

## 9 Public-private Sector Interaction in the Indian Agricultural Research System: An Innovation Systems Perspective on Institutional Reform.

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### **Abstract**

Although the majority of agricultural research in India is still conducted by the public-sector, significant private sector research and development capability is emerging. This could make an important contribution to the reform of the Indian Council of Agricultural Research through three types of public-private sector interaction: private distribution of public technologies; private purchase of public research services and technologies; and public-private collaborative research partnerships. However case studies suggest that patterns of interaction are not as extensive or as effective as the potential would imply. While many of the elements of agricultural innovation system are starting emerge, historical patterns of institutional development, as well as administrative traditions in public agencies, are preventing more effective interaction. Introducing institutional learning as way of re-mapping roles and relationships within an innovation systems framework, coupled with a more adventurous programme of institutional experimentation would give fresh impetus to the reform of public sector agricultural research in India.

### **Introduction<sup>1</sup>**

Agricultural research in India, along with many important sectors of the economy, has been dominated by the public sector for the last 40 years. The Indian Council for Agricultural Research (ICAR) is one of the largest national agricultural research organisations (NAROs) in the world. In addition to its enormous research infrastructure, ICAR represents a valuable store of skilled human capital, plant and animal genetic material, and production and post-harvest technology. Although the majority of agricultural research in India is still conducted in the public sector, over the past decade significant private agricultural research and development (R&D) and allied capacity has emerged. In part this has been associated with the growth of the agro-industrial sector in response to new opportunities in an increasingly liberal policy environment. Of particular significance has been the seed industry. However R&D capacity has also emerged in the horticultural and agro-chemical sectors. Similarly, potentially important agricultural

research and related capability exists in the non-profit private sector (non-governmental organisations (NGOs), farmer associations, and private research foundations).

The emergence of the private sector in India coincides with a widespread recognition of the need for reform of ICAR. This has been stimulated by the tightening in public funding for research; a need for better dissemination and up-take of technologies; a desire for improved client focus in research; and the need for capability building in frontier areas of science. The growth of the private sector offers opportunities that potentially could assist in addressing these issues through three types of public-private sector interaction: private distribution of public technologies; private purchase of public research services and technologies; and public-private collaborative research partnerships.

An on-going reform process in ICAR features public-private sector "partnerships" among the planned measures to improve the efficiency, funding, focus and output of the organisation. This forms part of a wider agenda of revitalising ICAR, improving its relevance to India's modernising economy, and strengthening its contribution to the rural sector where levels of poverty remain high. The thrust of this reform process implies a move towards a better integration of ICAR into the national agricultural research system as a whole, with improved interaction with other public sector research institutes as well as with relevant parts of the private sector (including NGOs). The progress of the reform process, however, is modest and to date the range and scope of public-private sector interaction is not as extensive as its potential. Furthermore it is becoming increasingly apparent that despite efforts to introduce reforms into ICAR, the broader institutional context of the organisation presents a considerable obstacle to the development of better working relationships with the private sector. Ways of proceeding to a more institutionally diverse, stakeholder-driven national agricultural research system remain a significant challenge.

The aim of this chapter is to explain the difficulties encountered in developing more extensive and intimate patterns of public-private sector interaction in India, and to draw implications for reform. An innovation systems framework is used to explore this problem from a wider institutional systems perspective. Using this framework the chapter describes factors that have shaped the relationship between the public and private sectors. Detailed case studies are then used to illustrate the limits to progress and prospects for public-private sector interaction.

## **The role of public-private interactions in the reform of public research agencies**

In agricultural research systems around the world the respective roles of the public and private sectors, and the relationship between them, is changing (Echeverría 1998). In part this has been a response to the re-evaluation of the role of State in providing research services and the associated desire to improve the efficiency of public research agencies. However it has also been a response to the related phenomena of the expanding R&D capability of the private sector that has resulted from a combination of technical advance, improved intellectual property regimes and a more liberal trade and economic environment. These changes have highlighted the possibility of privatising some of the organisations and functions previously under State control and indeed the reform process in many countries initially focused on reassessing public and private sector domains. However it is now recognised that it is more important to examine the patterns of interaction between the two sectors, focusing on the necessary adjustments that need to be made

to the goals and principles of the public sector in its new and evolving role (Tripp and Byerlee, 2000).

India is at a relatively early stage in reforming its national agricultural research organisation. The possibility of three broad patterns of interaction and role for public and private sectors exist, all of which can potentially contribute to the reform process.

*Private distribution of public technologies.* ICAR has traditionally had a very strong crop improvement programme. Potential opportunities exist for the private sector to multiply and distribute publicly-developed varieties. Hybrid technology exists for a number of important commodities, providing incentives for the private sector to invest in applied breeding research. The public sector may need to focus on facilitating private input supply and switch its research attention to more strategic areas of germplasm improvement.

*Private purchase of public research services and technologies.* ICAR has traditionally provided its services for free. However there is a range of routine testing and adaptive research services that the private sector would be able to pay for and it would be in the public interest to make them do so. Similarly ICAR has a large number technologies with potential commercial significance. The emergence of the private sector presents an opportunity for cost recovery, as well as for generating funds through sale or licensing of technology to private organisations that do not have sufficient R&D capacity of their own. The public sector might wish to develop or maintain an applied research role relevant to commercial enterprises and other organisations able to pay for technology services.

*Public-private research partnerships.* Traditionally ICAR has predominately engaged in research partnerships with other public research agencies. Of potential importance are joint collaborative arrangements where public and private agencies pool resources to take advantage of complementary skills, infrastructure, and even proprietary science. This can improve access to scientific and technical resources and provide opportunities for cost sharing. For example, ICAR institutes could collaborate in areas where the private sector has a technological advantage such as plant and animal biotechnology. Conversely there may be areas where fledgling private organisations may want to take advantage of research facilities and expertise held by ICAR. This suggests both the private and public sectors may need to play both strategic as well as applied roles depending on relative competencies, and patterns of resource and technology ownership.

## **An Innovation Systems Framework**

Conventional analysis of the roles of the public and private sectors in agricultural research has focused on the nature of technology products and the extent to which private organisations will be able to appropriate benefits from investment in R&D<sup>2</sup>. Similarly high rates of return to investments in public sector agricultural research are cited as evidence of “market failure” and persistent under-investment by the private sector (Thirtle and Echeverría, 1994). Taken together this type of analysis suggests that there is a natural division between areas of research that are in the public as opposed to the private domains. The implication is that the boundary between public and private sectors relates primarily to the extent of incentives that encourage the private sector to invest in research and that these incentives can be manipulated through economic policy, intellectual property regimes, tax incentives, and funding arrangements. While such policy and analytical tools have been used to great effect in the privatisation process, they provide little insight into patterns of institutional interaction in the national research system as a

whole. Since it is within this wider systems perspective that the role of NAROs such as ICAR needs to be judged, there is clearly a need for a supplementary policy approach that is more inclusive in its treatment of institutional context and relationships.

The recognition of the importance of the institutional context, and the study of institutional roles and patterns of interaction in systems terms, is an increasingly common theme in research and technology policy. In the context of agriculture, a widely cited example is Biggs' (1990) discussion of a "multiple sources of innovation" model. However, institutional context and institutional relationships have received much more attention in relation to research in industrial sectors in developed economies. Here the systemic idea of a "national system of innovation" (NSI) (Freeman, 1987; Lundvall, 1992) and related conceptual frameworks<sup>3</sup> have made considerable progress in policy analysis of the institutional systems that underpin innovation. Attempts to understand the structure and dynamics of such systems are at the core of modern thinking about the innovation process (OECD, 1996 a, b and 1997; Edquist, 1997; Clark, 2001). The NSI approach builds on a number of observations about the nature of innovation – by innovation we mean the process of generating new knowledge and applying it productively. These observations provide three broad principles for examining the relative performance of innovation systems which can be summarised as follows:

*Integrated systems of diverse institutional actors.* In contrast to the conventional linear notion of the relationship between research and economic production, it is observed that innovation takes place chiefly as a result of iterative relationships between those engaged in knowledge creation (research) and those engaged in knowledge application (economic production). In many countries not only have these tasks been viewed in the past as completely separate, they have also been viewed as predominately the purview of public and private sector agencies respectively. In contrast, successful innovation systems are judged to be those where productive relationships have developed between research and non-research organisations and between public and private organisations. These relationships are important as they facilitate the knowledge flows that underpin creativity. In the context of reform this analysis helps focus attention on the barriers to interaction and thus aids the development of measures that foster better integration of the system as a whole.

*Institutional learning and institutional innovation.* The second related observation concerns the importance of institutional learning and institutional innovation. In many countries institutional roles and mandates, particularly in public sector research systems, tend to be rather static. Again this relates to the highly polarised view of "public goods" and the need to perform this task separately in the public sector. In contrast successful innovation systems are judged as those where novel institutional relationships between, for example research and non-research organisations and between public and private sectors, are used as a way of addressing new tasks. Institutional innovation and the ability to create such new structures – institutional learning – is seen as of equal importance to technical innovation. While reform may be a way of introducing institutional innovations, building institutional learning processes into the system is the only way to ensure that an institutional reform programme does not need to be repeated periodically.

*Overall institutional set-up in the national context.* The extent to which different institutional actors are well integrated, the inherent ability of the innovation system to learn and the way this is achieved in practice, relates to the overall institutional set-up of a particular country. This is observed to be shaped largely by historical patterns of institutional development as well as by cultural factors. This national context is particularly important in the reform process because it provides an understanding of why current institutional arrangements exist and operate in the way they do. It also emphasises the point that there is no institutional blueprint for a successful innovation system – and hence neither is there one for successful institutional

reform. Rather, it suggests that principles of innovation-system thinking can be used to guide institutional change, and that ways of actually achieving, for example, more effective public-private sector interaction, are best devised on a case-by-case basis taking into account local contexts.

The application of the NSI framework in the agricultural research sector is starting to gain ground (Hall et al., 1998, 2000 and 2001a,b; Clark, 2001; Ekboir and Parellada, 2001)<sup>4</sup>. By focusing analysis on the institutional underpinning of the agricultural innovation system, the NSI framework is highlighting that capacity building in NAROs as conventionally conceived, is failing to address wider system constraints. The central message is that while individual organisations need to redefine their roles and build skills accordingly, this needs to take place in the context of improving the capacity of the system as a whole. The remainder of this chapter illustrates the challenges that this reform process faces in strengthening the Indian system, particularly with respect to better integration of public and private sector components and the related need to stimulate more effective institutional learning and change processes among public agencies.

## **The Institutional Context**

### ***Public-sector agricultural research.***

Public-sector agricultural research in India is organised under two main organisational groups, the research institutions that fall under the national apex body, ICAR, and the 29 state-level agricultural universities (SAU). In addition, 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 organisations are collectively described by ICAR as India's national agricultural research system (NARS). However from a policy perspective as well as from a practical perspective, it is only ICAR institutions and the SAU that can be considered as a coherent system.<sup>5</sup>

The early development of ICAR as a national institute can be traced to 1929. However its development as it is today began in the post-independence period. A significant impetus came during the 1950's and early 1960's from national and international concerns over the need to increase food production. In India this contributed to the development of a significant agricultural research infrastructure and stimulated technological advances in food crop production. The reorganisation of ICAR in the late 1960 around an applied research strategy focusing on food security, was critical to this success. Faced by the spectre of mounting food imports, increased funds were provided to implement the strategy. The result was the adoption of a mission-oriented public sector plant breeding focus on wheat, maize and rice backstopped by international technical assistance. The combined result of these technical and institutional factors was enormous, allowing India to achieve food self sufficiency 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 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 this imposes on communication between organisations, particularly extension and research, has been a pervasive characteristic of the public sector agricultural 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 complementarity 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 Project that began in 1998 supported through a loan from the World Bank has been part of this wider agenda to strengthen ICAR.

Two key reforms have specifically been introduced with respect strengthening ICAR's relationship with the private sector: (i) the establishment of mechanisms by ICAR to provide its services on a consultancy and contractual basis; (ii) making available germplasm and other technology products of ICAR to the private sector at nominal cost. The impact of these reform has not been as great as initially anticipated. (Paroda and Mruthyunjaya, 1999). Jha and Pal (1999) point out that private sector in-house R&D is growing, but in isolation and with few interactions with public sector research. As a result no major public-private collaborative research programmes tackling issues in-line with national priorities have emerged. Hall et al. (1998) suggest in the horticultural sector that the technology acquisition strategies of many private organisations are shaped by the fact that the public sector lacks the appropriate skills and perspective to provide the technologies for management of quality required for entry into export markets. In fact it is often more appropriate for the horticultural industry to buy technology from other private organisations (both nationally and internationally) or to develop R&D-related capacity in-house.

### ***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 on 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 the period, particularly the 1972 Patents Act which restricted intellectual property rights on agricultural technology. The liberalisation of technology importation and

foreign investment that began in 1991 marked the start of the third phase in which encouragement was once again 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 for most staple food crops -- although private organisations dominated vegetable and flower seed production and supply (Morris *et al.* 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 foreign participation. Import restrictions on vegetable and flower seed, and later on cereals, pulses and oil seed were subsequently relaxed. Pray and Kelley (2001) suggest that following liberalisation in 1988, private sector research in the Indian seed industry increased from US\$1.2 million 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. Pal and Singh, (1998), based on 1993 data suggest that 85% of all agricultural research is supported by public funds and the remaining 15 % is contributed by the private sector. The private share has increased during the late 1990's as a result of the growing pace of liberalisation. Agricultural research is also significant in non-profit private organisations including research foundations, co-operatives, farmers' organisations and non-government organisations ( Jha and Pal, 1999; Alsop *et al.*, 2000).<sup>6</sup> With the private sector taking an increasingly proactive approach, the potential for public-private sector interaction is clearly very strong indeed.

## Case Studies<sup>7</sup>

### *Public interaction with private sector seed industry*

**The small-scale seed industry.** In a recent study of the rice seed sector in Andhra Pradesh, Tripp and Pal (2001) explain the way in which the policy of open access to breeders' seed of public rice varieties<sup>8</sup>, has allowed the development of a diverse and dynamic private sector seed multiplication and supply industry<sup>9</sup>. Many of the companies are small, have limited or no variety development capability and are wholly dependent on public varieties. Breeders' seed is supplied by the State Agricultural University through an indent system in which private companies make advance requests and payments for seed. Of the breeder seed produced by the public sector 25% goes to private companies, 35% to co-operatives the remainder being used by the State Seed Development Corporation. The share of seed indented by the private sector is growing rapidly. The evidence from Andhra Pradesh is that while the private delivery of public varieties has worked well for old varieties, this has not extended to the promotion of new varieties that farmers are unfamiliar with. Since the public sector is unlikely to assign exclusive marketing rights of its varieties to private seed companies, the public sector will need to focus its efforts on promotion of new varieties. Private seed companies can then take over distribution and sale once varieties are popularised.

**The medium scale seed industry.** In contrast to the supportive interactions between the public sector and the small-scale seed industry, there appears to be a strong element of competition in the case of medium-scale seed companies that have their own plant breeding programmes. A significant proportion of maize, sorghum and pearl millet hybrids has been developed by the private sector (Pray and Kelley, 2001). However the public sector also has a breeding programme for these crops. The private sector perceives competition from the public

breeding programmes as a constraint to the promotion of the hybrids it has invested in developing. An important aspect of this is the way that the notification process (a pre-requisite for seed certification) can skew the ratio of public and private sector seeds released. One of the procedures for notification is that a new variety or hybrid has to be tested in multi-locational trials and outperform a “standard” variety by a specified margin. Conducting these multi-locational trials is a key activity of the All India Co-ordinated Crop Improvement Projects (AICCIP).

In instances where the co-ordinator for one of these commodity-based AICCIPs is the director of the national research centre for that commodity, private sector varieties have to compete with the varieties bred by the co-ordinator’s own institute. However, privately-developed varieties can be released without certification since there is a provision for selling truthfully-labelled seed. The point is that whereas the public sector could be playing an important regulatory role, perceived biases resulting from an overlap of its own research agenda with that of the private sector tend to undermine the system as whole. When competition of this type exists—perceived or otherwise—it is not surprising that collaborative interaction between the public and private sectors has not emerged.

**Large-scale vegetable seed industry.** The case of Bangalore Hybrid Seeds (BHS), one of the largest vegetable seed producers in India, illustrates another pattern of interaction with the public sector and one that has changed considerably over time. Established in 1964 the company developed a sophisticated in-house R&D facility to develop hybrid vegetable seed. It subsequently developed capability in tissue culture for vegetatively reproduced species and now has one of the most advanced plant biotechnology R&D laboratories in India. In the past, the Indian Institute of Horticultural Research and the National Bureau for Plant Genetic Resources (both part of ICAR) were important sources of germplasm for the BHS breeding program. However this reliance on germplasm has declined over time as it has developed its own collections and improved breeding lines. While there are currently no formal linkages with the public sector, the company has strong networks of personal contacts. In fact these networks extend both nationally and internationally and are perceived by the company as an important way of keeping abreast of relevant scientific developments, particularly those related to biotechnology. BHS recognises that in instances where formal collaboration with the public sector might be useful, bureaucratic constraints and the inevitable delays that these cause, act as a disincentive to entering into such arrangements. The findings of both Selvarajan *et al.* (1998) and Pray and Kelley (2001) suggest that in the Indian private seed industry, R&D managers feel the industry would benefit from innovative experiments in research partnerships involving private and public institutions. However, while the private sector is expressing a strong desire, progress so far is limited.

### ***Barriers to contract research in state-level agricultural universities***

A recent attempt by the Kerala Horticultural Development Programme (KHDP) to contract its research from the Kerala State Agricultural University (KAU) provides some useful insights into the practical implications of such approaches<sup>10</sup>. The case illustrates the need to consider such arrangements in the wider context of the public agency involved. Despite a promising start to the contract research arrangement, a series of problems arose that related to the procedural norms of the university and the way these obstructed the successful execution of the research contract. Following the signing of a memorandum of understanding between KHDP and KAU, the university identified scientists to undertake the agreed R&D activities and established a



dedicated R&D unit. However the details of the R&D plan could not immediately be given to KHDP (the client) because the activities of the R&D unit, being part of the university's research programme, required university approval according to KAU policy. Only at the end of the first year was the Programme Director of KHDP able to review plans and progress to date. Even though KHDP then wanted significant revision of the R&D plans, these could not be altered without once again seeking approval of KAU.

The monitoring of the completion of the contract by KAU was also constrained by university procedure. The terms of the contract linked payments to research results (rather than research activities completed). These terms implied that KAU would have to provide experimental data and results. However, according to university policy, 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. 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--although this arrangement subsequently broke down when the relationship between KAU and KHDP became increasingly acrimonious. In reality, the original terms of the contract were unenforceable.

As the programme proceeded, the divergent agendas of KHDP and KAU became increasingly apparent. KHDP had requested short-term, farmer-oriented technical backstopping. KAU was attempting to conduct research of scientific significance that was by its very nature part of a long-term series of experiments and was not necessarily farmer focused. This clash of perspectives was only heightened by attempts to introduce participatory research methods. In the end the programme failed, with KHDP withdrawing financial support after three years of a five-year programme. Both KHDP and the scientists from KAU had wanted the programme to succeed, but were only too aware of the constraints the policies and procedures of the university placed on them. While those involved could clearly see the changes required to allow contract research to operate effectively, no mechanisms existed to introduce and implement these changes. The introduction of such learning processes would appear to be a pre-requisite for the public sector entering into such types of funding arrangement.

### ***Interaction among multiple agencies in the horticultural supply chain.***

Recent studies of public-private interaction in the horticultural sector illustrates the difficulties of accessing integrated technical backstopping support from clusters of public agencies (Hall *et al.*, 2001a,b). This is particularly apparent in the horticultural supply chain where quality management--the key technical constraint--requires a combination of production, harvesting, handling and processing elements that show a high degree of interdependence. In contrast public-sector research institutes in India tend to be segregated along disciplinary lines. Even where the services of these different public agencies can be accessed successfully, integrating the different pieces of technical assistance can be difficult.

The efforts to export mangoes to the European market by Vijaya, a Fruit Growers Association in Andhra Pradesh, with the assistance of the Agricultural Processed Products Export Development Authority (APEDA) illustrate precisely this problem. A critical need was to develop controlled atmosphere (CA) container sea shipment protocols to access the new export market. This required significant adaptive research to develop the gas and temperature regimes for shipment specific to the characteristics of Indian mangoes. The protocol also included improved pre-and post-harvest practices at farm and packhouse level. To achieve this APEDA set up a series of contract arrangements with relevant institutes from both ICAR and from the

Council for Scientific and Industrial Research (CSIR) as well as with the horticultural department of the Andhra Pradesh State Agricultural University. These organisations then worked with Vijaya to develop and test the CA protocol with its associated quality management measures. The ICAR institute dealt mainly with pre-harvest pest management issues; the CSIR institute undertook experimentation on controlled atmosphere storage regimes; and the University departments advised on packhouse management.

Trial shipments took place over a period of three years. However consistent problems encountered with the quality of fruit exported, led to an evaluation of the export protocol and technical backstopping provided. Individually the quality management recommendations were technically robust. But there were a number of institutional constraints that limited interaction with farmers in the development of recommendations and this was part of a broader concern over the client focus of the contracted agencies. However the major obstacle was that quality management measures were not devised and implemented as a package across the supply chain. This resulted from the fact that pieces of useful and mutually supportive technical expertise were located in the different institutions falling under two different research councils. The scientists from each institution were contracted independently to work on individual components of the quality management problem. Vijaya was then left (unsuccessfully) to ensure that these component technologies and practices operated effectively together. This was particularly apparent with attempts to deal with anthracnose, a quality related disease that needs to be tackled with an integrated pre and post-harvest approach.

The notable feature of the Vijaya case is that even where interactions with the public sector can be developed through contracting arrangements, the ability of individual research institutes to assist is highly circumscribed by current institutional arrangements. Not only is there strong disciplinary segregation within ICAR, but different research council affiliation also tends to make integration difficult. While growers associations have the potential to form the hub of task-related institutional networks, more thought will have to be given to issues of accountability and institutional affiliation.

### ***Private lessons for public research: contrasting arrangements for sugar R&D.***

Unlike in many countries, land tenure arrangements in India dictate that sugar is grown on a smallholder rather than a plantation system. The sugar factory, which can be publicly, privately or co-operative owned, acts as a nodal point, assisting farmers with production planning, supply of planting material, production inputs, and technical advice. This ensures that factories have an assured supply of cane. The performance of sugarcane production technology is highly location specific requiring considerable local adaptation. As a result the sugar industry has needed strong technical backstopping, which it receives through a complex array of support from the public and private sectors.

Under ICAR there is the Sugarcane Breeding Institute (Tamil Nadu) and the Indian Institute of Sugar Research (Uttar Pradesh). Many of the State-level agricultural universities have departments and field stations related to sugarcane production research. Linking ICAR and the agricultural universities is an All India Co-ordinated Research Project on Sugar (established in 1970). Under the Ministry of Food there is a National Sugar Institute (Uttar Pradesh) and a *Sugar Technology Mission* with a focus on introducing improved sugar processing technology. Many private sugar factories have established their own R&D facilities, as has the co-operative sector in Maharashtra. The sector is also supported through the Indian Sugar Mills Association and the National Federation of Co-operative Sugar Mills that play an advocacy role.

Despite a significant public-sector research infrastructure related to sugar, the effectiveness of these arrangements is not as great as might be expected. Sugarcane breeding, sugarcane production research, and sugar processing research are undertaken separately and a number of institutional (and geographic) reasons prevent these complementary sets of expertise being linked together. In contrast the sugar industry sees the need for integrated technical backstopping as its problems often cut across disciplines and institutional mandates. So for example the National Sugar Institute, although set up specifically to improve the performance of sugar factories through improved processing technology, finds few private companies request their services. Sugar factories increasingly find that they need to deal with complex issues such as the recycling of factory effluents. This requires a more broadly based disciplinary approach than the components part of the public sector research system can provide. In response to these constraints, alternative mechanisms for sugar research have emerged in the private and co-operative sector.

**Research arrangements in the co-operative sector.** The Vasantdada Sugar Institute (VSI) is a co-operatively-funded research institute located in Maharashtra, with an annual research and training budget approaching US\$ 2 million. The institute was established because of a gap in sugar-related technical expertise in the state. Envisaged initially as a training institute for sugar development (extension) staff of sugar factories, it quickly became apparent that an R&D capacity was required for both sugarcane production as well as sugar processing. Other than relying on new sugar cane varieties from SBI, VSI has little formal interaction with relevant parts of the public research system. While the institute is made up of research divisions organised along disciplinary lines, a key feature is the use of task-based teams to help sugar factories and sugarcane producers solve production and processing problems. A related feature to this problem-solving ethic is the leverage that producer funding of research provides, although arrangements to ensure accountability are rather ad hoc, apparently relying on personal intervention of individual board members<sup>11</sup>.

**Research arrangements in the private sector.** TN Sugars, like many of the long established private sugar companies in Southern India, has developed significant R&D capacity to service the needs of its five sugar factories. Its annual research budget is US\$ one million from a company turn over of US\$ 95 million. Its R&D capability forms part of a wider set of support it provides to sugarcane producers. This includes: a network of 30 graduate level extension staff; farmer training centres through which 2000 farmers receive formal training every year; and "one stop" shops for finance, fertilisers, pesticides and bio-control agents in the supply areas of the company's factories. The company has some interaction with the local agricultural university, but does not find research of the National Sugar Institute of any relevance to the type of processing problems the company is facing. In contrast it has quite strong linkages with foreign research institutes.

The way the research is organised reflects company philosophy in two important ways. First, the company does not make a distinction between research and extension, pursuing integrated programmes and valuing the feedback it gets from these. Second, the company views its profitability as a function of the whole value chain and has build R&D skills that span sugar cane production, sugar extraction, down stream agro-processing and waste management.

The public research institutes serving the sugar sector were established at a time when disciplinary segregation combined with centralisation of R&D was thought appropriate. As such models have become less relevant to the industry, the co-operative and private sectors have established their own models to service their technically integrated location specific problems. They have structured their research around the task at hand, seeking additional assistance from wherever it can be accessed. Put another way they have established--albeit in different ways--

innovation systems based around sugar. Currently the public sector is neither easily accessible nor relevant to these innovation systems.

### **Prospects for public-private interaction in India's agricultural innovation system.**

Institutional reform in ICAR has undoubtedly created opportunities for greater public-private sector interaction. But how does the public-private interface measure up to the patterns of interaction that was anticipated and how can it contribute to on-going institutional reform?

*Private distribution of public technologies.* The seed industry benefited from earlier policy liberalisation and a successful private seed industry has emerged. The case study of the seed industry suggests that strong and positive interaction exists between the public sector and small-scale private seed distribution companies. However larger-scale seed companies, now an important source of new varieties and hybrids, feel that they suffer from a more competitive relationship with the public sector.

*Private purchase of research services.* Case studies from the horticultural sector suggest that contract research is starting to increase interaction. However there are still significant institutional constraints that need to be addressed before such arrangements can become more widespread. These constraints concern contractual accountability, bureaucratic procedural norms, and institutional segregation among public agencies. Our case study of the sugar industry has demonstrated how such concerns not only act as a disincentive for the private sector to engage with the public sector, but also how they greatly reduce the relevance of the technology and related services that the public sector can provide.

*Public-private research partnerships.* None of the case studies have provided experience of collaborative research partnership. However the findings of the case studies suggest the reasons why such patterns have yet to become widespread. In part this is the legacy of a long history of separation and mutual mistrust between the public and private sectors. Underpinning this are sharply contrasting views on the role of science and the way to apply it in problem-solving contexts. This is made worse by a public administration system designed for a centrally-planned state. The combined effect of these constraints is not only impeding the emergence of public-private research partnerships, but is also restricting the development of the agricultural innovation system as a whole.

*System challenges.* It is apparent that while many of the elements of an effective agricultural innovation system are emerging, the system is challenged in a number of important respects. The case studies suggest that implicitly there is still a fundamental misunderstanding of the way innovation actually takes place and the appropriate contribution that public sector research can make. This is demonstrated by two important omissions in the ICAR institutional reform process. Firstly, the broad patterns of institutional arrangements in the public sector remain unchallenged. This is demonstrated by the persistence of disciplinary divisions within ICAR as well as the even deeper divisions that exist between institutions from different research councils and government ministries. Unless these different elements are restructured in ways that allow them to work effectively together, their individual relevance to the needs of the private sector and the economy as a whole will gradually decline. Many of the research problems that the private sector is dealing with are embedded in complex production systems. This dictates a more integrated research approach than is currently possible through interaction with the public sector. The way the private sector is structuring its own research capability around a more inclusive interpretation of its technology needs is an important lesson for institutional reform.

The second and perhaps fundamental omission in the reform process, concerns institutional learning. For example, new policies that make provision for contract research will not be translated into greater interaction with the private sector unless wider systems changes can be made to accommodate the new working practices that this will entail. This relates to changes in administrative systems as well as aspects of the overall institutional set-up of the public-sector research system discussed above. The only way that appropriate changes can be made is to make institutional learning a more explicit part of institutional reform. This is going to be slow and difficult, but ultimately success depends on it.

*Changing roles.* The evidence from the seed sector suggests that the public sector should focus on facilitating private seed distribution in order to support public plant breeding programmes of open pollinated varieties. However its most appropriate research role in plant breeding for many crops probably needs to shift to strategic issues: developing a transparent regulatory system; negotiating IPR with national and multinational companies; biodiversity conservation and so forth. Issues affecting the role of the public sector in the seed industry are somewhat unique. There is a clear product and roles really do revolve around patterns of incentives to invest in technology development and distribution. Therefore conceiving the issues here as privatisation of public roles is useful. The case of the horticulture and sugar sectors is more complex and relates to provision for technical backstopping rather than the supply of product-embodied technologies.

In one sense a *de facto* privatisation of these research services is starting to take place in parts of the sugar industry in response to technical shortcomings of public sector backstopping. The public sector needs to shift from scientific research *per se*, to R&D activities focused around themes relating to improved economic production. While the role of the public sector may still be scientific, it should also be concerned with ensuring that task-based networks emerge around important economic opportunities that ultimately the private sector will manage and implement. This type of role for the public sector, which is clearly needed, will only be possible if it is driven by much stronger processes of institutional learning. There is still some way to go before such productive patterns of public-private sector interaction can emerge in India.

## Conclusions

Prior to 1991, the Indian agricultural innovation system developed against a political and ideological backdrop of a closed economy; a drive for self-sufficiency not only in food, but in science and technology generally; a dominant presence of the of the public sector in all areas of the economy; and a number of policy measures designed to restrict private sector activity in agricultural research, technology development and allied fields. While greater public-private sector interaction could make an important contribution to on-going institutional reform in ICAR, patterns of interaction remain a legacy of an earlier institutional model. ICAR has already introduced many useful reforms. But these need to be supplemented by measures to help it deal with the numerous institutional constraints that are deeply embedded in the organisation and in the wider public-sector research system. Introducing institutional learning, accompanied by a more adventurous programme of institutional experimentation would give fresh impetus to the reform process.

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<sup>2</sup> See Pray and Umali-Deininger (1998) for comprehensive discussion.

<sup>3</sup> 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. See also Clark (2001) for a treatment that stresses formal information theory.

<sup>4</sup> In fact other earlier analysis of agricultural research systems has been couched in terms very similar to the NSI approach. While Biggs' (1990) discussion of a multiple source of innovation model of agricultural research and technology promotion is a notable example, more recently discussion of a new NARS model with an interacting matrix of sources of funds and research organization (Echeverria, 1998; Byerlee, 1998; Byerlee and Alex, 1998) implicitly makes the same point.

<sup>5</sup> These two sets of institutions interface quite closely. The key mechanism is a large number of *All India Co-ordinated Projects*. These are collaborative projects that use the expertise of both ICAR and SAU to undertake regional testing of, for example, new crop varieties.

<sup>6</sup> Although the level of investment in R&D of this type of non-profit private sector research is unclear, important examples include: the Bharatiya Agro-Industries Foundation (BIAF) that undertakes research and community based development initiatives related to the livestock sector; The Vasantdada Sugar Institute, a co-operatively funded research and training organization; the Nagarjuna Agricultural Research and Development Institute, a charitable research foundation established by a private sector fertiliser company; and the Swaminathan Research Foundation, a non-governmental agriculture and rural development research organization established by the former director of ICAR, Dr M.S. Swaminathan.

<sup>7</sup> Company names have been changed in this section.

<sup>8</sup> This refers to rice varieties developed by Andhra Pradesh State Agricultural University and those developed at the Directorate of Rice Research an ICAR institute also based in Andhra Pradesh.

<sup>9</sup> This has also been supported by a strong demand for rice seed with up to half the seed used by farmers purchased in the market

<sup>10</sup> Although KDHP was not a private organization in the conventional sense, the contract research with KAU was part of an attempt, through technical backstopping, to create linkages between farmers and markets. As such it illustrates the potential of using contract research to improve interaction of the public sector as part of a wider process of linking public and private stakeholders.

<sup>11</sup> The success of this aspect of the system is the co-operative model it is based on. The sugar co-operatives in Maharashtra have a large element of political patronage. The membership of the VSI board is dominated by sugar factory chairmen, many of who are elected members of the state government. Formal mechanisms are absent for ensuring VSI is accountable to the producers funding its research. However, informal mechanisms ensure that VSI focuses on the needs of the co-operative sugar factories.