New science, capacity development and institutional change: the case of the Andhra Pradesh-Netherlands Biotechnology Programme (APNLBP)

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Abstract
North-South cooperation in the field of science and technology has been hampered by scientific and bureaucratic conventions that fail to see the systemic nature of knowledge creation and innovation. This paper discusses a Dutch development assistance programme on biotechnology that has made a specific effort to overturn these conventions. Using the example of the Andhra Pradesh-Netherlands Biotechnology Programme, the paper describes how this novel type of capacity development intervention takes a long-term perspective on institutional learning and change. The philosophy underpinning this is the 'integrated bottom up' approach, which emphasises direct links with user communities. It thus engages directly with the question of how a more socially embedded process of innovation may be developed that can permit biotechnology to be exploited for sustainable development.

Introduction

This paper explores a form of North-South cooperation that appears to be quite original. It concerns biotechnology development aid designed to bring the benefits of modern science directly to bear on rural development and to do so in ways that integrate recipient communities into all aspects of the knowledge transfer process. What is especially interesting about the Dutch Special Programme (SP) on Biotechnology is that it seems to have broken with a well-established tradition in international technical cooperation that emphasises the following:[1]

- Science and technology research activity should be conducted primarily in the Northern countries with results then transferred to the South for implementation purposes;
- Research and development are separate activities and should not be integrated in development assistance activity;
- Technical research should be sharply distinguished from socio-economic and policy research; and
- Interdisciplinary research is scientifically suspect and should therefore be discouraged.

1 We have deliberately polarised the issue here for analytical purposes. In practice, views are not always as extreme as this, although we should still argue that such views are still widely held by relevant interest groups.

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The Andhra Pradesh-Netherlands Biotechnology Programme (APNLBP), the main focus of this paper, is an example of the Dutch Special Programme's approach and how it has developed in the context of India. It shows how it is possible to implement technical cooperation projects in quite a different way. We believe many of the elements of the type of approach that it espouses are long overdue in mainstream development assistance. Of course, implementing such a change is by no means an easy task since not only does it confront conventional procedures of a bureaucratic kind, it also forces professional groups to change their underlying philosophies and to take on board tasks that are not part of their normal job descriptions. The APNLBP story is thus an account of attempts to change the normal procedures of technology development that has lessons for both planning and implementation stakeholders.

The remainder of this paper is in five parts. The second section following this one provides some background discussion needed to locate the APNLBP in the wider context of the Dutch SP. It charts its history from inception in 1992 to the present day. The third section provides a brief conceptual account of some recent literature dealing with innovation systems approaches to the questions of knowledge production and use. We argue that APNLBP's underlying principles fit naturally into this philosophy. In the fourth section, we outline a series of case studies. These cases illustrate some of the institutional changes in R&D that have been associated with the programme as well as the way the wider institutional context of agricultural R&D in India impinges on this process of institutional learning and change. The fieldwork for this account was conducted in July 2002 in Andhra Pradesh. It included reviewing project literature, visiting APNLBP projects in rural areas and discussing with programme administrators, scientists, NGOs and others some of the issues that appear to have arisen as the programme evolved. The authors also attended a three-day workshop that had been organised by the programme to review progress at the end of Phase 1. This included a public debate on the subject 'Agricultural Biotechnology: Promise or Peril'.

Our discussion in the fifth section points out that progress is apparent, but also that challenges remain. The fact that there continue to be issues to be resolved does not mean that the IBU approach has not been effective. Like any innovation (and we would argue that 'institutional' changes can be as 'innovative' as any other type) initial steps are bound to be imperfect and adaptive behaviour needs to take place. The APNLBP may be one way of creating the professional space in the agricultural science community to explore institutional experimentation and learning. The sixth section briefly concludes discussions of the paper.

Background – evolution of the special programme

Early history

The early history of the SP and the APNLBP may be summarised as follows. In 1987, the idea of a *Special Programme (SP) on Biotechnology for Development* was suggested as one potential mechanism to close the North-South gap through technology development. It matured into a unique type of 'special programme' under the guidance of Jan Pronk, when he became the Dutch Minister for Development in 1989. By this is meant that unlike other technology development assistance programmes, there was a conscious effort to build capacity and instil concern for biosafety issues within the recipient countries, and to focus explicitly on 'resource-poor farmers (RPFs) in a participatory manner'. This contrasted with the traditional approach (which still represents the mainstream) that had focused more on applying Dutch R&D results to production issues of developing countries. The geographic focus of the SP was Colombia, Zimbabwe, Kenya and India with initial preparatory work begun in 1992, although, as we shall see, it was some time before activities actually got under way.

The guiding philosophy adopted for what at the time seems to have been quite revolutionary in development assistance terms, was the *interactive bottom-up (IBU)* approach.[2] As the term implies the IBU places emphasis on R&D projects driven explicitly by RPF needs and requiring constant interaction between generators and recipients of new knowledge. End-user demands should be formulated by all stakeholders interacting with each other in multidisciplinary fora until common ground is achieved regarding what the priorities are and how they should be tackled. Equally, power relations should be such that no one group dominates any other. Basic scientists, for example, should not be in a position to dictate procedures, but on the contrary should be subject to constant scrutiny from other participatory groups. Moreover, the process should be interactive in the sense that constant monitoring and adaptation should take place throughout the life of projects. We return to how this worked in practice in our case studies.

In this way the philosophy was in keeping with recent theoretical developments in the analysis of knowledge production and use that emphasise the essentially systemic character of innovation and the importance of institutional contexts.[3] And in many ways it was clearly ahead of its time. This could be seen in the difficulties experienced by the SP in putting into place governance mechanisms that would both ensure programmatic success while at the same time remaining consistent with established scientific and bureaucratic norms and procedures. For example, the early establishment of the SP in Zimbabwe ran into a number of problems, in particular the view of the relevant scientists that they and they alone should be the group that made project decisions. 'Good science', it was argued, must not be compromised by farmers, NGOs, donors, government officials and other lay groups who did not really understand the esoteric nature of scientific research.

Similar problems were present at the Dutch end since the SP implicitly called into question well-understood conventions about the way development assistance programmes should deal with technology development and related capacity development in the South. Examples of issues included the extent to which the SP should be permitted to bypass standard DGIS[4] bureaucratic logic; differences of opinion regarding the degree of autonomy to be given to the national programmes (including the composition of national steering committees [SCs]); the appropriate legal status and form of intermediary organisations[5] in the recipient countries; and the most appropriate composition and mandate for the advisory group in The Hague. Partly to accommodate such differences, and also because of the innovative nature of the SP, a review (Rölings *et al.* 1996) was commissioned.[6] This review made a series of recommendations to the SP on what might be needed in the programme's future evolution.

2 See Commandeur (1997) for a brief account of the IBU philosophy. A more complete treatment is available from Bunders and Broerse (1991). See also Visser and Wessels (1995).

3 Important examples in a very large literature include: Lundval (1992); Gibbons *et al.* (2000).

4 The Dutch bilateral development assistance agency.

5 By this is meant the organisation in the host country responsible for hosting the programme. In India, this is the Institute of Public Enterprises.

6 In addition, the SP was originally intended only as a five-year programme with a fixed budget. Hence a review at this time was mandatory, though it must have been hard to evaluate a programme that had not yet really got going.

Pre-project phase (1993–96)

A Netherlands mission visited India in late 1993 to identify a suitable geographical region for the SP. The SP concept was considered important by the Indian Department of Science and Technology who gave approval for it to be developed. Andhra Pradesh was chosen following detailed discussions with relevant bodies in India and the Netherlands. The programme then began work on a 'priority setting' process.[7] This included identifying possible partner organisations in the region. A consultant was engaged to identify two suitable NGOs operating in two different districts, whose main activities included agriculture and rural development with special reference to RPFs. The consultant also identified a range of relevant research bodies and the administrative structures within which they each sat. There then followed in late 1994 a more detailed multidisciplinary assessment of end-user needs, constraints and opportunities. A team consisting of representatives of research bodies, government departments and NGOs carried this out. This formed the basis of a formal proposal to the Dutch Government.

It was decided to locate the APNLBP formally within the Institute of Public Enterprises (IPE) in Hyderabad. This organisation is an autonomous body engaged in training, research and consultancy in economics, commerce, administration and management. It is located on the campus of a local university (Osmania) and receives funding from the Indian Council for Social Science Research (ICSSR) and the State Government of Andhra Pradesh. It was chosen partly because being autonomous and 'non-scientific', it would be a more suitable home than other potential bodies that could skew the IBU philosophy into more conventional channels. The contract was hence one between the IPE and the R&D Countries Division of the Dutch Ministry of Foreign Affairs. This agreed that policy control of the APNLBP should be vested in a local Biotechnology Programme Committee (BPC) comprising of representatives of the main stakeholders.[8]

The actual operations of the APNLBP are run by a special unit within the IPE, the Biotechnology Unit (BTU). The main function of the BTU is to monitor, coordinate and evaluate the various activities of the programme as a whole. It now consists of a small multidisciplinary team comprising an economist (the coordinator), a rural development specialist and two biotechnologists.

First operational phase (1996–2002)

In 1996 work began on projects. This at first seems to have been a difficult process since project application and selection could not be handled in conventional ways where researchers make applications, which are then decided by peer review. In practice the BTU began a process designed to solicit good project proposals from groups that had been involved in the preparatory phase. This involved extensive consultation and was quite time-consuming. Potential projects had to be identified and presented to the BPC after a peer review that might go through a number of iterations. In addition there were bureaucratic delays encountered in dealing with research organisations in the public sector. For these reasons, it was not until 1998 that much substantive work could begin, though some projects did start in 1997.

Another issue that APNLBP realised was that it had to engage the interest of a large range of development stakeholders and that relatively rapid results in farmers' fields would be needed if momentum were to be main-

7 See Manicad (1997) for a general account of this process. Bunders and Broerse (1991) contains relevant papers written from an IBU perspective.

8 The chairman of the BPC is Dr Rao. He was the director of wheat research in India during the green revolution period. He is widely respected as one of the architects of the extraordinary changes in food production that took place in India at that time. His professional standing has been critical in aiding communication across different professional groupings

tained. On the other hand, however, many biotechnology applications (for instance, molecular biology and marker assisted selection) are part of a long-term process. To address this, APNLBP took the decision to start the first batch of projects mainly applying existing technology from the earlier era of biotechnology, fermentation and microbial culture, tissue culture, vermiculture and biopesticides. A small number of advanced biotechnology projects were started in parallel but out of the total number of 56 projects only nine (15 per cent) are connected to transgenic technology costing less than 25 per cent of total expenditure. This approach was based not only on the need to produce results fairly rapidly using existing techniques, but also on the realisation that this was an inductive process whereby the need for more advanced biotechnology applications would emerge along the way. And of course, the latter required the types of community-level interaction that existing technology interventions could provide. (The focus of projects and important institutional issues associated with some of the projects are discussed in more detail in section IV of this paper.)

Second operational phase (2002–07)

As a result of what appears to be seen as a successful first phase (including an external review), the Dutch Government has now agreed to extend APNLBP into a second phase of five more years, with the possibility of yet a third phase after that. The details of this second phase have not yet been fully decided but the impression given is one of proceeding on four fronts. The *first* is extending research projects that show promising progress. The *second* is to extend technology/production more widely in outlying areas and where possible on a commercial cost-recovery basis. The *third* objective is to increase emphasis on molecular biology applications in project activities, particularly in ways that will enhance resistance to biotic and abiotic stress in key crops of relevance to the RPF. *Finally* there is an intention to move more rapidly on human resource development. There are still major shortages of qualified biotechnologists in India, partly due to a higher education context that has not yet adapted curricula to focus on these types of skills despite growing demands from both public and private sector R&D bodies. For this reason the BPC is seeking to establish appropriate postgraduate facilities for degree and refresher courses tailored to the specialised areas.

Some defining features

There are a number of defining features of the IBU approach that need to be emphasised. *Firstly*, although the process was initiated by a Dutch team, as soon as practically possible an Indian committee was established to define the broad contours of the programme. *Secondly*, local consultants and NGOs were used to strengthen the IBU approach and ensure that programme-level planning was genuinely needs-based and consultative. *Thirdly*, while the proposal for the programme did not contain specific (sub) project details, the initial needs assessment work had helped the BTU identify what these might be and what were priority problems to be dealt with. A related point is that because the India-based planning process sought wide consultation and participation from a range of stakeholders, the project already had an active 'constituency' by the time funding was approved. The relationships built with NGOs in the needs assessment phase were important when it came to implementing the project, many of which were applying existing technologies at the farm level.

Fourthly, the programme had both a short- and a long-term perspective in its plans for exploiting biotechnology. In the short term, the use of traditional biotechnology applications to achieve tangible results would build credibility and social capital with developmental stakeholders, including farming communities. This, in turn, would permit the long-term exploitation of new biotechnology applications in a more socially inclusive way. The *fifth* point is that the Dutch have clearly been willing to take a long-term view of capacity development: a view that recognises the need to embed the initiative firmly in local actor and institutional contexts and sees capacity development as much in terms of institutional change as it does in terms of creating new disciplinary expertise. Equally important is the vision a senior Indian civil servant in the Department of Science and Technology had to support the establishment of the SP that could explore research management innovations related to biotechnology application relevant to RPF. Without this coalition between Dutch and Indian bureaucrats, it is arguable whether this initiative could have flourished. Before exploring the IBU approach in more detail, we shall first locate its underlying philosophy in contemporary debates.

Innovation systems

The APNLBP is an attempt to embed technology and capacity development in a broader set of relationships with the aim to link advances and applications in biotechnology to sustainable rural development. We therefore locate the analysis of APNLBP within an *innovations systems* perspective for the very good reason that both this perspective and the APNLBP respond to the need to redraw conventional approaches to technology development policy. This need stems from the challenge of the conventional or linear model of knowledge production and innovation which is based on the view of a division of labour between 'knowledge search' and 'knowledge use'. The emergent view is that knowledge cannot be independently produced in specialised research organisations and then transferred to passive users. The recent policy focus on innovation recognises that the production and use of new knowledge is a much more complex process often requiring technical, social and institutional changes, involving the interaction of actors across the conventional knowledge producer/user divide. Douthwaite (2002) believes that this holds true in cases of innovation ranging from rice drying in South Asia to wind turbines in Europe and North America.

The innovation systems perspective brings together much of this thinking. It concentrates on ways of effectively linking the right groups of stakeholders and explores the institutional environment and how this affects partnerships and the processes of learning and innovation. Such a perspective also recognises that knowledge production and use is a highly contextual affair. This has analytical implications, like, for example, the need to consider a range of activities and organisations related to research (particularly technology users and how these might function collectively); and the need to locate research planning in the context of the norms, culture and political economy in which it takes place – i.e. the wider institutional context. Similarly, it is no longer useful to think of institutional and organisational arrangements for research as fixed or optimal.

9 In practice, molecular biologists and plant breeders usually need to work with each other in this type of technology development.

10 See also Clark (1987) for a discussion of the tensions arising between science and technology in this regard.

Clearly, these must evolve to suit local circumstances. In the same way, the evaluation of innovation performance also becomes much more context-specific relating to the perspective of stakeholders and current imperatives.

The need for this innovation systems perspective can be seen in many different ways where existing conventions tend to encourage hierarchies and reductionism at the expense of integration, iteration and innovation. In a recent paper Haribabu (2000), for example, has explored the logic of this type of thinking in an empirical study of biotechnology approaches to rice research in India. He analysed 33 research groups of which 14 were led by molecular biologists and 19 by plant breeders. He found quite different approaches between the two. The former group is convinced that transgenic biological interventions are the way forward. That is, the best means of dealing with the many problems of rice production in India is to discover the relevant gene for any problem and insert it into the plant genome for expression, subsequent backcrossing and distribution to farmers. The latter group prefers approaches that do not involve gene transfer, such as molecular marker assisted selection (MAS) techniques combined with conventional breeding.

Haribabu's argument is that the objective rights and wrongs of the competing approaches is not the real point at issue.[9] Each approach represents a 'socially constructed view' derived from decades of culturally transmitted norms about what is really 'good science'. Molecular biologists see themselves as the scientific elite pushing forward the boundaries of basic and strategic science through high-minded and disinterested research. Inevitably also they are forced to 'reduce' analysis to narrowly defined experiments in order to maintain rigour and achieve robust results. These then get passed on to those whose interests are influenced by 'less pure' activities and goals. Plant breeders, on the other hand, see their professional work as 'both a science and an art. As science it has a theoretical component (but as) an art it involves the deployment of skills and aesthetic considerations that are gained over time as part of the practice of breeding. (They) also attempt to incorporate environment-specific factors ... into their research' (Haribabu 2000: 7). Such differences can easily become rivalrous and lead to situations where their respective organisations simply do not communicate, as is the situation, Haribabu argues, in India.[10]

All too often, conventional treatment of research arrangements pervades the philosophy of development assistance agencies. Indeed, one normally finds a sharp distinction drawn between those parts of the bureaucracy dealing with research, on the one hand, and those dealing with development, on the other. Even within the research category, one often finds that sharp distinctions are drawn between 'technical' and 'socio-economic' projects. Hall *et al.* (2000 and 2002b), for example, have analysed a farmer cooperative scheme established to produce and sell export-quality mangoes. The North-South research collaboration in this case was flawed by a failure to recognise from the start that the basic issues were socio-economic as well as technical. It was realised that this could only be addressed through interdisciplinary interventions. Clark *et al.* (2002) come to similar conclusions in a recent study of the introduction of packaging technology in the horticulture sector in Himachal Pradesh. Rather than seeing the emergent (and learning) nature of the process as a whole, the development assistance agency supporting the work wished to establish 'baseline' conditions (through socio-economic research) which could then be compared with '*ex post*' results at the end of the project. The paper argues that while this type of methodology may work in contexts where parameters are stable and the context is not evolving, it certainly is not a suitably scientific approach where such conditions do not hold.

Douthwaite (2002) believes that the issues here are deep-rooted and can often cause enormous levels of waste. He shows how innovative success is a complex process of learning and adaptation in which it is often better to proceed incrementally than go for quick solutions. Unfortunately, there are powerful social and political forces acting in the opposite direction. These often relate to professional interests, as with those outlined above. But equally they arise as a result of the desire on the part of social groups to be able to develop quick results regardless of whether there is any impact at all on the livelihoods of target groups.

What is common to all of these contributions (and there are many others) is the view that innovation is inevitably a highly systemic procedure where the need for constant interaction between stakeholders is a necessary condition for ultimate success. Conversely, where groups and organisations differentiate from each other and maintain professional distance, the collective as a whole is bound to fail, or at least waste resources, often to a significant extent. Much of the recent innovation systems literature explores this theme documenting numerous cases where this has occurred. The aim of the IBU approach was, therefore, we would argue, precisely to introduce biotechnology to developing countries in a way that minimised the chances of countries falling into this kind of trap. We shall now look in further detail at what this meant in practice.

IBU and APNLBP projects in practice

As outlined above, the APNLBP has now been effectively operational since 1998 and has some 56 functioning projects. We have chosen projects outlined in the following case studies that illustrate typical experience over this first phase. The IBU approach outlined in section II has been cited as the guiding philosophy of the APNLBP approach. Our last case study illustrates the challenges of introducing an interactive approach into Indian agricultural science practice.

Readers unfamiliar with agricultural research arrangements in India should bear in mind that India has both a very large public-sector agricultural science research infrastructure and a long and successful history of agricultural innovation and development. However, there are indications that it has persisted with a centralised model of technology development and transfer that has perhaps outlived its usefulness. The key public agency, the Indian Council of Agricultural Research (ICAR), recognises these issues and while there is no consensus on its form, the need for significant institutional reform is widely acknowledged. Key features of current arrangements include strong hierarchies and separation between research, extension and farmers; a 'hard science' culture within ICAR that gives relatively less importance to social science considerations, and which tends to perpetuate the hierarchy of science and society and the patterns of control and accountability that this implies (See Rajeswari 1995 and 1999; Raina 2001; Sulaiman and Hall 2002).

We raise these issues as a point of reference from which to examine the institutional developments that have been associated with APNLBP. It is within this context that the programme has had to create space to experiment with new modes of agricultural science. These innovations in science practice are therefore novel in the general context of norms of Indian science, but also are very much shaped by what is practically possible at the present time in this context.

Innovations in pest management R&D

First we focus on two projects run by the Directorate of Oil Seeds Research. Here there are two scientists each with their own laboratory, working on the same problem but from competing technological standpoints. The problem is insect pest control on castor, an important oil seed in low areas with poor soils. One scientist is a geneticist and is trying to identify a transgenic means of breeding resistant plants. Two genes have now been identified and in the next phase the modified plant will be grown and subsequently evaluated by farmers. The second project has developed a yeast-based biopesticide that will soon be produced by a micro-enterprise to be established by the BTU in collaboration with an NGO. Although there is a certain rivalrous situation here, it is interesting to note that the BTU has sanctioned two approaches. Presumably it is anticipated that this will diversify ways of dealing with pest control. But also it will provide a technology that can be put into farmers' fields fairly rapidly, as well as one (the transgenic technology) that may well prove a more effective technology, but only in the long term and perhaps only against a narrow range of pests.

The biopesticide project is interesting in that during the technology development phase the IBU approach encouraged the scientist to experiment with farmers, through an NGO, in order to refine the effectiveness of the approach. A key technological innovation has emerged in response to the farmers indicating that a liquid-based biopesticide would be ten times as expensive to apply as a solid-based one. This required the development and validation of a liquid-based batch production process. Such activities helped build up a series of relationships between the scientist, the NGO and the communities they are working with. These relationships have now become important in different ways in the second phase of the project. For this innovation in pest management to become effective, production and distribution facilities are required that allow farmers to access the biopesticide easily. In the second phase of the project, the scientist is exploring with the NGO ways of setting up village-level production as a micro-enterprise activity for members of the community. The NGO is involved in another APNLBP project that has already established successful village-level compost production systems using vermiculture. In the process, it has built up knowledge on ways of adapting technology to village circumstances and establishing a commercially viable intervention.

Arguably, what is novel about the biopesticide case is not that technology development has led to efforts to produce and distribute this technology. Rather that the scientist leading the project has recognised that this is part of the larger task of developing and introducing a pest management innovation. Seeking closer integration and partnership with both NGOs and the communities they represent is, therefore, seen by the scientist as critical to the success of the overall endeavour.

Innovations in technology transfer and the role of extension organisations

Another project on tissue culture has involved a public research institute and two NGOs located in the programme's two districts. The genesis of the project was that in 1997 the BPC approached the Central Research Institute for Dryland Agriculture (CRIDA) with a view to developing a tissue culture project in neem and teak tree propagation. CRIDA would be the lead partner but it was asked to identify and select two appropriate NGOs in the two designated programme districts as cooperating partners. The two selected were Youth for Action (YFA) in Mahaboobnagar district and the Sri Aurobindo Institute of Rural Development (SAIRD) in Nalgonda district.[11] The project objective was to 'scale up micro propagation protocols for the above species to pilot level, transfer the technology to the NGOs and establish demonstrations in farmers' fields' (CRIDA 2002).

CRIDA research concentrated upon the identification of suitable planting materials, improving the composition of nutrients and agronomic practices, reducing costs, and evaluating field performance. It also supervised the construction and equipment of the two field-level production laboratories. All costs were met by the BTU and farmers in the chosen villages received the resultant plantlets free of charge. Project management in a financial sense was devolved to the NGOs but technical control remained with CRIDA. By its end, some 25,000 plants of neem and 2,800 plants of teak had been produced and distributed. Project staff both at CRIDA and in the NGOs had been trained, suitable scientific protocols established, and viable production facilities had been established.

It has been agreed to proceed to a second phase but only with one of the NGOs. The objective in this second phase is to expand facilities and to proceed to self-sufficiency. The BTU has agreed to fund all necessary capital costs (mainly equipment and some facilities enhancement) and running costs for one year. Beyond that the operation will be deemed to be self-sufficient and will pay its own way. There will remain technical backstopping from CRIDA, however. CRIDA will continue to improve protocols in consultation with field activities, introduce new germplasm and forest crops, and collect performance data. By 2005, it is expected that some 50,000 plants per year will be produced. The project will also continue to control prices to be fixed at around Rs 25 per plant until support is withdrawn towards the end of this phase. In addition, as a fallback position, CRIDA has begun to establish two biocentre facilities to enable farmers to produce plants from direct tree cuttings.

The novelty of this case does not necessarily relate to the fact that two NGOs were the focus of this intervention, but rather that these NGOs were of a special kind and that this gave greater significance to these developments. Both of them, although established independently, had the status of Krishi Vignan Kendra (KVK) – literally 'farmers' science centres'. The creation of such organisations took place as part of a much earlier, nationwide initiative to strengthen agricultural extension activities associated with the Indian Council of Agricultural Research, the apex body for organisations like CRIDA.

11 These districts represent some of the most challenging agro-ecological environments in Andhra Pradesh, and are characterised by a high incidence of rural poverty.

12 Rhizobium inoculant technology is well known to two of the authors, see Hall and Clark (1995).

While the success of such KVKs and for that matter agricultural extension in India more generally has been mixed, their role in APNLBP hints at what their potential might be. In this case, the KVKs became a genuine functional node in the technology system rather than a passive conduit for research products. Relationships were undoubtedly strengthened with the central research organisation, although some hierarchies naturally persist. But the move towards a commercially viable production laboratory will be a critical institutional innovation that will force the KVK to test assumptions about the validity of its product and its approach to meeting the needs of its client farmers. This emphasis in APNLBP adds an entirely new learning dimension to R&D and extension arrangements that will undoubtedly be important for future biotechnology applications.

Tension between institutional innovation and institutional conservatism

A balanced picture of the APNLBP would be incomplete without illustrating some of the challenges that the wider institutional context poses for an intervention such as this. Critical is the inevitable tension between the IBU approach with its decentralised, iterative philosophy, on the one hand, and the hard science culture of Indian agricultural research, on the other. A fourth project with the KVKs discussed above, demonstrates what this can mean in practice. The context was biofertiliser production facilities set up in parallel with tissue culture laboratories. The technology involves the production of Rhizobium bacteria cultures to inoculate legume crops to improve biological nitrogen fixation. This is a naturally occurring process, but the introduction of Rhizobium through a seed treatment can, under certain circumstances, considerably enhance yield. The biofertiliser facilities were set up with technical backstopping from the National Biofertiliser Centre and a public agricultural research organisation in Andhra Pradesh.

There are a number of peculiarities about this type of technology.[12] Unlike equivalent chemical fertiliser, its mechanism of operation depends on the symbiotic relationship between Rhizobium bacteria and the roots of legume crops. As a consequence, the effectiveness of inoculant treatment is dependent on a series of interactions in the biological and ecological systems of the plant, the bacteria, soil microbiology and nutrient status. Put more simply, as a technology inoculation can have very variable results; it can work in one field and not another; and it can work in one season and not the next. This relates to the dynamics of soil populations of Rhizobia, crop histories, agronomic practices, climatic conditions and so forth. For it to be successful in the long run, it needs constant iteration between its users and fine-tuning of the technology through monitoring changes in effectiveness and the dynamics of soil ecology. If ever there were a technology that needs a decentralised approach, where research is embedded in the production and use process, it is that of Rhizobium inoculants.

Soil microbiologists around the world working at the sharp end of inoculant promotion programmes know these features only too well. The scientist in charge of the KVK biofertiliser production facilities was no exception. Recognising this need, the KVK made a request for funds to isolate Rhizobium strains from local soils and to characterise them. Often, such strains are adapted to local conditions and can out-perform introduced elites. However, this request was declined and it was intimated that the activities of the KVK biofertiliser centre were for technology transfer and not research. (Note also that the project leader was inevitably a scientist from a research organisation). While this reaction is in one sense understandable given the research/extension conventions in India, it is nonetheless regrettable. It also hints that institutional change in this regard is inevitably going to be slow and contested. The biofertiliser facility, like its tissue culture counterpart, is also moving into cost recovery-based operations. It was explained that no market research had been undertaken on which to base a business plan for this endeavour. The comment by the officer in charge of the KVK that they were wondering why farmers were not coming to collect inoculant, suggests that it is not only locally based biological research that is required for inoculants to succeed, but socio-economic investigation also.

Discussion

Key achievements and lessons

Several interesting findings emerge from this story. The *first* is that the Dutch development assistance agency (DGIS) and its Indian partners have responded to the emerging reality of innovation systems and the need to embed R&D in a much wider sense than has been traditional with this type of intervention. It has realised at quite an early stage that the need is much greater than simply 'working with farmers', the view still taken by many practitioners.[13] While the participation of farmers and the rural poor in the management of innovation is clearly critical, effective participation of a broader set of actors and the establishment and management of the relationships involved are essential if innovation capacity is to be developed. This leads to a *second* finding concerning the importance of discerning ways to identify and support institutional innovations that are necessary in this context, innovations that are inherently experimental and defined by the specific conditions obtaining.

To make the same point in a different way, institutional change has to emerge indigenously. The conundrum for development assistance agencies and national governments is how to create the conditions for this highly contextual process to happen without reverting to the usual tendency of simply transferring another institutional blueprint from elsewhere. DGIS has been clearly willing to take a long-term view here and not be constrained by short-term bureaucratic requirements. The logic of classifying the APNLBP as a 'special programme' is, therefore, obvious in retrospect. Had it been anything else it would have been constrained by all kinds of reporting and accounting rules. Ultimately these would have stifled progress. Hence we would suggest that the Dutch Special Programme, and the Indian partners that supported its establishment, has had the vision to create professional space for institutional innovation to take place. This coalition and participation between senior Dutch and Indian bureaucrats would need to be recognised in the context of the overall lessons emerging from the APNLBP.

Of course, things have not necessarily gone according to plan. And some would argue that there has been much 'business as usual' in the conduct of projects. But this would miss the point entirely, losing sight of the fact that institutional change has to be an evolutionary process of trial and error

13 See, for example, collected papers in Scoones and Thompson (1994). Although this volume, like much of the participatory debate, argues that integration between formal and informal knowledge is necessary for development, it does not really engage with the systemic reality of innovation. For a critique, see Biggs and Smith (1998).

(learning) that builds up momentum to gradually shift (often) fiercely guarded professional positions.

The *third* finding, therefore, is that DGIS has chosen an approach (IBU) that has relied on creating this space and flexibility according to the broadest possible set of principles consistent with operational control. Right from the start the aim has been to involve NGOs and scientists in one broad coalition and then to give the resultant system freedom to develop and to do so experimentally. The case study on approaches to pest-management research is an example of this experimentation in process, where novel working practices are emerging. In keeping with such a philosophy, the BPC is an autonomous organ with representation from all stakeholders, chaired by an eminent scientist but with day-to-day operations managed by a social scientist. DGIS continues, of course, to monitor proceedings for its own purposes. But in contrast to more conventional procedures, at the end of Phase 1 a review of the programme was organised that made use of Indian reviewers rather than reviewers from the North.

Fourthly, all projects are designed to build capacity at farmer and NGO levels and then gradually to withdraw as these capacities reach the stage of self-sufficiency. For example, from the projects on tissue culture we observed that considerable training has taken place in the field stations to build up staff ability to handle the various tasks needed to propagate, transplant and monitor tree cultures. However, having done this it is also clear that sufficient learning and adaptation has already taken place to permit field operations to become semi-autonomous. There is every likelihood that complete autonomy will be reached within a few years, or at least the feasibility of it will have genuinely been tested and perhaps different viable options will ultimately be pursued. This being so, the catalytic objective of the APNLBP would have been achieved.

A *fifth* point concerns the degree of genuine interaction between scientific and NGO communities. In India, the NGO sector plays a potentially important role in development, especially since it articulates the needs and aspiration of RPFs (although it is admittedly a highly variable sector). Indeed, as outlined above, right at the programme's inception it identified two NGOs who were to act as equal partners in the venture (including representation on the BPC). Some of the examples indicate that there has been a genuine attempt to build bridges between the scientists and these NGOs. The examples of the scientists working on biopesticides is a clear example of where this is starting to happen.

A *final* point is that there was a special effort on the part of the programme management to capture the interests of farmers by starting with interventions of a relatively straightforward type where technology was already available (e.g. vermiculture applications) that could produce tangible results quickly. This has helped build up enormous social capital that the project can use to launch future strategic opportunities presented by recent biotechnology applications. This innovation could only have been employed in a programme with the long-term vision of APNLBP. It reiterates once again the importance of social networks spanning the research/user divide as a key element of capacity development.

Challenges ahead

Having said all this, it is also clear that there is still some way to go. There are several issues here that need to be outlined. The *first* is the degree to which the scientific communities involved are willing to relinquish control of operational activities. For example, we were informed in one case that progress towards autonomous local production had been hampered by the reluctance of the research institution to reveal details of a substrate formula. Since the body in question is a public-sector institution (and there are, therefore, no property rights involved) it is hard for the outsider to understand why this has happened. Similarly, the example of the biofertiliser unit was told by the research partner not to get into adaptive research but simply to apply the technology in the original form developed in the central laboratory. Again, it is hard to see why this decision has been reached since surely adaptive research would benefit both parties.

Of course, the details of these examples are not in themselves important. Rather, what is important is the overall observation that North-South cooperation needs to recognise that there is an existing set of professional norms and power relationships. And these, initially at least, are going to skew institutional innovations such as that stemming from the IBU philosophy. This issue should be dealt with as part of the learning process and not ignored. Ways of accelerating institutional learning in programmes such as APNLBP, which by its nature is non-prescriptive and interventionist (at least on the part of the Dutch) is thus a point that requires further consideration by the BTU itself.

A *second* issue, which is related, concerns the degree of genuine interaction between the scientific communities, on the one hand, and the NGO/farmer communities, on the other. The NGOs have to maintain close links with farmers since otherwise their work would lose all purpose. But scientific bodies are different in that they may well wish to maintain a privileged position by virtue of their technical expertise beyond what is actually needed on the ground. It is hard to be definite in this respect but there were some indications that problems of power and control are never far below the surface. For example, 10 of the 13 members of the BPC (over 75 per cent) started off their careers as scientists, although many now hold down managerial positions in different agencies.

Another indication of this was the three-day workshop that had been organised by the programme to review progress at the end of Phase 1. It was difficult for the authors to avoid the impression that the workshop had been organised by scientists, for scientists and to demonstrate to the uninitiated the potential of modern science. Most of the workshop proceedings concerned the delivery of fairly complex scientific papers[14] with little discussion time available. What discussion took place tended to be dominated by the scientists themselves, asking and responding to esoteric questions. In addition, little time at all was devoted to the issues we expected to be high on the agenda, given the IBU approach agreed by the original project designers. For example, there was little discussion of technology transfer issues such as relationships between the NGOs and farmers in establishing innovative facilities, nor of project selection and monitoring procedures. Now admittedly, the intention of the workshop had been to explore the potential of two specific types of interventions (molecular marker and transgenic technologies)[15] and so it was perhaps inevitable that proceedings would move quickly in a technical direction. But if so, it was an opportunity missed to deal with an open and dispassionate review of the programme at the end of its first phase. A similar impression was given at the public debate where there seemed to be a certain defensiveness on the part of the science community.

14 There were sessions dealing with aspects of risk and intellectual property rights, but in our view, these did not really generate meaningful discussions on related issues.

15 Personal communication from the BTU Coordinator.

We would argue quite strongly that there are big dangers here of producing in India the kinds of problems that have begun to arise in Europe as a result of the emergence of crises associated with scientific expertise. The well-known ones include the public's rejection of genetically modified organisms in the food chain. A second example is the so-called mad-cow-disease debate where it is becoming increasingly clear that the British Government used flawed scientific evidence for its own political ends in the face of grave public concerns over food safety. Unfortunately, the general public has now lost a great deal of trust in scientists. Durant (1999) is one of many influential commentators who argue that once trust in scientists has been lost for whatever reason, it is very hard for it to be re-established. Polarised positions get taken up and as a result society as a whole suffers. In our view, countries like India cannot afford to let this happen with biotechnology.

Promoting a more consensual and balanced debate is the only way to lay to rest the demons of biotechnology and to start and explore the strategic opportunities that this may hold for sustainable development. In this regard, one cannot help but notice the conspicuous absence in the APNLBP story of a key biotechnology stakeholder, the private sector. This sector will inevitably play an increasing role in biotechnology development and if the poor are to benefit from its presence, the sooner that developmental capacity-building efforts engage constructively with this possibility, the better. A *third and final* point is that while many of the projects require social science inputs to help deal with farmer adoption and marketing issues, the programme as a whole would benefit from a social science perspective that could deal with the issue of embedding biotechnology in the complex development scenario of twenty-first-century India. This is not an uncommon lacuna in novel interventions of this kind. What is required is a new type of professional whose perspective spans the conventional distinction between the biological and social sciences, and who can think in systems terms (Clark 2002).

Conclusion

The Andhra Pradesh-Netherlands Biotechnology Programme is an example of North-South collaboration of an unusual and, we believe, far-sighted kind. Its strengths lie in its efforts designed to build sustainable links between science and development in a poor-farmer context. This has meant institutional innovations of a type that are hard for bureaucratic structures and associated mind-sets to come to terms with. Nevertheless, achievements have been clearly forthcoming and cracks are beginning to appear in the prevailing 'contextual edifice'. Probably the most important difficulties lie in the exercise of traditional habits of power and control on the part of scientific communities. APNLBP is an initiative that has much to commend it. In our view it embodies an approach that deserves consideration by the wider constituency of those involved in development assistance that seeks to bring the potential of the new biological sciences to those who need it most.

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