchal farmers have found that direct seeding enables them to meet the early October threshold date for sowing peas which attract a high price in the Delhi market.

The crop which has the greatest potential for cultivation over large areas after the rice harvest is chickpea (Box 5). There is a strong demand for chickpea in Bangladesh and in India and the crop can survive on limited surface moisture once it has established a good root system. In order to realise the full benefits of a rice-chickpea rotation, a minimum level of community action is needed to protect fields from grazing animals and to preserve and store seed for use in the next growing season. Community action is also needed to successfully overcome some other researchable constraints which were addressed by the RNRRS in rice-based systems. Cooperation among farmers and rural householders is a fundamental requirement of effective rodent management and community-based monitoring and trapping approaches have been piloted through action research in Bangladesh (R8184). For both the rice-chickpea and the rodent management research, further work is needed to establish whether the village level approaches utilised in the pilot studies can be replicated and made sustainable over a larger geographical scale.

Box 5 Rice-chickpea rotation in Bangladesh and Eastern India

RNRRS research has shown that establishment of chickpea is facilitated by priming the seed prior to sowing (R7540). This usually entails soaking the seed overnight in water before surface-drying and sowing, but the addition of small quantities of molybdenum to the priming water has led to significantly increased nodulation in acid soils. In Bangladesh, the mean response to the priming regime was an increase in chickpea yield from 22 to 48%. The yield response was inversely proportional to winter rainfall and priming reduced the risk of crop failure by half. In the 'rabi' (winter) season of 2001-02, in which almost no rain fell, net returns on chickpea of up to Tk 16,000 ha^{-1} (equivalent to *c*. US$242 ha^{-1}) were recorded (Kumar *et al.*, 2003). Complementary research was conducted to develop improved IPM options for control of the two major pest and disease constraints of chickpea in the region, *Helicoverpa armigera* and botrytis grey mould (R7885). The outcome of several linked RNRRS projects has been to provide a package of crop management options for growing chickpea in rice fallows which can be adapted to local environments.

Improved rice quality

The development, validation, optimisation and promotion of improved parboiling methods for rice in Ghana were supported by several CPHP projects; in particular projects R7543 and R8263. Rice milling quality was addressed through R7531 which was located in Ghana and Tanzania. The projects aimed at improving the quality of local rice and to make it more competitive with imported rice in order to enhance income for producers and processors. Rice processed using the prototype parboiler developed in Ghana was preferred to those samples of parboiled rice purchased from local markets. The benefits of the improved process include a greater quantity of processed paddy in a single batch, a reduction in fuel cost and processing time by half, and improved quality of rice. R7531 showed that rubber-roll dehullers resulted in improved rice quality, as compared to steel dehuller mills. However, the improvement in quality did not lead to higher market prices and rice imported from the USA was still preferred to the improved parboiled product. This highlights the fact that rice quality issues are extremely complex and involve considerations such as branding and maintaining consistency of quality before consumer acceptance follows. This was confirmed by the WARDA policy economist (see Annex 4).

Enhanced environmental benefits

Few RNRRS rice projects had a primary focus on environmental sustainability but several addressed issues of sustainable intensification, either in the favourable or more marginal environments. The PSP looked at varietal biodiversity in rice ecosystems (Witcombe *et al*., 2001). Soil fertility research in Bangladesh (R6751 and R7600), and linked research on sustainable pest management practices (R7296), helped to build trust between institutions with widely differing approaches to intensification. This paved the way for subsequent collaboration between these institutions through the PETRRA project. Much of the pest management research was oriented towards developing improved pest or disease control options which offered a more ecologically sound alternative to synthetic pesticides. This included the research to develop a rice stemborer pheromone (R8026) and the work on the ecology and

management of rice hispa (R7891). Research on improved weed management included a component on the safe use of herbicides (R8234). Few, if any, of the projects reached the stage where environmental indicators could be monitored to assess the impact of the research on environmental quality. Nevertheless, baseline data exist which would allow changes in insecticide usage or the diversity of rice varieties to be tracked.

One of the few more upstream, strategic pieces of research to be funded after 2000 was a CPP-funded project on biodiversity in rice-based cropping systems (R7570). The rationale for supporting this research was that the outputs would have application for other projects in locations where rice production systems were being intensified. The objective was to identify ecological processes that favoured stability in rice arthropod populations. This knowledge could then be utilised to prevent the type of perturbations which had resulted in loss of insect pest control in some intensive rice systems in Asia. The research resulted in several publications in high quality scientific journals and thus made a significant contribution to new knowledge (e.g. Wilby & Thomas, 2002). However, the anticipated linkages with other pest management projects did not materialise. This may have been due, in part, to the fact that much of the work was done in a country where no other RNRRS rice research was carried out.[5] The research might also have been more valuable to other RNRRS projects if it had operated earlier in the programme cycle. Nevertheless, there were opportunities to link with other non-RNRRS initiatives and to use the outputs to influence research and development policy in certain countries. Although these opportunities were not fully exploited the project developed a training manual and conducted an international training workshop which went some way to realising these aims.

Capacity development

Although capacity development was not an aim of the RNRRS initially, many rice research projects came to attach considerable importance to developing the capacity of research and development organisations. Capacity development includes the development of human resources, facilities and infrastructure, and organisational systems, processes and strategies (Pound & Adolph, 2005). Rice projects mostly enhanced research capacity through human resources development, either by enrolling staff of partner organisations in formal degree courses, including PhD programmes, or more often by training them in specific techniques and approaches. Informal on-the-job training and exposure visits have a less tangible and less visible impact on capacity. Nevertheless, these can be equally important because they usually affect more individuals than formal degree courses. This leads to the development of a 'critical mass' of trained staff and allows the transmission of skills in an applied environment, making it more likely that these will be sustained beyond the lifespan of the project.

Some strengthening of infrastructure took place through the provision of laboratory equipment and Information and Communications Technology (ICT) and transport facilities. The former was often linked to training on particular techniques. For

[5] Much of the research was done in Vietnam, which was not a DFID target country for RNRRS. The justification for this was that it allowed a link to be made to a project funded by the Asian Development Bank which had produced a large amount of relevant data that could be utilised.

example, R7778 developed or refined molecular tools for blast genetic characterisation, and training was provided to selected national programme and WARDA scientists through assignments in the UK. DNA fingerprinting for the identification of blast lineages and pathotyping on international rice differentials for virulence diversity were the key tools used. There is an issue about the sustainability of such approaches if appropriate facilities are not readily available to trained staff to allow the techniques to be used in their own institutions. The counter-argument is that donors are often more willing to pay for equipment when they know that there are people who are trained to use it. There are several new donor-funded biotechnology initiatives in sub-Saharan Africa and the capacity development conducted within R7778, and within the project on 'clean-gene' technology for marker-assisted breeding (R7548), should assist project partners to participate effectively in these programmes.

Some projects were able to influence organisational processes by changing the way in which research was conducted. For example, BRRI scientists became more farmer-oriented as a result of participation in the PETRRA project and in RNRRS projects that emphasised on-farm activities (R7471 and R8234). These projects provided resources such as transport allowances to enable on-farm work to be conducted, but also contributed to a change in attitude among BRRI staff and management by giving more importance and credibility to on-farm research. Similarly, NRSP was able to influence the research agenda of ICAR by closely working with senior management and member institutes such as the Central Research Institute for Dryland Agriculture on issues related to uptake and knowledge management (R7839). PSP research on PPB and PVS introduced new concepts that encouraged greater client-orientation in the research process and, as has been argued elsewhere, these approaches lead to greater empowerment of breeders and associated researchers in national breeding programmes (Almekinders & Elings, 2001). The impact studies in eastern India, Bangladesh and Nepal show that large-scale uptake strategies were put in place and that impact is already appreciable (John Witcombe, personal communication). Significant institutional changes in Nepal have also been achieved in terms of changing the seed laws for release proposals and changes in the way the Department of Agriculture works in its extension. Many DADOs now only work on unreleased varieties from the LI-BIRD/CAZS-NR/NRRP breeding programme - a significant change from the official approach of only recommending released varieties (Joshi *et al*. 2005).

RNRRS rice projects championed the use of systems approaches to research in which interdisciplinary teams were developed to address researchable constraints. The benefits of such approaches were generally apparent in the individual projects but wider efforts are required to ensure that they are adopted more widely in NARS institutions and within the CGIAR. In spite of efforts made at the project level, an overall lack of capacity in the NARS remains a constraint to project implementation. In many countries in Africa, there is a 'brain drain' problem with researchers taking better paid jobs at CGIAR centres or with NGOs – as has happened, for example, with socioeconomists in Gambia. Future DFID research programmes will need to give greater prominence to capacity development but the resources which are likely to be available will not be large enough to have a significant impact. This means that support for capacity development will have to be clearly linked to other initiatives and targeted in such a way that the maximum added value can be achieved.

Capacity development of input suppliers was conducted in some projects; for example, R8234 and R8304 in which the expertise and financial resources of the private sector were successfully leveraged. The aim was to use the input suppliers as intermediaries to transfer knowledge to farmers. Knowledge transfer to farmers was a more direct output of some research projects although this could usually only operate on a pilot scale. Nevertheless, some projects promoted learning between farmers, such as R8263, in which women farmers from the Upper East region in Ghana trained women from Northern region in rice processing. An interesting approach to knowledge development was tested in eastern India through experiential learning in farmer groups but this approach needs further evaluation before its potential can be assessed (R7839). The project developed a "Dialectic Approach" to mobilise communities for Participatory Technology Development through a process of empowerment, without externally provided incentives. The costs of the approach were significantly lower than other facilitation approaches (Gaunt, 2005).

Documentation and publication

A substantial number of documents were produced from all research programmes, ranging from internal project and workshop reports to extension materials, conference contributions and peer reviewed journal articles. The number of peer reviewed outputs varied considerably between programmes – probably the largest number of rice-specific articles were produced by the PSP with almost 30 papers from 2001 to 2006[6]. The number of social sciences / socio-economic publications emerging from the programmes were relatively small – possibly because of lower social science inputs during the earlier stages of the programmes. Social sciences often require verification of models and theories in a larger number of locations, making it more difficult to publish findings from just one country or project site. It would be useful to explore ways of utilising some of the farm data collected by the different projects to obtain a fuller picture of rice farming systems in different countries. For example, several projects collected farm level data in Bangladesh, the analysis of which together might well provide new insights about livelihood and production systems. The RNRRS did not make provisions for funds specifically for joint documentation and publication of results from different projects.

Taking forward research outputs

Promoting research outputs became increasingly part of the mandate of projects and programmes during the second half of the RNRRS as a result of changes in DFID's perception of the role of research, following the 1997 government White Paper. Ensuring uptake was a primary focus of the last two rounds of research calls in 2003 and 2005. However, programme budgets were reduced making it difficult to commission strategic research on uptake pathways without decreasing funding for on-going research projects whose outputs required further validation and promotion.

[6] Details of publications can be viewed in the programme websites: http://www.dfid-psp.org/; http://www.cpp.uk.com/; http://www.infobridge.org/nrsp/search.asp for NRSP outputs; http://www.cphp.uk.com/

Individual RNRRS programmes followed different approaches to identifying mechanisms for promoting the uptake of research outputs, but uptake was considered to be the responsibility of the projects. Although research programmes developed their own systems of clustering rice projects these could have been better utilised to promote uptake of research outputs both within and between countries. The CPP for example, funded a suite of projects in Bangladesh, some of which shared common research partners. However, linkages between projects tended to be informal and the potential for synergies was not sufficiently exploited. Similarly, where there was interaction between projects funded by different DFID research programmes in Bangladesh this tended to result from the initiative of project leaders. One area where a more coordinated approach was adopted was in the promotion of institutional acceptance of client-oriented approaches to plant breeding and varietal selection. The PSP funded a regional coordinator based in Nepal, but with a mandate to foster institutional partnerships in the region (Stirling *et al*., 2006).

The PPB and PVS research is perhaps the clearest example of research approaches that have been extended between countries in the region with activities based in Nepal, Bangladesh and India. There were other cases, but these tended to be smaller project-level initiatives. Experiences showed that an important factor in determining the potential for scaling out research outputs to new countries is the institutional capacity to engage in and support the research. This was seen when research on the management of weedy rices in West Africa was subsequently transferred to Tanzania. Promising results were obtained from a small promotional project, largely through the dedication of a local 'champion'. However, it remains to be seen how much impact the project will have without further donor support because there is limited capacity within the small Tanzanian rice programme to scale out the research outputs. The lack of rice research capacity in Tanzania was also the main reason why research on RYMV was discontinued (F. Kimmins, personal communication). This highlights the need to develop research initiatives where there is a critical mass of researchers and other stakeholders and where the outputs can be channelled through appropriate institutional structures.

An obvious route for uptake would have been through linkages with DFID country offices. In general, although programme managers and project leaders attempted to engage with DFID country offices, there were limited opportunities to promote technologies or other innovations through this means. This was partly because agriculture tended to be quite low on the list of priorities of DFID country offices and because of the move from project funding to direct budgetary support. It may also have been due to a lack of awareness of the potential of technologies and innovations to generate significant impact.

Box 6 Working with the private sector: Syngenta and rice stemborers

The government agricultural extension service in Bangladesh is poorly resourced and its capacity to popularise new technologies is severely constrained. By contrast, Syngenta-Bangladesh has a well organised network of dealers across the country who have frequent contact with farmers in their localities. RNRRS research on rice stemborer pheromones developed links with the government extension service, but the use of private service providers clearly offered significantly greater potential to influence farmer adoption. Training courses on pheromone products and their use were developed for pesticide dealers and farmers and tested at several pilot sites. Promotional materials were also prepared and evaluated with stakeholders. Syngenta-Bangladesh was the key private sector partner and used the feedback provided on the training and the promotional materials to refine its marketing strategy. Recognising the complexity of the technology compared to the conventional insecticide approach, the company decided to focus promotional efforts on specific areas in which additional technical support could be provided. This was done in preference to a more general nationwide promotional campaign.

Syngenta Bangladesh has invested considerable resources to develop its pheromone products. Although small in comparison, the donor support it received was useful in allowing it to access technical support in areas where it lacked expertise. This extended beyond issues of quality control for the production of the pheromone product to include inputs from social scientists to identify and address constraints to adoption. From the perspective of the donor and the government research institutions, Syngenta-Bangladesh's involvement was crucial to the commercialisation of the technology and the adoption process. It might be argued that the support provided to Syngenta-Bangladesh has given it an unfair advantage in the market place for these new products. The counter-argument is that, without its intervention, the market would not exist. Also, Syngenta-Bangladesh had the commitment and the necessary influence to successfully lobby the government to develop a regulatory framework governing the registration of pheromones. At the outset of the project, there was no registration process in place, but this has now been implemented through recent legislation. Now that this legislation is in place other companies will be able to compete on a level playing field. In preparation for this eventuality, additional donor funds were provided to help small and medium enterprises (SMEs) improve their technical capacity to produce pheromones. Training was provided and a technical manual produced (Cork, 2004).

The work on the rice stemborer pheromone was part of a wider set of DFID-funded activities that addressed problems of pest management in vegetables in Bangladesh. Progress with the rice stemborer pheromone would not have been possible without this broader support. This is partly due to economies of scale and also reflects the fact that the more immediate commercial drivers for Syngenta-Bangladesh were in developing products for vegetables and fruit.

Some programmes facilitated strategic linkages with key organisations; for example, the CPP encouraged linkages with the International Rice Research Institute and the Africa Rice Centre, which provided links to their networks. While such partnerships were encouraged, there was generally little guidance provided by the research programmes on uptake strategies. There was a requirement for uptake pathways for project outputs to be identified at the proposal stage, but in many cases an opportunistic rather than a strategic approach was used by project teams, linking with whoever in country was interested in the outputs. Only NRSP expected proposers to

develop a communication strategy that would specify the clients of the research, and the mechanisms adopted to engage them.

Uptake opportunities depend not only on the project strategy, but also on the policy environment that supports or hinders the strategy. During the meeting of UK-based project leaders at the Natural Resources Institute in November 2005, participants discussed how the policy environment influences research outputs and their uptake, and how research outputs may also influence policies. Where agricultural advisory services are poorly trained, motivated and resourced, it is difficult to promote technologies, especially when they are knowledge-intensive and require local adaptation. Therefore RNRRS projects often worked through NGOs and, more recently, with the private sector. In the rice stemborer pheromone research (R8026 and R8304), Syngenta-Bangladesh produced the traps and promoted the technology by training farmers through their own extension staff (Box 6).

CPHP promoted project outputs through their coalition approach. The emphasis was on partnership building with a range of stakeholders in the production chain, in order to achieve sustainable impact. Because of the nature of post-harvest operations, stakeholders involved included SMEs, such as millers, traders and processors. These were interested in making use of improved processing technologies, and provided an instant uptake pathway through the private processing sector.

The promotion of project findings through existing networks and databases was actively encouraged by programme leaders. The IRRI rice knowledge bank (http://www.knowledgebank.irri.org/) and the Bangladesh rice knowledge bank (BRKB) managed by BRRI (http://www.knowledgebank-brri.org/) both offer the opportunity to make RNRRS research findings more widely available. However, at the time of writing, very few of the RNRRS research outputs were available on these web sites. The BRKB is currently being updated, and very few of the links are actually working. While linking with such existing facilities is more sustainable than making project outputs available on the research programme web sites only, there need to be sufficient financial and human resources available within BRRI to update the database on a regular basis. The research programmes are currently compiling project summaries to be placed on the FAO TECA (Technology for Agriculture) web site (http://www.fao.org/sd/teca/index_en.asp).

Mechanisms for evaluating impact

Research can impact on poverty in various ways:

(a) Directly, through the development and promotion of knowledge and technologies that will in themselves, if taken up, lead to increased production, reduced risk, increased quality of produce, reduced use of inputs, increased income for farmers, etc.;
(b) Indirectly, through the development and promotion of innovative, participatory approaches to research and innovation that are more likely to result in (a);
(c) Indirectly, by lobbying policy makers, donors and other stakeholders to create an environment that will support (a).
(d) Indirectly, by building the capacity of organisations in partner countries

During the initial phase of the RNRRS, projects were meant to focus on (a) type impacts, and it was assumed that these would impact on poverty through trickle-down effects. However, a typical three-year research project is generally too short to expect significant impact at farm level. Projects that were working successfully on high priority constraints often received several extensions, resulting in total project durations of 5-7 years. However, as this was not known at the project design stage, and as proposals generally did not require proposers to specify how they were going to assess impact, there were generally no mechanisms in place at project level to monitor and evaluate impact at farm and at intermediary level. Baseline data, if collected at all, was usually specific to a small, possibly not representative project site - therefore it is normally not suitable for impact assessment. The PSP commissioned a number of *ex-post* impact assessment studies of participatory crop improvement initiatives in South Asia (e.g. Virk *et al*., 2004 in India and BMOS Agro-consultants (2006) in Ghana), some of them undertaken by external consultants[7].

Overall it is doubtful whether impact at farm level is an appropriate measure to assess research projects with a duration of 2-3 years, considering the time lag between technology development and adoption (see section "Reducing yield gaps"). An example of this time lag is the early research on rice tungro virus disease which ended in 1998 (R6519). One output of the project was the development and promotion of virus-resistant rice varieties. Several tungro-resistant varieties were released in Indonesia and the Philippines but it was not possible to track farmer adoption until official figures subsequently became available. For example, by late 2001 more than 10,000 ha of the variety *Tukad unda* were being cultivated on the island of Bali in Indonesia (Azzam & Chancellor, 2001). By the end of 2003, this figure had risen to 50,000 ha, representing more than 50% of the total irrigated area and overall tungro disease incidence was very low (I.G.N. Astika, personal communication). However, there was no formal mechanism at the programme level for monitoring the impact of the project. Therefore, whilst the impact appears to have been positive it is not possible from data currently available to establish whether the changes resulted in greater overall production or enhanced farmer income. Another example is research funded by the NRSP on modelling of soil organic matter turnover. This work emerged from earlier DFIF-funded research on the environmental impact of new rice technologies. Although the modelling studies were not taken forward through the NRSP after the late 1990's the underlying principles were adopted by an EMBRAPA programme in Brazil. The modelling approach was also utilised in the development of indicators for soil organic matter monitoring by DEFRA (John Gaunt, personal communication).

Impact on project partners and on the policy environment (b to d above) is possibly a more suitable approach to promote research outputs and stimulate further innovations, but was usually not a specific requirement of projects. Some of the impacts achieved on intermediaries, and points to the difficulty of quantifying these, have been described earlier. Impact on intermediaries, in particular key NARES players such as National Agricultural Research Institutes, has sometimes been considered a spin-off from research projects. However, such impact may well be one of the most important and most sustainable achievements. At the same time, even with sophisticated M&E techniques, it is difficult to capture changes in knowledge and attitude of research

[7] Details of impact studies are provided on the PSP website at: http://www.dfid-psp.org/

partners as a result of successful collaboration in projects. As there is no specific provision to document these impacts in formal project reports, and as many project leaders might not perceive them to be of interest to the reviewers, these changes often go unnoticed.

The way forward – future researchable areas

The challenge and context

Projections of future demand for rice indicate that production will have to increase substantially over the next few decades in order to meet the rapidly growing demand. The major challenge will be how to achieve this with less land, labour and water and without causing degradation of the natural resource base (Cantrell & Hettel, 2004). It has been estimated that, even with conservative projections of growth in aggregate demand for rice, annual global production will need to increase from current levels of *c*. 600 million tonnes to about 800 million tonnes by 2030 (Hossain & Narciso, 2004). The size of the challenge is graphically illustrated when the needs of individual countries are examined. In Bangladesh, for example, it has been estimated that paddy production will need to increase from 22 million to 50 million tonnes by 2020 in order to meet domestic demand. This would require an annual increase in yield of 1.5 to 2.0 per cent.

Rice economists have traditionally argued that productivity gains of the magnitude needed to meet rapidly growing demand for rice can only come from intensifying production in the more favourable environments. More than half of rice grown in Asia is produced under irrigation, whereas only 10% of rice in Africa is irrigated. Therefore the potential for increasing overall production from irrigated rice in Africa is much lower than in Asia, unless significant additional investment is made to expand the irrigated area. However, the levels of current water use in rice production are not sustainable and levels of water use efficiency will have to be dramatically improved. In Asia, 90% of the total diverted freshwater is used in agriculture and more than half of this is for irrigated rice production (IRRI, 2001). In Africa, there is tremendous potential for expanding the cultivation of rice in lowland valleys utilising relatively small-scale water management systems (Defoer *et al*., 2004). Increasing productivity in lowland ecosystems is not the whole answer. Delivering greater system productivity in rice-based rainfed environments in South Asia can make a significant contribution to food security and the livelihoods of the rural poor.

Applications of RNRRS research

The vital contribution that research in rice-based systems can make to raising production and reducing poverty has been well documented (Evenson *et al*., 1998). A key question for DFID is how it can use its limited resources to best effect and add value to the wider research effort. This issue was prominent in recent electronic consultations organised by DFID on the use of science and technology in development[8]. One way that the RNRRS programmes were able to add value to

[8] A summary of the discussions may be seen at:. http://www.dfid.gov.uk/consultations/summary-sis-3.pdf.

existing initiatives in rice research was by drawing on disciplinary expertise that was scarce within the NARES and was not readily available elsewhere. UK weed scientists, for example, were able to contribute to research which addressed needs identified by the ROCARIZ network in West Africa. In addition to providing technical inputs, the scientists were able to build capacity in the region and then to use a similar approach in South Asia in response to the demand identified there. However, this capacity remains weak and more concerted efforts are needed to build on the progress that has been made. Another distinctive contribution of the RNRRS programmes was to introduce and popularise the use of new research methodologies and approaches. Participatory plant breeding, for example, utilising marker-assisted selection has proved to be a rapid and effective way of developing improved rice varieties that meet farmers' needs. Moreover, this research has generated scientific advances that greatly enhance the potential for identifying genes that contribute to improved performance of varieties (Steele *et al*., 2004).

Results from RNRRS rice research have shown that there is considerable scope for increasing production in direct-seeded irrigated systems in West Africa through improved nutrient and weed management. The potential for direct-seeding has also been demonstrated in Eastern India and in Bangladesh where the uptake of the technology is being driven by scarcity of labour and water and by the need to reduce input costs. The development of new cropping practices may help to reduce vector-borne diseases and future research needs to be multi-disciplinary in nature in order to reap the full benefits (van der Hoek *et al*., 2001). However, in spite of the undoubted potential of direct seeding, particularly to save water, there are important implications for weed management. In particular, the possible development of herbicide resistance and the potential for long term shifts in weed populations will need to be closely studied. The stakeholder consultation in Bangladesh also revealed that there were concerns about the environment arising from an increase in the use of herbicides.

One concern that has been expressed about the promotion of labour saving technologies such as direct-seeding in rice is the potentially adverse effects these may have on rural employment. In a recent paper, Lipton (2004) argued that although research needs to raise labour productivity it should not do so by reducing the demand for poor people's labour. Similarly, DFID's new strategy for agriculture gives highest priority to small-scale, labour-intensive farming systems (DFID, 2005). This, it is argued, will reduce poverty by increasing employment opportunities for poor people and will also stimulate non-agricultural growth through the generation of additional spending. RNRRS rice research shows that the situation is complex and varies according to the structure of the local economy. PSP research on the rice-chickpea system in rainfed areas in India has shown that economic returns are higher than those where farmers grow rice and supplement this with income from migrant labour in the fallow season. However, in some areas in eastern India and Bangladesh the financial rewards from non-farm jobs will continue to attract rural labour away from farms. CPP studies indicate that in most localities both small and large farms will derive greater financial returns from direct seeding than from transplanting rice (Singh *et al*., 2005). However, transplanting is mainly done by women who are less mobile than men and are consequently less able to find alternative employment. Also, there are some migrant communities who are especially dependent on seasonal labour provided

in rice systems and these may be vulnerable to a large-scale shift to direct seeding. As with other labour-saving technologies, farmers will adopt direct seeding where it is profitable for them to do so but researchers, planners and policy makers will need to develop a broader understanding of the social consequences arising from them.

RNRRS research has shown that there is strong potential for increasing productivity in the less favourable environments rainfed environments. In Bangladesh, Nepal and Eastern India there are millions of hectares of land where total system productivity can be increased using technologies that allow the cultivation of a short-duration crop using residual moisture after rice. RNRRS programmes have demonstrated the potential for technical interventions such as seed priming, new varieties, and improved pest and disease management in these systems. Equally importantly, RNNRS research has shown that institutional innovations such as participatory varietal selection and community based approaches for soil and nutrient management can be used to scale up the promotion of the new technologies. However, these approaches are still not widely embedded in national research and development systems and more work is needed to popularise their use. In Sub-Saharan Africa, there is a huge potential for extending rainfed rice production to vast areas of underexploited land. There is a major political push to promote the uptake of the new 'NERICA' varieties, but considerable research is needed to ensure that suitable germplasm is deployed and adapted in highly diverse locations. It is important to note that inter-specific crosses are not always in highest demand from farmers. All of the preferred rice varieties promoted through two PVS projects in Ghana were sativa varieties (J. Witcombe, personal communication). Adaptation for resistance to local strains and populations of diseases and pests is one of many important issues that will need to be addressed and PVS can play a key role in this. Outputs from RNRRS research on rice blast and rice yellow mottle disease can help to inform this process.

Emerging themes

In August 2005, the International Rice Genome Sequencing Project (IRGSP) announced that the full sequence data of the rice genome were available and in the public domain (IGRSP, 2005). The IGRSP was a publicly-funded Japanese-led initiative, to which the UK also contributed. However, it is also significant that Monsanto and Syngenta contribute sequence data to the IRGSP thus enabling the work to be completed more rapidly than would otherwise have been possible. Rice is the first crop plant for which the genome has been sequenced but the information has much wider application. Due to the similarity of their genetic make-up, the rice genome data can be used to accelerate improvement of other important cereal crops such as maize, wheat, sorghum and sugar cane. Advances in genomics research have greatly widened the scope for the application of DNA markers in plant breeding. Much work remains to be done to identify the genetic loci and the specific allele variants that are responsible for the phenotypic expressions that breeders look for to improve rice plants. Perhaps the most interesting potential use of the new knowledge and the new genetic markers is for breeding for tolerance to drought and salinity. However, the culmination of many projects on evaluating root traits in rice to breed for better drought tolerance had limited impact when applied in a practical breeding programme (Steele *et al*., 2004). Novel approaches to the use of molecular markers,

pioneered in rice in the RNRRS can be applied to breeding for tolerance to abiotic stresses (Steele *et al*., 2006).

Genetically-modified rice varieties have been developed and are already being cultivated in some countries. Among the developing countries only Iran has officially released a transgenic rice variety, with 4,000 hectares of a variety expressing the *Bacillus thuringiensis* (*Bt*) toxin gene being grown in 2004. China has evaluated *Bt* rice in pre-production trials and is expected to approve one or more varieties for commercial release within the 'near term' (James, 2005). The so-called 'Golden Rice' is currently being tested in field trials to evaluate the absorption and bioavailability of the high levels of provitamin A which have been engineered into new rice lines. In spite of the opportunities for using transgenic approaches to develop novel resistance or tolerance to biotic and abiotic stresses, and to enhance the nutritional value of rice, public concerns remain about the safety of such approaches. New techniques to minimise risks are being developed and RNRRS research has contributed to this development. As discussed above, transformation technologies were developed (R7548) which were then used to introduce nematode resistance genes into rice without any selectable marker genes (R8031).

The International Rice Research Institute's new environmental framework reflects the growing awareness of the need to place environmental issues at the centre of the research agenda. In spite of recent successes, some familiar problems remain. Overuse of pesticides is still a problem in some areas, often resulting in the development of resistance and secondary infestations of pests. There is potential for scaling up and fine-tuning IPM techniques developed by RNRRS, in particular the control of stem borer. The degradation in irrigation schemes is a serious issue which needs to be addressed. DFID-funded research in Senegal, Burkina, and Mali has developed institutional mechanisms that allow a range of remedial measures to be explored, but detailed evaluation of options on-farm still needs to be done.

In West Africa, in particular, a key issue will be how best to make markets work for rice farmers. In the absence of appropriate policy interventions to provide incentives for increased productivity, the impact of technological advances will remain limited. Work supported by the United States Agency for International Development on input and output markets in Nigeria is important in this regard. However, there are other areas such as facilitating farmer access to credit and, at the macro level, promoting regional integration on tariffs where more work is needed. Improving post-harvest quality and branding are areas which need much greater attention. RNRRS research on rice quality generated useful outputs, but this was done on a pilot basis and the lessons learned need to be shared more widely.

In conclusion, there are several research areas in rice-based systems where future DFID research can make an impact on poverty reduction and in stimulating economic growth. There is good potential to scale up promising outputs from the RNRRS and to add value to other initiatives such as the Dissemination of New Agricultural Technologies in Africa (DONATA) project of the New Partnership for African Development. There are also emerging research areas where DFID research can make a distinctive contribution, but it will be important to ensure that the relatively

limited funds available are used to add value and to leverage additional resources most effectively.

Acknowledgements

We thank all those who participated in stakeholder workshops in Bangladesh, Benin and the United Kingdom and others who gave us their views in separate discussions. We are grateful to DFID research programme managers and advisors for providing guidance and suggestions and for making available to us a wide range of documents. This report is an output from a study commissioned by the Crop Protection Programme (CPP) of the UK Department for International Development. The views are not necessarily those of the CPP or DFID.

References

Almekinders, C.J.M. and Elings, A. (2001) Collaboration of farmers and breeders: Participatory crop improvement in perspective. *Euphytica* **122**, 425-438.

ASARECA (2005) Strategic priorities for agricultural development and agricultural research-for-development in Eastern and Central Africa. 81 pp.

Atkinson, H.J., Urwin, P.E. and McPherson, M.J. (2003) Engineering plants for nematode resistance. *Annual Review of Phytopathology* **41**, 615-639.

Azzam, O. and Chancellor, T.C.B. (2001) The biology, epidemiology, and management of rice tungro disease in Asia. *Plant Disease* **86**, 88-100.

Becker, M. and Johnson, D.E. (2001) Improved water control and crop management effects on lowland rice productivity in West Africa. *Nutrient Cycling in Agroecosystems* **59**, 119-127.

Cantrell, R.P. and Hettel, G.P. (2004) Rice-based production systems for food security and poverty alleviation in Asia and the Pacific. In: Van Nguyen, N (ed.) Proceedings of the FAO Rice Conference 'Rice is life'. *International Rice Commission Newsletter*, Vol, 53 (special edition), Rome: FAO

CPHP South Asia Regional Office (2002) *Regional Strategy for Crop Post-Harvest Programme in South Asia, 2002 – 2005*. Aylesford: CPHP

CPHP West Africa Regional Office (2002) *Regional Strategy for Crop Post-Harvest Programme in West Africa, 2002 – 2005.* Aylesford: CPHP

Craufurd, P.Q. (1997) *Research theme: Drought in rice*. Report commissioned by the Plant Sciences Research Programme, Centre for Arid Zone Studies, Bangor, U.K.

De Datta, S. K. (1981) *Principles and Practices of Rice Production*. John Wiley, New York.

Defoer, T., Wopereis, M.C.S., Jones, M. P., Lançon, F., Erenstein, O. and Guei, R.G. (2004) Rice-based production systems for food security and poverty alleviation in sub-Saharan Africa. In: Van Nguyen, N (ed.) Proceedings of the FAO Rice Conference 'Rice is life'. *International Rice Commission Newsletter*, Vol, 53 (special edition), Rome: FAO.

DFID (2005) *Growth and poverty reduction: the role of agriculture*.

Diarra, D. (2004) *Analyse des Déterminants de la Compétivité du Riz de l'Office du Niger sur les Marchés Nationaux et Sous Régionaux*. Bamako: Projet Trade Mali.

Evenson, R.E., Pray, C.E. and Rosegrant, M.W. (1998) *Agricultural research and productivity growth in India.* Research Report 109, International Food Policy Research Institute, Washington D.C.

Fan, S., Chan-Kang, C., Qian, K. and Krishnaiah, K. (2005) National and international agricultural research and rural poverty: the case of rice research in India and China. *Agricultural Economics* **33**, 369-379.

FAO (2005) FAOSTAT database (available at www.fao.org)

Gaunt, J.L. (2005) An account of the dialect approach developed by DFID NRSP project R7839. Annex Bi to the Final Technical Report of F7839. NRSP

Haefele, S.M., Johnson, D.E., Diallo, S., Wopereis, M.C.S. and Janin, I. (2000) Improved soil fertility management is profitable for irrigated rice farmers in Sahelian West Africa. *Field Crops Research* **66**, 101-113.

Hossain, M. and Narciso, J. (2004) Global rice economy: long-term perspectives. Paper presented at the *FAO Conference on Rice in Global Markets and Sustainable Production Systems*, Rome, Italy, 12-13 February 2004.

IRGSP (2005) The map-based sequence of the rice genome. *Nature* **436**, 793-800

IRRI (2001) *Water in rice: The way forward.* IRRI Annual Report, *2000-2001*. 17 pp.

James, C. (2005) *Global status of commercialized biotech/GM crops: 2005*. ISAAA brief no. 34.

Johnson, D.E. (1997) *Weeds of Rice in West Africa.* West Africa Rice Development Association, Bouaké, Côte d'Ivoire, 312 pp.

Johnson, D.E., Wopereis, M.C.S., Mbodj, D., Diallo, S., Powers, S. and Haefele, S.M. (2004) Timing of weed management and yield losses due to weeds in irrigated rice in the Sahel. *Field Crops Research* **85**, 31-42.

Joshi, K.D., Biggs, S., Gauchan, D., Devkota, K. P., Devkota, C. K., Shrestha, P. K. and Sthapit, B. R. (2005) *The Evolution and Spread of Socially Responsible Technical and Institutional Changes in a Rice Innovation System in Nepal.* Discussion Paper no. 8 December 2005. Bangor: CAZS Natural Resources.

Joshi, K.D., Musa, A.M., Johansen, C., Gyawali, S., Harris, D. and Witcombe, J.R. (2006) Client-oriented breeding (COB) produces widely adapted rice varieties. *Experimental Agriculture* (submitted).

Kumar, J. *et al*. (2003) Promotion of chickpea following rainfed rice in the Barind area of Bangladesh (R7540). Final Technical Report.

Lipton, M. (2005) *The family farm in a globalizing world: The role of crop science in allevaiating poverty*. Discussion Paper 40, International Food Policy Research Institute, Washington D.C.

Macintosh, D. (2005) The gene revolution. *Rice Today* **5**, 14-18.

Matteson, P. C. (1996) Implementing IPM: Policy and Institutional Revolution. *Journal of Agricultural Entomology* **13**, 173-182.

Moody, K. (1993) Weed control in wet seeded rice. *Experimental Agriculture* **29**, 393-403.

Omamo, S.W. (2005) *Agricultural Development Policy in Eastern and Central Africa: Strategic Priorities for Growth and Poverty Reduction.* Unpublished report.

Peng, S., Laza, R.C., Visperas, R.M., Sanico, A.L., Cassman, K.G. and Khush, G.S. (2000) Grain yield of rice cultivars and lines developed in the Philippines since 1966. *Crop Science* **40**, 307-314.

Pinto, Y.M., Kok, R.A. and Baulcombe, D.C. (1999) Resistance to rice yellow mottle virus (RYMV) in cultivated African rice varieties containing RYMV transgenes. *Nature Biotechnology* **17**, 702-707.

Pierce, J. (Ed.) (2003) *Establishing DFID Priorities for Development Research.* Workshop held at the Natural Resources Institute, University of Greenwich, 20th October 2003. PARC Project No: 146. http://www.dfid.gov.uk/research/newresearchworkshoptaaice.pdf

Pound, B and Adolph, B (2005) *Developing the capacity of research systems in developing countries: Lessons learnt and guidelines for future initiatives.* Chatham: NRI and East Kilbride: DFID CRD.

Settle, W.H., Hartjahyo, A., Endah, T.A., Widyastama, C., Arief, L.K., Dadan, H., Alifah, S.L. and Pajarningsih (1996) Managing tropical rice pests through conservation of generalist natural enemies and alternative prey. *Ecology* **77**, 1975-1988.

Singh, S.P., Orr, A.W., Singh, S. and Singh, G. (2005) *The economics of direct-seeded rice in eastern India.* Unpublished Report. G.B. Pant University of Agriculture and Technology, Pantnagar, India. 24 pp.

Steele, K.A., Edwards, G., Zhu, J. and Witcombe J.R. (2004) Marker evaluated selection in rice: shifts in allele frequency among bulks selected in contrasting agricultural environments identify genomic regions of importance to rice adaptation and breeding. *Theoretical and Applied Genetics* **109**, 1247-1260.

Steele, K.A., Price, A.H., Shashidhar, H.E. and Witcombe J.R. (2006) Marker-assisted selection to introgress rice QTLs controlling root traits into an Indian upland rice variety. *Theoretical and Applied Genetics* **112**, 208-221.

Stirling, C.M., Harris, D. and Witcombe, J.R. (2006) Managing an agricultural research programme for poverty alleviation in developing countries: an institute without walls. *Experimental Agriculture* (in press).

Urwin, P.E., Troth, K.M., Zubko, E.I. and Atkinson, H.J. (2001) Effective transgenic resistance to *Globodera pallida* in potato field trials. *Molecular Breeding* **8**, 95-101.

Vain, P., Afolabi, A.S., Worland, B. and Snape, J.W. (2003) Transgene behaviour in populations of rice plants transformed using a new dual binary vector system: pGreen / pSoup. *Theoretical and Applied Genetics* **107**, 210-217.

van der Hoek, W., Sakthivadivel, R., Renshaw, M., Silver, J.B., Birley, M.H. and Konradsen, F. (2001) *Alternate Wet/Dry Irrigation in Rice Cultivation: A Practical Way to Save Water and Control Malaria and Japanese Encephalitis?* Research Report Series no. 47,International Water Management Institute, Colombo, Sri Lanka.

Virk, D.S., Bourai, V.A., Choudhary, A., Misra, M. and Witcombe, J.R. (2004) *Participatory crop improvement in Eastern India: An impact assessment*. (available at www.psp.org).

WARDA (2000) *Rice in the economy of West Africa. A time series set for economic analysis.* Bouaké: WARDA

WARDA (2005, 3rd ed.) *Rice Trends in Sub-Saharan Africa*. Cotonou: WARDA (Africa Rice Center)

Wilby, A. and Thomas, M.B. (2002) Natural enemy diversity and pest control: patterns of pest emergence with agricultural intensification. *Ecology Letters* **5,** 353–360.

Witcombe, J.R., Joshi, K.D., Rana, R.B. and Virk, D.S. (2001) Increasing genetic diversity by participatory varietal selection in high potential production systems in Nepal and India. *Euphytica* **122**, 575-588.

Witcombe, J.R., Joshi, K.D., Gyawali, S., Musa, A.M., Johansen, C., Virk, D.S. and Sthapit, B.R. (2005) Participatory plant breeding is better described as highly client-oriented plant breeding. 1. Four indicators of client-orientation in plant breeding. *Experimental Agriculture* **41**, 299-319.

Annex 1 Terms of reference for the study

Background and Objectives

Through its Renewable Natural Resources Research Strategy (RNRRS) the UK Department for International Development (DFID) has, since 1995, been funding research projects to improve the livelihoods of the poor through sustainable enhancement of the renewable natural resource systems. One of the RNRRS programmes, the Crop Protection Programme (CPP) has provided significant funding for research into the development and promotion of knowledge and technologies which reduce losses by pre-harvest pests, weeds and diseases of crops which are essential commodities for poor people. Of these crops FAO estimates that global demand for rice will continue to increase substantially within the next few decades, particularly in sub-Saharan Africa.

Therefore the CPP is seeking to fund a synthesis study with the objective of reflecting on research conducted in this sector with a special emphasis on that funded through the RNRRS – knowledge gained, lessons learned and compatibility with other initiatives (both from other funding sources and from pre-RNRRS programmes). Inputs should be sought from the Plant Sciences Research Programme, the Crop Post Harvest Programme as well as the CPP. The study should address issues in Asia and in East and West Africa. This reflection should be used to provide evidence-based recommendations of further researchable constraints which will lead to poverty elimination.

Activities

Through review of the literature and CPP documentation, and discussion with CPP/CPHP/PSP managers, project leaders and other stakeholders

a. Review the livelihood context of those involved in rice production and processing systems in south Asia and West and East Africa.
b. Identify the major constraints in rice-based farming systems in the target regions and how these are reflected in CPP/PSP/CPHP strategy.
c. Assess the criteria that have been used to identify and commission research projects and examine whether these have changed over time.
d. Identify the main stakeholders involved in rice-related activities in the target regions and also the main research initiatives.
e. Examine how stakeholders were involved in the different projects and how effective was the communication between them.
f. Assess how the project has utilised available skills and expertise and how project tasks were allocated and subsequently evaluated.
g. Identify what lessons have been learned by project partners about the research process and whether and how have these been documented.
h. Assess the tangible **and intangible** outputs which the projects have produced and who are the clients for these outputs.
i. Examine how the project has taken these outputs forward and how widely available they are to other stakeholders.
j. Assess the potential for wide-scale impact of project outputs at different levels and what implications this has for policy in the target countries.

k. Outline the emerging areas of priority research for the future and how this will feed into pro-poor growth and wider economic development.
l. Discuss what processes are best suited to defining such researchable areas in the future.

Particular attention will be given to future research needs and to the activities specified in points j-i above.

Specific Outputs with dates of delivery

Outputs *(please add or expand rows as needed)*	**Dates of delivery**
Review of background literature and project selection finalised	**05/08/05**
Discussions with key informants in Asia and Africa completed	**26/08/05**
Discussions with UK project leaders and programme managers completed	**30/09/05**
First draft of final report ready for discussion with CPP management	**14/10/05**
Final report ready for submission to CPP	**31/10/05**

Annex 2 Projects with relevance for, or primary focus on, rice commissioned by different RNRRS programmes (project completed in or after 2001)

CPP

Project number	Project title	Country
R6519	Tungro virus disease	Philippines
R6738	Rice blast disease in West Africa	Various
R6763	Rice yellow mottle virus	Tanzania
R7296	IPM	Bangladesh
R7471	Weed management	Bangladesh
R7570	Biodiversity in rice-based cropping systems	W. Africa, Vietnam
R7885	IPM options for chickpeas pest and disease control	Nepal
R7778	Rice blast	West Africa
R7891	Hispa management	Bangladesh
R8026	Rice stemborer pheromone	Bangladesh
R8184	Rodent management (PETRRA initiated)	Bangladesh
R8233	Weed management	India
R8234	Herbicide use / weed management	Bangladesh
R8304	Rice stemborer pheromone	India, Bangladesh

NRSP

Project number	Project title	Country	Production system
R8306	Better options for integrated floodplain management - uptake promotion	Bangladesh	Land Water Interface
R8195	Integrated floodplain management - institutional environments and participatory methods	Bangladesh	Land Water Interface
R7888	Promotion of rainwater harvesting systems in Tanzania - Phase 1	Tanzania	Semi-Arid
R7872	Renewable natural resource-use in livelihoods at the Calcutta peri-urban interface	India	Peri-Urban Interface
R7868	Maximisation of joint benefits from multiple resource use in Bangladeshi floodplains	Bangladesh	Land Water Interface
R7600	An assessment of strategies for integrated crop management	Bangladesh	High Potential
R7583	Livelihoods improved through integrated crop management: Bihar and Uttar Pradesh	India	High Potential
R7562	Methods for consensus building for management of common property resources	Bangladesh	Land Water Interface
R7323	Participatory crop improvement in high potential production systems and salt affected areas of Patiala district of Punjab State	India	High Potential
R6751	Soil fertility management	Bangladesh	
R7839	Knowledge management	India	

CPHP

Project number	Project title
R8274	Improvement of maize marketing through adoption of improved post-harvest technologies and farmer group storage: A case study of Kiboga and Apac districts
R8263	Enhancing rural livelihoods through a new coalition arrangement for the dissemination of improved rice post-production and marketing technologies in Northern Ghana

R7929	Access to good quality agri-inputs (fertilizer, pesticides and seed) for resource poor rice producing households
R7531	Post-harvest practices affecting rice milling quality
R7496	Marketing constraints to increasing financial returns to small and medium scale rice paddy producers in Bangladesh
R7372	Development of a methodology for assessing the impact of rodents on rural household food security, health and nutrition
R7373	Understanding the mechanisms of bio-activity in botanically derived materials used to protect stored grain in farm-level storage systems
R7013	The role of warehousing in improving performance of agricultural markets, Phase II

PSP

Project code	Project title
R8269	Improvement of rainfed cropping systems in the High Barind Tract of Bangladesh
R8221	Promotion of rainfed rabi cropping in rice fallows of eastern India and Nepal: phase 2.
R8031	Genetic transformation of rice, potato and cooking bananas for nematode resistance.
R8099	Participatory plant breeding in rice and maize in eastern India - its scaling up and evaluation of products and methods.
R8200	Marker assisted selection for participatory plant breeding in rice.
R8071	Participatory plant breeding in rice for high potential production systems in the terai and low hills of Nepal.
R8024	Molecular analysis of sexual and somatic hybrids of *Oryza sativa* and *O. granulata* for comparative genome characterization
R7415	RYMV resistance in rice.
R7657	Participatory rice variety improvement in Ghana II.
R7548	*Agrobacterium* -mediated transformation of rice for pest and disease resistance, the development of clean gene technology, mapping natural resistance to RYMV and nematodes in interspecific crosses and investigation of QTLs linked to components of yield
R7535	Analysis of environmental effects on expression of root penetration QTLs in upland rice, and development of PCR markers for QTL selection in drought resistance breeding
R7438	Participatory promotion of 'on-farm' seed priming
R7540	Promotion of chickpea following rainfed rice in the Barind area of Bangladesh.
R7434	Innovative methods for rice breeding - combining participatory plant breeding (PPB) with molecular marker techniques.
R7415	Containment testing of transgenic rice lines with resistance to RYMV, the development of markers to assist selection for nematode and RYMV resistance in WARDA introgression lines from *O. glaberrima* and *O. sativa* crosses
R8098	Promotion of rainfed rabi cropping in rice fallows of India and Nepal: pilot phase.
R7541	Assessing the potential for short-duration legumes in South Asian rice fallows.
R7417	Cytoplasmic diversification for hybrid rice improvement. Phase III.
R7294	Full and durable crop resistance in rice and potatoes to nematodes.
R7323	Participatory crop improvement in high potential production systems and salt affected areas of Patiala district of the Punjab State

Annex 3 Summary of a stakeholder meeting in Bangladesh to discuss lesson learning from rice research supported through the DFID renewable natural resources research strategy

IRRI office, Banani, Dhaka
26th July 2005

Background

The meeting was held as part of a lesson study on rice research supported by the United Kingdom's Department of International Development (DFID) through its Renewable Natural Resources Research Strategy (RNRRS). The background and objectives of the study and the proposed Terms of Reference are shown in Annex 1.

Introductory session

Dr Hamid Miah, liaison scientist for the International Rice Research Institute (IRRI), welcomed participants to the meeting and thanked them for their attendance. He summarised the background to the meeting and invited the Chairman, Dr M.A. Baqui of the Bangladesh Rice Research Institute, to open the proceedings. Dr Baqui then requested Tim Chancellor, advisor to DFID's Crop Protection Programme, to introduce the agenda.

Tim Chancellor expressed his appreciation to participants for attending the meeting at short notice and for taking time out of their busy schedules. He gave particular thanks to Dr Hamid Miah and colleagues at the IRRI office for arranging the meeting and for facilitating his visit. He also acknowledged the strong commitment to the research shown by the organisations represented at the meeting and recognised the tremendous enthusiasm and hard work shown by project staff over the last few years. He noted that there were no farmers represented at the meeting but indicated that he would have the opportunity to speak with some farmers during a planned field visit to Rajshahi the following day.

Tim Chancellor explained that the lesson learning study was not an evaluation; an evaluation of the current RNRRS had recently been conducted and the report was available on the DFID website at http://www.dfid.gov.uk[9]. The Bangladesh stakeholder meeting provided an opportunity for project collaborators to share experiences and to provide feedback on the DFID research programmes, based on their assessment of the individual projects in which they were involved. He also invited participants to think about future research priorities which DFID might support and to consider how any future research might be best carried out. He indicated that, for the rice lesson learning study, the focus is on research activities undertaken during the past five years in West and East Africa and South Asia. In the case of Bangladesh, most of the work has been commissioned by the CPP but there have also been activities funded through the Plant Sciences programme, Crop Post-harvest programme and Natural Resources Systems programme.

Tim Chancellor explained to participants that DFID currently funds research in the natural resources sector in two main ways. Firstly, through ten RNRRS research programmes which began in 1995 and which are administered by the Central Research Department. Secondly, DFID country offices may commission their own research activities to contribute to their national programmes. In Bangladesh, the Poverty Elimination Through Rice Research

[9] This is quite a large pdf file which can be accessed by typing 'Evaluation of RNRRS' in the search box

Assistance (PETRRA) project was funded through the DFID office in Dhaka. Tim Chancellor suggested that participants consider how the DFID RNRRS programmes complemented PETRRA and other donor initiatives. He also indicated that, traditionally, the DFID country offices were responsible for scientific capacity building. Consequently, capacity building was not an objective of the present DFID RNRRS central research strategy. The RNRRS strategy was originally designed to generate new scientific knowledge that could be used by research institutions, extension agencies, NGOs and other organisations to improve productivity and appropriate management of renewable natural resources. However, approximately half-way through the strategy there was a change of policy. This involved a stronger poverty orientation and an emphasis on more downstream activities to try to ensure that end users had greater access to improved technologies. Capacity development then began to be implemented through the RNRRS programmes, although this was never officially approved by DFID.

Tim Chancellor gave a short Powerpoint presentation in which he showed 'timelines' for the DFID RNRRS projects and linkages with other initiatives such as PETRRA and the Rice-Wheat Consortium. He summarised the Terms of Reference (ToR) for the rice lesson learning study and suggested that these ToR might be classified into four broad categories and used as a framework for discussion in the meeting. These categories were:

- How research priorities were identified and project commissioned.
- How the research was conducted.
- The major research outputs and issues relating to their promotion and influence on policy.
- Future research priorities for DFID-funded research and the process to be used to identify and articulate them.

Tim Chancellor asked participants to comment critically on the ToR and to propose any other issues that might be included. No new issues were identified and the group agreed to proceed with the discussion on the basis outlined above.

Research issue identification and prioritisation

The discussion on the identification and prioritisation of research issues was quite brief. With regard to the CPP approach, it was considered that the use of a programme review followed by a priority-setting stakeholder Workshop was appropriate. In the case of BRRI, the research topics were consistent with their core programmes and were problem-oriented. The strong farmer orientation of some of the CPP projects, such as the weed management research, was viewed as a positive feature. It was also noted that, whilst support for most projects continued beyond the first phase, there was also flexibility to commission new research into emerging problems. This was the case, for example, with the rodent management work which was jointly funded with PETRRA.

How the research was conducted

Several participants shared their experiences about how they worked with farmers at project field sites. Farmer group formation was encouraged in weed management research conducted in the Barind and farmer leaders were identified who were willing and able to test and demonstrate new technologies. Rodent management research in Comilla was conducted at the village level and involved bringing the whole community into the project activities. The stemborer pheromone projects used a community-based approach and, for the vegetable research in Jessore, agricultural clubs were identified and strengthened. It was agreed that, in order for some appropriate crop and pest management strategies to be developed, a

community approach was essential; individual farmers implementing their own control measures independently of their neighbours could not achieve the desired result.

Wide networking was viewed as crucial to ensure successful technology development and transfer. Engagement with policy makers is important. This has been recognised in the rodent management project in which local policy makers and government officials have been invited to meetings and made aware of the aims and findings of the project. In some cases, cross-sectoral approaches are necessary to achieve a successful outcome. The rodent management project again serves as an interesting example. Attempts have been made to bring in partners from the health sector and to raise awareness among policy makers in this sector but such linkages are not easy to develop and maintain. It was also suggested that benefits would accrue from engagement with the Roads and Highways Department and with the Local government Engineering Department.

In each of the projects discussed, training activities were conducted and were an important means of developing local ownership of the projects as well as transferring knowledge. The experience of AID-Comilla and BRRI with the PETRRA-funded Livelihoods Improvement Through Ecology (LITE) project was cited as an example of the successful replication of research outputs in new areas. This was done through farmer-to farmer extension. There was some discussion about the relative merits of training individual farmers or household groups. In certain situations, such as raising awareness about health issues associated with rodents, it would be preferable to conduct training at the household level.

It was pointed out that the selection of the target farmer groups differed between programmes. In PETRRA projects, the focus was on resource-poor farmers. Some participants argued that, in order to introduce and validate certain technologies, it was necessary to work with better-resourced farmers; at least initially. However, the ultimate objective was to develop management strategies that could be used by resource-poor farmers. Thus, for example, the intention for the rice pheromone technology was to make it available to farmers at a cost that was comparable to, or cheaper than, insecticide-based approaches.

Some participants argued that continued scientific involvement was needed during promotional activities in order to ensure that farmers received adequate technical back-up when new technologies were introduced. The example of plant grafting techniques was given, where the method was not always transferred successfully to farmers. Participants from AID-Comilla reported that they recognised the importance of strong linkages with scientists who were frequently involved at every level of activity in its programmes. Clearly, it is not possible for such linkages to be developed with all NGOs and extension agencies but the AID-Comilla approach highlights the value of a strong research-extension interface.

The role of international scientists in DFID RNRRS research projects was discussed. Some participants attached importance to the mutual sharing of ideas and to the access to a wider range of technologies and inputs. The example of pheromone technology was cited in which new knowledge and products were made accessible through the collaborative research projects. It was recognised that the available resources only allowed relatively small time inputs from international scientists and that their contributions had to be targeted carefully. Examples were provided of how visits from international scientists were scheduled in order to obtain the maximum benefit from their involvement. Some participants considered that three visits a year was a minimum for field-based research. It was pointed out that the increasing use of electronic communication media helped to optimise the contribution of overseas collaborators.

The participants exchanged experiences on communicating research findings to farmers and other end users. Mass communication was considered to be an important means of popularising new technologies such as the drum seeder which is currently being promoted in

Bangladesh. Visual images were capable of having a strong impact, especially if they were repeated several times. A film had been made of the LITE project and a video is being produced through the rodent project which is also aimed at a television audience. Videos and CDs now had a wider reach as most villages had a household or other facility with a television and a computer player. Nevertheless, participants recognised that complementary approaches were needed for effective communication and that field demonstrations were essential to convince farmers to adopt new technologies.

RNRRS projects had been utilising PETRRA communication fairs to publicise research findings and most had made a commitment to contribute material to the BRRI Rice Knowledge Bank. At a recent meeting at BRRI the issue of how to update the Rice Knowledge Bank was discussed. It was agreed that this should be a core activity of the institute and that updates would be linked to the annual review process. Fact sheets would be encouraged as project outputs.

There was consensus that new projects should include a budget line for communication. This will be a requirement for research commissioned through the next DFID agricultural research strategy.

Outputs and policy issues

Much of the discussion on project outputs and policy issues revolved around aspects of the research on insect pheromones. The pheromone research has been highly productive but concerns were expressed about the some of the requirements for completion of the registration process. In particular, the availability of laboratory facilities for testing the purity of pheromones and other biopesticides was questioned. It emerged that Dhaka University has suitable testing facilities and BARI has an MoU with the university. Field efficacy tests could be carried out by BARI, BRRI or other research institutions, as appropriate. Thus, it appeared that there were available solutions but further discussion is needed with the Pesticides Technical Advisory Committee to help move the process forward. It was noted that pesticide testing facilities were also lacking and that these were needed for ecological work as well as for registration purposes.

Future research

The discussion on future research centred mainly on pest management problems. Currently, the most economically important pests have been targeted for research in different cropping systems in Bangladesh. It was argued that for horticultural crops, new emerging problems such as tomato leaf curl virus would benefit from more detailed studies. Certain major constraints such as *Helicoverpa* and *Maruca* are of regional importance and would fit into a regional research approach. A possible framework for one component of a regional research programme might be production of safe and nutritious horticultural produce. Given some of the current issues in rice production, this framework might also have relevance. For example, some participants expressed concern about the growing use of herbicides and the possible effects on flora and fauna. Research on effects on non-target organisms might build on earlier study conducted in collaboration with the University of Newcastle. A cross-sectoral approach would accommodate research on rodent management, which remained a priority.

Other specific research priorities that were mentioned during the discussion were:

- Biological control of insect pests and diseases, to complement the DANIDA programme.
- Improved weed management in rice, vegetables and sugar cane; need for multi-row weeders.

- Rice gall midge; an emerging pest for which no effective management options are currently available. Prospects for research on pheromones (Swedish group involved).

Declining soil fertility remains a key issue for Bangladesh and it was suggested that there was a need for further research on the more efficient use of crop residues, both for soil improvement and to provide improved gross margins for farmers.

Chairman's summary

Dr Baqui concluded the meeting by drawing attention to the need to clearly identify target groups for research and to ensure that research findings were robust and economically feasible before making recommendations to farmers. With regard to publicising research outputs, he expressed the view that creating awareness is only a start and that continuing inputs are needed to facilitate farmer adoption. Dr Baqui suggested that future regional research in south Asia might include a focus on Bangladesh and neighbouring states in India; in particular, West Bengal. Increased food production would continue to be a priority and, in order to achieve this, effective crop protection was crucial. The IPM approach was the way forward for the region and much could be done to improve IPM strategies and encourage their widespread use.

List of Participants

Dr Md. Hamid Miah	IRRI liaison scientist
Dr M.A. Baqui	Director of Research, Bangladesh Rice Research Institute
Dr Nazira Quraishi Kamal	Director of Administration, Bangladesh Rice Research Institute
Dr Mainul Haque	Head of Entomology, Bangladesh Rice Research Institute
Dr Jashimuddin	Head of Agronomy, Bangladesh Rice Research Institute
Dr Mazid	Head of Station, Rajshahi, Bangladesh Rice Research Institute
Dr M.A. Jabber	Economics Division, Bangladesh Rice Research Institute
Dr Anwar	Plant Pathology Division, Bangladesh Rice Research Institute
Mr Mahbub Rahman	Product Development Manager, Syngenta Bangladesh Ltd.
Dr Sayed Nurul Alam	Entomology Division, Bangladesh Agricultural Research Institute
Md. Harun-Ar-Rashid	Executive Director, Agricultural Advisory Society
Two representatives	AID-Comilla

N.B. Representatives from the Bangladesh Agricultural Research Commission, the Department of Agricultural Extension and Proshika were invited, but were unable to attend due to other commitments.

Annex 4 Emerging issues from discussions with WARDA staff in relation to the DFID lessons learning study on rice cluster projects in West Africa

Barbara Adolph, NRI, September 2005, B.Adolph@gre.ac.uk

This is a summary of discussions held with staff from WARDA, FRI (Food Rearch Institute, Ghana) and MoFA (Ministry of Food and Agriculture, Ghana) on their views in relation to lessons learnt from DFID funded rice research in West Africa. The summary is based on face-to-face discussions with individual scientists on 27 and 28 September, and a group discussion on a first draft of this summary on 29 September. A list of individuals consulted is included in the annex, as well as the checklist used.

The main focus of this study was on research funded within the RNRRS (Renewable Natural Resources Research Strategy) of DFID during the past five years. However, few scientists were actively involved in research under this funding stream. Therefore, other DFID-funded research under attributed funding (Sahelian Irrigated Rice Research project and INGER network) was included.

The findings of this visit will be used to compile a synthesis of lessons learnt from DFID-funded rice research in South Asia and Africa, carried out jointly by Tim Chancellor and Barbara Adolph from NRI. A final version of the study should be available to all contributors by the end of 2005.

The outcome of discussions can be divided into two main areas:

1. Lessons learnt about research process
2. Suggestions for future researchable areas

1. Lessons learnt about research process

With research process, we mean the way in which research calls issued, research priorities were identified, partnerships were developed and sustained, research was implemented, monitored and evaluated, outputs were shared and promoted, and capacity of the various partners was built in the process.

Project development / proposal writing

- Often there is insufficient time to develop research proposals in partnerships with organizations overseas. There is a need to have more time to develop proposals to ensure equal opportunities for partners in the South, who might require more time to communicate due to technical problems (e.g. ICT problems). There is a difference between real partnerships (which require a two-way process) and consultations, where the Northern organisations only present their ideas to Southern organizations in the last minute, rather than developing them together.
- Donors can identify wider themes (e.g. IPM / NRM / post-harvest), but calls should not be too restrictive in order to allow addressing local priorities.

- The coalition approach used during the last two years by CPHP (DFID's Crop Post-Harvest Programme) has increased ownership of NARS scientists.
- Generally there have not been pre-project meetings between partners to develop the proposals. This was considered a shortcoming, because as a result Northern partners often did most of the proposal development, and inputs from Southern partners and stakeholders was less. Inception workshops can be used to make (minor) adjustments to agreed projects, but many projects did not budget for an inception workshop.
- When there are follow-up projects / extensions of projects on related topics, there is generally a lot more ownership by Southern partners. In the blast project, Southern ownership was higher during the second phase.
- Sometimes there is a communication gap between Southern partners and donors, because communication often goes via the Northern project leader. This can lead to delays and to lack of information (e.g. reasons why proposals are refused are not given)

Identification of research priorities

- It is important to identify priorities together with NARS. This was done by the IPM task force of ROCARIZ, consisting of NARS and WARDA staff, which identified blast and RYMV as the two most important diseases in the region.
- Focusing on regional priorities could potentially controversial, if some national constraints are very severe, but geographically limited in scale (e.g. bacterial blight is also important, but localized in Niger and Mali). To address this, WARDA uses a range of funding channels, in particular competitive grants under ROCARIZ. Small amounts of funding can have a large impact, if used strategically. That way, work on bacterial blight and nematodes has been funded.
- ASI Senegal: The need for a small-scale thresher was identified by farmers at community level
- Other stakeholders (extension, NGOs, farmers organizations / civil society organizations) are included in the priority setting through membership in the ROCARIZ task force on technology transfer. This also includes NGOs.
- Farmers participate indirectly in research priority identification through NARS and by being involved in M&E / impact assessment surveys
- The Sahelian project (irrigated rice research project) used intensive characterization (socio-economic and bio-physical) of farmers, which included constraint analysis.
- It is useful to hold meetings at the beginning of the season with farmers to discuss important constraints and opportunities. This could be done by NARS and extension in each country (actually some countries are doing it).

Farmer involvement in research

- There has been involvement of farmers through on-farm testing of technologies, in particular PVS (participatory variety selection) – with an emphasis on research or extension (PVS – R or PVS – E – researcher or extension lead).
- The technology transfer task force involves developmental organizations and farmer organizations – it is lead by a woman farmer, who is also a seed producer.
- Farmers are also involved in CBSS (community-based seed systems) and PLA (Participatory Learning and Action).

- IFAD-funded project on Participatory adaptation and diffusion of technologies for rice-based systems in West Africa (phase II) looks at PTD and farmer innovation. This might be a useful resource for other WARDA scientists to get involved in local knowledge documentation and use.
- The blast project in Ghana worked through AEAs (agricultural extension agents), who were the direct link to farmers. There was no inception workshop, but that would have been useful to make adjustments to the initial project and ensure that all stakeholders / partners agree with it.
- Generally there was no differentiation of farmers by resource endowment for RNRRS funded projects – only the Sahelian Irrigated Rice Research Project developed options for different types of farmers. Generally there is a perception that most rice farmers in West Africa are poor and have few resources. There is however differentiation by gender, as in Burkina and Northern Cote d'Ivoire most rice farmers are women.

Extension involvement in research

- In the CPHP rice quality improvement project in Ghana, extension agents were not involved in selecting target areas and participating farmers (was done by FRI instead). It would have been useful to include AEAs in the selection, as they have a better overview of the production and processing constraints in different parts of the country.
- Sometimes remuneration for extension staff working on research projects is too low, which discourages their participation (Ghana)

Flexibility in research design

- It is important to design research projects with a longer time horizon (5 years), in order to have enough time to build partnerships, implement the project and share the outcomes. Including a wide range of stakeholders requires time.
- At the same time, projects need to be flexible in terms of specific activities and their timing, as well as in the selection of partners. During a 5-year horizon, things change and the projects need to be in the position to react flexibly to this change. The DFID support to INGER was mentioned as an example for a flexible project design.
- Longer time horizons would also allow to scale out research findings from the initial pilots.
- Blast and RYMV projects: The core funding to WARDA and the CPP funded smaller projects (R7552/blast and R6723/RYMV) were complementary. The smaller projects with NARS allowed applying findings that emerged from the larger projects funded through core funds. Donors should look for such complementarities and synergies.
- No-cost extensions can be useful to exploit the opportunities for dissemination, e.g. during workshops. However, they are generally discouraged by WARDA and by the main donors, except for specific circumstances. Some donors will ask for unspent funds to be send back to them.
- Donors sometimes push paradigms to much (e.g. sustainable livelihoods, innovation systems). It is not good for donors to tie people down to one single framework / approach that is in vogue.

- Sometimes other projects (funded by other donors) can be useful partners in research. Again, if the project design is flexible, synergies can be better exploited (e.g. French lowland rice development project – also worked on milling)

Partnerships

- All consulted agreed that building partnerships is crucial for the success of research projects. It requires time and resources, which are often not adequate in the project budgets.
- It is important to build and sustain partnerships within countries, within the region, and internationally. Exchange visits are an important tool for this, but need to be targeted and integrated into project design.
- Good communication and joint field activities between WARDA staff based at HQ and in the partner countries are important. ICT systems don't always work, so relying on email alone is not enough.
- Exchange between South Asia and West Africa exists, but could be intensified. WARDA is part of the IHP project (Interspecific hybridization project), which involves South Asia, Africa and the US. The GSI (Good Seed Initiative) covers South Asia and Africa. See also CABI book on 'The African food crisis, Lessons from the Asian Green revolution' and the PETRRA book (Paul Van Mele et al.) on 'Innovations in Rural Extension: case studies from Bangladesh'.
- Linkages between NARS and universities need to be improved. NARS often perceive universities as competitors for research funding. However, universities have a more stable HR capacity, and obviously play a key role in training future generations of researchers. ROCARIZ has some mechanisms for supporting students from NARS for further studies.
- University scientists are often more interested in basic research and teaching, whereas NARS focus on applied research. This is another reason for universities not often being involved in collaborative research activities. The main link is through research students at different levels. The WARDA DJ always urges staff to engage with universities and focus on capacity development of NARS to develop future partners.
- At project level, WARDA usually does not work directly with farmer groups, but through national partners, who in turn work with farmer groups
- A flexible project design allows the development of new partnerships and of capacity of partners (e.g. INGER in Guinea)
- In some projects (e.g. DFID attributed funding to irrigated rice research project (previously programme) in Senegal / Sahel), NGOs were involved in on-farm testing of technologies.
- In the same project, local artisans and private sector firms (threshing services provider) participated to develop and test an improved small-scale rice thresher (ASI). The partnership worked, because roles were clearly defined, and key stakeholders (including farmers – association of women rice farmers) were actively involved
- Overall the involvement of "non-traditional" partners in research projects is increasing (e.g. private sector, NGOs). For example, the blast project worked primarily through MoFA in Ghana, as agricultural NGOs were not much developed when the project started.
- If follow-up projects take too long to be approved, continuity is lost and NARS scientists move on to working on other issues (relates to the need for longer time horizons of projects).

Networks

- ROCARIZ is the main network of WARDA, coordinated by a WARDA staff, and managed by NARS directors. ARI (African Rice initiative) works with a wider range of stakeholders on development / technology transfer. DFID-funded research on blast and RYMV was priorities by network partners (IPM task force)
- ROCARIZ membership is decided by country coordinators. Sometimes WARDA lobbies for inclusion of particular partners, e.g. universities.
- The ROCARIZ coordinator is a NARS staff, seconded to WARDA for a period of 2-4 years. CORAF and NARS DGs select the coordinator.
- ROCARIZ has a competitive fund, but the amounts available are very small (around 1000$ per project). Some scientists argued that this can be enough to do some specific, targeted work, while others argued that it is too little and therefore of limited use.
- WARDA is keen on research for development, and the partners in the ROCARIZ are NARS, who have an interest in research and development. There is however a perceived separation between research and extension.
- Besides ROCARIZ, there are other networks and channels that enable working with universities and other partners.

Capacity development

- Developing capacity of NARS is one of the main objectives of WARDA. There is a brain drain problem (e.g. scientists moving 'up' to CG centres, or to NGOs – such as socioeconomists in Gambia). CD needs to be a continuous activity, not just one-off
- Because of capacity shortage among NARS, the 'good' NARS scientists get overloaded – they take on more work than they can possibly do. There is a need for governments to be committed to agricultural research and NARS.
- If funding for projects is not in line with available human resources, this will generate problems in the long term. It is important to build a critical mass of qualified people, who can support each other and share experiences. HR development should be included as a separate, but integrated budget line in projects.
- However, it can be useful to train NARS scientists even if not all the require equipment is available in country. This is because donors are more willing to pay for equipment when they know that there are people who know how to use it, and NARS scientists are more likely to apply for funds to buy equipment, once they realize the usefulness.
- Using a systems approach that benefits from the inputs from different disciplines is very useful. However, many scientists in the NARS (and in the CGIAR) do not have a lot of experience of working in interdisciplinary teams. There is a need to build capacity in interdisciplinary work and to raise awareness of the implications of a systems approach.
- The CPP funded blast project included capacity development of Southern scientists through visits to the UK (HRI, CABI biosciences and NRI). Partners found these visits very useful ('eye-operners') to enhance their knowledge and skills in basic sciences / molecular characterization.
- The benefit of exchange visits (as part of collaborative research) are both ways. When Dr Prasad came to Ghana, he realized how seriously rice production was

affected by blast. Exchange visits should include N-S, S-N and S-S visits (e.g. for Ghanean researchers visiting Cote d'Ivoire and Guinea to assess RYMV)

- The blast project applied for funds to train NARS in the two techniques developed, but this proposal was not approved – possibly because of doubts about WARDA's capacity at that time to carry out the training due to the relocation.
- Capacity development of farmers is an important output of research projects (e.g. RYMV: Farmers in Mali now understand where the disease came from and that they need to use resistant varieties to control it. The enhanced knowledge of farmers is often not captured in project documents.
- Learning between farmers is also important. In the CPHP funded rice quality project in Ghana, women farmers from Upper East region trained women from Northern region in rice processing.

Outputs and promotion of outputs

- Irrigated rice research project Senegal: focused on different crop management *options* ('supermarket concept') for different types of farmers, acknowledging that they have different resource endowments. This was a useful lesson – projects should move away from an 'optimal' solution / complete package towards a range of options targeting different socio-economic and agro-ecological groups
- However, this approach requires a rethinking and change of attitudes for both researchers and extensionists. Initially it is time consuming and requires skills not readily available in national systems. HRM is key to this approach. Initially costs are higher than conventional research, but over time confidence develops and the process becomes easier and cheaper.
- Northern partners / donors often assume that material available electronically (www) is accessible to Southern partners. However, IT infrastructure is often very basic, Internet connections are unreliable, slow and expensive, and therefore large files can generally not be downloaded. For example, NARS partners in Ghana have not had access to the rice blast proceedings (Nutsugah et al.), as hard copies had not been sent to them, and downloading the file from the WARDA web site was not possible to them (Dr Nutsugah took a pile of the proceedings with him back to Ghana).
- The final project workshop for the rice blast project was useful, as it brought together NARS from the region, as well as policy makers. It might have been useful to involve policy makers earlier on, but there were no specific provisions for this in the project. However, the directors of SARI and CRI were involved in the project and they participate in policy fora. Dr Salifu (NARI director Ghana) is still using the blast work as one of the success stories for agricultural research in Ghana.
- Increased knowledge and skills of researchers involved in capacity development is an intangible output that is not usually reflected in research reports. For example, Dr Nutsugah got a much better overview of biotic constraints to rice production in Ghana as a result of his involvement in the blast project. He can use this knowledge to advise the government (MoFA), e.g. which areas have high disease pressure and require resistant varieties.
- Other intangible outputs can be environmental impact and impact on work load (e.g. through improved parboiling methods, reducing fuel requirements and labour – Ghana CPHP)

Monitoring, evaluation and impact assessment

- In principle all research projects have an M&E component for reporting against the log frame. In addition, the WARDA economists in partnership with NARS, carry out impact assessment of selected project in more depth. Staff capacity for impact assessment is low and it would be good to have the resources to hire MSc, PhD and Postdocs, to work on impact assessment.
- Overall the reporting requirements for the CG and for some donors have increased a lot, and as a result scientists are spending a lot of time on reporting. Administrative staff could probably do some of this reporting, but there is a shortage of admin staff since the moves. It would be better if documentation and reporting were better targeted and reduced in volume and frequency.
- Impact assessment focuses on quantitative techniques. There is little skill and experience with participatory monitoring and evaluation. To increase the depth of surveys, enumerators can be paid extra bonuses for "stories" from farmers that illustrate the points made.
- The research process and how it impacts e.g. on capacity of partners is not systematically assessed – the focus is on impact of research on poverty, food security, etc. This would require more resources.

Role of Northern partners

- Partners from the North can make a good contribution to projects, in particular in terms of technological facilities available with their organizations (physical facilities and ability to use them, and to train others to use them).
- Contributions from Northern partners need to be carefully targeted and assessed for cost effectiveness

Financial management

- Projects that are directly funded by DFID have the largest chance of succeeding, because funds are earmarked for these projects. Core funding has attractions for WARDA (greater flexibility), but can mean that a project does not receive all the funds required for completion, because other urgent expenses occur.
- RNRRS projects generally only covered operational costs directly related to the project. Internet access is normally not included, as it is an institute-wide expense. This limits scientists' ability to communicate effectively. In response to this, some organizations (e.g. CSIR Ghana) now charge 7.5% overheads on all projects to cover facilities and infrastructure.
- NARS and WARDA scientists sometimes do not have a good understanding of the available funding opportunities and procedures. This means that not all opportunities are effectively utilized. There is a need to develop the capacity and awareness of Southern scientists on fundraising, including a knowledge of the major donors and their priorities and programmes.

2. Possible future research areas

The research areas presented below emerged from the discussions with those individual scientists involved in the discussions, and have not been debated with other WARDA staff or NARS partners. Understandably, most scientists perceive their own area of research as being of special importance. Therefore, it is important to consult WARDA's recent mid-term plan (the latest version is 2005-2007, but updates for 2006-2008 have been done for individual projects) and its strategic plan (2003-2012), where research priorities are identified and justified.

Research priorities for funding under DFID's SRSA (Strategy for Research on Sustainable Agriculture – see also www.dfid.gov.uk) should:

- Be cross-country / regional priority areas
- Contribute to achieving the MDGs (Millenium Development Goals)
- Link with CGIAR priorities
- Should include a capacity building component (not just formal training, also exchange visits, on-the-job training, collaborative research, South-South exchange etc.)
- Build on successful outputs from RNRSS (but this will be covered partly by the Facility)

In addition, any research undertaken by WARDA needs to be in line with WARDA's MTP and strategic plan.

Policy / impact assessment / lesson learning

- Making markets work for farmers (input and output markets) in West Africa to complement work funded by USAID in Nigeria. Markets for seed and fertilisers are important, but one needs to consider the whole commodity chain ('Field to fork')
- Post-harvest quality and branding are key in order to respond to the needs of consumers
- Access to credit is important to enable farmers to invest in both increasing productivity and output quality.
- Regional integration (policies, tariffs, etc.): Need to identify and measure the impact of this
- Public-private-community partnerships: Scaling them up and document good practices
- Legislation on transgenic crops: Is lagging behind the scientific advances.
- Impact of labour saving technologies (e.g. small scale harvester) on labour displacement and poverty

Variety development

- Important to address emerging challenges, such as drought, and to breed for multiple stress tolerance. Pest and disease resistance is not enough.
- Use of genetic markers: USAID is funding a project on the development of RYMV resistant varieties in Mali, Burkina, Guinea and Gambia. However, this project focuses only on one disease. When the project was developed, the marker for blast had not been identified yet. It would be useful to screen materials at the

same time for blast and RYMV, and possibly other traits, and to expand to more countries (to include Togo, Benin, Niger, Cameroon, Tchad, Sierra Leone)

NRM / Soil fertility

- Low soil fertility is a major constraint to realize the yield potential of new varieties. Yield increase is much more likely to come from increased soil fertility than from improved varieties
- Possibly potential for further use on resource use efficiency, such as done in Senegal for the irrigated rice project (increase resource use efficiency without increasing input levels)
- Degradation in Sahelian irrigation schemes has been explored by the DFID-funded irrigated rice research project in Senegal, Burkina, and Mali. Using the same partnership mechanisms as for the ASI development, option to address degradation were explored. The evaluation of options on-farm still needs to be done.

Diseases

- Blast: Training of NARS scientists in the two methods developed through DFID funding (field trapping methods and DNA finger printing) is a high priority. As the pathogen changes continuously, resistance breaks down and new resistant varieties need to be identified continuously. This requires the skills and knowledge among NARS scientists to use these methods, as well as the equipment. The equipment required (PCR machine: 5-8,000 $, plus other equipment, total around 15,000$ for equipment, plus 5,000$ per year for running costs / materials.
- There is a need for continuing sampling, pathogen characterization and screening for blast resistance.
- Resistance to RYMV is breaking down (Sere's PhD student is working on this). Needs further investigation.

Integrated crop management

- Scaling up / scaling out of technologies developed (to other countries in the region)
- Adaptive research to adapt the technologies developed for irrigated systems to intensified lowlands
- Explore possible improvements in rice-based systems: Integration vegetable-rice crop

Processing / post-harvest

- The CPHP project on rice quality operated more on a pilot basis. Lessons learnt need to be shared more widely.
- Mills can be improved further, in particular in terms of fuel efficiency

List of people involved in discussions

Name	Position	Contact details	Interests / topics discussed
Diagne, A Dr	Impact assessment economist	WARDA Cotonou, a.diagne@cgiar.org	Impact assessment of INGER network
Gridley, H Dr	Upland rice breeder	WARDA Cotonou, h.gridley@cgiar.org	Soil fertility, yield potential of available varieties
Haruna Andan, F Dr	Post-harvest specialist	MoFA Northern Region, Tamale, Ghana, nritam@africaonline.com.gh	Post-harvest issues: milling, parboiling
Kebbeh, M Dr	Production economist	WARDA Sahel station, m.kebbeh@cgiar.org	Increasing resource use efficiency, involvement of non-traditional research partners, basket of options instead of packages
Keya, S Dr	Assistant DG – R&D	WARDA Cotonou, s.keya@cgiar.org	DFID SRSA, interdisciplinary research, ways to improve writing skills of NARS scientists
Kormawa Patrick M Dr	Policy Economist	WARDA, 01 B.P. 2031, Cotonou, Benin, p.kormawa@cgiar.org	WARDA Programme 2
Ndjiondjop, M-A, Dr	Molecular biologist	WARDA Cotonou, m.ndjiondjop@cgiar.org	Genetic markers
Nguyen, L T Dr	Assistant DG – Corporate services	WARDA Cotonou,	DFID SRSA
Nutsugah, S Dr		Tamale, Ghana, sknutsugah@hotmail.com	Rice blast research in Ghana
Sere Yacouba Dr	Plant pathologist	WARDA Cotonou, y.sere@cgiar.org	Rice blast
Van Mele, Paul Dr	Technology transfer agronomist	WARDA Cotonou, p.vanmele@cgiar.org	Farmer innovations, increasing creative thinking among scientists
Youm, Ousmane Dr	Assistant Director Research – Integrated Rice Production Systems	WARDA Cotonou, o.youm@cgiar.org	Rice blast, rice yellow mottle virus, role of UK organizations

Annex 5 Rice Synthesis Study - Meeting of UK project staff

NRI, Chatham Maritime, 30th November 2005

Participants: Dr Steve Belmain, Dr Alan Cork, Dr Martin Mortimer, Dr Alastair Orr, Dr Charlie Riches, Dr Sreenivasaprasad, Dr Tim Chancellor, Dr Barbara Adolph

Background

The Crop Protection Programme of DFID has commissioned a lesson-learning study of RNRRS rice projects that have been carried out from 2001 onwards. This study will help to shape the direction of future DFID-funded research within the new Sustainable Research Strategy for Agriculture. Following a review of project documents and recent literature on rice, consultations with overseas project staff were held in Bangladesh in July and in Benin in September. Preliminary findings were circulated to UK-based project staff and their views sought in a meeting held at the Natural Resources Institute on 30th November. This report provides a summary of the discussions which took place at the meeting.

Issues discussed

Introduction

Barbara Adolph welcomed participants and explained the purpose of the meeting. She indicated that the views of participants were sought in the following areas in particular:

- Research partnerships and stakeholder involvement in projects.
- Research outputs and their uptake / dissemination.
- Future researchable areas and their justification.

The proposed framework for considering these issues is summarised in Figure 1 overleaf. Questions relating to the research process, such as how research priorities were identified, would be considered in relation to different types of research output. Outputs might be viewed as ‘tangible’, such as pest-resistant crop varieties, or ‘intangible’, such as networks developed or capacity built. The lessons learnt would help to identify knowledge gaps and future researchable areas. The proposed agenda was agreed (see Annex) and participants indicated that they were generally happy with the process. However, some concern was expressed about contributions being placed in the public domain at a time when institutions were developing proposals for the management of new DFID programmes. Further discussion led to consensus that discussion about new research priorities would be quite general and was unlikely to cause any difficulties.

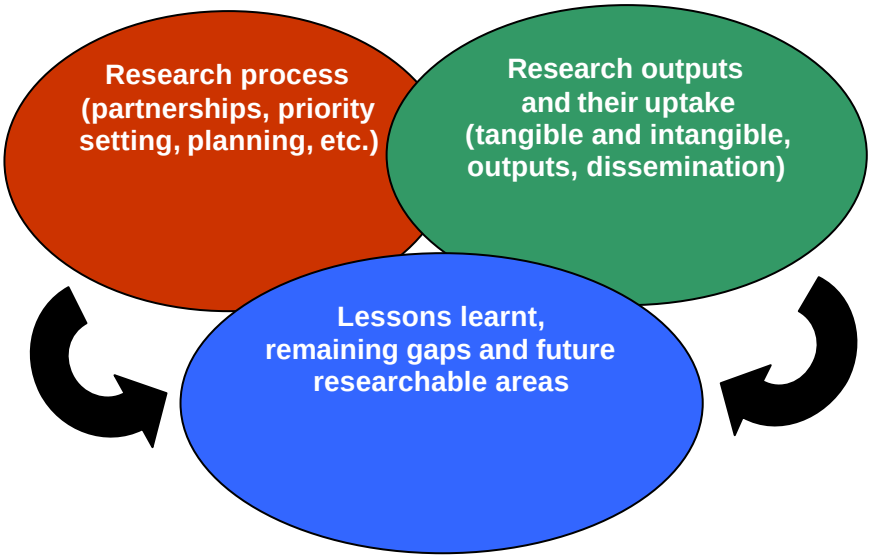


Figure 1 Framework for lesson learning

Research process

Barbara Adolph presented a summary of the findings from the overseas stakeholder consultations on research process issues. Comments made during the subsequent discussion included the following:

General comments on research process:

- The FTR formats used by the research programmes do not specifically encourage project leaders to include learning from the research process. The FTRs report against outputs and activities, and insights gained during the project that do not align with outputs are generally not recorded.

Priority setting:

- CPP calls for proposals in south Asia were very prescriptive in terms of subject matter, location and partnerships. As projects evolve, there should be sufficient flexibility to reorient the activities (some thought that this was possible) and to include new partners.
- It was pointed out that, in Bangladesh, it was necessary to work through the available Memorandum of Understanding with IRRI and that it was crucial to get activities moving quickly.
- RNRRS National programmes attempted to align projects with national priorities, but these were not necessarily pro-poor. For example, in India the national priority is to obtain food self sufficiency by maximising the yields in high potential areas, and not to support poor farmers in marginal areas. Higher food production is expected to indirectly benefit the urban poor through lower food prices.
- For weed research a UK-led review was commissioned which identified large issues and institutional systems to work with. CPP weed projects were also

linked with the Rainfed Rice Research Consortium and this had identified priority research areas in different countries.

- It was generally agreed that the research systems in Bangladesh was functioning and that RNRRS projects added value. This might not necessarily have been the case in some other countries.

Partnerships:

- Different partnership strategies might work in different situations. It was clearly desirable to work in collaboration with researchers in well-resourced organisations located within a structured research system. However, working with 'champions' inside weak organisations could still lead to substantial leverage and successful projects.
- A longer time horizon is required to build effective partnerships – at least 5 years for a project that has a capacity development function.
- The NRSP model of funding pre-project meetings to develop concept notes and full proposals was considered to be useful and should be generally adopted for DFID research.
- Inception workshops, such as those used by ASARECA, are useful to develop partnerships early on during the project
- Partnerships carry high transaction costs and become increasingly difficult to manage as they grow in complexity. Nevertheless, examples of successful partnerships that have emerged during the promotional phase of RNRRS projects were cited.
- It is important to retain a certain amount of flexibility in the budget to be able to include other partners if and when required.
- In some countries, especially with large and fragmented national agricultural research systems, it takes considerable time to establish what research has been done and is currently being conducted. Institutional mandates and institutional boundaries are also difficult to identify. One of the benefits of RNRRS research projects is to bring people together who might not otherwise engage with each other. This 'honest broker' role could be extremely valuable.
- Programmes did encourage certain strategic partnerships. For example, the CPP encouraged links with IRRI and WARDA as these organisations had strong links with national research systems. UK expertise was often complementary to skills available at IRRI and WARDA and thus added considerable value.
- Complementarity of skills was also applied in the links between RNRRS-funded research and PETRRA. Weeds were prioritised in some PETRRA stakeholder consultations but weed research was not supported because it was recognised that the CPP was addressing this area.
- RNRRS research added value to the Rainfed Rice Research Consortium by helping to reorient it towards more on-farm work. This happened in parallel with similar approaches promoted by PETRRA. The outcome is that mainstream research organisations in Bangladesh are now much better geared towards participatory, on-farm research.
- There was concern among participants that research teams would disperse as a result of lack of funds once current RNRRS projects end.

Capacity development:

- As the RNRRS progressed, capacity development became an increasingly important component of projects. Split PhDs were used effectively within the programmes. Commonwealth-funded Fellowships are an example of other opportunities that can be utilised.
- In CPP-funded work on rice fungal diseases, the transfer of new molecular tools for disease characterisation and for use in rice breeding programmes
- Exchange visits provided an incentive to some developing country researchers, although DFID came to see this as an expensive option which could only be extended to small numbers of staff. There was a move towards workshops held in developing countries that could involve large numbers of participants.
- Capacity development through RNRRS was mostly by training individuals. This might not always be the most effective way of developing organisational capacity – however, there were no pathways under RNRRS to enhance organisational capacity by improving organisational systems and processes.
- Brain drain and loss of human capacity is a concern in both SSA and South Asia. For example, both weed scientists who worked alongside David Johnson passed away, leaving no weed scientist in the region.

Integration of programme activities:

- There was little attempt to integrate research activities across DFID programmes. The NRSP was initially supposed to perform this function but this did not happen in practice. However, the CPP and NRSP did conduct a joint programme development exercise in Bangladesh. This led to linkages between an NRSP-funded project on soil fertility and a CPP project on rice pests and natural enemies which included several common research partners.
- Different programmes focussed on different target countries and this made linkages more difficult.
- Calls for cross-cutting research proposals were issued during the early phase of the RNRRS but little work was funded in this way.
- Links between research projects funded by different DFID programmes often resulted from initiatives of individual scientists.

Research outputs

Tim Chancellor introduced the topic of research outputs and their promotion. Research outputs could take a variety of forms, including products (such as insect or rodent traps), information or knowledge and enhanced capacity. ‘Impact pathways’ could be shown for particular outputs showing (a) horizontal linkages that facilitated the wider adoption of the technology and (b) vertical linkages that helped to create the enabling conditions for the technology to be ‘institutionalised’.

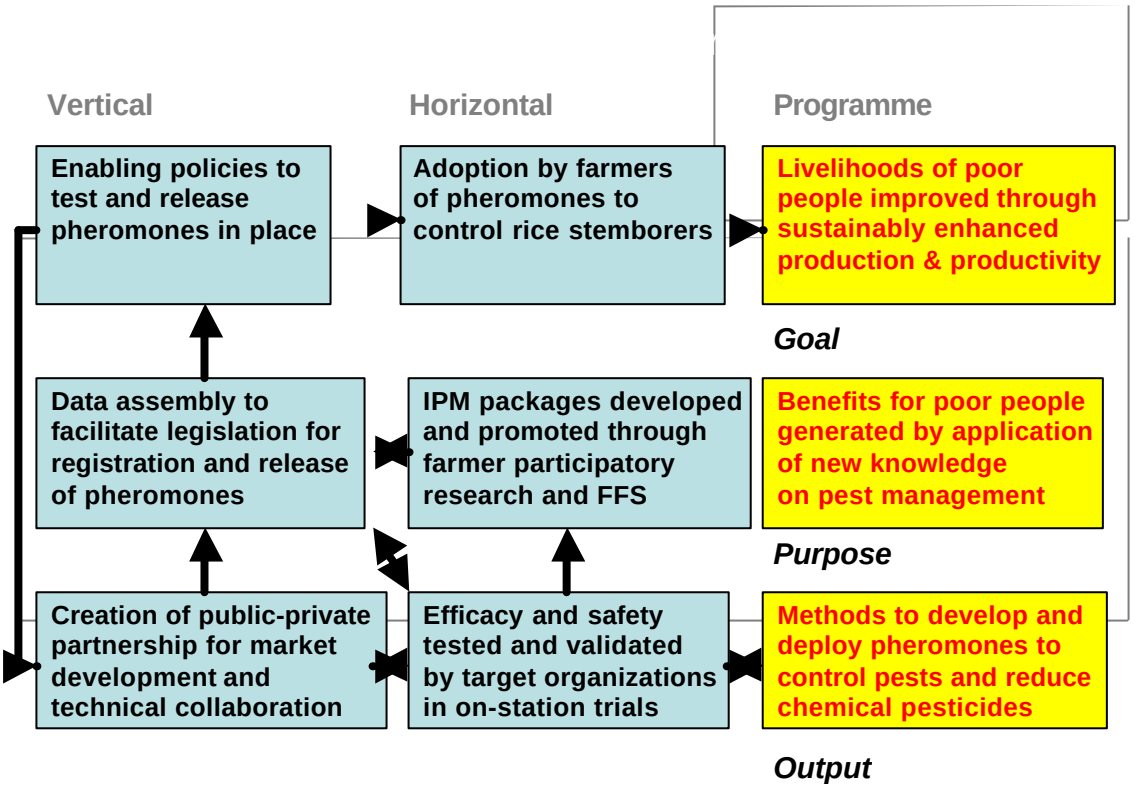


Figure 2 Impact pathway: rice stemborer pheromones

The distinction between different types of output was somewhat artificial because 'products' usually needed to be packaged with information in order to make them accessible to users. For example, herbicide technology is knowledge-intensive and requires collaboration between various groups (researchers, extensionists, private sector, input suppliers and farmers) before it can be applied effectively and safely.

At the beginning of the RNRRS, DFID saw the role of the programmes as generating new products and knowledge; uptake and adoption would be achieved through linkages with bilateral programmes and other initiatives. As the strategy progressed, DFID became increasingly concerned to demonstrate impact at the farm level and to see effects of research outputs on policy. Programmes have found it difficult to show large-scale impact, but the RNRRS evaluation study presented examples of where there was potential for significant future impact. However, in many projects there is insufficient baseline data to be able to carry out adequate assessments of impact.

There was much discussion at the meeting about the issue of the impact of research outputs on policy and whether this was an appropriate objective for DFID research. It was agreed that the successful introduction of some technologies depended on overcoming policy constraints. An example of this is seen for biopesticides in Bangladesh where there was no regulatory process that would allow registration of products. RNRRS research directly addressed this problem and new legislation has just been introduced. On the other hand, the introduction of the technology was also favoured by policy change; the phasing out of Category 1 and 2 pesticides and the introduction of IPM as a national strategy. Lobbying by pressure groups is important

for generating policy change and cannot usually be achieved without the formation of strong groups.

The absence of a conducive policy environment is not necessarily an argument for not doing innovative research. Demonstrating that a new technology works can bring about policy change. An example might be transgenic varieties, although the evidence for this is still weak in developing countries. The Plant Sciences Programme invested in transgenic approaches (RYMV in rice) but was not able to advance the technology.

In some areas, RNRRS research was responding to needs created by policy changes. For example, the effect of liberalisation of the water market was to increase the number of imported pumps and increase the irrigated area. This led to …..In India, the increase in fuel prices has led to higher tillage costs and this is favouring the adoption of reduced tillage practices, including direct-seeded rice. There are several examples of where research is responding to change. Sometimes policy changes arise in random and unplanned ways. For example, drum seeders are currently being promoted in Bangladesh following a ministerial visit to Vietnam and a subsequent donation by the Vietnamese.

It is not clear to what extent RNRRS projects have made an effort to understand the policy framework within which they are working. DFID itself is not always aware of changes that are taking place, or their full implications. An example is labour shortages in areas where there are non-farm jobs which pay higher wages.

A particular problem arises with cross-cutting research issues which are not the primary responsibility of specific ministries. In such situations a policy vacuum may exist; for example, the management of rodent pests. Awareness raising is important and this may be done most effectively through grass roots initiatives and mass media.

Concern was expressed by some about the sustainability of certain approaches where mainstream research institutions were by-passed. An example was the participatory varietal selection work of the Plant Sciences Programme. An alternative model was being promoted in Bangladesh by IRRI which might be more sustainable. However, others considered that the PSP approach built on what farmers were already doing and was justified.

Typology of outputs:

The group attempted to identify different types of research output and the factors that affect their adoption (see Table on page 9). This proved to be a difficult exercise. One way of categorising outputs is on the basis of their knowledge intensity.

Changing attitudes and facilitating the adoption of new approaches is also an output, but less tangible than a technology. Examples include:

- Strengthening BRRI's on-farm research.
- Changing the attitude of the DAE in Bangladesh towards herbicides.

New technologies must be cost-effective to be adopted.

There was some discussion about whether component technologies developed through RNRRS research should be integrated. For example, CPP funded several projects on insect, disease and weed management in Bangladesh. How could the outputs be most fully utilised and made available to users? Some felt that attempting to package essentially different technologies was neither feasible nor desirable. What is the appropriate mix of strategic and applied research and is it most efficient to focus effort in one geographical area?

Knowledge dissemination:

- Final Technical Reports are not suitable for dissemination, partly because reporting is done by output. This cannot be easily understood by anyone who is not familiar with the project.
- Documents such as workshop proceedings and leaflets should be placed on the CPP website. These provide sources of evidence for impact.
- BRRI rice knowledge bank. RNRRS projects have developed material that will be placed in the knowledge bank.

Future research areas

Key issues include how to produce more rice with less water, land and labour. Production increases will come mainly from intensification of rainfed areas. Total system productivity will be important in some areas; for example, increased production from legumes and vegetables in India. Intensification must be sustainable and not result in resource degradation or loss of biodiversity. How best to harness the benefits of biotechnology will become an increasingly important issue.

Rice production must be competitive and quality must be increased. This is a particularly important issue in Africa where demand for rice is increasing significantly. Currently, this increased demand is largely being met by imports rather than enhanced local production.

New research should add value to, and complement, other initiatives.

Research organisation:

- New projects/programmes have to be organised in a different way. More time and resources needed to address researchable constraints.

Capacity development:

- Capacity development will feature more prominently in future DFID research programmes. The needs for capacity development in rice research are especially evident in Africa where the human resource base has declined.
- There is a strong need for mentoring. The transfer of specific skills is perhaps less important than the ability to view and conduct research in a systems perspective.
- The experience of most projects is that there is limited capacity to use and apply non-standard methods of data analysis. This is sometimes because of the lack of inclusion of biometricians / statisticians in project design and implementation – they are brought in towards the end of the project for analysis, but do not fully understand the purpose and aims of the project.

- There may be a case for capacity development in the areas of biosystematics, bioinformatics and biosafety.

Partnerships:

- Farmer involvement should be 'optimised' rather than 'maximised'.
- Networks such as the Weed Ecology working group and the Rodent Ecology group have extended the reach of RNRRS research. Such networks should be fully utilised in future DFID research.

Communication:

- Future DFID research programmes will have a requirement for a communication component (as with the new DFID-ESRC programme).

Promotion:

- There is scope for the transfer of RNRRS outputs to new areas. For example, diagnostic tools developed in West Africa can be utilised in Bangladesh and elsewhere.
- In general, successful promotion will require multi-stakeholder participation.

Market orientation:

- Future research will need to take into account the demands of markets and recognise the importance of farmer associations and their requirements for market information.

Typology of research outputs

Technology	Understanding	Pathways
SFM in striga	Awareness raising – rats and weeds	- Exchange visits of farmers. - Knowledge dissemination (Primary school). - Capacity development. - Training programmes and tools: rats & pheromones. - Information disseminated by private sector. - Changes in attitude: on-station to on-farm. - Gov. agencies. - NGOs (logistics/age of staff). - Critical mass of people with changed attitude.
Pheromone traps and supporting knowledge	Seasonality/regionality of stemborers - understanding	
Improved grain storage for rodent protection.		
EBRM		
Decision support systems in direct-seeded rice – weed management		
DSR –responding to water shortage. Options for different systems: - Rainfed system Bangla - High Potential India		
Seed priming		
- Tools for pathogen diagnoses. - Understanding disease epidemiology. - Identify varieties. - Biological control (sheath blight)		
Management of wild rice		
Participatory varietal selection-PPB in Plant Sciences Programme. - Short duration varieties (Nepal) successful in Bangladesh - Trade-off : alienation of BRRI. - Sustainability of the approach? - ‘Optimise’ or ‘maximise’ farmer participation?		