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INSTITUTIONAL LEARNING THROUGH TECHNICAL PROJECTS: HORTICULTURE TECHNOLOGY R&D SYSTEMS IN INDIA

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Abstract

This paper demonstrates the way in which institutional learning has been adopted by a post-harvest technology research project in India to cope with the institutional constraints associated with various public agencies, as well as to help formulate broader lessons for institutional reform in horticultural R&D systems. The case study presents an institutional history of public and private efforts to assist farmers from the Vijaya Association of Fruit and Vegetable Growers' Cooperative Societies of Andhra Pradesh to produce and sell export quality mangoes. Problems in the relationships between stakeholders reveal the need to see technology transfer in a much more holistic light than is conventionally understood.

Research findings

- *While technology development (and transfer) is certainly key to sustainable development, it will only succeed if the institutional context is appropriate.*
- *Institutional learning is proposed as a process through which adaptations can be made to accommodate shortcomings in the prevailing institutional environment.*
- *The recognition of the importance of institutional learning is rooted in contemporary thinking that conceptualises technical and economic change in systems terms, and where technical and institutional innovations are seen as of equal importance.*

Policy implications

- *The integrated systems nature of technical issues indicate the need to conceptualise project interventions and associated institutional arrangements in a systems framework.*
- *It is necessary for donor-funded technical research projects to recognise institutional lessons as valid technical research outputs.*
- *Ever-evolving institutional roles emphasise the need for policy recommendations to contribute to the institutional underpinnings of technology systems, as well as better technologies.*

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Boxes

Acronyms

APAU Andhra Pradesh State Agricultural University (India)
APEDA Agricultural and Processed Food Products Export Development Authority (India)
CFTRI The Central Food Technology Research Institute (India)
CPHP Crop Post-Harvest Programme (DFID)
DFID Department for International Development (UK)
HEQA Horticultural Export Quality Assurance
ICAR Indian Council for Agricultural Resarch
IIHR Indian Institute of Horticultural Research
NGO Non governmental organisation
NRI Natural Resources Institute (UK)
NSI National system of innovation
R&D Research and development
SAU State agricultural university (India)

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1 INTRODUCTION

This paper is about the need for institutional learning in agricultural science research projects. Its underlying message is that while technology development (and transfer) is certainly key to sustainable development, it will only succeed if the institutional context is appropriate. It has been written in response to an implicit (and still widely held) belief that it is possible to think of development projects as purely *technical* activities. The corollary is that implementation of results is then something that can simply be left to other agencies or the market. Such rationalisation fits neatly into an organisational context where professional identities can be maintained and promoted. The problem is that it is almost certainly highly inefficient in the normal economic sense. There are simply too many examples of technical projects producing outputs that sit on shelves, inaccessible to the range of stakeholders that might in better circumstances have been able to make productive use of them. Conversely, where institutional learning is allowed to occur it is likely that there could be significant improvement in the value added of technical projects.

The Vijaya mango export project discussed in this paper is a case study of precisely this phenomenon; a technical and policy study of recent developments in the mango sub-sector of the Indian economy involving an institutional marketing innovation, the Vijaya Association of Fruit and Vegetable Growers' Cooperative Societies of Andhra Pradesh (Vijaya). Conceived initially as a purely technical series of projects and interventions, it gradually became clear that the issues were equally about institutions and the need for institutional change. Thus what is interesting about the Vijaya case is not so much its success in integrating small farmers into a wider economic market (including the high value export market) but rather Vijaya's relationships with other stakeholders, in particular those that have been potential sources of technology. Problems in these relationships reveal the need to see technology transfer in a much more holistic light than is conventionally understood. And the relative failure of public sector technology sources also indicates the need for associated policy reforms that again have an institutional dimension.

In the case studies described here, an external research institute was brought in from overseas to assist with a *technology* problem that the local scientific infrastructure was apparently having difficulty resolving. The external body, however, still saw the hiatus as a technical one initially, and it was only as time went by that the importance of the *institutional dimension* became clear. From that point a degree of institutional learning began to take place. First was the realisation on the part of the marketing association, and to a lesser extent the export development authority, that better mechanisms were needed to link farmers to public sector technology sources, and that the technical outputs needed to be made relevant.

Second was the institutional learning on the part of the project, as well as on part of the donor funding the series of studies. In the final phase the institutional roles within the project changed significantly. The project no longer focused primarily on technical solutions. Instead, it addressed ways of strengthening institutional processes and linkages to ensure that the private marketing association, Vijaya, and the farmers it represents, was better integrated with public sector sources of science and technology and related services. Further cycles of institutional learning are still required on the part of all the stakeholders involved.

Institutional learning is key to the success of continuing efforts of public agencies to help farmers take better take advantage of new markets. While export success has yet to be achieved, this case study has important implications for the types of donor-funded research projects that are likely to be of assistance in the future. In addition to generating and reporting technological findings, projects must also address and generate knowledge on the processes associated with technology development and delivery systems. The conclusion therefore must be that if an institutional perspective is built into projects at an early stage, the likelihood of successful interventions becomes much greater.

The remainder of the paper is divided into five sections. The next section provides a very brief introduction to the concept of institutional learning and the importance that is given to this in current policy analysis and debate about innovation systems. The third section provides background orientation, describing the general institutional environment of public sector agencies allied to horticultural R&D and export market development, elaborating the role and capabilities of the key agencies relevant to the case study. The fourth section presents the case study. This describes an institutional history of attempts to support farmers' entry into mango export markets and the interlocking and evolving roles of Vijaya, the project and Indian public agencies in this process. The discussion in section five elaborates the implications of the case study. In particular, the implications of the systems nature of the technical and economic issues being addressed and the need to conceptualise interventions and associated institutional arrangements in a similar systems framework. The final section draws conclusions for international research policy for developing countries.

2 INSTITUTIONAL LEARNING

The recognition of the importance of institutional learning is rooted in contemporary policy analysis of the innovation process and its performance. A common theme has been the conceptualisation of innovation in systemic terms, where institutions act as nodes in the production and application of new knowledge. In the context of agriculture, a widely cited example of this is

Biggs' discussion of a 'multiple sources of innovation' model in agriculture (1990). However, institutional learning has received much more attention in the context of industrial production in developed economies. Here the systemic idea of a national system of innovation (NSI) (Freeman, 1987; Lundvall, 1992) and related conceptual frameworks have made considerable progress in understanding the innovation process and how to plan and manage it[1].

The contribution of NSI is that it provides a way of analysing institutional roles and relationships, and the way these change over time. This is conceptualised in terms of an *innovation system*. This type of analysis is more inclusive than the narrower notion of a *research system*, the distinction being that the latter is a system of predominantly public sector organisations engaged in producing technical innovations. In contrast, an innovation system encompasses all the elements of the system or network of private and public sector institutions whose interactions produce, diffuse and use economically useful knowledge. Unlike research systems, innovation systems are viewed as producing both technological and institutional innovations. It is in relation to the latter that institutional learning is so important. It underpins the evolutionary dynamic that often creates the new institutional forms that allow the development and utilisation of new technology. This process of institutional learning is a central feature of successful innovation systems.

The application of the NSI framework in the agricultural research sector is starting to gain ground (Hall et al., 1998; 2000; 2001 in press a & b; Clark, 2001 in press; Ekboir and Parellada, 2001, in press)[2]. The associated debate has two very simple, although rarely applied lessons for agricultural research projects[3]. Firstly, technological constraints can neither be conceived nor addressed without reference to the institutional context in which they are embedded. This means that consideration needs to be given to the range of institutions involved in research and technology application. Specifically, consideration needs to be given to the way the attributes, characteristics, norms and agendas of these institutions are likely to influence research outcomes, as well access to and application of new technology. Secondly, since R&D and technology application is so intimately bound up with this institutional context, the institutional innovations that are necessary to produce and use technology in new ways are equally valid and important 'scientific' outputs. It is these outputs and the institutional learning opportunities that they represent, that are so often forgotten in agricultural research projects.

Another way of making the same point, and one which is now mainstream in innovation systems thinking, is to recognise that new technology, (and attempts to generate and apply it), has no meaning unless it is considered in an institutional context. This has profound implications for traditional technology research projects. The remainder of this paper demonstrates the practical importance of recognising the institutional context and the potential role institutional learning can have in dealing with the constraints and opportunities contained within institutional contexts.

The case study presented in this paper is an institutional history of public and private stakeholder efforts to assist Indian farmers to produce and sell export quality mangoes. This concerns the way Vijaya sought the assistance of public agencies in India such as the Agricultural and Processed Food Products Export Development Authority (APEDA), who in turn facilitated Vijaya's access to both local and international sources of technical assistance and marketing advice. The reporting of the case study results from a series of projects supported over a number of years by the UK Department for International Development Crop Post-Harvest Programme. These projects focused on export horticultural development in India. The problem of farmer access to high value mango export markets remains unsolved and the efforts of Vijaya, APEDA and DFID are still continuing. However the experience of working on this issue has given many useful insights into the critical importance of addressing issues of institutional context, and the way the various stakeholders, including the externally funded project, have learnt important institutional lessons. The case study documents this institutional learning process.

3 INSTITUTIONAL ROLES AND ARRANGEMENTS FOR TECHNOLOGY SUPPORT

Agricultural Research

Public sector agricultural research in India is conducted by institutions that can be categorised into two main organisational groups. In the first group are the research institutions that fall under the national agricultural research organisation, the Indian Council for Agricultural Research (ICAR). In the second group are the 29 state agricultural universities (SAU). In addition to these institutions, and less well integrated, are non-agricultural universities and other scientific organisations – notably those under the Council for Scientific and Industrial Research, the Department of Biotechnology and the Department of Science and Technology, all of which conduct research related to agriculture. Similarly under the Ministry of Food there are networks of grain storage research institutes and sugar research institutes.

All these organisations are collectively described as India's national agricultural research system. However, from a policy perspective, as well as from a practical point of view, it is only the ICAR institutions and the SAU that can be considered as a coherent system. This is mainly a result of the many collaborative All India Coordinated Research Projects that draw on the combined efforts of the SAUs and the ICAR institutes. In theory, there is nothing preventing linkages between public sector research institutes and related support agencies that fall under different research councils and different ministerial and departmental control. In practice, this rarely happens. The consequences of this are discussed in the case study.

A similar situation is also reflected in the relationship between public sector research institutes and the private sector. Although agricultural research in India has been heavily dominated by the public sector for the past 40 years, over the last decade significant private agricultural research and development (R&D) capacity has emerged. In part this has been associated with agro-industrial growth in response to new opportunities in the increasingly liberal policy environment (particularly apparent in the seed industry). However, R&D capacity has also emerged in the horticulture and agro-chemical sectors. In addition, there has been growing recognition of the potential importance of the non-profit private sector (NGOs, farmers associations, and private research foundations) in undertaking agricultural research and allied activities.

ICAR has recognised the opportunities that such institutional development can provide, particularly for public/private sector partnerships. Part of the reform process that ICAR has implemented over the last five years has been to address this issue. However progress is modest and to date the range and scope of public/ private sector partnerships is not as extensive as its potential suggests. Furthermore it is increasingly apparent that despite efforts to reform the system, institutional arrangements in ICAR still present a considerable obstacle to better working relationships between the two sectors (Mruthyunjaya and Pal, 1999; Paroda and Mruthyunjaya, 2000). Ways of proceeding to a more institutionally diverse, stakeholder-driven research system remain a significant challenge[4]. And it is not just ICAR that is trying to address these types of issue. Many public sector support agencies in India are facing the need to make themselves more accountable to clients, with the quality of their services coming under the scrutiny that has accompanied entry into global markets. The case study concerns in part the consequences of this process. To understand the implications of this it is first useful to give more contextual details of the horticultural sector, key agencies involved and the way this institutional landscape is starting to evolve.

Horticulture

The Indian Eighth Plan allocation for horticulture sector development increased from US$ 6 million (Rs24crores) to US$ 250 million (Rs1000crores). This, coupled with many concessions, subsidies and incentives to producers, was both an important impetus to growth, as well as recognition of its developmental potential. At the macroeconomic level, India has created an increasingly liberal economic policy environment since 1991. This has eased procedures for foreign collaboration and access to international markets. In turn it has precipitated an unprecedented expansion in Indian exports, among which horticultural exports have been important (APEDA, 1998). However the sector has not only witnessed strong growth and policy support. Kaul (1996) comments that the trend observed since 1991 is that the horticultural sector has gradually moved out of its rural confines as a traditional agricultural activity into something approaching corporate enterprise. This trend has led to the adoption of improved technology, greater commercialisation and professionalism in the management of production and marketing.

However horticulture in India continues to be troubled by constraints such as major plant diseases across commodities, low yields compared to other producer countries and in particular, poor post-harvest practices. All this leads to low final product quality. Quality management is thus a major concern for export marketing where standards are high and punitively enforced. It would appear therefore that improved productivity, post-harvest management, hybrid development, and product diversification are all challenges which horticultural science is to face if it is to continue to play a strategic role in sector development. Furthermore, these efforts will need to be supported by an adequate market infrastructure and policy environment, together with relevant mechanisms for articulating the technological needs of producers and processors to scientists, which in turn must be linked to efficient mechanisms for technology transfer (Kaul, 1996).

Relevant Organisations

The main sources of R&D and technology services related to horticulture fall under ICAR, the State Agricultural Universities and, in the specific context of post-harvest and food science, the Central Food Technology Research Institute. The horticulture related institutes under ICAR include: 8 Central Research Institutes, with 27 regional stations, 1 Project Directorate, 10 National Research Centres, and 7 multi-disciplinary institutes. In addition there are 15 All India Coordinated Research Projects related to horticulture, with 223 research centres collaborating in these projects. There is one fully-fledged University of Horticulture, and 24 State Agricultural Universities with horticulture departments (see Box 1 for details). Post-harvest research, while not a traditional focus, has received greater attention in recent years. While the SAUs do not have strong post- harvest capability many of the ICAR institutes have started to develop such capabilities (Ghosh, 1998). These skills range from processing and preserving produce, to developing post-harvest treatments, to control storage deterioration, and increasing storage life and shipment duration.

As can be seen from Box 1 the institutes related to horticulture are quite numerous and geographically dispersed throughout the country. While some of these institutes, particularly the commodity related ones, have a specific regional relevance, the more thematic focused institutes have a more nation-wide relevance. There is considerable overlap between institutions, particularly in cross cutting themes such as post-harvest. With only the recent emergence of private sector clients, many of the horticulture related ICAR institutes have a history of focusing on smallholder producers as their main clients. As a result, relevant institutes do not have a long history of working with the corporate enterprise sector. Similarly, with participation in export markets recently becoming of importance in the newly liberalised policy environment, related expertise is still being developed. It has been suggested that the future strategy of ICAR in

the horticulture sector should focus on the following three points: (i) the building of research capacity for post-harvest technologies; (ii) enlarged partnership arrangements with the private sector; and (iii) the creation of institutional linkages both between different ICAR institutes, and between ICAR and SAUs (Ghosh, 1998).

For this case study there were several organisations that have played an important part in the story. It is useful to summarise them at this stage:

Agricultural Processed Food Products Export Development Authority (APEDA)
Established under the Ministry of Commerce, the mandate of APEDA is to build links between Indian producers and global markets. The organisation was initially conceived as a marketing/export promotion organisation, providing exporters with information on market requirements and performing regulatory functions. All exporters of scheduled products are required by the APEDA Act to be registered with APEDA.

However this initial role has broadened to include technical backstopping (IFW, 1996). APEDA lacks the expertise and infrastructure to provide this technical backstopping support in house, and instead sub-contracts these activities. For example, APEDA set up a Controlled Atmosphere Programme to develop a protocol for the shipment of mangoes to Europe. This was initially contracted out to the Indian Institute of Horticultural Research and the Central Food Technology Research Institute. Similarly in the absence of a dedicated horticultural extension system[5], APEDA has played an important role in facilitating the supply of technical advice to farmers. While the mainstay of these technology-related activities has used scientists from national (public) scientific research institutes, APEDA has also sought technical assistance from outside India for the purchase of equipment; international transport; and the monitoring of fruit on arrival at export destinations.

Box 1 Research institutes related to horticulture in India

ICAR crop/commodity Central Research Institutes
Indian Institute of Horticultural Research, Bangalore, (Southern India)
Central Institute of Sub-Tropical Horticulture, Lucknow (North Central India)
Central Institute of Temperate Horticulture, Srinagar (Far North West India)
Central Potato Research Institute (CPRI), Shimla (Far North India)
Central Tuber Crops Research Institute (CTCRI), Thiruvananthapuram (Far South India)
Central Plantation Crops Research Institute (CPCRI), Kasargode (South West India)
Indian Institute of Spices Research (IISR), Calicut (South West India)

Project Directorates
Project Directorate for Vegetable Research, Varnasi (North Central India)

National Research Centres
Citrus, Nagpur (Eastern Central India); Banana, Tiruchirapalli (Eastern Southern India); Grapes, Pune (Western Central India); Arid Horticulture, Bikaner (North West India); Onion and Garlic, Rajgurunagar (Western Central India); Mushroom, Solan (Far North,India); Orchids, Gangtok (North East India); Oilpalm, Elurur; (South Central India); Cashew, Puttur (South West India); Medicinal and Aromatic Plants, Anand (Western India).

Other ICAR Institutes related to horticulture.
Central Institute of Post Harvest Engineering and Technology, Ludiana (North West India)
Indian Agricultural Research Institute, New Delhi
(ICAR complex for North East Region)

Non-ICAR Institutes related to horticulture
Indian Institute of Packaging, Ludiana (North West India)
Central Food Technology Research Institute, Mysore (Southern India).

The Indian Institute of Horticultural Research
(IIHR) is an ICAR institute located in Bangalore in Southern India. Historically, IIHR has been important for germplasm development of both vegetable species and fruit trees. Its other strengths have included agronomy and crop protection. IIHR has also undertaken research on post-harvest processing, but this has focused mainly on farmer and cottage level industry. In common with other ICAR institutes, IIHR has traditionally had laboratory / field station research mandates and has not played a major role in extension. Like many ICAR institutes social science expertise in the institute is restricted to economics and statistics, dealing with macro trends in production and markets. Since 1998, in line with ICAR policy, scientists from IIHR have been able to engage in consulting contracts. IIHR has experience in certain niche commercial horticultural sectors, but has only more recently started to engage in the high value commercial sector and particularly export markets. Extensive contracting arrangements with private sector horticultural export companies have yet to emerge[6]. However since 1995, IIHR has been contracted extensively by APEDA in connection with developing protocols for mango exports, including the training of farmers and exporters.

Andhra Pradesh Agricultural University
State agricultural universities in India are based on the Land Grant Model from USA. They perform a predominantly teaching and agricultural extension function and undertake adaptive research to support these activities. Many state agricultural universities have a horticulture department dealing with crops relevant to a particular state. Of relevance to the Vijaya case study was the involvement of the Department of Horticulture at the Andhra Pradesh State Agricultural University (APAU). Scientists provided training to Vijaya staff, and advisory services for field practice and post-harvest handling. The university also undertook routine analysis of soil samples and health of farmers' orchards. (This was a prerequisite for farmers wanting to join the Vijaya association.)

The Central Food Technology Research Institute
(CFTRI) is India's premier food science research institute. It falls under the Council for Scientific and Industrial Research (CSIR) and is located in Mysore in Southern India. The original mandate of the organisation focused

on low cost food processing technology, utilisation of indigenous raw material, and excellence in food science and food safety. Clients were originally from cottage industry food enterprises and large-scale (often publicly-owned) food industries. More recently the focus has started to shift toward corporate private enterprise. Like other CSIR institutes there has been a move towards cost recovery, and this has shown considerable success in many CSIR institutes (World Bank, 1989). The challenge for organisations like CFTRI is to be able to maintain their pursuit of scientific excellence, while at the same time catering to the needs of new and discerning customers, whose agendas are strictly commercial. In the context of the Vijaya project CFTRI was contracted to lead the post-harvest component of the work. They were selected on the basis of their professed expertise in controlled atmosphere technology.

Private sector organisations

Private organisations are becoming an increasingly important institutional node in the Indian horticultural sector. A notable example of this is the grape growers association of Maharashtra[7] and the creation of Mahagrapes, a confederation of grape growers societies (Rasheed Sulaiman and Sadamate, 2000; Hall et al., 1998). The expanding institutional role of such private organisations, and their increasingly proactive search for the technology to access new markets presents important opportunities for partnerships with the public sector. This in turn could be an important way of linking farmers with the types of public agency that can facilitate access to new economic opportunities. It should be remembered that private firms still need to rely on small farmers for produce due to current land tenure arrangements (Haque, 2000). However the reality is that farmers or private entrepreneurs quite often have to contact several agencies for different requirements. This reflects the poor coordination between agencies under different ministries and departments. It also reflects the more general feature of the public sector agencies and particularly the research institutes; viz. the tendency to compartmentalise activities along professional lines rather than on a more system-wide basis. This point is discussed in more detail in the case study.

4 CASE STUDY

The Vijaya Fruit and Vegetable Growers Association

The Vijaya Fruit and Vegetable Growers Association (Vijaya) was established in 1992 in Vijayawada in southern Andhra Pradesh, India. The association is made up of 16 fruit and vegetable cooperatives (primary societies) spread over three districts around Vijayawada. The primary society membership consists of approximately 500 farmers who between them cultivate almost 3,000 acres of mangoes. Vijaya acts as an apex organisation to undertake and coordinate the marketing of mangoes in export and high value domestic markets. Vijaya is ostensibly a private enterprise established with the initial support of the Andhra Pradesh State Marketing Department. Vijaya's specific goal is to find better prices for farmer members' produce through direct marketing to high value domestic and export markets without the produce being handled by middle men, wholesalers and traders.

Vijaya rents pre-cooling and packhouse facilities during the mango season (April/May) to process the fruit it purchases from farmer members. It identifies markets, negotiates prices and organises transport/ shipment of fruit. Farmers receive a premium price for fruit that is of export quality. In turn, a key function of Vijaya is to act as a source of technical advice and inputs to assist farmers to increase the proportion of fruit which reaches export quality criteria – initially only 10% of fruit were attaining this level of quality. Vijaya has a network of field officers that provide production and post-harvest advice. These officers supervise the harvesting of mangoes and processing in the packhouse.

Criteria for membership of the primary cooperative societies are designed to screen out the largest farmers (those with more than ten acres of mangoes). Although these types of equity criteria are understandably difficult to enforce, households with small land holdings (up to five acres) are represented in the membership of the society. Furthermore, the labour intensive export harvesting procedures provide a significant source of additional income for the poorest households. The efforts of Vijaya to develop export markets for its members' mangoes have been given significant assistance from APEDA. This has included both promotional and technical assistance. Recognising the importance of forming linkages between Vijaya and relevant sources of technical expertise, both nationally and internationally, APEDA provided 50% of the costs of engaging scientists from IIHR, CFTRI and APAU.

The support that IIHR provided to Vijaya was through this type of contract arrangement, although it was APEDA that contracted IIHR as part of the export support role (see discussion below). It is important to highlight that this arrangement was therefore one public agency contracting another public agency on behalf of the private marketing organisation (Vijaya). This had significant implications. The linkage mechanisms associated with Vijaya were extensive and demonstrate the potential dual function of both market and technology access mechanisms that organisations like Vijaya can provide. As part of the support that APEDA provided to Vijaya, scientists from the Natural Resources Institute (NRI) in the UK were encouraged to focus their efforts on critical technical constraints that Vijaya was facing. The most important of these was the development of controlled atmosphere sea shipment protocols. The origins and development of NRI involvement with APEDA and the way the series of recent research projects evolved is worth recounting in some detail.

The research project

The origins of the recent research project funded by DFID's Crop Post-Harvest Programme (CPHP) can be traced to the activities of the Overseas Development Natural Resources Institute (later renamed NRI). Between 1993 and 1995 a series of activities was begun to assist countries with potentially important horticultural export

industries. The activities focused on developing a manual on Horticultural Export Quality Assurance (HEQA) to help promote the development of exports of horticultural produce by improvement of quality and achievement of market requirements. Driving this was the realisation that horticultural export industries were a potentially important source of economic development, held many benefits for small-scale producers, as well as generating important employment opportunities for the poor in rural areas.

The HEQA manual was designed to support producers and exporters targeting European markets. The purpose of the HEQA manual was to provide a source of information on European Union legislation (such as pesticide residue levels, hygiene requirements and protocols to ensure produce could be traced to the point of origin). Information was also provided on parameters set by the market (size, shape, colour of fruit, size of consignment, and so forth). The HEQA manual set out how these parameters could be achieved, providing practical information for the development of a total quality management system for handling and export of produce. The manual was validated in Kenya in 1994, but the main emphasis soon shifted to India. In 1995/96, in collaboration with APEDA, NRI presented training sessions on horticultural export quality assurance in India based on the manual. Using the HEQA manual as a template APEDA went on to develop HEQA for specific commodities, namely grapes, lychee, kinnow and mangoes, with a view to providing useful and practical guidance for the establishment of quality assurance procedures by packhouses. APEDA have developed a scheme that issues a 'Certificate of Registration of Premium Quality Exporter' to packhouses complying with requirements of the manual.

Since the mid 1990s APEDA has been promoting the development of the mango export sector. As such, it had been helping organisations such as Vijaya access Far East markets using airfreight. However, APEDA realised that in order to be competitive in European markets, mangoes need to be transported by sea, as sea transport can accommodate a larger volume of exports than air freight and offers considerable cost advantages. As a result, APEDA commissioned a programme of work to develop controlled atmosphere sea-freight methods to extend the storage life of mangoes from harvest to arrival in Europe. In contrast to the approach based around quality management standards of the HEQA manual, achieving successful mango exports to Europe was seen as a largely technological task. Considerable research was required to develop the types of controlled atmosphere regimes that would be needed. And these had to be developed specifically for Indian mangoes and specifically for a minimum post-harvest life of 30 days.

Scientists from CFTRI with expertise in post-harvest technologies were commissioned by APEDA to undertake the initial work on developing controlled atmosphere (CA) protocols (gas and temperature regimes and so forth) as well as the post-harvest component of export protocol (fruit handling, packaging and packhouse procedures). The approach was to undertake a number of trial shipments from Andhra Pradesh, using Vijaya as a focus for this activity. At the same time scientists from IIHR and APAU were commissioned to formulate a set of pre- and post-harvest protocols to improve export quality. These included: pre-harvest disease control and tree management; advice on harvest maturity and fruit selection; improved harvesting practices; handling and packaging protocols. Once the recommendations had been formulated, CFTRI, IIHR and APAU trained the staff of Vijaya and provided written advice for Vijaya's farmer members. In the following season (1997) trial shipments of mangoes under CA storage conditions were sent to Europe. The results of the first sea shipment suggested that further work was required on the development of the CA technology.

Phase 1: Technical quality parameters

The shape of the new project was not just determined by the fact that APEDA (and Vijaya) viewed the presenting problem as largely technological. Major changes had also taken place at both NRI and within DFID's funding mechanisms, resulting in a stronger physical sciences research mandate than the more developmentally focused initiative of the HEQA manual. This, along with the personalities involved in the UK team, resulted in APDEA and NRI embarking on a predominantly technical research project. And since a large part of the project was to be done as the thesis work of a doctoral student, the project was destined to lean towards the theoretical rather than the applied part of the spectrum. The project work began in late 1996, with the next sea shipment to take place in April/May 1997. Initial activities of the NRI scientists focused on trying to gauge the reasons behind the poor performance of shipments to date and define the scope of further research needed on the CA protocol. As part of this process one of the scientists started to examine the whole of the production–harvesting–handling chain as a way of getting some idea about the quality of fruit and the factors affecting fruit in sea shipment containers It quickly became apparent that there was a much larger range of technical problems in the quality chain than had first been anticipated. Furthermore, discussions with Vijaya and its farmer members raised concerns over the types of recommendations being provided, particularly in the context of a predominantly small and marginal farmer production system.

The results of the trial shipment of mangoes supported the suggestion that farmers were having difficulty adopting and implementing the advice that was being provided by scientists from IIHR and APAU (Box 2). There were clearly also some issues concerning the efficacy of the CA sea-shipment protocols that CFTRI had developed. Furthermore it was apparent that many of the problems observed in the fruit at the export destination were a combination of field-level disease problems (particularly anthracnose) made worse by inadequate storage and shipment conditions.

Lessons from Phase 1

The different stakeholders, while all recognising that there was a problem, defined it in different ways. Vijaya

felt unhappy with the technical content and appropriateness of the advice it was receiving. However it appeared to be unable to leverage any improvements. Neither did Vijaya take issue with the rather prescriptive approach to providing recommendations to its farmers. APEDA viewed the problem as mainly an issue of the intensity of the technical backstopping, although it also realised the need to take a more proactive approach in managing the technical components that had been subcontracted to IIHR and CFTRI. APEDA then responded in two ways. Firstly, it contracted scientists from NRI to undertake further out-turn assessments in order to monitor the technical validity of the protocols and practices being developed. Secondly, it intensified farmer-training efforts in mango growing areas by devising a more intensive training programme that covered both pre-harvest and post-harvest issues and took an active role in coordinating these efforts (although this was not implemented until 1999).

The NRI scientists also recognised that while there was a strong technology dimension to the problem there were a number of facets to this. Firstly, export quality would only be achieved if the production, handling and CA sea-shipment components were dealt with in an integrated fashion. The different problem areas were strongly interrelated and a technical solution would only be relevant in a 'total systems' perspective. In contrast, technical assistance was being provided in component form. Secondly, it was clear that there were a number of process problems with the way technical backstopping was being provided. So while many of the quality issues needed to be addressed with (often location-specific) adaptive research, the assistance provided tended to be pre-formulated. Furthermore, this related to the professional traditions of the institutes providing field level technical backstopping, as well as the limited resources and incentives available for field visits under the terms of the contract (Box 3).

The technical support provided to Vijaya was suffering from a number significant institutional constraints. Since NRI was itself only contributing certain components as part of an overall cluster of technical support initiatives, it was difficult to see how this could succeed if the overall cluster was not working in a systemic fashion. While Vijaya and APEDA were keen to continue with the project, it was clear that a technical solution alone was not going to solve this type of issue. At this point, and hastened by the departure of the principle investigator from the UK team, DFID's CPHP decided not to take the project forward in its original form. Residual money in the first year's budget was used to review the extent that organisations like Vijaya were playing a role in linking farmers with markets and technologies. This tended to confirm that important developments were taking place with private organisations playing a potential brokering role. However, technical backstopping of these efforts by various public agencies left much to be desired (Hall et al., 1998). It must be emphasised that the scientists themselves were not at fault, rather it was the institutional environment they came from and the restrictions this placed on their professional experience and mandate. Closer examination of the organisational and institutional context of the technical support was clearly needed.

Box 2 Results from trial shipment of mango

The results of the out-turn assessment indicated only partial success. Only 31% of the fruit were regarded as Class 1 fruit. Out of 2,441 cartons received by the importer, 33% were lost to disease, mainly anthracnose, but also stem end rot. The following technical constraints were identified:

- Pre-harvest management constraints, particularly control of pests including anthracnose.
- Size grading – fruit present of mixed and uneven size.
- Maturity indices – the consignment contained fruit of mixed maturity, some over-ripe on arrival, some under-ripe.
- Post-harvest control of disease – particularly anthracnose and stem end rot developed during storage, suggesting that post-harvest treatment for these diseases was also required.
- Heat damaged fruit – suggesting the need for improved temperature control in the field and during transit to packhouse.
- CA technology – fruit had suffered from chilling injury suggesting that the temperature and possibly gas mixtures had not been correct for the particular variety of mango being shipped.

Phase 2: Technology development and institutional analysis

The second phase of the project took these ideas regarding the institutional environment forward in the form of a pilot action research project, which entailed undertaking a further piece of technical research with Vijaya. This was used as a vehicle to understand the institutional constraints presenting among relevant public agencies; the way these constraints impinged in a practical sense on attempts to solve technical problems; and to identify possible ways of moving forward. The point here is that the design of the second phase project explicitly recognised the need to understand technical issues in terms of the institutional context associated with ways of addressing the problem. The findings that this approach produced reveal a set of institutional constraints that, in broad terms, are widely recognised and documented problems encountered with public sector agricultural research institutes in India, as well as around the world[8]. These findings are briefly presented in Box 3 to demonstrate the process by which the understanding of these issues provided important lessons that allowed the project to evolve into its third phase.

Lessons from Phase 2

While the project as a whole learnt a number of lessons from the Phase Two activities, each of the stakeholders probably learnt less. After all, they still saw the problem in broadly technical terms and while aware of the constraints that the institutional environment imposed, they viewed it as a fixed parameter about which little could be done. While in one sense this was correct, was there room for manoeuvre? One of the lessons that emerged from both Phase One and Phase Two of the project was that the experiences of Vijaya were not unique: attempts to access technology from public sector research institutes form part of more widespread institutional changes related to the growth of the private

sector in agricultural/horticultural development. In the case of corporate enterprises and some grower associations, dissatisfaction with public services had encouraged a diverse range of technology acquisition strategies, including the establishment of independent R&D facilities.

The lesson here was that, despite the problems faced by Vijaya, alternative institutional groupings held the promise of an operational technology system – at least potentially. Furthermore, it was felt that alternative and multiple partners might represent a more effective model than the traditional donor-funded research model where one group of public sector scientists from the international research community is linked with another set in a developing country. Important here was the finding that (diverse) partnerships strengthen the stakeholding of interest groups other than scientists, and this helps create and operationalise new technology[9]. The way this finding has been acted upon is discussed below under the Phase Three project.

Box 3 Institutional constraints identified in Phase Two

1. Professional mandate of scientists:
- limited opportunities for interactions with farmers or private enterprise;
- much of the experience of scientists based on the results of laboratory research and literature reviews;
- little exposure to implementing research findings in either a commercial scale context or the contingencies of servicing the needs of European export markets;
- absence of any social science expertise among the team members, resulting in a lack of complementary guidance on farmer practice and interaction.

2. Institutional mandates:
- complementary knowledge and mutually supportive technical expertise locked up in different non-communicating institutes with the responsibility for linking these components left to a third party.

This was particularly so in the context of attempts to deal with anthracnose, a disease which needs to be tackled with an integrated pre and post-harvest approach: the two sets of national scientists (one set predominantly pre-harvest, the other predominately post-harvest) were functioning as quite separate entities. Each set visited Vijaya and its farmers at separate times. Neither communicated with each other, while the implied institutional ownership of potentially commercially sensitive information created much mistrust between them.

3. Resources and incentives:
- top-down institutional tradition within public sector;
- bureaucratic arrangements often make it difficult to work in new and more useful ways, even where scientists are keen to assist organisations like Vijaya;
- logistical arrangements and short-term inputs provided limited resources for fieldwork.

Fairly short inputs were provided for, with limited provision for allowances, travel and number of visits. As a result, while it was apparent that there was a need for *in-situ* adaptive research, logistical arrangements dictated that the inputs of scientists were short and took the form of technical advice of a pre-formulated nature.

4. Client-contractor relationships:
- lack of overall systemic control because APEDA, rather than Vijaya, had contracted and paid for the services of the scientists;
- no contractual recourse on the part of Vijaya to enforce accountability from the service providers;
- inability of APEDA to play an informed and active management role due to distance from the point of service provision.

5. Institutional capabilities of marketing organisation (i.e. Vijaya):
- not able to facilitate more productive interaction between farmers and scientist, nor articulate farmers' concerns about the inappropriateness of some of the recommendations;
- lack of awareness of the interrelated nature of many of the presenting problems, putting it in a weak position to press the scientists for the types of technology that would be useful.

The second lesson relates directly to Vijaya. It concerns the fact that given the resources available to Vijaya (and there must be many organisations like it in India), its technology acquisition strategies are probably limited to those it can access from public agencies within the country. While this reiterates the urgent need for policy reform in public agencies, what options does it leave open to Vijaya? The second phase project had also provided a number of lessons about the institutional role and capability of Vijaya (Box 3), specifically the way institutional capacity had limited its ability to enforce accountability standards on the types of technical assistance it was receiving. This related to the way one public agency was providing assistance to a private organisation by contracting directly another public agency. However even under direct contracting arrangements, it is doubtful whether Vijaya would have been able to enforce improved service delivery. This was because Vijaya did not recognise the systemic nature of the quality management issue, and therefore the need for an integrated approach to problem solving. Furthermore it did not recognise that the process by which technical advice and services were delivered to farmers had enormous implications for the effectiveness of any programme of technical support. Important here is the recognition that if organisations like Vijaya are to become important and useful nodes in a technology system, they need the capabilities to perform this role. In the Indian context this means the technical and managerial skill to enforce accountability in technology service provision and the ability to do so, bearing in mind the stringent requirements of export markets and resource constraints of farmer members.

Phase 3: Combined technology and institutional learning protocols

The lessons from the second phase of the project affected not only the design of the third phase project but also the overall DFID Crop Post-Harvest Programme strategy for projects in South Asia[10]. The third phase of the project concerns undertaking adaptive action research with Vijaya and APEDA to develop management systems that will allow Vijaya to better access technology suitable for a smallholder production context. In this sense the project has shifted from its initial emphasis on a technical fix, to one of understanding and developing ways to strengthen the institutional role and capability of Vijaya. The project will allow it to operate more effectively within the overall institutional context of public sector support agencies in India. The project was commissioned in late 1999 with the same NRI team and has been operating for one year at the time of writing. In practical terms the project involves the development of a manual that will assist organisations working with smallholder

producers to access more effectively scientific resources and bring these to bear on those pre- and post-harvest constraints which are preventing market access (Taylor, 1999). APEDA and Vijaya continue to form the focus of this work. However it is probably fair to say that their interest initially lay in the technical content of the manual to be produced, rather than the combined institutional agenda.

The out-turn assessments of the earlier phases continued in Phase Three. However the result of the assessments at the export destinations showed that the mango consignments had achieved the lowest rates of success to date. The consignment from Vijaya was a total failure, with the mangoes being rejected by the importer on arrival. APEDA and Vijaya were both extremely disappointed with the results feeling that they had progressed very little since their first shipments five years previously. The reason behind the failure was initially identified as poor maintenance of a cool chain, most critically a delay of 24 hours of the sea-shipment containers on the dock in high temperature before leaving India. While these factors undoubtedly contributed to the failure, if the mangoes had been first class, disease-free fruit, picked at the correct level of maturity, correctly handled and packed, the effect of the delay at the dock would not have been critical. In other words it was not that one element of the chain failed, rather that stress at one point highlighted the weakness in the whole chain of procedures all the way from tree management to packhouse practice. Clearly the problem was not only technical, but also managerial. In other words it was a systemic problem, and needed to be addressed as such.

The positive outcome has been that APEDA and Vijay have learnt, albeit through a rather painful process, that they need to think more systemically about the technical and managerial issues associated with mango production. And inevitably this requires a lot more thought about existing institutional mechanisms for supplying technical backstopping to mango producers. The project hopes to address this by starting with a pilot training programme that contains an explicit monitoring element. This will build on the systems learning approaches that have been found to be so useful in the earlier phases of the project. It is envisaged that this will create opportunities for all stakeholders to reflect on the training process and not just technical content and geographic coverage. This is a modest step towards helping farmers export mangoes to lucrative markets. However it appears that all concerned are now making explicit efforts to learn the institutional lesson that will underpin future success.

5 DISCUSSION

What lessons does this case tell us? Returning to our earlier discussion of innovation systems, it is clear that what we are seeing is the interaction of two isomorphic systems – one economic and the other technical. In the economic sense the successful production and sale of export quality mangoes comprises a supply chain of considerable complexity where each task is highly dependent on the successful outcomes of related production stages. And in turn this means that the central enterprise (in this case Vijaya) should have the managerial ability to understand the overall picture and to have procedures in place to troubleshoot where things are going wrong. This does not mean that it carries within its organisation complete expertise relating to each stage. But it does mean that it has the capacity to deal effectively with whatever problems arise through buying in this expertise where necessary from other complementary nodes in the innovation system. This paper has shown that there have been managerial shortcomings here.

More significant perhaps, however, is the apparent inability of all stakeholders to grasp the significance of the *technological system* that underscores successful production and sale. Here the implicit assumption was that any technical problem could be dealt with in isolation from everything else and that the relevant knowledge could be accessed from some easily identifiable source. And even when it became abundantly clear that this was not the case, it has proved remarkably hard to persuade the stakeholders of the true lacuna. It was initially assumed that the issue was a narrowly technical one and could therefore be handled by deploying appropriate personnel, yet it only slowly began to dawn on staff that the issue was really much wider and required the ability to see the technical problem in holistic terms across different stages of the supply chain. In this case a clear lesson is the necessary complementarity between pre-harvest and post-harvest activity.

In other words it is evident that the successful production, distribution, marketing and export of mangoes in India has to be seen as a total systems activity where ultimate success depends on the effective interaction of each component node. Had that appreciation been there at an early stage it is likely that the interventions would have been much more successful, saving considerable resources (both public and private). In terms of our earlier discussion, an agricultural innovation system is starting to emerge in response to new markets, incorporating new players and new capabilities. But public agencies, particularly scientific research institutes, are clearly having problems relating to this type of development. Two major operational reasons for this can be identified. First are the deeply held beliefs about the nature of knowledge and how it should be sought, validated and disseminated; expertise is seen in highly reductionist terms where scientists are taught and encouraged to think in narrow disciplinary terms about problems and solutions. The second reason is the perceived vested interests that existing institutions have. The two reasons are interrelated of course since threats to expertise inevitably lead to denial and inward-looking behaviour on the part of threatened organisations and their managerial structures.

An outcome of this situation was the inability to benefit from institutional learning. As our case study demonstrates only too well, despite the weak performance of the technical quality management system and the obvious institutional dimensions of this problem, the key stakeholders continued to view the problem in technological terms. The realisation of the systemic nature of the problem and the institutional implications

of this has been very slow and only really prompted by the total failure of last year's consignments. A clear lesson here for public policy more generally is the need to embrace institutional learning much more explicitly. Without institutional learning, institutional structures designed decades previously will become increasingly irrelevant to the demands of the modern economy and the developmental opportunities it presents. Globalisation makes this doubly important.

The practical steps needed to stimulate institutional learning are extremely difficult to formulate in the absence of a significant change in the incentives and sanctions that come to bear on public sector research institutions and their scientists. Again, partially this relates to the implicit denial that the linear module of technical backstopping is not appropriate. This is all too evident from the continued reliance on performance indicators such as number of farmers and extension workers trained, number of interactions and linkages between stakeholders and so forth, without any consideration of the functional consequences of these events. Some way has to be found to sensitise scientists and administrators to the importance of institutional learning. In the longer term it needs to be embodied in the professional tool box of all scientists, suggesting that amendments are needed to the way agricultural science its taught at the graduate and undergraduate levels. Competitive grant schemes offer another way of bringing pressure to bear on research procedures, although such schemes are not without their own institutional problems. Perhaps in the short term the best that can be done is to continue to build a body of empirical evidence through case studies in order to demonstrate the importance of institutional contexts and the practical implications of learning institutional lessons.

For the donor and international research community perspective, what are the implications for the future agenda of agricultural science research projects? A simple lesson is to make institutional learning an explicit output of projects and to ensure that projects are designed with cognisance of the particular institutional environment in which their technical solution will be put into operation. A related aspect is that institutional innovations will be increasingly important as a complementary activity – and even a prerequisite – for technical change. This is implicit in recent thinking on poverty and development – for example the livelihoods framework with its emphasis on institutions as transforming structures (Carney, 1998).

Of greater significance, however, are lessons concerning the proper institutional role of agricultural science research projects, and by implication the proper institutional role of the international research community and the donors that support it. If the Vijaya case is representative, the role of project funding needs to shift from providing narrow technical solutions alone, to projects that provide lessons which allow nodal organisations to play a more useful role within the wider innovation system. In other words, the emphasis will shift to developing the effectiveness of technology systems as a whole. Technical inputs and competencies will still be important for projects to be able to devise such lessons. However agricultural science and technology will need to be embedded in a more inclusive process that requires wider stakeholder participation and, in particular, a large element of institutional awareness and learning.

6 CONCLUSIONS

Using a case study that has had a significant donor technical cooperation component, this paper has argued that attempts to separate technical and socio-economic interventions – and to do so without an analysis of the institutional context – represents a highly inefficient procedure. By inefficient we mean in the formal economic sense that considerable resources are wasted. In the Vijaya case not only were technical interventions relatively unsuccessful over a number of years but a potentially valuable enterprise designed to enfranchise poor farmers thereby failed to capture benefits that could well have had considerable developmental outcomes. In addition, the evidence shows quite clearly that the main problem has been an institutional one. The paper therefore suggests that henceforth policy analysis for agricultural development should specifically aim to include institutional reform as part and parcel of its recommendations. In addition, project aid must include policy analysis of likely outcomes as an integral component of research design. In this way technical aid may begin at last to have a sustainable impact on developmental possibilities for the world's poor.

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ENDNOTES

1 Edquist (1997) provides substantial discussion on the precise definition of national systems of innovation and different ways authors have interpreted the concept and its shortcomings. Carlson (1995) discusses a similar concept using the term technological systems. See also Clark (2001, in press) for a treatment that stresses formal information theory.

2 In fact other earlier analysis of agricultural research systems has been couched in terms very similar to the NSI approach. Biggs' (1990) discussion of a multiple source of innovation model of agricultural research and technology promotion is a notable example of this. However more recently, the new NARS model discussed by Byerlee and Alex (1998) develops a similar theme. The discussion of an interacting matrix of sources of funds and research organisation (Echeverria 1998; Byerlee, 1998) implicitly makes the same point.

3 Clark and Clay (1986) present a good example of this in their discussion of the Indore Dry Land Farming project in India. The project was generally seen as only moderately successful from a technical point of view. But Clark and Clay recognised that where the project had really succeeded was in the institutional innovations it had put in place to undertake development-focused research, and that this would underpin success in the long run. Key stakeholders, including the donor, were reluctant to accept this as a way of judging the project's success.

4 For comprehensive discussion of the challenges facing public sector agricultural research in India, see Mruthyunjaya, and Ranjitha (1998).

5 While district level horticultural officers may be posted in some cases, their activities are restricted to the establishment and management of horticultural nurseries for the supply of seedlings (Rasheed & Sadamate, 2000).

6 Information provided in the IIHR Annual Report 1998-99 (pp132–133) suggests that the majority (60%) of revenue raised from consultancy services arises from sale of seeds and breeding material; the next most important source (25%) of revenue comes from evaluation of the efficacy of new pesticides (described as contract services). Contract research accounts for only 6%. The remainder is derived from: conducting national training courses (5%); general consultancy (2%); conducting international training courses (1%); and advisory consultancy (1%). Total revenue for 1998–99 was Rs24,70,866 (US$ 62,000) (IIHR, 1999).

7 The full name of the association is Maharashtra Rajya Draksha Bagaitdar Sangh. Not only has this organisation developed new export markets for its members, it has also established mechanisms for accessing and supplying the technology needed to participate in these markets. Important here was the establishment of a dedicated grape R&D facility. Furthermore, this R&D facility provided a focus for the establishment of the relevant ICAR institution, the National Research Centre for Grapes.

8 For general critique see Biggs and Clay (1981), Biggs (1990), Chambers and Jiggins (1987 a&b), Byerlee (1998), Hall et al. (2000). For country studies see: for India, Farrington, et al. (1998), Hall et al. (2001,in press (a)), for Thailand, Hall and Clark (1995) for Uganda see Hall and Nhady (1999).

9 These types of finding from the Phase One and Phase Two projects are discussed in detail in Hall et al. (2001, in press b).

10 The CPHP developed a regional strategy designed to both understand and address the problems contained in the institutional environment. In part this concerned adopting an approach to test out the viability of alternative institutional groups, breaking with the previous tradition of choosing predominantly public sector research institutions as the primary in-country collaborators. Rather, DFID's CPHP attempted to develop a portfolio of projects with contrasting institutional frameworks, with the understanding these would in one respect represent institutional experiments, and that learning institutional lessons would be an explicit agenda. Operationally this was achieved by commissioning a cluster of technical projects, but with issues of institutional diversity seen as an important criterion for project development and selection. To facilitate lesson learning, an umbrella policy research project was put in place with a view to gaining a thorough understanding of the institutional issues, presenting and using the individual technical projects in the portfolio as case studies of alternative arrangements. The third phase of the mango project emerged as one of those projects.

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