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Institutional developments in indian agricultural r&d systems: emerging patterns of public and private sector activity

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ABSTRACT

The process of economic liberalisation in India has focused attention on the role and structure of its national agricultural research system. The emergence of the private sector in the agricultural research arena has raised questions concerning the most appropriate role of the state in the sector. Using extensive case study material, this paper discusses some of the institutional developments among private enterprise engaged in the horticultural sector in India in order to illustrate the way in which the wider landscape of agricultural research is changing. These case studies describe the ways in which institutional developments have evolved in response to the need of both farmers and enterprise to seek new patterns of accessing knowledge and innovations, often driven by the emergence of new market opportunities. It is argued that the pattern of institutional behaviour observed is similar to that reported in innovation and technical change studies in other fields, in particular blurring the institutional distinction between research and economic activity. It is concluded that the theory of "national systems of innovation" (Lundval, 1993), which conceptualises these different actors as nodes in an integrated innovation system, may provide a useful framework for understanding the functioning of the Indian NARS and planning its reform.

1. Introduction

The agricultural sector in India, as in many developing countries, remains a core economic activity and a sector upon which the livelihoods of the predominantly rural population depend. As such, R&D investments in agricultural have been a central tool of public sector efforts to promote economic development and alleviate widespread rural poverty. During the last decade the global process of economic liberalisation has brought with it fresh thinking concerning the structure of national economies and in particular the role of the state. Governments are slowly (often reluctantly) divesting themselves of responsibilities that in principle can be performed either by the private sector itself or by organisations distanced from central control. This process is now coming to bear in India and on the Indian national agricultural research system (NARS).

The advent of the liberalisation process in Indian in 1991 took place against the backdrop of one of the most closed economies in the world with highly centralised state control in many sectors of the economy, particularly agriculture. The Indian NARS was and remains one of the biggest such national research systems in the world. Over a 1000 institutions, research centres and field stations fall under the Indian Council for Agricultural Research (ICAR), the main body governing the agricultural research sector. In addition State agricultural universities a have a mandate for agricultural research while there are also research institutes in allied fields which fall under other apex bodies, such as the Council for Scientific and Industrial Research (CSIR). Hence for reasons of size alone the system was already facing many financial and operational problems. These included unplanned growth, duplication/overlap of institutional mandates, loss of complementarily among institutions, lack of funds for operating expenses, a need to modernise research infrastructures, and a need for training and upgrading scientists skills in frontier science and management areas (Mruthyunjaya & Ranjitha, 1998). The highly bureaucratic and hierarchical nature of institutional arrangements and the complexities of governance of the NARS as a whole, further entrenched such problems.

The liberalisation process also began at a time when it was becoming increasingly clear that, despite some remarkable scientific achievements, the Indian NARS still needs to make significant inroads into persistent problems affecting the sector. Not only do the issues of food and nutritional security, poverty, employment and equity still need to be more adequately addressed, but alos new challenges are emerging in areas such as the sustainability of natural resources, bio-diversity and increasing exports through quality enhancement. At the same time, arrangements for achieving a client-orientation in research, particularly for the poorest farmers, is still to be found while traditional extension arrangements further weaken the linkages between publicly funded research and farmers (Mruthyunjaya & Ranjitha, 1998).

To some extent lower public sector funding seems to have focused minds on the task of restructuring the system in response to these challenges. However the emergence of private enterprise in the agricultural sector, including research, has had more fundamental implications for the role of the *new state* in the current climate of liberalisation. The extensive NARS of India, like many developing countries, has its conceptual roots in the post colonial period when its was assumed that large scale investments in public sector science would necessarily lead to enhanced economic production. Experience from around the world, and in many different research sectors, now indicates that the relations between public sector scientific research and economic production are much more complex than had originally been assumed. Increasingly it is

being recognised that the public sector is not the only provider of scientific knowledge and R&D capacity -- nor does it need to be.

What this means in a practical sense for the Indian NARS is that it now needs to reposition itself with respect to the emergence of these new actors in the research arena. It needs to identify and withdraw from areas were private enterprise has comparative advantage. Conversely it needs to concentrate resources in areas of R&D where the private sector is unlikely to invest. It needs to redefine its relationship with the private sector and devise partnership arrangements in which the complementary and synergy of institutional styles can be exploited. In other words it needs to redefine the strategic role of public sector agricultural science. At the same time it needs to achieve these changes in roles and relationships bearing in mind the poverty, equity and environmental sustainability issues which are central to the development of the sector.

The India NARS is cognisant of these issues, but still faces many challenge in devising and implementing an appropriate package of institutional reform. Part of this process has already begun with the launching of the National Agricultural Technology Project[1]. This not only aims to upgrade scientific skills, infrastructure and management procedures, but is also addressing institutional issues by facilitating linkages between components parts of the system, seeking the involvement of NGO and private enterprise organisations (ICAR, 1998).

This paper discusses some of the institutional developments among private enterprise engaged in the agricultural sector in India in order to illustrate how the wider landscape of agricultural research is changing. Case study material is presented from the horticultural sector where private enterprise has already emerged as a significant player[2]. In particular the paper discusses how institutional developments have evolved in response to the needs of both farmers and enterprise to seek new ways of accessing knowledge and innovation, often driven by the emergence of new market opportunities. The relationship between these private enterprise organisations and the NARS and the way the NARS has responded to such developments are examined.

Section 2 begins by discussing the background to the project on which this research is based. Starting as a purely technical project on mango quality management with an export growers association, it was found that institutional arrangements governing the supply of R&D inputs needed much further investigation. This led to a series of studies on the comparative roles of public and private organisations engaged in the horticulture. Section 3 describes in some detail the logical progression of the work undertaken with the mango enterprise and the institutional issues presenting. Section 4 goes on to relate the experience of a similar type of farmers association enterprise, but one which has been in operation for a longer period of time and where the organisation has undergone significant institutional change in response to the issues described in the earlier case. Section 5 summaries the wealth of case study material collected to illustrating the different organisational modes in operation and the various strategies used to access technology. This provides a wider perspective of the institutional

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[1] The National Agricultural Technology Project is a US$ 200 million conceived to "bring in needed reforms towards technology generation, assessment and refinement before the same is disseminated to stakeholders" (ICAR 1998)

[2] Although the horticultural sector is relatively small compared with th Indian agricultural sector it is widely perceived as having significant potential, not only in terms of export earning, but also in terms of the vast domestic market which is emerging in conjunction with the growing, urban based middle income group. This importance has found focus in the most recent 5 year plan of the India government, where substantial provisions have been made towards its support (see Kaul 1996).

developments characterising the sector and allows broad patterns of activity to be synthesised.

Finally the discussion in Section 6 argues that the pattern of institutional behaviour observed is similar that reported in connection with innovation and technical change in other fields. This suggest that increasingly access to new markets is closely associated with access to technology and that this is starting to blur institutional distinctions between research activities and economic actors. It is argued that the type of "knowledge market" that accompany this change -- pro-active search and acquisition of knowledge and by the process of innovation becoming closely associated with production itself is beginning to emerge in the Indian horticultural sector. This suggest that a wider set of actors and institutions are involved in the innovation process. We conclude by suggesting that the theory of "national systems of innovation" (Lundval, 1993), which conceptualises these different actors as nodes in an integrated innovation system, may provide a useful framework for understanding the functioning of the Indian NARS and planning its reform.

2. Study Background.

The case studies presented have arisen from a series of studies of the Indian horticultural sector[3] undertaken over the past three years by scientists from a U.K. based natural resources development research institute in collaboration with Indian scientists, entrepreneurs and farmers. The initial work stemmed from an interest on the part of Agricultural Processed Products Export Development Authority (APEDA) (Ministry of Commerce, Government of India) in resolving problems associated with high value horticulture exports. At that stage the issues were thought to be purely technical and were approached through a study of the smallholder grape sector. This was then extended initially to a wider range of crops, accessing also domestic markets and then finally to an in depth analysis of the mango sector. The original study in this area was concerned with developing protocols for quality management for mango export. This was conducted with Vijaya Vegetable and Fruit Growers Association (referred to as Vijaya), an association of 16 village co-operatives created to support farmers in the production and marketing of export quality mangoes.

As this technical work proceeded it became increasingly clear that many of the presenting problems were institutional as well as technical and that some kind of integrated institutional analysis was also warranted. Simultaneously therefore a complementary study reviewed the involvement of public sector research institutes and private commercial organisations in particular instances of export horticulture in a number of developing countries (Andrews and Hall, 1997). It analysed institutional arrangements from a science and technology perspective, addressing issues of institutional capacity to undertake or facilitate the creation and transfer of client focused technology in order to support smallholder participation in the sector. The review also focused on the capacity to target the smallholder sector and provide appropriate marketing management support. It identified the evolving nature of institutional complexes involving private sector enterprise, smallholders and associated marketing mechanisms. It went on to recommend the need for further study of the range of organisational forms emerging in India, the need for a critical assessment of the relevance of these to smallholders and the implications for institutional partners for donor-funded research.

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3 All of this technical work has been supported by the Crop Post-Harvest Programme of DFID.

As it began to become apparent that institutional issues were of greater importance than originally anticipated, and informed by the review of Andrews & Hall (1997), the original technical project shifted to a twin-track basis. The primary focus remained on technical aspects of improving quality management in the post-harvest chain, albeit with a less extensive scope. In parallel, a series of case studies were conducted of the different organisational modes through which growers can get access to significant markets. The objective here was to obtain a clearer understanding of the different marketing and technology access options available to the poor farmer and to make some kind of preliminary assessment of the relative advantages of each option (this is summarised in section 5). At the same time the links between these different institutional modes and sources of technology were explored, again with a view to assessing the broad constraints involved.

The findings of that study (Sivamohan 1997, Malins, Hall and Taylor, 1997) and other related work (Hall, Taylor and Malins, 1997) highlighted the fact that agribusiness was to varying degrees acting as a successful mechanism for linking farmers (including the poor) to both markets and technology. However, private sector R&D capacity was sporadic and usually these organisations acted as "nodes" linking NARS (or other sources of knowledge and technology) with farmers or other associated parts of the wider enterprise. While many of these arrangements where at a formative stage, it was still very clear that public/private sector relationships were not as supportive as would be hoped and that R&D support left much to be desired.

The final phase of the work continued the twin track approach of technical research and institutional analysis with Vijaya. The emphasis was on using the technical research as a "vehicle" for gaining a more intimate understanding of the factors in the wider institutional environment that impinged on public/private sector relationships and the implication of this for R&D support. At the same time a further series of in-depth case studies were undertaken to gain a broader perspective on these issues in a range of organisational modes. The following is an attempt to bring together the information from a series of unpublished project reports[4] arising from the work of the past three years. This is used to illustrate the patterns of institutional development which are emerging in the private enterprise sector and draw lessons for agricultural R&D policy in India.

3. Vijaya Vegetable and Fruit Growers Association

Vijaya was established in 1992 in Vijawada in southern Andhra Pradesh, India. The association is made up of 16 fruit and vegetable co-operatives (primary societies) spread over three districts around Vijawada. The primary society membership consists of approximately 500 farmers who between them cultivate almost 3000 acres of mangoes. Vijaya acts as an apex organisation to undertake and co-ordinate the marketing of mangoes in export and high value domestic markets. It is ostensibly a private enterprise established with the initial support of the Andhra Pradesh State

[4] These reports includethe following: Andrews J and A Hall (1997), Clark (1998) Gray, A. and Kleih, U (1997), Gray, A (1997), Hall, A, (1996), Hall, A., and Andrews J (1997), Hall, A., Taylor, S.J. and Malins, A. (1997), Malins A, S.Taylor and H. Pitcher (1996), Malins A, Hall A and Taylor S (1997), Hall, A, M.V.K. Sivamohan, N. Clark, S. Taylor and G. Bockett. (1998). Malins A (1996), Malins A and S. Woodhead (1995), Malins A, S.Woodhead S.Taylor H.Pitcher (1996), New, SW (1982), Sivamohan, MVK (1997), Sivamohan, MVK and A Hall (1998b), M V K Sivamohan, A. Hall (1998b), Thompson AK, Malins A, Taylor SJ and Gray A (1996), Woodhead S and D.Padgham (1996).

Marketing Department. Its specific goal is to finding a better price 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 which is of export quality. In turn, a key function of Vijaya has been 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). Criteria for membership of the primary co-operative 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 5 acres) were represented in the membership of the society. Furthermore, the labour intensive export harvesting procedures were a significant source of addition income for the poorest households.

The efforts of Vijaya to develop export markets for its members mangoes have been given significant assistance from the Agricultural Products Export Development Authority (APEDA). Subsides have been provided for the cost of air freight to help establish overseas markets in the far east, costs of producing promotional literature, and costs of samples and trial shipments. APEDA also underwrites commercial shipments. In terms of supporting technical capacity of the enterprise and its farmers, not only has APEDA provided 50% of the costs of engaging national scientists, it has been important in forming linkages between Vijaya and relevant sources of technical expertise both nationally and internationally, including the U.K. based scientist involved with this research. The linkage mechanisms associated with Vijaya were extensive and demonstrate the duel function of both market and technology access mechanisms that organisations like Vijaya can provide. (These are presented in figure 1.). The sources of technical assistance in this case were as follows:

On-farm:

- The horticulture department of the local state agricultural university.
- A national horticultural research institute (pre-harvest).
- A national food science research institute (post-harvest)
- An international natural resources development research institute.

Packhouse/shipment:

- A national food science research institute.
- An international shipping company.
- An international natural resources development research institute.

The technical research with Vijaya began as an attempt to devise a protocol for quality assurance of export mangoes. Specifically this was to be devised for controlled atmosphere shipment of mangoes to European markets. The initial step of this work was to better understand the post-harvest system and critical points involved in supplying this export market utilising an assessment of product quality at point of production, through picking and packaging, loading in to the sea shipment container and at the point of arrival at the final European destination. This was to be done by undertaking a trial shipment of mangoes. The ultimate objective was to outline key researchable needs to support small farmer access to this lucrative export market.

By the beginning of the first phase of the work national scientists had already provided considerable technical advice to Vijaya and its farmers on production quality management, disease control and tree management. Post-harvest advice had also been given on harvesting methods, assessment of harvest maturity and handling practices. The mangoes for the trial shipment were produced and harvested based on this advice, or at least to the extent that farmers had been able to implement the recommended practices.

As the project scientists began working with Vijaya and with national scientists sponsored by APEDA, it became apparent that the institutional linkages and support which APEDA had facilitated were not as productive as they may initially have appeared on paper. The two set of national scientist (one set predominantly pre-harvest and the other set predominately post-harvest) were functioning as quite separate entities – each visiting Vijaya and its farmers at separate times; not communicating with each other; and the implied institutional ownership of potentially commercially sensitive information creating much apprehension. Of more concern was the feedback from farmers about the appropriateness of the types of recommendations being provided such as harvesting poles that were locally unavailable, agro-chemical inputs that were costly and scarce, and management practices that were inordinately labour intensive.

It soon became apparent that the source of these problems was twofold. Firstly the scientist were struggling to provide technical advice that took any account of the agendas and perceptions of farmers. The second issue was related to the logistical arrangements for the inputs of the contracted scientist. Fairly short inputs were provided for, with limited provision for allowances, travel and number of visits. As a result, while it quickly became apparent to the project scientists that there was a need for *in-situ* adaptive research, the logistical arrangements dictated that the inputs of scientist were short and took the form of technical advice of a pre-formulated nature.

The implications of these arrangements can best be illustrated by the experience of developing harvest maturity criteria. These are presented in box 1. Despite the reservations expressed concerning the nature of technical support, the first phase of the project did succeed in running a controlled atmosphere (CA) shipment trail to test maturity indices developed by the national scientists. This identified a number of technical constraints associated with long distance transport of mangoes. These included the need for improved harvest maturity indices for export markets, post-harvest control of diseases, improved temperature control in the post-harvest handling chain and, optimisation of sea transport. As the project entered the next phase it was evident that on the one hand Vijaya and its farmers still faced technical constraints to achieving sustained production of export quality mangoes. However, on the other hand it was also apparent that the nature of technical inputs provided by national scientists would not solve these constraints. Furthermore it was apparent that it was not necessarily the scientists themselves that were at fault, but the institutional environment from which they came and the professional mandate that this burdened them with. Of equal concern was the fact that Vijaya was disappointed with these inputs but was not able facilitate more productive interaction between farmers and

Experiences of developing harvest maturity criteria.

The out-turn assessment of fruit shipped to the UK using controlled atmosphere (CA) technology indicated that many of the cartons contained fruit that had been poorly size-graded and were thus at mixed stages of ripeness. Also some fruit was immature (green) whereas others were more yellow than green. This indicated that either farmers were not adhering (or were not able to adhere) to the recommendations provided on harvest maturity or that these were inadequate for long distance shipment.

Selection of criteria

Choice of harvest maturity criteria was made on the basis of information collected through laboratory/field work, literature surveys and discussions with farmers who grow the export variety Banganpalli. A list of 7 criteria were drawn up for selecting material for the export market. This was too many criteria for fruit selection at the time of harvest and as such was inappropriate for farmers' actual use. Furthermore, two of the criteria recommended (estimate of the total soluble solid content & pulp firmness) involved making destructive measurements and are only suitable for determining harvest date for the purpose of production planning rather than for the selective harvesting of fruit for export. The findings suggest that in actual fact the recommendation had been made without any real understanding of the commercial context in which the farmer operates. The advice is more suited to selecting fruit for research purposes. Although some discussion took place with farmers before the criteria were selected, scientists had not cross checked these criteria with farmers once they had been developed.

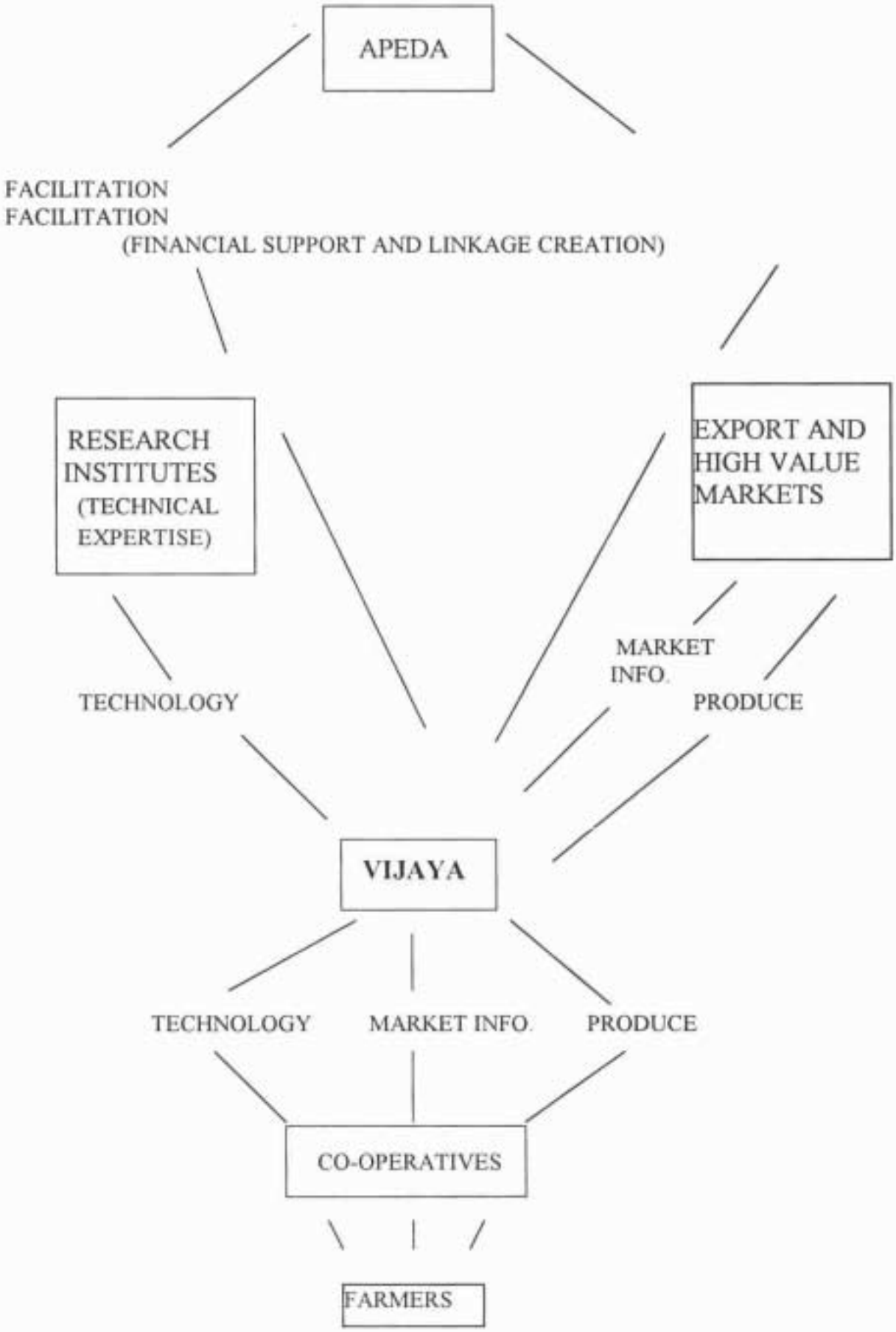
Implementation of Criteria

The scientists provided Vijaya with the list of criteria for dissemination to farmers. It was clear from discussions with scientists that they felt they were not responsible for ensuring that farmers followed their recommendations (which contractually may in fact be the case). This however, precluded opportunities for feedback from farmers to scientists concerning practical aspects of implementing the criteria. The findings of the fruit quality from the out-turn assessment indicated that fruit which did not meet these criteria were being harvested and processed for export. This suggests that either the transfer of information to Vijaya was poorly undertaken, and/or that the transfer of information from Vijaya to its farmer base was inadequate, and/or farmers thought the recommendations were inappropriate. This raises a number of issues concerning the nature of the contract between Vijaya and the scientists. Exact responsibilities seem to have been "loose"[5]. It seems that this is a consequence of the wider aspects of the relationship between these two organisations.

scientist. Nor could it articulate the concerns farmers had about the inappropriateness of some of the recommendations. The final phase of the project therefore made a more explicit attempt to understand these issues.

Figure 1. The structure and function of the institutional framework associated with Vijaya

[5] Arrangements seem to conducted on the basis of a set of terms of reference (where the research team did not mange to see) rather than any type of formal contract.



Consequently the second phase of the project paid specific attention to the nature of the relationships between the various actors involved and the institutional factors

which condition these relationships. The study was widened beyond the Vijaya enterprise in order to gain a better understanding of the nature of the wider institutional environment. Findings concerning the nature of the relationships between farmers, the enterprise and scientists highlighted the following:

- Communication between farmers and Vijaya were good and farmers had raised their concerns about the recommendations that scientists were providing.

- In general Vijaya felt that it had good relations with both the pre and post-harvest scientists, but it was a passive recipient of the advice that it was provided.

- While Vijaya undoubtedly had concerns over some of the recommendations provided it seemed unable to bring any pressure to bear which would make these inputs more appropriate and therefore useful.

- No interaction took place between the production and post-harvest scientists. Information concerning production problems (anthractnose) identified by post-harvest scientist was not passed on to production scientists.

- Subsequent discussions with scientists indicated that the historic role of their institutes and therefore their experience, had been predominantly laboratory based. They had not needed to visit farmers nor had they had the opportunity to use commercial scale facilities. Although accomplished scientists, their expertise was theoretical rather than practical.

Study of the wider institutional environment explained some of these issues. A brief review of relevant parts of the Indian NARS revealed a pattern of institutional arrangements characterised by centralised basic research institutes with additional institutional arrangements in the form of state agricultural universities and associated extensions systems to facilitate the transfer of technology. Despite the fact that linkages between, and mandates of, these hierarchical components had in practice fall into disuse, the professional mandate of scientists in the NARS was still very much conditioned by this type of institutional culture. Scientists from these institutions offered two types of opinion. The first type indicating that as scientists their role was to undertake rigorous (usually laboratory based) research and that it was the responsibility of other agencies to transfer to farmers and entrepreneurs (although which agencies were not specified). The second type of opinion was that as scientists, they valued the opportunity to work with the private enterprise sector. They acknowledged that their expertise was laboratory based and, in the case of packhouse and shipment facilities, they indicated that they would value the chance to gain experience of commercial scale plant which they did not have access to in their own institutions.

Another aspect of these arrangements was found to be the institutional segregation of disciplinary and theme focused research that exists in the NARS. In this instance the pre and post-harvest scientists came from completely separate institutions (and different Apex organisations). The institutional loyalties and self esteem of each group of scientists further distanced them. Difficulties of professional working relationships aside, the consequence in this case was that neither group of scientists had a clear overview of the entire production and marketing systems. The issue here was that constraints to achieving export quality mangoes occurred in both pre and post-harvest phases of the production and marketing chain and were therefore of an integrated nature. For example anthractnose causes fruit damage during shipment and storage and

post-harvest treatments are used in its control. However the infection of the fruit takes place in the field during fruit ripening.

Another issue arising from institutional arrangements concerned the process of public sector scientists entering into contract arrangements with the private sector. Only within the past few years has provision been made for scientists in the NARS to engage in consultancies on behalf of their institution. As such, arrangements are still at a formative stage. However, while this approach has been devised to raise revenue for the institutes and provide incentives for the individual scientist, the evidence suggested that many obstacles to the transition to these arrangements exists in the institutional culture of the NARS. Discussions with scientists certainly suggested that it would be some time before scientists were socialised to these types of activity as part of their normal professional mandate. Administrative procedures within the NARS are also another area of conflict between the working styles of public and private organisations. The specific implications of these issues are illustrated in box 2.

These types of issue go a long way in explaining the types of input which Vijaya was receiving. However the inability of Vijaya to bring contractual obligations into play is slightly more complex. It appears that the public sector links of the Vijaya Chief Executive and the public sector funds his organisation had received for inputs from national scientists (via APEDA) rendered him powerless, in the cultural context of India, to openly criticise these inputs and enforce a "contract", therefore compromising any viable client/contractor principle. process of technological innovation in the horticultural sector. Public sector scientists are poorly placed, through reasons of professional mandate, to provide the types of adaptive research inputs that the commercial and farming sectors require. Institutional and administrative arrangements reinforce this both logistically and in terms of the breadth of experience held by both individuals and their institutions. Having said that, the Vijaya case is also partially a story of transitional problems. The institutions from the NARS are trying accommodate the types of relationships which are needed. However the long tradition of organisational and professional culture within the NARS weighs heavily against this process of change. Similarly Vijaya is yet to devise its own mechanisms of fully assessing the nature of its technical requirements (particularly the integrated nature of production and post-harvest problems) and to access the types of knowledge and technology which it needs for success. The remaining of this paper examines the strategies which have been used by other organisation to acquire technology and the institutional changes which have accompanied these strategies.

Experiences of national scientists engaged in contracts with the private sector.

A scientist from a national horticultural research institute recounted his experience arising from his involvement in a formal partnership under an Memorandum of Understanding (MOU) between his institute and a local enterprise. The enterprise had seen a strong export market for its product and was seeking to expand its facilities. The lending agencies involved had stipulated the need for an R&D consultant. The enterprise had approached the scientist's institute on the strength of his experience. The scientist was contacted via the terms of the MOU to oversee the technical aspects for establishing a production facility, screen for disease problems, and negotiate tie-ups with foreign markets. Targets for the execution of these tasks were stipulated in a fixed timetable in the MOU.

The scientist's perception of these arrangements was that he found no difficulties emerging from the private sector partner. His problems stemmed from the bureaucratic rules and procedures of his own institute. He indicated that the administration of the institute had its own priorities dictated to some extent by its linkage to the wider ICAR system. This could not accommodate the urgency required for this type of interaction with the private sector. Release of funds and procurement had been particularly difficult. All the while timetabled progress reports were pending.

Current arrangements in the ICAR system are such that in consultancy arrangements such as this, 70% of total income generated is return to the institute itself. This 70% is shared between the institute and the consultant scientist, with the individual receiving 25-35 % (after tax) of the original man/day fee. Discussion with the scientist indicated that he found it professionally satisfying to take up these type of problem-solving tasks and the welcome opportunity to do this in the context of commercial applications. However the financial incentives are not substantial. Furthermore, the frustrations arising from the clash of enterprise urgency and the bureaucratic institutional culture of the scientist's own organisation negate, to some extent, the financial incentives available. In the past this type of work would have been undertaken on a personal basis.

4. Maharasthra State Grape Growers Association (Maharahthra Rajya Draksh Bagaidar Sangh [MRDBS]) and the linked organisation, Mahagrapes.

Like Vijaya, the case study of MRDBS and Mahagrapes, concerns a private enterprise which is founded on the farmers association and co-operative model. However in contrast to Vijaya, MRDBS has been established for over 20 years and some of the technology input problems experienced by Vijaya have been overcome. The key feature of this case study is the way institutional arrangements have evolved over time in response to market factors and opportunities and the associated need for new technology farmer members required to benefit from these opportunities. The sequence of events was as follows.

Phase 1. The growers association, MRDBS, was established by farmers in the 1960s as a mechanism to support members to produce and market grapes in the domestic market. During the 1970's MRDBS sought technical advice from both national scientists and from scientists abroad. This allowed the introduction of improved grape varieties which were further developed and selected by the farmers themselves. This

combination of prescriptive technical advice from the NARS and the adaptations and innovativeness of farmers increased production of grapes to the extent that by 1985 the domestic market was in over supply with prices slumping.

Phase 2. In response to the market situation, MRDBS encouraged the formation of co-operatives to assist with marketing. Simultaneously a number of enterprising farmers began to explore export opportunities in the UK and Europe and the Middle East. It was apparent that significant export markets did exist. As a result exports started on an *ad hoc* basis. From previous experience with the NARS, MRDBS was aware that suitable post-harvest technology was not available in India to allow the shipment of grapes to European markets. Some of these farmers therefore imported "cool chain" technology from USA.

Phase 3. With the potential of significant export markets becoming apparent, grape growers saw the need to create an institutional structure to handle grape exports. The result, Mahagrapes, was created from the grape growers co-operatives already established by MRDBS. Mahagrapes was given the mandate to locate internationally acceptable quality grapes from growers, identify lucrative foreign markets, and to access and develop pre-cooling and storage facilitates using imported technology. Mahagrapes went through a process of learning in export marketing, with initial failure in the Middle East, and subsequent success in European and far eastern markets.

Phase 4. At the same time that the functions of Mahagrapes were being developed (predominately on the export and post-harvest aspects), MRDBS was strengthening its arrangements to support farmer members. A well equipped laboratory was established at Pune, with regional branches, to undertake routine analysis of soil, water, cuttings etc. These centres also provided advice and demonstrations to members. Subsequently an R&D wing was established to work mainly on grape production problems and matching varieties and grape quality for international market needs.

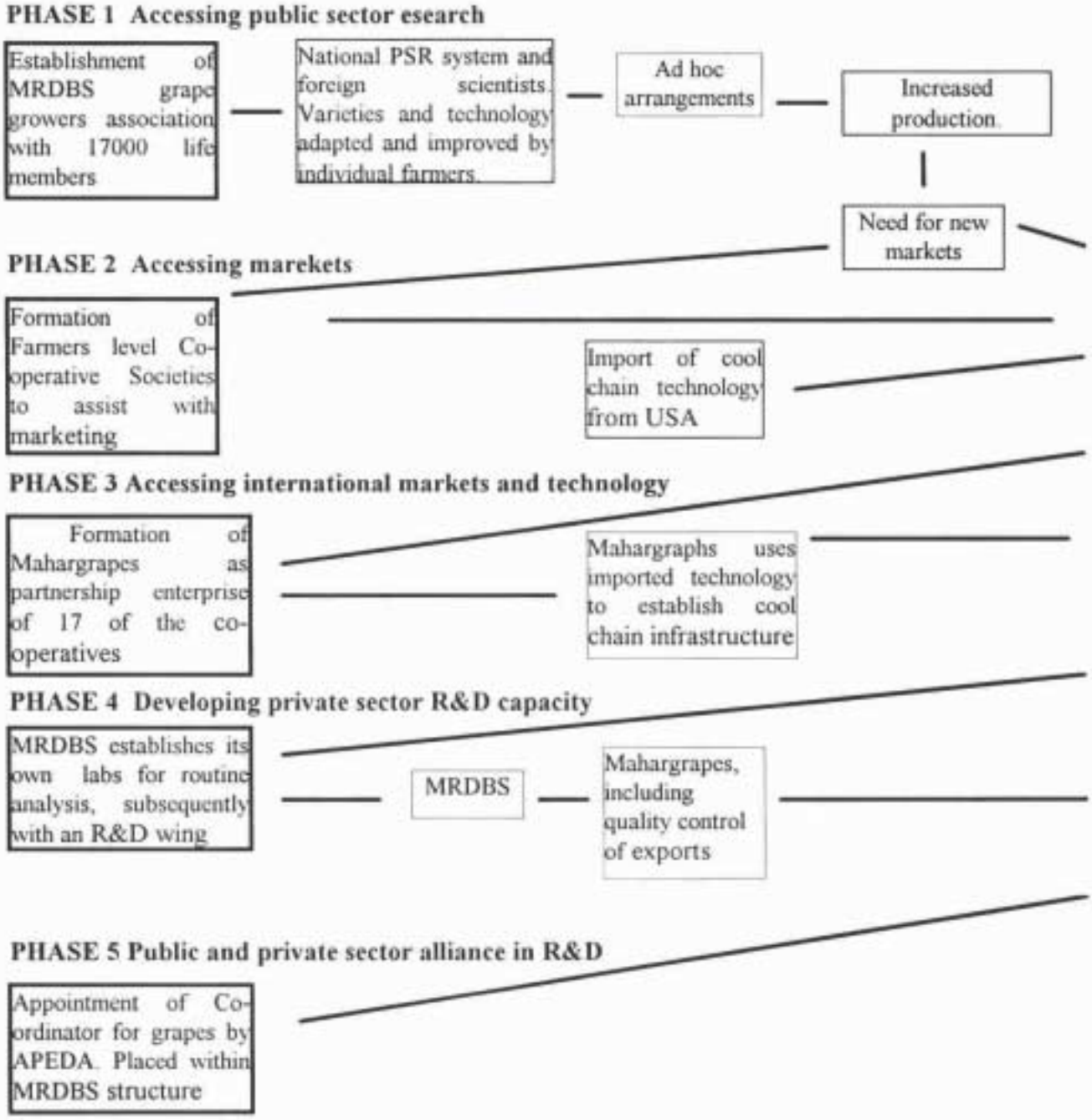
Phase 5. Having established such facilities in response to gaps in public sector provision, the public sector then began to recognise the importance of MRDBS and its facilities. The R&D wing was formally recognised by the S&T Division of the Government of India. The Agricultural University at Rahuri granted affiliated status to MRDBS. The state government allocated land to MRDBS to conduct research. APEDA appointed a full time co-ordinator for grapes who works within the structure of MRDBS and has a role of promoting grape production and export, with a specific focus on technical support. It is interesting to note that APEDA, a public sector body, chose to implement grape extension and promotion through a private structure rather than through its own regional office or through existing state level extension institutions. The final response of the public sector has been to establish a National Centre for Grape Research under ICAR in the buildings of MRDBS. The key points are therefore as follows:

Strategies for accessing technology During phase 1, the key source of technology was from the NARS. However to a great extent production gains were achieved through the adaptations made by farmers, stimulated by this external technical impetus. In phase 2, as post-harvest technologies became more critical, grape growers resorted to imported "cool chain" technology. This process continued with the establishment of Mahagrapes in phase 3. During phase 4 routine laboratory facilities were established and subsequently these developed into needs-based R&D facilities. As a result of "due diligence" requirements for pesticide residues for European markets, both MRDBS and Mahagrapes were led to develop relatively sophisticated facilities for monitoring

quality. Finally in phase 5 with the establishment of the National Centre for Grape Research in the buildings of MRDBS the potential for the NARS to contribute technology to grape growers again exists, albeit in a more integrated fashion than before. Its performance has yet to be tested.

The relationship between MRDBS and the NARS As seen above, although the NARS did contribute to grape growers in the early phases it was the efforts of farmers themselves who made the innovative link between technical advice and productivity gains. The NARS was used as a source of planting material, but the development of this material was undertaken by grape growers. In other words there was a *de facto* shift of the innovation process from the research institute to the site of production. This shift has been formalised by MRDBS and Mahagrapes by the establishment of their own rudimentary R&D facilities. However this shift could not have taken place without the initial technical impetus from the NARS which "seeded" grape production. Grape growers still value the visits of NARS scientists. Although the direct relevance of these inputs is not always clear, farmers seem to value scientists' validation of practices which they have developed themselves and the identification of new and unknown pest and disease problems. However the mis-match of academically derived knowledge with the production and marketing context of farmers is evident from discussions of their experiences. Despite this, the process of exposure to new ideas and techniques is appreciated by farmers. It may be that it is the informal aspects of this dialogue process which is of most importance to farmers, viz professional networking. It can only be assumed that scientists also benefit from this symbiotic process. The very recent creation of the NCRG within the facilities of MRBDS suggests that the wheel has come full circle and that the potential exists for the NARS to make more direct inputs into grape production.

Institutional evolution. The most notable feature of this case study is the way in which evolutionary institutional changes have taken place both in the private enterprise and in the NARS. Furthermore the institutional changes in the NARS have been driven by events and approaches which have occurred within the private enterprise (These evolutionary changes are presented in Figure 2.) In turn, the institutional changes which have occurred in the private enterprise have themselves been driven by knowledge gaps. Faced with a knowledge supplier unresponsive to client needs, grape growers first experimented with technology individually and subsequently, as an association, then developed their own rudimentary R&D facilities. Grape growers also accessed the international markets for post-harvest technology. A notable feature of this case is that there was some tacit recognition that the innovation process needed to be much more firmly embedded in the production process, although still needing and seeking external S&T inputs. It appears that the implantation of the NCGR within MRDBS has been a recognition of this need. The final section briefly reviews the experiences of other private enterprise activity.



5 Summary of case studies.

As indicated earlier the project has undertaken a large number of case studies of different organisational modes of private enterprise activity in the horticultural sector. The following provides summary of these activities. It provides a wider perspective of the institutional developments characterising the sector and allows the broad patterns of activity to be synthesised. These case studies are broadly stratified into five different organisational modes. The various strategies to access technology are indicated for each organisational mode.

- **A commercial NGO.** A unique organisation, established as the commercialised off-shoot of the national NGO responsible for "Operation Flood", the dairy co-operative initiative. Mandated as a farmer operated enterprise, it in fact managed more in the style of a ethical corporate enterprise or as not for profit organisation – a privatised NGO.

- **Technology strategies.** Using an appropriately trained group of trained technical officers, the organisation provides advice to farmers on pre and post harvest technologies. The organisation has evolved much of this technology to suit the needs of farmers. This "R&D" has been conducted in association with predominately foreign scientists and expertise (some from the agribusiness sector, for example planting machines), but also with national scientist (plant protection). Improved seeds had also been imported from overseas. **Example.** *The Fruit and Vegetable Project*, of the National Dairy Development Board.

- **Co-operative societies.** Farmer operated enterprises created by mutual consent for collective negotiation of prices and products and for the procurement and distribution of inputs. Societies are registered under the Co-operative Societies Act and their annual statements of accounts are audited. Mandated as profit sharing enterprises established with an overt social benefit agenda.

- **Technology strategies.** The societies were unable to facilitate the farmers with anything more specific than "on the shelf technologies". The societies were not playing a significant role in creating institutional links with the NARS to resolve farmer problems unless the societies were them selves linked to other organisations – such as larger farmers associations or other marketing organisations -- who could play this role. **Examples**. Bhaktavarpur and Palla Fruit And Vegetable Growers Co-Operative Societies, Delhi; Khadoli and Belhapur fruit and vegetable growers' co-operative societies, Meerut; Tandoorwadi Hingone Group of Co-operative Fruits sale societies, Khajgaon Khajula Fruit sale co-operative society, Khajula; and Jaiprakash Narain Fruit and Vegetable Co-operative Society, Vade

- **Farmers association.** Membership is flexible and not governed by co-operative law. Often theme or commodity based – grape growers or horticultural exporters. The landholder size of member varies with crops and association activities. For vegetable production it is predominately small farmers, but may be larger farmers for fruit crops. Like the co-operative societies such village level organisations provide a means of bulking up the produce of the fragmented production base of small farmers to create viable quantities for procurement by other agencies or by the APEX association itself. Often based on some form of profit sharing arrangements, but not necessarily with such a strong social benefit agenda.

- **Technology strategies.** Initialy national scienits and imported technology were used, but in more mature associations, rudimentary R&D facilities had been developed.Examples: Vijaya Fruit and Vegetable Growers association and Mahargrapes.

- **Corporate sector agribusiness.** Large scale for profit organisations in private ownership. Usually producing seeds, planting material, production inputs and equipment for sale to farmers. Often characterised by sophisticated in-house R&D

facilities which, in the case of seed and planting material enterprises is characterised by the use of biotechnology techniques to capture intellectual property rights of germplasm. The farmer is viewed purely as a customer for company products.

- **Technology strategies**. Organisations established by entrepreneurial scientists had built on their specific area of expertise, developing it for commercial advantage. Technological advantage was maintained by links to the wider national and international science community working in the field – material methods and staff often originated in the public sector. In contrast longer established organisations had built up R&D capacity by investing in facilities and using various strategies to attract skilled scientific staff. This was often undertaken in a way that complimented the other activities of the of an integrated agribusiness. **Examples**: Indo American Hybrid Seed and Jain Brothers.

- **Corporate sector horticultural exporters.** Large scale for profit organisations in private ownership. Activities revolve around export of fresh or processed horticultural produce. Dependant on farmers as a source production and often provide production assistance drawing related experience and products from the wider agribusiness enterprise. Support farmers to the extent that it helps ensure adequate supplies of quality product.

- **Technology strategies**. As in the second mode mentioned under Coprorate sector agribusiness. **Examples**: Jain Brothers and Godrej Agrovet.

ORGANISATIONAL MODE	SERVICES TO THE FARMER					
	Identifies markets for produce	Procures directly from farmer.	Procure from farm level organisation	Supplies / sells high quality inputs to farmers	Supplies R&D services	Relat farm
Commercial NGO	X		X	X	X	Farm base. better
Co-operatives	X	X		X	(weak)	Nego behal
Farmers association	X	X		X	X	Nego behal farm
Corporate agribusiness: input production				X		Farm mark
Corporate agribusiness: exporters and processors	X	X	X	X	X	Depe farm base

The case studies suggest that there is a diversity of private enterprise activity emerging in the horticultural sector and that there are strong linkages between the development of new markets and the need for facilitating technology to access these markets. The provision of technology and information appears to be a key function of private sector activity. Not only is this advantageous to the farmer, but also it may be fundamental to the success of these initiatives. The studies suggest that it is only through this type of support to farmers that such marketing mechanisms can stabilise their supply base, aid production planning, ensure supplies of adequate quality, and comply with export market requirements for "due diligence". Also it is apparent that different organisational modes approach the problem of accessing technology in different ways depending on individual organisational structures, agendas and available resources. Lessons from these case studies relating to these issues are summarised below.

1. Organisational developments linking individual farmers to both organised markets and modern technology are quite well established. Moreover these are not just confined to the larger farmer but are exploited by the smaller (and poorer) farmer as well. The economic advantages lie in higher farm gate prices, assured sales and possibilities for access to modern technology.

2. Such developments take a number of different forms ranging from small local co-operatives through larger parastatal initiatives to private sector activity. Each form has advantages and disadvantages depending on factors such as nature of crop, type of market, operational efficiencies, competitive context and the ultimate agenda of the enterprise.

3. To some extent there is competition between domestic and export markets. In particular the higher standards needed for the export market tend create the need for fairly specific quality management knowledge and technology. In fact there may be the emergence of two distinct market segments here with organisations treating exports as a specialised market with distinct technical requirements and necessary support mechanisms. However, this type of economic differentiation is still at an early stage of development in India.

4. In many instances the small farmer still has recourse to traditional traders, trading off lower prices against lower risks and assured sales. However, the nature of the crop is important here with some (e.g. leafy vegetables) being more attractive for sale to the modern bulk-buying institution. In this connection "contract growers schemes" were not observed, but loose associations cemented by input supply and guaranteed prices are beginning to emerge.

5. Co-operatives and Farmer Societies themselves appear often to act as sub-contractors to the main marketing organisations. It is not clear, however, to what extent farmers choose this route as opposed to direct access to the main contracting organisations. However it appears that the contingencies of a fragmented smallholder production base, which characterises the sector in India, dictates that such farm level organisation play a key role as assemblers of produce and collective negotiations. Without them the transaction costs of procuring large quantities of produce would be prohibitive.

6. Technical constraints associated with both pre and post-harvest quality management exist. However these are not fundamental (basic research) issues, but are more often concerned with location and variety specific problems.

7. The data on the whole indicate that the private sector (with the possible exception of some of the co-operatives) seems to be a successful mechanism for identifying technical constraints and transferring appropriate solutions. The strategies to achieve this varied. However there was an underlying pattern in which recourse to the NARS was seldom effective causing organisations to seek alternative approaches. Thus an increasing tendency was observed for organisations to resolve technical constraints using their own R&D facilities or through recourse to other private sector sources. Sometimes the latter sources are imported from overseas. While these in-house R&D facilities are rather rudimentary in the "farmer association" type of organisational mode, those in the corporate sector are often at the cutting edge of technological sophistication.

The combined need for new technology to access markets with constraints that exist in current public sector provision of such technology is a theme running through all the empirical evidence presented in this paper. Underlying this are a number of linked causal factors. While public sector scientists are keen to assist, their view of what is needed is usually highly circumscribed. In practice this means that each scientist will be able to offer advice on part of the problem but will tend not to see other parts. Moreover, there appears to be a general (and misconceived) presumption among scientist from the NARS that the client will be able to access these other pieces of assistance fairly easily. A second (and related) point is that there appears to be lack of interchange among component parts of the NARS itself. This is especially significant in so far as it is clear from the research that there are important technical links between pre-harvest and post-harvest conditions. Yet on the whole the two institutional components with responsibility for these areas do not communicate closely. A third factor is that many scientists appear to lack commercial/field experience or direct contact with the rural sector leading to inappropriate recommendations. Conversely technical information appears to have been gained through literature and/or laboratory based experiments. The experiences of the Vijaya case highlighted this point.

What all this means in terms of policy is clearly a matter for discussion and debate but a number of preliminary conclusions clearly suggest themselves. A first point that appears to have great importance is the systemic nature of the supply chain. Not only are the different stages closely inter-linked economically but more significantly perhaps, technically as well. For example, the precise CA conditions needed for overseas transportation of mangoes are a function of maturity and disease affectedness at harvest. Another way of making the same point is that the "technology" relevant to this branch of horticulture (and probably most other branches as well) should really be seen in holistic terms. Unless the suppliers and recipients of knowledge see the whole picture, solutions to problems affecting individual parts of the total production operation are unlikely to be successful. Indeed they may actually make things worse.

6 Discussion

Based on the findings of the empirical studies presented, it is apparent that the emergence of private enterprise, in its various organisational modes, has brought about a number of institutional changes in the way science-based knowledge and innovation relate to the development of the horticultural sector. Whereas in the past the public sector was, or was perceived to be, the main supplier of science and technology services, it is now evident that alternative sources are available and recourse to them is increasingly importance. Relatedly the evidence points to the integrated nature of production and post harvest chains and the associated technical constraints from which they suffer. The inability of

public sector institutional arrangements to deal with either technical integrated constraints or the economically and socially integrated context has been a key weakness in public sector R&D support. The need to access technology reflecting these features (essentially the technological demands of new markets and the specific demands of the context of production) has been the impetus for the array of technology acquisition strategies that are in evidence among private enterprise.

The authors believe this reveals a pattern of institutional behaviour similar to that extant in much of the current literature dealing with innovation and technical change in other fields, a literature that in particular stresses the need to see technical change in systemic terms and to link access to international markets with access to technology (Hobday 1994). But more importantly perhaps, what do these results mean from a policy standpoint? Perhaps the answer to this question lies in an evaluation of international developments where the "knowledge market", the process of supply and acquisition of knowledge and technical innovations, has begun to evolve in new and exciting ways. Over the past twenty years or so there has begun a slow, but growing, tendency to see the generation and productive use of knowledge in systemic terms, that is in terms of a more all-embracing set of concepts regarding how knowledge may be sought, validated and then used for productive purposes. (See for example Forest 1991 and Senker 1998). The essence of this (change in) approach is that the conventional institutional distinction between *knowledge search/validation* (in separate bodies such as universities and research institutes) and *knowledge use* (in bodies concerned with economic production) cannot reasonably be maintained in today's very complex world.

The literature relating to these issues is growing very fast indeed. For example, Gremmen (1993) has shown how much of the knowledge required for economic production is usually acquired as an integral aspect of the production process itself and therefore denies the primacy of any particular type of scientific knowledge. Knowledge nowadays has become so much part and parcel of all types of practical activity that its pursuit, processing, validation and dissemination take place at all levels. In similar vein Gibbons (1994) contains a series of papers that have as a common thread the distinction between *mode 1* and *mode 2* types of knowledge, the latter being the kinds of context related knowledge that are increasingly coming to dominate the picture as a whole.

In the context of agricultural research the institutional distinction between *knowledge search/validation* and *knowledge use* manifests itself in the institutional model of most NARS in developing countries. It has created institutional structures where knowledge flows through a "pipeline", in a linear fashion, which has basic research activity at one end and knowledge embodied as useful products at the other. The core criticism of this model is the hierarchical nature of the systems which it has engendered. The research process is centralised and relies on an extension system to disseminate "proven" findings to farmers. Thus the two activities (agricultural research and farm practice) are separated to such an extent that efficient interaction has ceased to exist [see Biggs and Clay (1981), Biggs (1990) Hall and Clark 1995]. This model also has a propensity to reduce problems to a narrow disciplinary focus, segregating what would otherwise be mutually supportive areas of enquiry. The consequences of these types of arrangement are all too clear from evidence of the Indian horticultural sector.

The case studies summarised in this paper support the view that the hierarchical model is no longer viable in itself as a core methodology. Instead it needs somehow to be supplemented by methodologies that take account of the evolutionary nature of knowledge

itself. In other words if all knowledge that is useful depends increasingly on the context of application (and there is growing evidence that this is indeed so [see for example Stokes (1998)], then it is no longer useful to rely on centralised institutions as the primary source of the organised knowledge required for economic change. Instead the need is for flatter, more decentralised structures where the knowledge relevant to any particular operation is locally determined to a considerable degree. There may indeed be a need for generic knowledge from "centres of excellence", but how that knowledge is specified and how it is utilised in context, require new types of capabilities determined mainly by the dictates of the production task to be accomplished.

A related aspect of this is the recognition that institutional change is a systemic phenomenon. As Freeman and many others have pointed out[6], it is countries that have recognised this that have succeeded economically in recent years. Their "national innovation systems" have flourished not because of the individual success of their component parts, but rather how these parts have linked together as part of a dynamic whole. And in the case of the "knowledge market" in particular, this has taken the form of new and innovative partnerships between the public and the private sector. The "national systems of innovation" theory (Lundval, 1993) that deals with these issues is useful in understanding these phenomena. It conceptualises innovation as a wider set of activities than simply scientific research. The concept captures the process nature of a group of activities which link scientific and technical knowledge acquisition and accumulation with changes in economic production. This is essentially viewed as a learning process, and therefore as a social system, characterised by interaction between people, and by its iterative and therefore dynamic nature. The various institutions and actors are seen as "nodes" in an integrated system and the degree of integration of these "nodes" (the nature of which varies depending on country and cultural context and economic sector) is seen as a measure of the success of the innovation system.

Thus the evidence from private sector activity in Indian horticulture sector suggests that indeed a "knowledge market" is starting to develop and one in which traditional institutional distinctions are beginning to blur (albeit with the caveats mentioned above). Furthermore this development relates to the wider process of process of economic and institutional restructuring which are taking place. The way we understand this process of change and guide its development is clearly open to much further debate. However this study suggests that it is no longer valid to confine deliberation on the structure and function of the national agricultural research system (NARS) to the activities of public sector institutions alone. An analysis more akin to a "national systems of ***agricultural*** innovation", inclusive of the wider set of actors implicit in this concept, would help to provide an understanding the true nature of the system which is evolving and to areas where strengthening linkages between "nodes" would enhance the performance of the system as a whole. This would also help identify the appropriate institutional groupings (partnerships) that are best able to serve the technological needs of target social groups in the sector. Without such an approach public sector research will continue to be fragmented and isolated from important areas of economic activity and, as a consequence, the uptake and impact of publicly funded research effort will be compromised.

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[6] See, for example, Freeman, C (1987 &1991).

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