Why Research Partnerships Really Matter: Innovation Theory, Institutional Arrangements and Implications for Developing New Technology for the Poor.

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Abstract -- Why research partnerships really matter.

This paper explores the conceptual basis of existing and emerging patterns of agricultural research institutional arrangements in the context of partnership arrangements and technology development. Drawing on lessons from the debate concerning the innovation process in other research and economic sectors. The paper draws examples from a series of studies of private enterprise activity in the small holder horticultural sector in India undertaken over the past 2 years. Findings suggest that despite the policy focus on public sector research institutes with its hierarchical arrangements, more frequently innovation is taking place at the interface of research and production "institutions". This suggests that a wider set of actors and institutions is involved in the innovation process. It is concluded that the concept of "national systems of innovation", which views these different actors as nodes in an integrated innovation system, may provide a useful framework for understanding the role and performance of partnerships in the context of technology development. Only by developing a clear understanding of the theoretical basis for the institutional linkages that are emerging can the innovation potential of partnerships be focused on the poor.

Acknowledgement.

This paper was prepared with the financial support of the UK Department for International Development (DFID), Crop Post-Harvest Programme. The views express are those of the authors alone, and do not necessarily reflect the policies and practices of DFID.

Introduction.

This paper explores the conceptual basis of existing and emerging patterns of agricultural research institutional arrangements in the context of partnership approaches to technology development. We do this at a time when "partnerships" as a approach are gaining increasing currency among the donor and international research community (see for example DFID, 1997, ICRISAT 1999). The concept implies collaborative relationships consisting of the public and private[1] sectors, and between "research" and non-research institutions. The rational for this change in approach has often been couched in terms of "the complimentarity of different organisational styles", "pluralism in funding", "comparative advantage" and "institutional synergy". However we argue that while the move to this approach reflects the realities of the circumstances associated with successful technology development, current concepts have difficulties dealing with this as a process. In particular we argue that the institutional dimension of the technology development process dictates that a more inclusive set of analytical principles are require to understand why partnerships really matter, and to formulate policy to support them

We begin by reviewing current concepts concerning the agricultural innovation process, highlighting the difficulties these have dealing with institutional dimensions. Two case studies are then presented of partnership arrangements to these support our position that institutional issues warrant much greater attention if productive partnerships and successful technology development are going to take place. Finally we discuss the implication of the empirical evidence and the way it suggests a pattern of institutional behaviour similar to that in other economic sectors where innovation is viewed in systems terms. We then present this as an alternative framework and the analytical principles that it suggests. We conclude by suggesting that these concepts could be developed to help focus agricultural technology development efforts on the needs of the poor.

Agricultural R&D: Concepts Of Innovation.

The conceptual basis concerning the innovation process in agricultural sector and the way public sector R&D supports this process are revealed in the literature dealing with the measurement of performance of R&D activities and policy analysis concerning the arrangements for undertaking R&D. Two broad traditions appear to exist, each with its own implicit conceptual underpinning.

Quantitative analysis.

The first of these traditions is characterised by quantitative analysis of performance and takes an essentially neo-classical economics approach. The conceptual basis of this is that a linear relationship exists between investment in research, the development of agricultural technology, its subsequent adoption by farmers, and the impact of this on economic production. This is broadly reflected in the institutional set up of agricultural R&D in serving developing countries. Namely: a loose association of international agricultural research institutes[2] supporting to various degrees sets of commodity and or disciplinary based public sector research institutes at the national level (referred to as national agricultural research systems - NARS), which in turn provide technology for dissemination via a publicly funded extension system.

Using this conceptual framework investments in research are compared with adoption (outputs) of technology and increases in factor productivity (stemming from Schultz, 1953). This is often used as part of the priority setting process where financial allocations are made to sub-sectors (often commodities or research themes) based on rates of return to investment. This is often conditioned by collective wisdom concerning areas of strategic importance (for discussion see Jha et al 1995). Institutional issues are

addressed in the sense that decisions are made concerning the appropriate mixture of specialised commodity and thematic research centres. This is very useful in providing a snapshot of the performance of the research system, but has difficulty taking into account "process" and qualitative factors that condition both research and innovation performance, nor the dynamics of the process over time. Furthermore consistently high rates of return, particularly for major commodities, tend to confirm the perception that the innovation process, and the institutional arrangements to achieve it, is functioning effectively (see Rajeswari, 1995 for comprehensive critic).

At the macro-level this type of analysis has difficulty dealing with equity issues (although some priority commodities will clearly be more important to the poor than others). A sub-set of this quantitative approach has therefore examined the impact of technical change (partly through adoption studies). This has lead to explicit recognition of concerns over of the scale neutrality of technology.[3] Mechanisms to address this have focused on the factor consuming characteristics of technology, (often implemented through priority setting exercises), and does not appear to question the effectiveness of current arrangements of the R&D process to capture and account for these issues.

A more recent branch of the debate concerns the emerging public / private sector relationships in agriculture – for example the seed and biotechnology industries. Again, broadly neo-classical approaches are used predict which areas of R&D and subsequent goods and services will be provided by the private sector and in which areas market failures will necessitate public sector provision, regulation or subsidies (see for example Umali-Deininger 1998; Pray and Umali-Deininger 1998). The core of these arguments surrounds the relative degree to which goods and services are of a public or private goods nature. The concepts of *rivalry* (in the supply of knowledge) *excludablity* (the capture of propriety rights to knowledge) are used to predict which areas, through market failures, will need to remain in the public domain. This line of reasoning is also used to predict where market failures will cause the under investment in research due to concerns over private *appropriablity* and therefore areas where public sector research will remain a strategic activity in support of the private sector. Similarly this approach is used to

identify which mixture of specialist institutions will be needed to deal with farmers directly.

Process analysis

The second broad set of debate takes qualitative approach to R&D systems analysis and has developed to compliment the approaches discussed above. This has tended to have a more explicate focus on the process rather than the outputs and impact of R&D. In particular it has examined and questioned the validity of the institutional arrangements, methods and concepts which underpin the process. (see Hall and Clark 1995 for a detailed review of these concepts). The underlying proposition in this set of debate is that in actual fact hierarchical institutional arrangements of centralised agricultural research are unable to deal with the complex technology need of farmers, particularly small farmers.(Biggs and Clay, 1981; Chambers and Jiggins 1987a&b; Biggs 1990) [4]. This debate suggests that innovations are produced not by organised science alone, but by a number of actors including farmers, often in combinations with other elements of the system. It also suggests that institutional arrangements embodied in the centralised science model of innovation separate scientists and farmers to such an extent that productive relations are not established and that this is detrimental to the R&D process (Biggs and Clay, 1981).

A subset of this debate concerns the conceptualisation of agricultural production as a system and the need for this to be appreciated in the R&D process. The farming systems research approach debate (see for example Trip, 1982; Collinson, 1987) has been mainly methods driven and has struggled to find explicit form in an appropriate institutional framework. Issues of multidisciplinary have been particularly difficult to achieve institutionally as well as the in-ability of existing institutional structure to genuinely accommodate farmers in the research process (Biggs, 1989; Ewell, 1989; Farrington and Martin 1991; Biggs and Farrington, 1993; Biggs, 1995).

The issues in the broader debate concerning the role of farmers in the research process have found expression in the participatory research movement. However, while the original conceptual basis of this debate explicitly made the link between the nature of institutional arrangements and the performance of the R&D process (for example Chambers and Jiggins 1987b) much of the subsequent debate has focused on participatory methods rather than underlying institutional issues.[5] Biggs and Smith (1998) argue that this methods bias masks the fact that the most successful participatory methods arose in specific institutional and political circumstances and often evolved to deal with a specific problem area in this given context. This it is suggested often occurs through coalition building -- associations of people brought together out of the necessity to deal with a specific problem and the shared belief in the choice of approach to solving it. They go on to suggest that the participatory approaches that evolved in his way were associated more with institutional innovations rather than new methods per say. And that transferring the methods element of the approach to new and often unreceptive institutional contexts stands little chance of success.

The coalition concept of Biggs and Smith (1998) highlights the fact that successful technology development is a very complex process indeed; it often results from the "nuances" of personal, professional and institutional relationships which change and evolve (often rapidly) over time; and that these (often institutional) changes take place in response to new technological needs (or opportunities) as well as political and economic circumstances. Furthermore it is these "nuances", often only identifiable through detailed case histories, that are so difficult to capture in neo-classical analysis of the innovation process and the relationship between research investments and impacts on the poor. Clearly partnerships of various types are important in this view of the way innovation and technology development actually works. However as the following case studies illustrate, forging successful partnerships needs a much more holistic understanding of the process of technology development and the institutional policy arrangements necessary to achieve it.

Case study No. 1: A case of systemic failure in institutional arrangements for technology supply.

This case study was originally undertaken to understand the links between private sector activity and its relevance as a mechanism for linking small farmers with technology and markets. It was undertaken as part of wider series of studies dealing with the technological development of the Indian horticultural sector[6] This case illustrates the experience of an export promotion organisation in its attempts to forge partnerships between a private organisation and an associated group of farmers and public sector scientists in order to overcome post-harvest constraints associated with access to new export markets.

Partnership arrangements

Vijaya Fruit and Vegetable Growers Association (Vijaya) was established in 1992 in Vijawada in southern Andhra Pradesh, India. The association is made up of 16 fruit and vegetable co-operatives (primary societies) spread over three districts around Vijawada. The primary society membership consists of approximately 500 small and medium scale farmers (1-10 acres) who between them cultivate almost 3000 acres of mangoes. Vijaya acts as an apex organisation to undertake and co-ordinate the marketing of mangoes in export and high value domestic markets. Vijaya is a private enterprise established with a specific goal of finding a better price for farmer members' produce through direct marketing without the produce being handled by middle men, wholesalers and traders. Farmers receive a premium price for fruit of export quality. In turn, a key function of Vijaya has been to act as a source of technical advice and inputs to assist farmers to increase the proportion of fruit which reaches export quality criteria – initially only 10% of fruit were attaining this level of quality.

The initial efforts of Vijaya involved marketing its farmers' mangoes in the high value domestic market and subsequently to the Far Eastern export market relying on airfreight arrangements. In 1995 Vijaya began exploring the potential of European markets. Assistance was sought from the Agricultural Processed Products Export Development Authority (APEDA) (Ministry of Commerce, Government of India). APEDA provided considerable assistance to Vijaya in its efforts to link farmers to this new export market. Subsides were provided for: collecting market intelligence; cost of samples and trial shipments; costs of producing promotional literature; and underwriting commercial shipments. APEDA supported the technical capacity of Vijaya and its farmers, not only by providing 50% of the costs of engaging national scientist, it was also important in forming linkages between Vijaya and relevant sources of technical expertise both nationally and internationally.

Most critically, because of the uneconomically high costs of airfreight to European markets, APEDA used these technical partnership arrangements to assist Vijaya to develop controlled atmosphere (CA) container sea shipment protocols. While the technology for CA shipments in a general sense is well developed internationally in the horticultural export trade, the duration of sea shipment to Europe, coupled with the uncertainty of storage characteristics of local varieties meant that significant adaptive research questions existed. It was also apparent that strong backward linkages existed between final destination quality and the pre and post-harvest practices of Vijaya and its farmers. Furthermore the introduction CA storage and shipments added another element to the overall need for new quality management practices in the supply chain as a whole.

The arrangements for technical assistance to deal with these issues looked particularly impressive. . The partnership arrangements that had been put in place – through contractual arrangements -- for bringing together public sector scientists, Vijaya and its farmers, and held the promise of bringing to bear significant technical expertise to the problems at hand. The linkage mechanism associated with Vijaya were extensive and appeared to demonstrate the duel function that organisations like Vijaya can provide to a small farmer production base as a mechanism of both market and technology access

The sources of technical assistance in this case was as follows:

On-farm:

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

Packhouse/shipment:

- A national food science research institute.
- An international Shipping Company.
- An international natural resources development research institute.

Partnership performance

Scientists worked with Vijaya and its farmer members to formulate a set of pre and post-harvest protocols to improve export quality. This included: pre-harvest disease control and tree management; advise on harvest maturity and fruit selection; improved harvesting practices; handling and packaging protocols; gas and temperature regimes for sea shipments; and to provide training to Vijay staff and farmers. In the following 2 seasons trail shipments of mangoes under CA storage conditions were sent to Europe. The fruit was harvested and package under the supervision of the science from the post-harvest research institute that had developed the protocols for Vijaya.

Shortly after the initial trail shipments began APDEA requested the assistance of an UK based natural resources development research institute. Initially this request came in the context of assisting with "out turn" assessment of fruit consignments arriving in European destinations. Later as a range of technical constraints emerged, assistance was sought to review protocols and making recommendations for remedial action. Initially this was seen as a purely technical task, but further investigation revealed that a more

inclusive study of the organisational context of technical support arrangements was required.

The results of the out turn assessment indicated only a partial success. Only 31% of the fruit were regarded as Class 1 fruit. Out of 2441 cartons received by the importer, 33% were lost to disease, mainly anthracnose, but also stem end rot. The following technical constraints were identified:

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

The results of the trail shipment of mangoes seemed to suggest that either recommendation provided to Vijaya and its farmers were not adequate for improving export quality or that they were not being implemented. Preliminary visits to Vijaya and its farmer members raised concerns over the types of recommendations being provided, particularly in the context of a predominately small and marginal farmer production system. For example:

- maturity indicators (with 7 criteria) that could not be realistically used in routine harvesting operations (including destructive testing);
- recommendations for harvesting poles that were locally unavailable;

- agro-chemical inputs which were costly and scarce; and
- management practices which were inordinately labour intensive.

Rather than the productive partnership that had been envisaged, indications suggested that both Vijaya and its farmers had been passive partners in the development of new practices. At the same time the scientists were clearly struggling to provide technical advice that took full account of the agendas and perceptions of either party.

As work entered a next phase with a further trail shipment planned for the following season, it was evident that technical constraints to achieving sustained production of export quality mangoes remained and that Vijaya and its farmers were aware of this. However it was also apparent that the nature of technical inputs that were being provided by national scientists was going to continue to struggle to solve these constraints. Furthermore it was apparent that it was not necessarily the scientist themselves that were at fault, but the institutional environment they came from and the restriction this placed on their professional experience and mandate. Closer examination of the organisational and institutional context of the technical support was clearly needed.

This revealed that to a large extent the weakness in the Vijaya partnership were the result of historical patterns of institutional development in Indian public sector research; an institutional pattern where all too often useful technical expertise is "locked up" in research institutes with limited opportunities for interactions with farmers or as in this case private enterprise. In this case it was apparent that much of the experience that the scientist were drawing on was based on the results of laboratory research and literature reviews. They had little exposure to implementing their research findings in a commercial context nor the contingencies of servicing the needs of European export markets. Rigid institutional distinctions between research and extension organisations have tended to reinforce this situation.

Equally, different pieces of useful and mutually supportive technical expertise is often located in different institutions with the responsibility for linking these components left to a third party. This was particular so in the context of attempts to deal with anthracnose, a disease which needs to be tackled with an integrated pre and post-harvest approach. In this case the two set of national scientist (one set predominantly pre-harvest, the other predominately post-harvest) were functioning as quite separate entities. Each set visiting Vijaya and its farmers at separate times. Neither set communicating with each other, and the implied institutional ownership of potentially commercially sensitive information creating much apprehension between them.

Perhaps more importantly is that even where scientists are keen to assist organisations like Vijaya -- which they clearly are -- bureaucratic arrangements often make it difficult to work in new and more useful ways. The logistical arrangements for the inputs of contracted scientist also partly reflect this context. Fairly short inputs were provided for, with limited provision for allowances, travel and number of visits. As a result, while it was apparent that there was a need for in-situe adaptive research, the logistical arrangements dictated that the inputs of scientist were short and took the form of technical advice of a pre-formulated nature.

Of equal concern was the fact that Vijaya, which was on the one hand was disappointed with these inputs, was not able facilitate more productive interaction between farmers and scientist, nor articulate the concerns which farmers had about the inappropriateness of some of the recommendations. Vijay was clearly not aware of the interrelated nature of many of the presenting problems and this meant that it was in a weak position to press the scientists for the types of technology that would be useful in this context.

Lessons from Vijaya

Despite the numerous difficulties with technical support that Vijaya suffered, it illustrates both the factors that have led to the emergence of a partnership and the types of systemic failures which are impinging on this approach to technology development. In this case the recognition (by both Vijaya and APEDA) of the need for new technology to access new markets was pivotal in the move to seek a partnership with the national research system. Achieving this by introducing contract research arrangements was in fact a fairly significant institutional innovation for both public sector and private enterprise organisations, against a backdrop of considerable mutual apprehension. It also took place at a time when institutional policies for such arrangements had only recently been put in place for the national research scientists involved. The fact that in practice this partnership approach highlighted a fairly significant set of "second generation" institutional constraints only goes to illustrate the deeper systemic weakness that plague the sector as whole, and the pressing need for some sort of more inclusive analysis of the process involved, and the policy reform required.

Before going on to discuss the implication of these finding in greater detail, we present our second case study[7] to illustrate a more mature scenario based on a similar set of technology and market needs.

Case study No. 2. Institutional innovation in response to technology needs.

Like the Vijaya, the case study Maharasthra state grape growers association (Maharahthra Rajya Draksh Bagaidar Sangh [MRDBS]) and the linked Mahagrapes concerns a private enterprise which is founded on the farmers association and co-operative model. However in contrast to Vijaya, MRDBS has been established for over 20 years and approaches to solving some of the technology-input problems experienced by Vijaya have been overcome. The key feature of this case study is the way institutional arrangements have evolved over time in response to market factors and opportunities and the associated need

for new technology that farmer members required to benefit from these opportunities. The sequence of events was as follows.

Phase 1.

The growers association, MRDBS, was established by farmers in the 1960s as a mechanism to support members to produce and market grapes in the domestic market. During the 1970's MRDBS sort technical advice from scientists from the Indian National Agricultural research System (NARS) and from scientists abroad. This allowed the introduction of improved grape varieties that were further developed and selected by the farmers themselves. This combination of prescriptive technical advice from the NARS and the adaptations and innovativeness of farmers increased production of grapes to the extent that by 1985 the domestic market was in over supply with prices slumping.

Phase 2.

In response to the market situation, MRDBS encouraged the formation co-operatives to assist with marketing. Simultaneously a number of enterprising farmers began to explore export opportunities in the UK and Europe and the Middle East. It was apparent that significant export markets did exist. As a result exports started on an *ad hoc* basis. From previous experience with the NARS, MRDBS was aware that suitable post-harvest technology was not available in Indian to allow the shipment of grapes to the European markets. 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 mainly 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 Agricultural University at Rahuri granted affiliated status to MRDBS. The state government allocated land to MRDBS to conduct research. APEDA appointed a full time co-ordinator for grapes who works within the structure of MRDBS and has a role of promoting grape production and export, with a specific focus on technical support. It is interesting to note that APDEA, 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.

Lessons from MRDBS.

The MRDBS case is a story of the way that partnerships form and change in tandem with the institutional structures needed to sustain them. And the way this occurs in the context changing of technology needs associated with new markets. MRDBS' initial partnerships were with the NARS. As its technology needs (required for export markets) outpaced that available from the NARS, MRDBS formed new alliances with foreign sources of technology. At the same time it created its own new institutional structure to deal with export markets and the acquisition and application of the required technology. As MRDBS' own technical skills developed it became less reliant on these partnerships with foreign technology suppliers. The final partnership has once again been with the NARS, presumably as the latter viewed the structure put in place by MRDBS as an effective mechanism for delivering public research and extension services to the grape sector.

Keys points here are that the technological developments that led to economic changes (of farmers) were the result of a dynamic process, of which institutional evolution played a fairly significant role. Partnerships were important, but it was the ability of MRDBS to form and dissolve partnership as circumstances dictated that was key to the whole process. The institutional flexibility, not mention the foresight to do this, suggests that change and the ability to change is a central component to partnership approaches.

Discussion

On the whole the case studies presented suggest that the use of partnerships in research and technology development, while clearly important, reveals the complexities of the wider process of technical and economic change. In particular there has been a strong institutional dimension to this process and, in the case MRDBS this has been associated with evolutionary dynamics. As we have argued earlier in the paper, it is these feature of

technical change that both neo-classical traditions and even the more process oriented approach have had difficulty dealing with conceptually and, as a consequence from a policy perspective also. However the authors believe the these case studies reveal a pattern of institutional development that is similar to that found in much of the current literature dealing with innovation and technical change in other sectors. This is a literature that stresses the need to see technical change in systems terms, where flows of knowledge between actors and institutions in the process, and the factors that condition these flows, are central to innovative performance. The way the concepts contained in this literature developed exhibit some striking similarities to the conceptual and policy challenges which partnership approaches are raising and as such warrant closer examination.

Concepts of innovation in industrialised economies

Historically, analysis of technology performance in the industrialised economies used neo-classical traditions similar to those discussed in the context of agriculture, with analysis focused on inputs (such as expenditures on R&D) and outputs (such as patents). While these indicators remain important as sources of information about content and direction of technological endeavour (see for example OECD 1996a), their ability to measure the "innovativeness" of an economy is small (OECD 1997). Critically, the indicators used fail to account for all the inputs and outputs in the process; the approach takes little account of the way in which the process works; and most fundamentally it has difficulty dealing with the dynamic, complex[8] nature of the process (Clark, 1990 and 1995).

Over the past decade or so, fresh think has supplemented this input / output type analysis, with the development of a conceptual framework to account of the process nature of innovation. The literature dealing with these issues is very large indeed, but the conceptual framework that this provides contains a number of broad principles that are useful in the context of partnership arrangements[9]. The introductory comments of a

review of these concepts by Edquist (1997, pp 3) provides a useful overview of the main elements of recent thinking.

"Innovations are new creations of economic significance. They may be brandnew, but are more often new combinations of existing elements. Innovations may be of various kinds, e.g. technological as well as organisational. The process through which technical innovations emerge are extremely complex; they have to do with the emergence and diffusion of different knowledge elements, i.e., with scientific and technological possibilities, as well the 'translation' of these into new products and production processes. This translation is by no means follows a 'linear' path from basic research to applied research and further to the development and implementation of new processes and new products. Instead, it is characterised by complicated feedback mechanisms and interactive relations involving science, technology, learning, production policy and demand."

Central to this view of the world has been the recognition that innovation increasing takes place at the interface of formal research and economic activity, thus denying the primacy of either knowledge creation and validation institutions (R&D institutions universities etc), or knowledge application institutes (usually enterprises). Rather that its is partnerships between these types of actor which are important. As economies increasingly become dependant on the production, distribution and use of knowledge – "knowledge based economies" (OECD, 1996b) -- analysis has focused on flows a knowledge. This analysis stress the importance of these institutions as nodes in a systems where their interaction and interactive relationship along with other contextual factors is key to these knowledge flows. Attempts to understand the structure and dynamics of such systems are the core of modern thinking about the innovation process (Edquist, 1997; OECD 1997).

This conceptual framework has come to be known as "national systems of innovation"(NSI) (Freeman, 1987, Lundval 1992)[10]. A NIS is defined in number of slightly different way (see Freeman, 1987; Lundvall, 1992; Nelson 1993; Patel and Pavitt

1994; and Metcalfe, 1995). Broadly speaking it can be described as the system or network of private and public sector institutions whose interactions produce, diffuse and use economically useful knowledge. The component parts of the systems and their interactions are determined by culturally defined norms, historical defined institutional development, national priorities and defined by geographic boarders and national policies. [11] It is not necessarily suggested that national governments have explicitly developed innovation systems in this way, although some clearly have. Rather that in economies where such interactive systems have evolved successfully, the innovative performance of these economies has been strong and this has been reflected in rates of economic growth (Freeman, 1987 & 1991).

Rather than presenting a blueprint for institutional reform, NIS is concerned with mapping and evaluating channels for knowledge flows, identifying bottlenecks and suggesting appropriate remedial action. In this sense NIS presents a set of analytical principles for understanding the innovation process in a national context, and identifying leverage points for enhancing innovative performance. These principles include:

- Assessing the extent of institutional interactions
- Assessing impediments to flows of knowledge between nodes
- Assessing the opportunities for and constraints to interactive learning and institutional innovation; and
- Assessing policy and practices that can give rise to failures of the component parts working as a system.

The authors believe that if partnerships in agricultural technology development are to emerge as a core methodology, the analytical principles of NIS have a lot to offer. Not only could it provide a useful approach to analysis the types of systemic failure that the Vijaya case demonstrated. But more importantly it can be used in the context of policy formation to identify leverage points where innovative performance can be improved and ways in which this can for the benefit of the poor. The suggestion here is not that it should replace existing approaches, but rather that it supplements them. Economic analysis of returns to investment in research will still be important. Participatory

methods in, an appropriate institutional context, will be a key tool in increasing flows of knowledge between farmers and other parts of the innovation system.

While the NIS approach is now main stream with organisations such as OECD its application in the agriculture sector of developing countries is mainly untested. Further work is required to develop its application in contexts where the institutional nodes in the system may be NGO's or civil society organisations or instances or where market incentives for technological change are absent. However, as the circumstances in the developing country agricultural sector suggest an overriding need for a more inclusive approach to understanding technology development as a process, NSI should provide a useful starting point.

Conclusions

Partnerships in technology development are important because of the benefits in innovative performance derived from productive relationships between those organisations engaged in formal research and those engaged in the use of new knowledge in economic production. From a policy perspective, many of the shortcomings of existing conceptual approaches to technology development in the context of partnerships could be supplemented by the analytical principles that NIS provides. A key lesson for those advocating the adoption of partnership approaches is the need to be prepared to accommodate sufficient scope for the continuous process of institutional change that is implicit in much of the current thinking about the way innovation actually works.

[1] The term private sector is used to cover all organisational types out side of government including the enterprise sector, non government organisations, farmers association and co-operatives.

[2] These international agricultural research centres are collectively know as the Consultative Group on International Agricultural Research and are often referred to as the CG Centres. They are supported by multilateral and bilateral support as well as by contributions for member countries that they are serving.

[3] Lester Brown's Seed of Change (1970), which highlighted the equity issues arising from early experiences with the Green Revolution, was undoubtedly the seminal work in a very large body of debate which either implictly or explictly questioned the ablity of agricultural R&D, despite its apparent successes, to befit the economic well being of the poor. Lipton and Longhurst (1989) provide a comphrenesive review of this debate and draw conclusion of the impact of technical change in the Green Revolution era.

[4] Others had discussed the role of farmers as innovators (notably Richards, 1985), but these authors explicty linked it to a critisim of institional arrangemnts.

[5] Abundant examples of this methods driven debate can be found in PLA notes. For critic see Trip 1989; Biggs 1995; Biggs and Smith 1998; and Hall and Nahdy 1999.)

[6] The case studies presented have arisen from a series of studies of the Indian horticultural sector undertaken over the past three years by scientists from the Natural Resources Institute in collaboration with Indian scientists, entrepreneurs and farmers with funding from the DFID Crop Post-Harvest Research programme. This work is reported in more detail in : Andrews J and A Hall (1997)**;** Hall, A., Taylor, S.J. and Malins, A. (1997); Hall, A, M.V.K. Sivamohan, N. Clark, S. Taylor and G. Bockett. (1998); Malins A, S.Taylor and H. Pitcher (1996); Malins A, Hall A and Taylor S (1997); Sivamohan, MVK (1997); Sivamohan, MVK and A Hall (1998a); M V K Sivamohan, A. Hall (1998b); Taylor and Malins (1997); and Taylor, Hall and Sivamohan (1998)

[7] Drawn from study described in the previous footnote.

[8] Clark's (1990) explanation of the terms complex and evolutionary (as implied by dynamic) is useful here " complex in the sense that they are composed of many agents whose interactive behaviour is only predictable by to a limited extent since it is conditioned continually by relatively unknown future events: evolutionary because the agents are continually shifting their identify (forming, dissolving and reforming) in response to the variable environments in which they are placed."

[9] A useful review of the development of systemic approaches to understanding the innovation process is contained in Edquist 1997.

[10] Carlsson (1995) discusses a similar concept using the term *technological systems*.

[11] Edquist (1997) provides substantial discussion on the precise definition of national innovation systems, and the way different authors have interpreted the concept and its short comings.

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