Emerging Patterns of Public and Private Sector Partnerships in Indian Agricultural Research

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1. Introduction

Agricultural research in India, along with many important sectors of the economy, has been heavily dominated by the public sector for the last 40 years. However over the last decade significant private[1] agricultural research and development (R&D) capacity has emerged in India. In part this has been associated with the growth of agro-industrial sector in response to new opportunities in the increasingly liberal policy environment.

This has been particularly apparent in the seed industry. However R&D capacity has also emerged in the horticulture and agro-chemical sectors. There has also been a 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.

These developments provide potentially important opportunities for research partnerships between the public and private sectors in India. The emergence of such opportunities coincides with widespread recognition of the need for significant reform of the national agricultural research organisation (NARO) – the Indian Council For Agricultural Research (ICAR). A reform process has been initiated, but progress is modest. To date the range and scope of public private sector partnerships is not as extensive as its potential suggests. Furthermore it is becoming 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. Ways of proceeding to a more institutionally diverse, stakeholder driven research system remain a significant challenge.

The aim of this chapter is to present an explanation of why it is difficult to develop more extensive and intimate patterns of public / private sector interaction in Indian agricultural research and to discuss alternative ways of thinking about this problem. An innovation systems framework is applied to the analysis of these issues. The chapter presents detailed case studies to illustrate the nature of the relationship between the 2 sectors and

the factors that shape it. These are then discussed in terms of constraints to the emergence of an agricultural innovation system and the practical steps that might taken.

2. An Innovation Systems Framework

Economic theory suggests that a clear distinction can be made between areas of research that are of a private good as opposed to a public good nature. These can be determined by analysis in terms of rivalry (in the supply of knowledge) and excludability (the capture of propriety rights to knowledge)[2]. In reality things are never so straightforward. Thirtle and Echeverria (1994) argue that the boundary between public and private sector research is variable between research sub-sector; may have significant overlap; is dependent on the general degree of institutional development in a specific country (particularly the market); and is highly dynamic and likely to change over time.

The policy prescriptions for the reform of NAROs around the world follow a familiar pattern, drawing on elements of civil service streamlining, market driven cost recovery, privatisation and the introduction of competition for research resources. While these are clearly important considerations, this generic approach tends to ignore the often-unique institutional and cultural make-up of NAROs. India is no less unique, shaped as it is by a history of strong institutional distinction in the economy between the pervasive public sector, and the until recently suppressed, private sector. This is overlaid by strong social and professional hierarchies and the inevitably bureaucratic forms of organisation and management practice that this induces in public sector research institutes. It in this

context that recent developments need to be viewed and in which future reforms must be set. What policy frameworks can help to rethink such a system in its national context and supplement the "State vs. Market" type of analysis?

One approach a number of countries and international organisations are adopting in science and technology policy analysis in other sectors is the National Systems of Innovation[3] (NSI) framework (Freeman, 1987, Lundvall 1992). The NSI provided a conceptual framework to study innovation performance as a systemic event orchestrated by a specific institutional environment in a national context. Of importance to policy formulation is the insight the NSI framework provides concerning the constraints to the development and evolution of a **system** rather than a collection of unconnected public and private sector components. The application of the NSI framework in the agricultural research sector is starting to gain ground (Hall et al 1998, 2000; 2001; Clark 2001; Ekboir, this volume[4]). The approach is particularly relevant to the public private /sector partnership debate by virtue of its focus on linkages and system synergy. Attempts to understand the structure and dynamics of such systems are at the core of modern thinking about the innovation process (Clark, 2001; Edquist, 1997; OECD 1997).[5]

The development of the NSI framework over the last decade[6] has highlighted a number principles and process that are associated with high innovation performance. These provide a useful set of principles that can be used to examine agricultural research in India. The following have been recognised as important.

- Innovation is a process that is concerned not only with creating new knowledge and technology, but also of creating new institutional arrangements to create that new knowledge and apply is productively. This often involves complex, iterative, non-linear processes and relationships. In this sense it is both institutional as well as technical innovations that are important.
- The ability of a nation's institutional set-up to evolve to meet changing technological economic and social demands is a key measure of its effectiveness as an innovation system.
- Innovative performance is strengthened by improving the connectivity between different institutional "nodes", particularly between research and non-research nodes and between private and public nodes.
- Degrees of connectivity are examined in terms of flows of knowledge between institutional nodes and impediments to these flows
- The national institution set-up, the way this has evolved, and the extent to which inter-institutional connectivity allow it to operate as a system, are intimately related the institutional development of a country and the social, economic and political events that have shaped it.

These principles raise a number of important questions that assist the analysis of public/ private sector partnerships in agricultural research in India. Namely: Are institutional innovations taking place in agricultural research? Are these taking place in the public sector as well as the private sector? Are there institutional rigidities in the public sector, or does it have the ability evolve to meet the changing environment? How does public

sector research "learn" as a system? What are the patterns of linkage between different public sector institutions, as well as their linkage with the private sector? Does this pattern suggest innovations in agriculture are a systemic event? What prevents linkages and what are the opportunities to strengthen them? What is the national agricultural innovation system of India and what are the inherent features of this system that are likely to shape potential patterns of public and private sector partnerships in the country? The remainder of this chapter begins by addressing this last issue to give context to the subsequent case studies and analysis.

Section 3. The Institutional Development of Agricultural Research in India.

Public sector agricultural research. Public sector agricultural research in India is organised under 2 main organisational groups. Firstly, the research institutions that fall under the national agricultural research apex body, ICAR. Secondly 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 (CSIR), for example the Central Food Technology Research Institute, 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 organisation are collectively described by ICAR as India's national agricultural research system (NARS) (see table one). However from a policy perspective as well as from a practical point of view also, it is only ICAR

institutions and the SAU that can be considered as a coherent system[7]. Our discussion of the reform of public sector research therefore applies only to the ICAR part of the system.

The early development of ICAR can be traced to the 1930's. However the development of the organisation as it is today began in the post-independence period. A significant impetus came during the 1950's and early 1960's from international concerns over the need to increase food production in Asia[8]. In India this contributed to the development of a significant amount of India's agricultural research infrastructure and stimulated technological advances in cereal food crop production. Critical was the reorganisation of ICAR in the late 1960 around an applied research strategy focusing on food security. This was specifically designed to capitalise on advances in wheat breeding that had taken place in the Mexican/Rockefeller breeding programme. Faced by the spectre of mounting food imports, increased funds were provided to implement the strategy. The result was the adoption of a short-term, mission-oriented public sector plant breeding focus on dwarf wheat, backstopped by international technical assistance (Rajeswari, 1995). The combined result of these technical and institutional factors was enormous, allowing India to achieve food security within a decade.

Another tangible outcome of the international political economy of the time was the establishment of state level agricultural universities based on the land-grant model. Although this model had worked well in 19th century USA, for a number of social and cultural reasons it proved to be less satisfactory in the Indian context (Brass 1982). One reason concerns the social hierarchies that characterise Indian society. Naturally, where

social hierarchies are strong, professional and institutional hierarchies will develop similarly. The difficulties such hierarchies create for inducing a client focus in research, and the constraints it imposes on communication between organisations, particularly extension and research, has been a pervasive characteristic of the public sector research system in India..

The Reform of ICAR. By the early 1990's, for reasons of size alone, ICAR was already facing severe financial and operational problems. These included unplanned growth, duplication/overlap of institutional mandates, loss of complementarily among institutions, lack of client focus, lack of funds for operating expenses, a need to modernise the research infrastructure, and the need for training and upgrading scientists' skills in frontier science and management areas (Mruthyunjaya and Ranjitha, 1998). In response ICAR has implemented a number of reforms to improve its efficiency and accountability; forge linkages with other partners; and mobilise resources. The scale of reforms in an organisation such as ICAR makes this a formidable, time consuming and costly task. The National Agricultural Technology, supported through a US$ 200,000 loan from the World Bank has been part of this wider agenda to strengthen ICAR.

Two key reforms have specifically been the introduced with respect strengthening ICAR's relationship with the private sector. Firstly, the establishment of mechanisms by ICAR to provide its services on a consultancy and contractual basis. Secondly, making available germplasm and other technology products of ICAR to the private sector. The impact of these reform has been disappointing (Paroda and Mruthyunjaya (1999). Jha

and Pal, (1999) point out that private sector in-house R&D is growing, but in isolation with few interactions with public sector research. No major public/private collaborative research programmes tackling issues in-line with national priorities have emerged (Mruthyunjaya and Pal, 2000). Hall et al (1998) suggest that the technology acquisition strategies of many private organisations in the horticultural sector are driven by the fact that the public sector is no longer the most useful source of knowledge and technology. In fact it is often more appropriate to source technology overseas or to develop R&D related capacity in-house or to seek other private sector technology sources.

The private sector in Indian agriculture. Private sector activity in agriculture and agricultural research has gone through three distinct phases. In the immediate independence period policy encouraged the importation of technology for commercial purposes. This stimulated the private sector to undertake research on imported fertiliser, pesticides and machinery to ensure adaptation to local conditions. (Evenson *et al* 1999). However starting in the early 1960's the scope for this was restricted by controls placed on the imports of foreign technology and foreign investment to India. As a result India developed its own production capacity for these technologies, often in public sector companies. Indigenous private sector development and investment in R&D was discouraged by the policy environment of this period, particularly the 1972 Patents Act. The liberalisation of technology importation and foreign investment that began in 1991 marked the start of the third phase in which once again encouragement was given to the private sector.

The private sector seed industry has had a slightly different evolution. The Central Seed Act of 1966 ensured control by government organisations over seed of most staple food crops -- although private organisations dominated vegetable and flower seed production and supply (Morris, Singh and Pal 1998). However the seed sector was one of the earliest areas to be liberalised with the enactment of the New Policy for Seed Development in 1988. This not only encouraged greater participation by the private sector; it also allowed the entry of foreign participation. Import restrictions on vegetable and flower seed, and later on cereals, pulses and oil seed were subsequently relaxed. Pray and Kelley (1997) suggest that following liberalisation in 1988, private sector research in the seed industry increased from US$1.2 million annual in 1987 to US$ 4.7 million in 1995.

While the resurgence of private sector activity in Indian agriculture is clearly taking place, the magnitude of private sector research in India is difficult to determine. Most recent estimates suggest that 85% of all agricultural research is supported by public funds and the remaining 15 % is contributed by the private sector (Pal and Singh, 1997). However the figure refers to 1993 statistics and it is anticipated that both the magnitude and the proportion of private sector research will have grown considerably during the mid to late 1990's as a result of the growing pace of liberalisation. These data place India above Brazil where the private sector only contributes 8%, but below the Philippines at 32 % and below the OECD countries which average above 50% (Jha and Pal 1999; Alston *et al* 1998).[9]

Agricultural research is also significant in non-profit private organisations including research foundations, co-operatives, farmers organisations and non-government organisations are also important (Jha and Pal 1999, Alsop et al 2000). Important examples include: the BIAF livestock research foundation; The Vasantdada Sugar Institute, a co-operative funded research and training organisation: the Nagarjuna Agricultural Research and development Institute (NARDI) in Hyderabad; and the Mahagrapes Growers associated research facility (see case studies). The level of investment in R&D of this type of non-profit private sector research is unclear. However with the private sector as whole taking an increasingly proactive approach, the potential of partnerships with the public sector is clearly very strong indeed.

Section 5 Case studies

(i) The private sector seed industry[10] – alliance for strategic materials and informal networks for "know who".

Bangalore Hybrid Seeds (BHS)[11] is one of the largest vegetable seed producers in India supplying both domestic and export markets. Since its initiation in 1960 the company has developed an in-house R&D facility using cutting edge technology to capture intellectual property rights (IPRs) in horticultural material (seed and planting material). It has since identified and developed a substantial market for this material both international and domestic, initially by hybrid technology in the 1970's and subsequently enhanced through gene manipulation and tissue culture (for vegetatively reproduced species). The

company's R&D facility has developed into probably the most advanced seed and planting material R&D laboratory in India. The presence of highly accomplished scientists in senior management positions has been key in keeping abreast of relevant science and technology developments internationally. Professional networks have evolved as a mechanism for understanding the type of knowledge needed and how to access it. This involves nurturing informal alliances with advanced research institutes, often overseas with alumni connections playing an important role. This has been particularly important in relation to advances in biotechnology.

In the past the Indian Institute of Horticultural Research (IIHR) and the National Bureau for Plant Genetic Resources (both part of ICAR) were important sources of germplasm for BHS but this has declined over time. An important observation about BHS is that an informal partnership with the public sector does exist and this provides nurturing intellectual inputs into in-house R&D. However it is clear that sources of technical innovations that have been embodied in the company's products are firmly rooted in this in-house capability. It is also clear that relevant institutes in the ICAR have little to offer BHS in terms of research collaboration in frontier areas of science. Similarly BHS recognises that in cases where interactive collaborative relationship might be useful the high transaction costs of bureaucratic regulation act as a strong disincentive. The key problem associated with this are the delays that inevitably occur.

In contrast to BHS there are many smaller seed companies in India who have a different relationship with the public sector. For example, Trip and Pal (forthcoming) explain the

way in which in Andhra Pradesh (Southern India) the policy of open access to breeders' seed of public rice varieties has allowed the development of a diverse and dynamic private sector seed multiplication and supply industry. Many of the companies are small, have limited or no variety development capability and are wholly dependent on public varieties. Breeders' seeds are supplied through the State Agricultural University (the main source in Andhra Pradesh) through an indent system. Up to half the rice seed used by farmers is purchased in the market. Of the seed produced by the public sector 25% goes to private companies, and another 35% to co-operatives. The share of seed indented by the private sector is growing rapidly (Ibid.).

Interviews[12] held with two medium sized Indian seed companies (both now owned by multinational corporations) revealed the perception in the private sector that a state of rather unhealthy competition exists between themselves and their public sector counterparts. This is particularly so in the case of development of new cereal varieties, areas where both sectors are active. One of the companies complained that the public sector had the mentality of "I develop, I disseminate". Another company illustrated the same point by explaining how the notification process (a pre-requisite for certification) of the public sector could skew the ratio of public and private sector seeds released. The procedures for notification are that a new variety has to be tested in multi-locational trials and outperform a "standard" variety by a specified margin -- a key activity of the All India Co-ordinated Crop Improvement programmes (AICCIP). The company cited the case of the AICCIP for a particular commodity in which the co-ordinator was the director

of the National Research Centre for that commodity. As a result the private sector varieties were having to compete with the varieties of the co-ordinator's own institute.

Morrison et al (1997) and Pray and Kelley (1997) report the way breeding lines from the International Agricultural Research Centres have been used by the private sector seed industry in India (specifically maize lines from the international Maize and Wheat Improvement Centre (CYMMT) in Mexico and sorghum, pearl millet and pigeon pea lines from the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) in India). This has not necessarily occurred through formal partnership agreements. More recently a consortium of five Indian seed sector companies has contracted ICRISAT to develop over the next five years a bold grained sorghum genotype. The findings of both Pray and Kelley (1997) and Selvarajan, Joshi, and Toole. (1998) suggest that in the Indian seed industry, R&D managers feel that India's seed industry would benefit by innovative experiments in research funding as well as contractual agreements and partnerships involving private and public institutions. However, while the private sector is expressing a strong desire, progress so far is limited.

(ii) Kerala Horticultural Development Programme (KHDP) and Kerala Agricultural University (KAU)[13] – bureaucratic constraints to contractual arrangements.

The Kerala Horticultural Development Programme (KHDP) was an initiative supported by the Commission of European Communities and the Government of Kerala, started in 1993 with the objective of developing replicable models of smallholder horticultural

sector development. Although not a private organisation in the conventional sense, it was an attempt to develop a self-sustaining framework linking farmers though village level institutions with both markets and technology. A Memorandum of Understanding was signed between KHDP and Kerala Agricultural University (KAU) in March 1993. Under the terms of this agreement KAU agreed to undertake R&D activities for KHDP. The partnership began relatively smoothly in late 1993. However it then deteriorated into an unworkable relationship between two organisations with fundamentally different goals, mandates and procedural norms.

During the first year KAU identified scientists to undertake the necessary R&D activities and established a dedicated R&D unit. A research plan for the year was prepared. However the details of this plan could not immediately be given to KHDP because the activities of the R&D unit, being part of the university's research programme, required university approval according to KAU procedure. At the end of the first year the Programme Director of KHDP was able to review these plans and progress to date. It was at this point that KHDP first began to raised doubts regarding the utility of some of the on-going experiments and expressed fears that results might not lead to practical conclusions before the end of the five-year project.

At about the same time it started to become apparent to KHDP that it was impossible to monitor the progress of research activities based on qualitative reports from KAU. This was critical as according to the terms of the agreement between the two organisations, payments were linked to research results (rather than just research activities completed

irrespective of outcomes). In an attempt to resolve this KHDP requested experimental data and results. However the co-ordinator of the R&D unit, according to university rules, did not have the powers to pass on the findings direct to KHDP. Instead the university policy required that research findings could only be released through the Director of Research and even then only after research findings had been presented and discussed in the faculty's annual research meeting. What lay behind this cautious release of results was that KAU considered early dissemination of findings/results to farmers via KHDP involved too much "risk" since comprehensive on-stations trials had not taken place to scientifically validate recommendations. Interestingly, KAU's practical solution to this was to suggest more informal meetings between KAU scientists and KHDP officials to understand and share the ad-hoc findings. Presumably this sided stepped some of the communication barriers mentioned above. Nevertheless, the reality was that the original terms of the contract were unenforceable.

By year 2 it was clear to KHDP that definite results were not coming from the on-station trials of the KAU unit. This was starting to impinge directly on the ability of KHDP to provide technological solutions to its farmers and was thus undermining the horticulture export development programme. This in combination with a number of other weakness that had emerged in the ability of KAU to deliver other aspects of the contract, caused KHDP to make a substantial cut in the budget for year 2. Inevitably this led to wrangles over the expenditures KAU had made in anticipation of the next year's activities and led to acrimonious disputes over money. A Mid-Term Review Mission (MTRM) during the second year made little difference to the performance of the programme. Both parties

used the MTRM observations to criticise the functioning of the other party. KHDP had requested short-term results and farm-oriented technical backstopping. KAU was attempting to conduct experiments of scientific significance that were by their very nature part of a long-term series of experiments and were not necessarily result or farmer oriented. These divergent positions could not be reconciled. The consequent termination of much of KAU research sponsored by KHDP caused further disputes over finances and perceptions of the utility of the work being undertaken.

By the end of year 2 KHDP had made several suggestions for a revised approach to both R&D as well as some of the procedural constraints that were limiting the effectiveness of the partnership between the two organisations. These could not be implemented by KAU. At the beginning of year 3 KHDP made it clear to KAU that no advance payment would be made without results at the farm level and that to achieve results KAU would have to implement a number of measures including some participatory technology development (PTD). Though five KAU scientists participated in a PTD training programme, the scientists were unable to experiment with the PTD approach. KAU officially communicated to KHDP to explain that the university was still to make a decision on whether the PTD approach was valid and whether it was appropriate for its scientists to use it. The fourth year was dominated by protracted negotiations to reimburse expenditure to KAU. In the mean time the scope of work of the R&D unit and the number of scientists working there slowly dwindled until it closed after 5 years of operation.

(ii) Public sector partnerships with Fruit Growers associations – systemic failures in public sector technology supply and evolutionary successes.

This case study contrasts 2 examples of partnerships between fruit growers' associations and public sector research organisations[14]. The first, focusing on mangoes, is at a fairly early stage of development and is experiencing problems in successfully acquiring technical backstopping. The second focusing on grapes, is a mature organisation that had evolved institutionally to a significant degree to cope with many of the problem observed in the first case.

The first case concerns the experiences of The Vijaya Fruit and Vegetable Growers Association (Vijaya) and its efforts to export its member's mangoes to the European market. Vijaya received significant support in this from the Indian The Agricultural Processed Products Export Development Authority (APEDA), a government organisation under the Ministry of Commerce. Critically, APEDA not only provided 50% of the costs of engaging national scientists, but it also assisted Vijaya to identify and form linkages between Vijaya and relevant sources of technical expertise both nationally and internationally. The focus of this technical support concerned the development of controlled atmosphere (CA) container sea shipment protocols, including the necessary pre and post-harvest practices at farm and packhouse level. This required significant adaptive research to develop protocols for the CA shipment of Indian mangoes. A related task was the need for new quality management practices in the supply chain as a whole.

The result of APEDA's assistance was a series of partnership arrangements between Vijaya and relevant Indian public sector research institutes from both ICAR and from the Council for Scientific and Industrial Research (CSRIO). The former dealt mainly with pre-harvest issues and the latter mainly post-harvest issues. Support was provided through contractual agreements between APEDA and the public sector research institute involved. Consistent problems encountered with the quality of fruit exported led to an evaluation of both content and process of technical backstopping put in place. This revealed three interrelated problems. Firstly because of scientists' lack of farm level and commercial sector experience they tended to provide quality management recommendations that while technically robust, were impractical for mango farmers to implement. In part this reflected the laboratory-based mandate of their institutions. Secondly while it was apparent that adaptive research support was needed, technical support tended to be advisory and of a pre-formulated nature. This resulted from contractual constraints and organisational rules governing fieldwork of scientists that tended to limit provision for allowances, travel and number of visits. It therefore made a programme of *in-situ* adaptive research unrealistic.

Thirdly, different pieces of useful and mutually supportive technical expertise were located in the different institutions falling under two different research councils. This was particularly so with attempts to deal with anthracnose, a disease that needs to be tackled with an integrated pre and post-harvest approach. In this case the two sets of scientist were functioning as quite separate entities. The implied institutional ownership of potentially commercially sensitive information created much mistrust between them.

Lastly, while Vijaya as well as the scientists involved, could recognise many of the shortcomings of the support being provided, there was no apparent mechanism to address the lack of practical measures to address quality management in the export chain.

The second case study of a public sector partnership with a growers association details the evolution over a period of about 20 years of Mahagrapes, the Maharashtra Grape Growers Association. This occurred in 5 phases 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 scientists from the ICAR and from scientists abroad. As a result improved grape varieties were introduced and these were further developed and selected by the farmers themselves. This combination of prescriptive technical advice from the ICAR and the adaptations and innovativeness of farmers increased production of grapes to the extent that by 1985 the domestic market was over supplied with prices slumping.

Phase 2. In response 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, MRDBS was aware that suitable post-harvest technology to allow the

shipment of grapes to the European markets was not available in Indian public sector research institutes. Some of these farmers 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 on grape production problems and matching varieties and grape quality with 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 nearby Agricultural University granted affiliated status to MRDBS. The state government allocated land to MRDBS to conduct research. APEDA appointed a full time co-ordinator for grapes located within the structure of MRDBS and who 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 through its own regional office or through existing state level extension services. The final response of the public sector has been to establish a National Centre for Grape Research under ICAR in the buildings of MRDBS.

6. The emerging agricultural innovation system and its constraints.

The case studies presented above are of a limited number and focus mainly on the horticulture and seed sectors – albeit sectors where private sector activity has been high. Nevertheless there is every indication that they represent some broad features of the public private/sector interface as a whole – particularly the for-profit and farmer association sub-sectors. The patterns of interaction observed suggest an institutionally diverse pattern of agricultural research activity is starting to emerge, even though some efforts have not yet been very successful. The principle elements of this pattern of institutional development include:

- The emergence of significant R&D capacity in the private sector particularly for large seed companies, but also in the horticultural sector.

- The private sector is emerging as an important way of distributing public seed varieties. Although not governed by formal partnerships, the operations of the sectors are clearly mutually beneficial.
- Private producers' associations are starting to act as a potentially important nodal organisation linking small-scale producers with sources of technology as part of a process of providing access to new markets. This is part of a wider set of changes where institutional developments are being shaped by the need to provide some type of organisational focus for articulating technology needs. This contrasts sharply previous public sector emphasis on arrangements designed on a technology supply driven approach.
- As part of this process client/contractor relationships are starting to develop. This is probably the first step in the direction of introducing accountability into the supply of agricultural technology services from the public sector.
- A widespread recognition exists of the usefulness of improving information flow between related organisations and professions. It is explicit in the increasing calls from both sectors for better working relationship with each other.
- Personal relationships and informal professional networks are widespread. These mechanisms are enormously important communication channels between and within the public and private sectors.
- Implicit in a number of developments has been the apparent need to blur distinctions between research and application of the findings of research by commercial organisations or by farmers.

This emergent pattern of institutional development thus shares many of the features that the NSI framework recognises as important in the creation of an effective innovation system. It is useful therefore to discuss these events in terms of a transition from an agricultural **research** system to an agricultural **innovation** system[15]. The case studies reveal that much of the initiative here has come from the private sector, more specifically from the private sector's need for new technology, usually in conjunction with accessing market opportunities. The public sector has been drawn into this process as a key scientific resource within the innovation system. However, as the case studies have shown, currently there are limitations to the extent to which the public sector can operationally contribute technology and allied R&D capability. This reveals the central challenge of the emerging agricultural innovation system in India: namely the challenge of more effectively engaging the public sector.

Our case studies illustrate how pervasive this challenge is. For example, in the seed sector, even though significant R&D capacity is developing, the public sector has not been able to move much beyond providing germplasm – admittedly useful for smaller companies. In fact for commodities where both sectors have breeding programmes the relationship remains competitive rather than collaborative. Attempts to contract both agricultural research institutes and agricultural universities are plagued by administrative inefficiencies and the narrow professional mandates of scientists involved – even though the scientists themselves are often keen to assist. Accountability for the outcome of research is particularly difficult to enforce. Introducing policies to allow these types of contract research arrangements to take place is not the same thing as introducing

institutional changes that allow them to work effectively. Lack of fit with commercial working practices, technology applications and contingencies of foreign markets is a particular problem in providing technical backstopping to the export horticulture sector for example.

The historical overview of institutional development of public sector agricultural in India helps to explain many of these problems. In the main the research system was simply not designed to work with private sector organisations. In fact quite the contrary. Its structure and ideology is that of a large public organisation producing a public good commodity for society to use. The case studies illustrate the mind-set this brings with it. For example, the dominant professional approach of devising scientifically robust recommendations that that can then be transferred to others for use, is a direct result of this way of thinking. It also reflects the social hierarchies of society and the way these have inevitably embedded themselves in professional institutions.

Another part of the public sector mind-set can is revealed in the reforms that are being brought in to engage the private sector more usefully. These implicitly suggest that partnership is concerned with giving the private sector access to the technology products of the public sector. This suggests conceptually a clear demarcation is still made between public and private "goods" and therefore the respective roles of the two sectors. In fact this is working well in some parts of the seed industry. However it clearly underplays the potential for the types of collaborative research an NSI analysis would suggest as enormously useful. The discussion of reforms has also placed emphasis on the financial

aspects of partnerships. The implication is that cost recovery and private financing of research will help substitute for dwindling public funding of research. None of the case studies presented indicated that this was an important consideration in entering partnerships, nor an important outcome. The NSI analysis suggests that what is important is to plan and engage in partnerships to expand creativity. Certainly cost saving and sharing will emerge, but it would be unwise for the public sector to focus primarily on this motivation. Furthermore one of the most important forms of partnership arrangement that is apparent in the Indian innovation system (namely informal networks) concerns only knowledge flows rather than financial ones.

In fairness the majority of agricultural research performed by the public sector research system in India will not attract the for-profit private sector and therefore partnerships are unlikely. However this misses the generic weakness that our NSI analysis reveals. Namely that the system as presently arranged has very serious difficulty engaging with client sectors. While this is all too obvious in the context of the commercial sector, it is equally apparent that the same constraint prevents it engaging with organisations representing farmers or even farmers themselves. The central issue is accountability and the absence of any instrument to make scientists and the organisations they work for responsible for the utility of the service and technologies that they provide. This partly relates to the nature of R&D and the difficulties in monitoring its progress and utility. However even where contractual arrangements have been put in place, our case studies suggest that it is difficult to impose sanctions for non-compliance. Nor is possible to leverage changes that will improve the services and technology being provided. Until this

is tackled the public sector cannot play its potentially central role in the agricultural innovation system. Without accountably for outputs many of the other reforms currently being put in place will fail to contribute to the innovation system.[16]

A related element highlighted by NSI analysis is the absence of iterative learning processes and particularly institutional learning. The case studies reveal a number of instances where it was quite clear to everybody concerned that rigid bureaucratic procedures were preventing a productive partnership develop. The real concern here is that no mechanisms exist to respond to these constraints and adapt procedures accordingly. The reason relates to hierarchies that are endemic to the public sector and the extended lines of command that they produce. As a result day to day working practices often of a trivial nature, cannot be changed without reference to a higher authority. If public sector organisations are going enter partnerships with a wide range of organisations, often with different working styles, a higher degree of flexibility is required. This must be result orientated and exhibit a greater degree of administrative delegation.

The reform programme is still at a fairly early stage in India and the reform of an organisation as diverse, extensive and complex, as ICAR will not be achieved over night. Nevertheless there are clearly some fairly significant institutional challenges to be tackled. At one level it would seem appropriate to recommend what have come to be the standard prescriptions for reforming agricultural research system. These might be: separation of policy and funding from execution of research; creating competition

between research providers; encouraging stakeholder involvement in priority setting; rationalising the strategic function of public sector research organisations; encouraging cross linkages between different research councils and other relevant public sector bodies; creation of joint public private sector "Directorates" with the sole purpose of mobilising funds (both public and private) to invest in research activity at the interface of public and private sector domains; reform of personnel policy and incentives schemes; developing a policy research and planning capacity that can cope the systemic nature of modern techno-economic requirements.

Indeed changes of this type will undoubtedly be required. However how can these measures be introduced and implemented in a practical sense? We raise this issue because the case studies seem to agree with a growing recognition (see for example Mruthyunjaya, 2000. Pp19) that the current administrative system, the incentives and controls and procedural norms it contains can frustrate many of the reforms currently introduced. One way forward is to make the institutional learning process a much more explicit component of the reform agenda. What this would mean in practice is that different forms of engagement should be tried out with the private sector and other relevant agencies. The key would be to undertake detailed empirical studies of these types of innovation in order to understand the way the wider context of the current institutional set-up impinges and constrains such developments. NSI can provide the principles for this type of analysis. However it still requires the commitment of the relevant policy bodies in India to act upon the insights such analysis provides, and give a

fresh impetus to the evolution of one of the major agricultural science resources in the world.

References

Alsop, R., Gilbert, E., Farrington, J. and R Khandelwal 2000 Coalitions of Interest: Partnerships for Process of Agricultural Change. Sage Publications. New Delhi

Alston, J.M., PG Pardy and J. Roseboom 1998 Financing Agricultural research: International Investment Patterns and policy Perspectives. World Development Vol. 26 No 6 pp. 1057-1071

APEDA 1998 Export statistics for Agro and Food Products India 1996-97. Agricultural and Processed Food products Export Development Authority, New Delhi, India

Biggs, S.D., (1990). "A multiple source of innovation model of agricultural research and technology promotion" *World Development* 18 (11), pp 1481-1499

Brass, RP, 1982 Institutional Transfer of Technology: The land-grant model and the agricultural university at Pantnagar. In RS Anderson, P.R. Brass, E. Levy and B.M. Morrison. *Science, Politics, and the Agricultural revolution in Asia*. 1982 Boulder Co. Westview Press.

Byerlee, D., (1998) "The Search for a New Paradigm for the Development of National Agricultural Research Systems", *World Development Vol.26*, No.6, pp.1049-1055, 1998.

Byerlee, D and G.E.Alex 1998 "Strengthening National Agricultural Research Systems: Policy Issues and Good Practice" The World Bank Washington DC.

Carlsson, Bo. 1995."Introduction" in Carlsson(ed.) 1995, *Technological Systems and Economic Performance: The case of Factory Automation.* Dordrecht: Kluwer Academic publishers.

Clark N G (1990) "Development Policy, Technology Assessment and the New Technologies", *Futures 25*, November, pp 913-931.

Clark, N G (1995) "The Interactive Nature Of Knowledge Systems: Some Implications for the Third World" *Science and Public Policy* 22, August.

Clark N G (2001) "Innovation Systems, Institutional Change and the New Knowledge Market: Implications for Third World Agricultural Development" *Journal of the Economics of Innovation and New Technologies* (forthcoming)

Echeverria, R.G. (1998) "Agricultural Research Policy Issues in Latin America: An Overview", *World Development Vol. 26*, No.6, pp. 1103-1111.

Edquist, C, (ed.) (1997) *Systems of Innovation Approaches – Their Emergence and Characteristics.* Cassell Academic, London.

Evenson, RE, CE Pray and Rosengrant 1999 Agricultural *Research and Productivity Growth in India.* International Food policy Research Institute, Washington, DC.

Freeman, C. (1987). *Technology and Economic Performance: Lessons from Japan.* Pinter, London.

Freeman, C. (1991), 'Japan: a New National System of Innovation', in G. Eliasson, 'Modelling the Experimentally Organised Economy', *Journal of Economic Behaviour and Organisation, 16* (1–2) July, pp.153–82.

Indian Council of Agricultural Research 1998 ICAR Perspective and Vision 2020. ICAR, New Delhi (Draft)

Hall A.J., , M.V.K. Sivamohan, N. Clark, S. Taylor and G. Bockett. 1998 Institutional Developments In Indian Agricultural R&D Systems: The Emerging Patterns Of Public And Private Sector Activity. *Science, Technology and Development*, Vol.16, No.3, pp. 51-76

Hall, A.J, N.G. Clark, Rasheed Sulaiman V., MVK Sivamohan and B Yoganand. 2000. New policy agendas for agricultural research: institutional implications and policy analysis. *Knowledge Technology and Policy*, Spring 2000, Vol. 13 No 1. Pp 70-91

Hall A.J., , M.V.K. Sivamohan, N. Clark, S. Taylor and G. Bockett. (2001) Why Research Partnerships Really Matter: Innovation Theory, Institutional Arrangements and Implications for the Developing New Technology for the Poor. *World Development in press.*

ICAR, 1998 *The National Agricultural Technology Project: Project Summary.* Indian Council of Agricultural Research, Krishi Bhavan, New Delhi, India.

Jha, D. and S. Pal 1999 Strengthening ICAR-Private Sector Interface in Agricultural Research. In Pal, S and P.K. Joshi (eds.) 1999 New Paradigms of Agricultural Research Management: Institutionalisation of research Prioritisation, Monitoring and Evaluation, and Partnership with the Private Sector. Workshop Proceedings 6. National Centre for Agricultural Economics and Policy Research, New Delhi.

Kaul, GL (1996) Development of Horticulture—Eighth plan Experiences and Strategies for the Future. In Kaul, GL and N.K. Dadlani (eds.) 1996. Strategies for Horticulture Development in India. Department of Agriculture and Co-operatives Government of India, New Delhi.

Lundvall, BA, (ed.) (1992). *National Systems of Innovation and Interactive Learning.* Pinter Publishers, London.

Metcalfe, J S. (1995) "The Economic Foundations of Technology Policy: Equilibrium and Evolutionary perspectives". In P Stoneman (ed.). *Handbook of the Economics of Innovation and Technological Change*. Blackwell, Oxford, UK.

Mruthyunjaya, and Ranjitha, P., (1998) "The Indian Agricultural Research System: Structure, Current Policy Issues, and Future Orientation", *World Development Vol.26*, No.6, pp.1089-1101, 1998.

Mruthyunjaya and S. Pal 2000 ICAR-Private Sector Interface in Agricultural Research. Background paper for workshop on ICAR-Private Sector Interface February 8 – 9 2000, National Centre for Agricultural Economics and Policy Research, New Delhi.

Morris, ML, Singh, R.P and S. Pal 1998 India's maize seed industry in transition: changing roles for the public and private sectors. Food policy, Vol. 23, No 1 pp 55-71

Nelson, R. (ed.) (1993). *National Innovation Systems. A Comparative Analysis*. Oxford University Press, New York / Oxford

OECD, (1996a). *Main Science Technology Indicators*. Paris.

OECD, (1996b). *The Knowledge Based Economy*. Paris

OECD (1997), *National Innovation Systems*. Paris.

Patel, P. and K., Pavitt (1994). "The Nature and Economic Importance of National Innovation Systems". *STI Review, No 14*, OECD, Paris

Pray CE. Umali-Deininger D, (1998) "The Private Sector in Agricultural Research Systems: Will it Fill the Gap?", *World Development Vol. 26*, No. 6, pp. 1127-1148, 1998.

Pal, S. and A Singh 1998 "Agricultural Research and Extension in India: Institutional Structure and Investments". Policy Paper No.7 National Centre for Agricultural Economics and Policy Research, New Delhi.

Paroda and Mruthyunjaya (1999) "NARS in the Asia Pacific Region – a perspective" Asia Pacific Association of Agricultural Research Institutions. FAO RAPA, Bangkok.

Pray, CE and TG Kelley. Impact of liberalisation and deregulation on technology supply by the Indian seed industry. ICRISAT working paper, International Centre for Crops Research in the Semi Arid Tropics, Patancheru India

Pal, S and P.K. Joshi (eds.)1999 New Paradigms of Agricultural Research Management: Institutionalisation of research Prioritisation, Monitoring and Evaluation, and Partnership with the Private Sector. Workshop Proceedings 6. National Centre for Agricultural Economics and Policy Research, New Delhi.

Rajeswari S 1995 Agricultural Research Effort: Conceptual Clarity and Measurement. *World Development* Vol 23 no.4 pp 617-35

Rajeswari S 1999 Patronage and Evaluation in the Indian Council of Agricultural Research. *Evaluation* Vol 5 No 3 pp 278-302

Selvarajan, Joshi and Toole (1998)

Thirtle, C. and R.G. Echeverria 1994 Privatisation and the roles of public and private institutions in agricultural research in sub-Saharan Africa. *Food Policy* 19 (1) 31-44

Tripp R and S. Pal 2001 The Private delivery of public crop varieties: Rice in Andhra Pradesh. *World Development* in press

Table 1. Number of Institutions under the NARS in India

Institutions	**1973-74**	**1974-78**	**1980-85**	**1985-90**	**1992-97**

Indian Council of Agricultural Research					
Institutes	23	35	39	46	49
National Research Centres	-	2	11	20	30
Project Directorates	-	5	5	9	10
All-India Co-ordinated Research Projects/Network Projects	69	57	63	71	80
Central Agricultural University	-	-	-	-	1
Others	-	4	8	2	14
Total	**92**	**103**	**126**	**148**	**184**
Agricultural Universities	17	21	23	26	29

Source: ICAR Annual Report, 1999

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[1] Unless specified otherwise the term private sector includes for profit organisations (firms, companies etc) non-profit organisations (NGO, foundations etc) and mutual organisations (farmers associations, co-operatives, trade associations etc)

[2] Pray CE. Umali-Deininger D, (1998) provide a thorough discussion of this topic.

[3] We use the term National Systems of Innovation as short hand for a cluster of policy analysis frameworks found in contemporary innovation literature, all of which deal with innovation and economic change as a systemic phenomena. For a useful introduction concepts, taxonomy of terms and examples of applications and analysis see Lundvall 1992; Nelson, 1993 and Edquist, 1997.

[4] 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. 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.

[5] Carlsson (1995) discusses a similar concept using the term technological systems. See also Clark (2000) for a treatment that stresses formal information theory.

[6] 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.

[7] These two sets of institutions interface quite closely. The key mechanism being a large number of commodity improvement focused *All India Co-ordinated* projects. These are collaborative projects that use the expertise of both ICAR and SAU to undertake regional testing of new crop varieties.

[8] Anderson (1991) describes the way that this was very much a reflection of American foreign policy at the time. The concern was that growing numbers of hungry people in Asia would lead to political instability and the spread of communism. The decision of the Rockefeller foundation to shift its emphasis from health to agriculture was of critical importance.

[9] Data sources for these comparisons distort the picture to some extent as the OECD country data is more up to date than the developing country data, some of which dates back to 1991. Growth in private R&D spending has grown strongly in the 1990 even in the developing countries, particularly of Asia, but it is difficult to demonstrate this statistically at present.

[10] Company names have been changed in this section.

[11] Based on unpublished case study material collected by the authors.

[12] Based on unpublished case study material collected by the authors

[13] Based on unpublished case study material collected by the authors.

[14] These examples are discussed in greater detail in Hall et al (1998)

[15] The difference can be defined as follows. On the one hand a research system is a group of **mainly** public sector scientific research institutions whose main concern is the production of new science based knowledge. An innovation system is a group of organisations both public and private whose main concern is the development, transmission and application of knowledge that will provide social and economic benefits in the agricultural sector. In contrast to the research system this new knowledge includes institutional innovations to create technical breakthroughs and apply them productively.

[16] See Rajeswari, 1999 presents a detailed critique of the current evaluation system in ICAR, suggesting that many of the accountability issues arise because evaluation is vested in bureaucratic bodies rather than scientific ones.