Technology supply chain or innovation capacity? : contrasting experiences of promoting small scale irrigation technology in South Asia

UNITED NATIONS UNIVERSITY

UNU-MERIT

Working Paper Series

#2007-014

Technology supply chain or innovation capacity?: Contrasting experiences of promoting small scale irrigation technology in South Asia.

Andy Hall, Norman Clark and Guru Naik

United Nations University - Maastricht Economic and social Research and training centre on Innovation and Technology
Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499, e-mail: info@merit.unu.edu, URL: http://www.merit.unu.edu

Technology supply chain or innovation capacity?: Contrasting experiences of promoting small scale irrigation technology in South Asia.

Andy Hall[1], Norman Clark[2] and Guru Naik[3]

Abstract

The most effective approach to agricultural technology promotion and innovation is still a source of considerable debate, and nowhere more so than in the context of agricultural engineering hardware. Contemporary perspective on agricultural innovation stress the importance of institutional change and give emphasis to the need to develop innovation capacity in systems terms rather address limitations of technology transfer mechanisms. This paper illustrates using the case of manual irrigation technology – treadle pumps -- in Bangladesh and India. It identifies 5 elements of this capacity: (i) A sector coordination mechanism; (ii) a developmental rather than technical organising principle for sector development; (iii) habits and practices (institutions) of key organisations; (iv) Interaction as a learning and knowledge transmission mechanism (v) Market demand as key an incentive for innovation; and (vi) Policies and institutional innovations to ensure adequate stakeholder participation. The paper concludes by suggesting that identifying new sources of institutional innovation is the most presses task for initiatives that seek to make more effective use of knowledge and technology in development.

Key words: Agricultural machinery; technology, innovation systems, innovation capacity, agricultural research, poverty reduction, small scale irrigation, supply chains.

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research and training centre on Innovation and Technology, UNU-MERIT

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at the Centre to stimulate discussion on the issues raised.

[1] Coordinator Learning, INnovation and Knowledge Network (LINK), United Nations University, MERIT, Maastricht, The Netherlands. hall@intech.unu.edu
[2] Professor of Innovation Systems and Development at the Open University, UK, and Director of Research at the African Centre for Technology Studies (ACTS), Nairobi, Kenya n.clark@cgiar.org
[3] Director, Livelihood Solutions, New Delhi, India.

Technology supply chain or innovation capacity: Contrasting experiences of promoting small scale irrigation technology in South Asia.[4]

Andy Hall, Norman Clark and Guru Naik

I Introduction

The issue of innovation and technical change sits at the heart of agricultural development and remains a potentially critical driver of social and economic transformation in the agrarian based economy of many developing countries. Yet the most effective approach to agricultural technology promotion and innovation is still a source of considerable debate, and nowhere more so than in the context of agricultural engineering hardware. Starkey's (1989) work on the adoption of animal-drawn cultivators in India, aptly titled "Perfected yet rejected", warns of the dangers of a technology led approach. Douthwaite (2002) recounts the unsuccessful experience of designing and promoting a stripper-gatherer rice harvester in Myanmar and the Philippines and his observations on the obstacles to enabling innovation. There are many more such examples[5]. More generally the model of agricultural scientists and engineers developing new technology that is then transferred to farmers via a specialist technology transfer agency – agricultural extension services – is now widely discredited (Sulaiman and Hall 2005). But what alternative approaches could be followed?

From literally decades of experiences, five important principles emerge.

1. Despite the planning emphasis on setting up specialised research centres for developing agricultural technology, success rarely takes place unless technology users are consulted and involved in R&D processes from a fairly early stage.

2. Technology development is only a relatively small component of the larger process of technology production, supply and use – i.e. the entire innovation process where emphasis is placed on putting knowledge and technology into use. Technical change often requires complementary changes in, for example, the organisation of production or the marketing of products. As a result interaction between a diverse set of players is usually required for innovation to take place.

3. While innovation may involve radical technical changes such as a new crop variety or a new type of machine, it is usually a series of incremental changes – tinkering, adaptation and creative imitation -- in technology, organisation or strategy.

4. Technology production and supply processes need to adapt to the agricultural, market and livelihood conditions prevailing in specific contexts at specific points

[4] A shorter version of this is paper under the title Institutional change and innovation capacity: contrasting experiences of promoting small scale irrigation technology in South Asia is to be published in the International Journal of Technology Management and Sustainable development. Vol 5.

[5] Gass and Biggs, 1993 provide a valuable review of issues concerning rural mechanisation.

in time – that is to say that there is not a "one size fits all" recipe for this. And because of this context specificity, local processes of experimentation and learning assume great importance in the innovation process.

5. It is the institutional context of technology development and promotion initiatives – i.e. the combinations of different organisations, and the roles, routines and rule sets associated with them – that determine the extent to which these wider processes operate effectively and thus whether innovation is enabled or not. And if welfare of poor households is to be addressed by innovation, specific institutional and governance innovations are usually required.

It is becoming increasingly apparently that institutional contexts, because of their centrality to the innovation process, determine the extent to which technology-related interventions result in technological change. Institutional settings thus determine whether agricultural technology contributes to the development process. Using the case of manual irrigation technology – treadle pumps -- in Bangladesh and India, this paper illustrates how the institutional context of agricultural machinery promotion initiatives has had enormous influence on the success of these initiatives. Specifically it shows that where this context facilitates a continuous process of programme learning and product adaptation in response to user needs and market conditions, interventions can achieve considerable success -- in this case, widespread technical change amongst small scale farmers and a major innovation in access of poor households to water for crop irrigation.

These findings seem to resonate with a growing body of debate on agriculture innovation and innovation capacity in developing countries that takes a systems view and which places interaction in the innovation process and learning at centre stage. Using these concepts the paper explains the divergent success of two apparently similar technology promotion programmes by arguing that the Bangladesh programme intuitively moved towards developing capacity in ways that are now increasingly discussed in terms of an agricultural innovation system (Hall et al 2002, World Bank 2006). In contrast the India programme explicitly developed supply chain capacities that more closely resemble the concept of the classic value chain and unwittingly created conditions that prevented the emergence of innovations needed for programme success and impact.

If indeed the capacity to innovate rather than only a capacity to simply manufacture and supply technology can lead to large impacts on the livelihoods of poor people in rural areas – as this case would seem to suggest – there are important lessons here for the interventions of governments and donors wishing to use technological change as a way of improving social and economic conditions in developing countries. The paper begins in section 2 by reviewing recent thinking on agricultural innovation. It goes on in section 3 to outline the nature of treadle pump technology and IDEs efforts to promote it in each country. Sections 4 and 5 deal in detail with comparative country experiences. Section 6 draws some lessons while Section 7 draws the paper to a conclusion.

2. From technology transfer to innovation capacity.

Linear and systems perspectives on innovation[6] Over the past 40 years there have been a number of views on how best to deploy science and technology as a driver of innovation.

[6] This section draw heavily from the lead authors work published as World Bank 2006.

At the risk of oversimplifying a diverse reality two distinctly different views have emerged. The first, and earlier view, is that scientific research is the main driver of innovation, creating new knowledge and technology that can be transferred to different contexts of application. The second view, while not denying the importance of research and technology transfer, recognizes innovation as an interactive process. That is to say, innovation involves the interaction of individuals and organisations possessing different types of knowledge – scientific and non-scientific, codified and tactic -- and their interaction with particular social, political, policy, operational, economic and institutional contexts. The idea is that any innovation requires the putting together and use of complementary pieces of information in ways that respond to local situations and needs. The first view is usually described as the linear or transfer of technology model. The second is a systems view and is increasingly being discussed in terms of an innovation system[7].

These two perspectives place emphasis on different capacities, activities, processes and roles for public policy and intervention. The linear model concentrates on scientific research and the capacities, resources and priorities needed to support and guide (usually) public research and training organisations. Technology transfer takes place independently after technology development and is assumed to be handled by either the market or by specialised public technology transfer services.

The innovation systems perspective also views these aspects as important. Its unique emphasis, however, is the attention it gives to (i) interaction between research and related economic activity (technology users, but also others); (ii) habits and practices (institutional setting) that promote this interaction and the learning that accompanies it; and (iii) the enabling environment that encourages interaction in the economy and helps knowledge be put into socially and economically productive use. (iv) the emergent properties of this system of interacting agents, the capacity of which can not be understood by its component parts separately i.e. its sum is greater than its parts.

Edquist (1997) sums up the main feature of the innovation process in the following way

> "The process through which 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."

Why is agricultural innovation so difficult? Agricultural innovation and particularly agriculture innovation in developing countries presents some particular problems that are worth highlighting to those unfamiliar with the sector. In contrast to industrial

[7] This view originally articulated in terms of a national system of innovation emerged from the work of Freeman (1987) and Lundvall (1992). Its application to agricultural innovation in developing countries has been gaining ground in recent years (Hall et al 2001, 2003, 2004, 2005; Clark et al 2003 World Bank 2006).

production, agricultural production is different in four major respects. (i) The production context (agro-ecological conditions) is highly variable both between locations (soil type, climate) and over time (pest incidence, markets, climate). Secondly, this heterogeneity is compounded by the fact that the sector is made up of very large numbers of uncoordinated production units – farmers. Social variability – wealth, gender, ethnicity, individuality – is also very high. These two points together mean that technology and innovation needs to address multiple and often micro agendas and application contexts. In turn this tends to reduce the relevance of strategies that rely on the centralised development of generic technologies. Thirdly, much agricultural technology is embodied in biological material – new seed varieties or animal breeds – which, since these are highly sensitive to production conditions, tends to compound the problems of production heterogeneity discussed above.

Fourthly, agricultural technology has long been viewed by planners as falling into two distinct types of economic good: those classically thought of as private goods -- generally seeds, fertilizers, pesticides and machinery; and public goods -- those that are described in economic terms as non-excludable and non-rival and are usually information or training. The character of a good does not depend on a whether it is produced by the public or private sector, but depends on these different properties. Never the less it has been used by planners as a way determining where the public sector should focus its efforts and what should be left to the private sector. One of the problems is that that not only does this give responsibility for different parts of the innovation process to different agencies, it also suggests that these roles are mutually exclusive, and independent of contexts and particularly the degree of institutional development. This is particularly problematic in poor countries since the private sector may be poorly developed and reluctant to take risks in setting up manufacturing and distribution arrangements.

As our case will show, treadle pumps was an example of this sort of technology – i.e. one that had been developed as a public good, but which needed the private sector to manufacture and distribute it. The role of IDE, in the absence of private sector initiatives, was to facilitate the development of a manufacturing, distribution and retail network. In other words technology development and promotion is not a public or private sector domain, but a partnership between the two sectors. There is now recognition that getting these sort of public-private sector collaborations to work for agricultural innovation is far more difficult than had been expected – mainly because of the institutional changes needed in both sectors to make these sorts arrangements work effectively (Byerlee and Echeverria 2002; Spielman and von Grebmer2003).

Evolving paradigms of agricultural innovation. Systems ideas on innovation are relatively new to agriculture and rural development policy discourse in developing countries. The tradition policy focus has been on building the capacity of agricultural research systems and related technology transfer arrangements and providing operational funds for these. While there have been many critiques over the past 4 four decades on how agricultural technology development and promotion should be organised[8] it is useful to recognise the types of approach that have emerged and evolved over time. For illustrative purposes Table 1 summaries characteristics of the main paradigms of agricultural innovation over the last 4 decades or so.

[8]Some key texts include Biggs and Clay 1981; Richards 1985; Chambers and Ghildyal 1985; Collinson 1987; Byerlee D, Alex GE. 1998.

Table 1 Characteristics of different paradigms of agricultural innovation.

Paradigm	**Transfer of Technology**	**Farming Systems Research**	**Farmer first / Farmer participatory research**	**Interactive learning for change/ innovation systems**
Era	Widespread since the 1960, but building on a very long history	Starting in 1970s and 80s	Starting in 1990s	Work in progress
Organisation focus	Agricultural research organisation arranged as a National Agricultural research organisation	Agricultural research organisation arranged as a National Agricultural research organisation NARS	NARS as part of AKIS including agricultural extension and education organisations	NARS as part agricultural innovation systems
Mental model of activities	Supply through pipeline	Learn through survey	Collaborate in research	Interact and learn for innovation
Farmers seen by scientists as	Progressive adopters, laggards	Objects of study and sources of info	Colleagues	Key actors among many others
Farmers' roles	Learn, adopt, conform	Provide information for scientists	Diagnose, experiment, test adapt	Co-generate knowledge, processes and innovation
Scope	Productivity.	Input output relationships	Farm based	Beyond the farm gate
Core element	Technology packages	Modified packages to overcome constraints	Joint production of knowledge	Facilitated interactive innovation, learning and change
Driver	Supply push from research	Scientists' need to learn about farmers' conditions and needs	Demand pull from farmers	Responsiveness to changing contexts
Key changes Sought	Farmer behaviour	Scientists knowledge	Scientist-farmer relationships	Institutional, professional and personal, affecting interactions and relationships between all actors
Intended outcome	Technology transfer and uptake	Technology produced with better fit to farming systems	Co-evolved technology with better fit to livelihood systems	Enhanced capacities to innovate
Innovators	Scientists	Scientists adapt packages	Farmers and scientists together	Potentially all actors
Intervention mode	Core funding of research and research infrastructure development	Core funding of research and research infrastructure development	Decentralised technology development and planning	Strengthening systemic capacity to innovate
Role of policy	Set priorities and allocate resources for research	Set priorities and allocate resources for research	Set priorities and allocate resources for research in consultation with different stakeholders	Integral part of innovation capacity Strengthening enabling environment and support system coordination.

Source: Adapted from an unpublished note by Robert Chambers and Andy Hall

There are perhaps two points about the changes illustrated in Table 1 that are worth emphasising. The first is that the technology transfer paradigm has been questioned by scientists and social researchers since at least the 1970s. In other words the question of how to organise the process of innovation has been with us for a long time. The fact that fortunes of some of the technology transfer and alternative paradigms have waxed and waned, however, does not necessarily mean that they should be judged inferior. Rather they were often products of their time, suited to historical development scenarios (Hall et al 2001). Furthermore farming systems and participatory research paradigms were important institutional innovations and helped build up further knowledge on the relative merits of alternative ways of organising the innovation process. These models in many senses laid the foundations for the innovation systems paradigm – they legitimised the role of technology users (farmers) in the innovation process; they recognised that innovation draws information from multiple sources; they championed the idea of participation; and they saw how action research could be use to explore development phenomena that are complex and evolutionary in nature.

The actual idea of an innovation system emerged in parallel in relation to economic studies of industrialising countries (particularly in East Asian). Its central ideas, however, resonated with the institutional innovations taking place around agricultural research approaches in the 1990's and the increasingly globalised economic conditions that developing countries were facing. Of course social equity and the need to improve the livelihoods of poor rural households in developing countries was an additional and unique concern for agricultural development policy. Innovation systems ideas, never the less, brought fresh thinking and impetus to the discussion of agricultural science technology and innovation in development that had in many senses got stuck in polarised debates farmer knowledge and invention with tackling how this could be integrated with scientific knowledge (Bell 2006); and had to a large extent slipped off the agenda of many development agencies.

The second and arguably most important point about these changing paradigms is the gradual shift from technology delivery to capacity enhancement and specifically the capacity to innovate. Underlying this is the idea that to be effective in an ever-changing world a continuous process of innovation is required to adapt economic processes to presenting situations -- for example, livestock disease outbreaks or changing consumer preferences. As a result, it is not technology per se that is important, but the ability to adapt -- often through technical or design changes – to meet new demands of production conditions, markets or technology users. The caveat here is that changes in ways of working – institutional innovations – go hand in hand with technical and design changes. Thus the propensity for institutional learning and change in enterprises, research organisations and developmental agencies and their programmes is central to innovation capacity.

This is where the innovation systems perspective is particular valuable because it is a way of conceptualising capacity in terms of the different actors, process skills and resources that are need to allow innovation to take place on a continuous basis. This is a major departure from earlier agricultural innovation paradigms. To make the same point differently, the innovation systems perspective shifts the underlying premise of agricultural development interventions from framing them as a problem of information

and technological scarcity on production, processing or markets, to framing it as capacity scarcity in relation to the ability to innovate. This capacity can be defined as follows:

the context specific range of scientific and other skills and information held by individuals and organisations and the practices and routines (institutions), patterns of interaction and policies needed to create and put knowledge into productive use in response to an evolving set of challenges and opportunities. A large element of this capacity arises from learning-by-doing whereby organisations engaging in the innovation process continuously adapt ways of working and routines – institutional learning --, thus incrementally improving their ability to utilise knowledge and information (Hall, 200)

It is from this perspective then that the case of treadle pumps can be explored.

3. Case study treadle pump adoption in India and Bangladesh[9]

3.1 Background the IDE approach, the technology and its impact

The IDE approach to technology promotion International Development Enterprises (IDE) was established in 1981 by a Canadian psychiatrist, Paul Polack. Based on experiences during a visit to Central America he conjectured that a major constraint to poverty reduction was lack of access to appropriate technology. But unlike the Schumacher view of appropriate technology[10] he believed that the problem was wider than the simple invention of intermediate technologies. What were also needed were viable arrangements for production, marketing, distribution and retailing of technology that, once established, could be maintained by entrepreneurs of various scales that made up this network.

The IDE approach that subsequently developed centred on the establishment of such arrangements. It refers to this as a technology supply chain. The approach combined a number of guiding principles. The first was to apply modern commercial marketing principles in the establishment of the supply chain and the promotion of the technology through mass marketing techniques. The second was that the poor were customers and that they could and should purchase technology. Thirdly, the role of IDE should be to facilitate the development of a network of private enterprises -- manufactures, wholesalers, distributors, retailers/dealers and installers and repairers – to create the supply chain. And fourthly the price of the technology/ product should not be subsidised and that all subsidies on similar products in the market should be removed so as not to undercut the private sector. And finally, having established the supply chain, IDE would then slowly withdraw its support and allow the market to take over.

In the case of treadle pumps the facilitation role of IDE involved: performing technology research and development; technical training to manufactures; training in marketing to dealers and pump installers; technical training to installers in pump and well installation

[9] Information presented in this case study is partially based on a consultancy assignment to review the success of treadle pumps in India and Bangladesh conducted by Guru Naik April 2002. This assignment involved extensive field visits and interviews with key informants from organisations central to this story in both countries.

[10] See, for example, Schumacher (1973)

and repair and maintenance; business linkage services to the enterprises in the supply chain and promotional services. In reality IDE often found that it had, initially at least, to play a direct role in the supply chain as, for instance as wholesaler or as a dealer, since enterprises were not sufficiently well developed or absent in the markets in developing countries where IDE was working (Downing and Polack, 2000). As will be seen from our case study the interpretation of these broad principles and the interaction of these with different country contexts has lead to markedly different levels of success with the programme.

The treadle pump: technical characteristics. In the words of Shah et al (2000)

> "the treadle pump is a foot-operated device that uses a flexible pipe (usually of bamboo or PVC) as a suction/tube well to pump water from shallow aquifers. It consists of a sheet metal or cast iron pump-head, a bamboo frame with two treadles and a bamboo or PVC strainer. The pump–head has two cylinders welded together with a single suction inlet at the bottom and two plungers with or without a rope and pulley…..The cylinders are joined together at the base by a junction box, which connects through check valves to the suction pipe. As pedalling commences, water penetrates the filter and rises up through the suction pipe to the dynamic groundwater level. From there it is lifted in a pulsating stream following the strokes of the two pistons. The action of the two cylinders provides a virtually continuous stream of water. This makes it more efficient than single cylinder pumps….. ".[11]

Shah and his colleagues go on to analyse the technology in some detail and conclude that for the poorest farmers it is an attractive option. It is an improvement in engineering efficiency terms over other manual irrigation devices (see also Srinivas and Jalajakshi, 2004).

Cost, social fit and impact.
The biggest advantage of the treadle pump however, is in its capital costs (running costs are practically equivalent to the labour time expended in operation). The cheapest treadle pump can be installed for less than US $12 with the more expensive ones costing US $ 25-35 (Ibid). A study in Orissa, in India, showing that out of a sample of 400 small holder farmers (i.e those with less than 0.5 ha of land) by far the majority spent $25 or less in total installation costs (cited by Shah et al 2000).

Steenbergen (undated) estimated that in IDE's programme in North Bengal in India the promotion cost for each pump at US$25 and the cost to a farmer of pump and installation at about US$20. This gives a cost per irrigated ha at about US$200[12]. This compares with the "going rate for the capital costs of new canal irrigation potential in South Asia of $4000-4500 (and) new tube well irrigation costs of $800-1000/ha." (Shah et al). Steenbergen also estimates that treadle pump can pay for itself in one season. Downing and Polack (2000) cite a 1999 survey (that they describe as exhaustive) of treadle pump impact in Bangladesh that estimated the net income of farmers using the treadle pump at

[11] See Shah et al. (2000) p 3.
[12] Shah et al estimate this to be slightly lower at $100-120/ha

US$100. This is significant in a country where annual per capita income is US$220 (Ibid).

Total sales of treadle pumps (IDE and non-IDE) up to 2000 were close to 1.3 million[13]. IDE's surveys of socio-economic impact for their programme in Bangladesh (reported by Downing and Polack, 2000 citing Shah, Alam et al 1999), and finding in North Bengal (reported by Steenbergen) suggest that " Early adopters are among the poorest. First generation adopters tend to be the less poor, and over time, the poorer "join in" and the less poor move to mechanised (diesel) pumps".[14]

It seems safe to conclude that the innovation processes detailed in the case study below are relatively well focused don the poor and their needs and are having tangible impacts on improving the livelihood of poor people.

3.2 Treadle pump promotion in Bangladesh

The case for manual irrigation. IDE started operations in Bangladesh in 1984 and it soon identified low cost irrigation as a way of improving the income of poor rural households. The rural context at that time had the following features:

- The country as whole was not food self-sufficient, with large annual imports of the main food staple, rice.
- Agricultural production had been disrupted through a series of particular heavy annual flood in the early 1980's.
- Since poor households relied on rice production for either food or for employment, the aftermath of the floods were causing considerable distress in rural areas.
- The majority of rural household had land holding of less than 0.5 ha mostly used for rice production.
- Three crops of rice a year are possible in areas with access to irrigation in the dry season, but the poorest household had the most limited access to irrigation water.
- The shallow water table in many areas of Bangladesh makes it suitable for low lift manual irrigation.
- The cheapest diesel pump available at the time cost US$ 500 whereas annual incomes of farmers were about US$ 200.

An affordable manual irrigation pump appeared to the answer and was chosen as the target for IDE's mass marketing techniques. IDE of course was not the first organisation to recognise the potential of manual irrigation. A number of initiatives had been going on since the 1970s in both Bangladesh and eastern India (personal communication with Stephen Biggs). IDE's work in manual irrigation in Bangladesh began in 1984, not with

[13] Shah et al (2000) explore the basis of this "magic figure" quoted in many IDE documents. They conclude that while it is not based on a census (the figure includes IDE and non-IDE treadle pumps), there is credible evidence to support this level of sales, although only about 7-800,000 may be in service taking into account asset retirement.

[14] It's interesting to note that while IDE in Bangladesh routinely collected data on number of pumps sold and the types of entrepreneurs in the value chain, it didn't collect information on the land sizes of farmers purchasing pumps. This would have been useful for market segmentation and documenting impacts on the very poor (Downing and Polack, 2002)

the treadle pump, but with the rower pump[15]. This had been designed by George Klassen a volunteer with another international NGO in Bangladesh, the Mennonite Central Committee; they had already installed 2000 rower pumps. UNICEF had introduced 90,000 cast iron No. 6 hand pumps for drinking water, but farmers had started to use them for small scale irrigation. The rower pump was more bio mechanically efficient than the hand pump and was found better by farmers for long term pumping. The treadle pump, which was being introduced in Northern Bangladesh at this time by another NGO (see below), was also more efficient, but IDE felt the rower pump was easier to manufacture in volume with high quality.

Rower Pump Phase Having selected the Rower Pump, and having consulted with key players, IDE set itself a target of install 20,000 pumps a year and secured funding for a three-year project from CIDA, Canada. One of its first activities was to set up a regular manual irrigation coordination committee meeting attended by all organisations promoting manual irrigation. IDE used these meeting to successfully convince other organisation to remove subsidies on pumps and installation. Manufacture of the pump was initially by the same organisation that the Mennonite Central Committee had used – actually a training centre rather than a private enterprise. Gradually other manufacturers started to appear. During this period IDE implemented "100% quality control" procedures to ensure initial installation worked effectively. In parallel, IDE started to facilitate the development of a pump dealer and installer network. Backing this up was a mass marketing campaign consisting of advertising billboards, calendars, leaflets and posters. By the end of the third year of the programme sales passed 1,000 a month.

The Rower to Treadle Pump transition In 1986 IDE was contracted by the Bangladesh Tobacco Company (BTC--a government parastatal organisation) to supply rower pumps as part of its input package to farmers. However, BTC wanted treadle pumps as well as rower pumps because there was a great deal of interest from farmers in the treadle pumps. IDE eventually installed equal numbers of the two types of pump. After the first season of use farmers reported a strong preference for the treadle pump. IDE then face a dilemma. In the words of Paul Polack, the founder of IDE:

"*We has seen ourselves as a rower pump organisation, and even carried pictures of Rower Pumps on the sides of our vehicles. But were we a rower pump organisation or an organisation dedicated to opening access to affordable irrigation water to small poor farmers? We decided that we were dedicated to the latter and changed our focus to treadle pumps".*

Clearly this was a very difficult decision. In retrospect it can be seen as a major institutional change that was to effect the direction and success of the whole programme. And it was a decision made in response to feedback from technology users and shaped by the desire of the IDE programme to address the needs of a particular social group -- small holder farmers.

The treadle pump programme -- introduction phase 1987- 89 The introduction of treadle pumps can be traced to an NGO, Rangpur and Dinajpur Rural Services (RDRS). A Norwegian volunteer with RDRS, Gunnar Barnes, along with colleagues, design the treadle pump bearing in mind that a manual irrigation pump should cost about the

[15] The history of IDE's programme in Bangladesh draws heavily on Polack (undated)

equivalent of a sack of rice. RDRS started operations in 1971 to assist Bangladeshi refugees in camps in the Coochbehar district of the neighbouring Indian state of West Bengal following the Bangladesh war of independence. During the resettlement project period, RDRS identified the treadle pump as a technology, which could help farmers re-establish agriculture activity. RDRS produced treadle pumps establishing 4 workshop and provided them free to the farmers in its project area of Rangpur and Dinajpur districts.

In 1987, IDE began to refocus its programme on the RDRS-designed treadle pump. They did not abandon the rower pump completely and continued to install about 5,000 pumps a year. More importantly, IDE found that in making the shift, virtually all the experience it has gained in the promotion of the rower pump was directly applicable to the treadle pump as well; for instance, criteria for selecting well-respected village dealers; the importance of training well-drillers; criteria for selecting IDE field staff; and tactical knowledge about the sorts of things that stimulated supply chains (Polack, undated). Armed with this experience IDE then went about establishing a much expanded private sector dealer network.

In the early years of the treadle pump, IDE introduced two important institutional innovations. The first was the provision of credit directly to farmers to purchase the pumps. IDE soon learned that the real cost of providing credit in Bangladesh required an interest rate of 40% and was complicated to administer. They quickly withdrew from this and instead partnered with micro-credit programmes like the Grameen Bank and Proshika. The second innovation concerned a much expanded array of promotional activities. It dawned on IDE that since most of their potential customers did not read visual approaches were required. As a result they expanded their activities from leaflets and posters to films, plays, troubadours, rickshaw processions and demonstration farmers. The other notable feature of the programme in those early years was a strong emphasis on quality. IDE talk of 100% quality control and this means quality control of the product itself, as well as installation and follow-up of the pump. The logic was that for the pump to gain acceptance it had to build a reputation for reliability – at it turned out this assumption was a critical one and not entirely correct.

By the 1989 annual sales had risen to 60,000 and IDE had handed over its direct role as a wholesaler to private sector distributors. At this point 50% of the market place consisted of new producer dealer networks that entered the market place without IDE's involvement because they saw an opportunity for profit. In the period after 1989, as the market grew, IDE remain involved in only about 25% of the private sector players in the supply chain.

The copycat phenomena and the innovations it led to. This rapid expansion in the market for the pump saw the entry of a new type of player – copycat fabricators that made perhaps a few hundred treadle pumps of very low quality that failed after a week or two, by which time the fabricators had disappeared. IDE realised it could not control this; so it educated customers to differentiate between high and low quality products. But some of these small producers were actually filling a niche in the market, producing lower cost pumps that could still last two years instead of the seven year life of the high quality, but also higher priced pump. IDE learned that these lower quality pumps were the product of choice for many thoroughly informed customers! (Polack, undated).

Once again IDE was facing a dilemma. Should it stick with its quality standard or should it follow the demand of pump users. Fortunately IDE was sufficiently flexible to see this as market information and an opportunity to respond to the demonstrated demand for a cheaper product (Downing and Polack, 2000). From 1989 IDE started producing 3 qualities of pump – the thickness of the sheet metal used in manufacturing was the key quality criteria. The cheapest had a life expectancy of 2 years and the best 7 years. Almost over night the cheapest "2 year" model captured 50% of the treadle pump market and remained the highest volume seller. Meanwhile fabricators continued to take advantage of the market that IDE had created and introduce innumerable design changes in an effort to reduce production costs and make the best use of locally available materials.

This innovation in IDE quality management strategy was important because it allowed IDE to address the needs of its target customer – rural households with weak purchasing power. But it was also important since it suggested that IDE had created and was part of a large process or system that was starting to respond to a market, made up mainly of poor consumers, with technical and institutional innovations that suited their needs. IDE had created a market for treadle pumps not only by promoting them, but by creating networks of manufactures, distributors and dealers. This opportunity in turn triggered innovation by fabricators, the more scrupulous of which recognised that poor rural household are more sensitive to price than quality. Thus the information flows between fabricators, customers and IDE changed IDE's approach. It appeared that a capacity to continuously innovate was starting to emerge

1990 onwards Promotion of the treadle pump continued through the 1990s with the same modus operandi of facilitating manufacturers, distributor retailer networks, creating demand and then moving on. During this period sales of IDE pumps averaged about 45,000 a year, and non-IDE pumps maybe twice as much again. Two notable points remain to be mentioned.

The first concerns a new strategy that emerged in the early 1990's from a new IDE project director that led to the establishment of Krishi Bhandu, Ltd to market branded pumps – Krishi Bhandu (farmers friend) or KB for short -- under strict quality control. IDE's donor at that time vetoed this idea. Nevertheless IDE staff members left the organisation and set the company up in 1995 establishing a marketing chain with tight control over prices and quality of its manufactures and dealers. It was still functioning in 2000, although with its high cost pumps and with small margins in a competitive market it performed modestly (Downing and Polack, 2000 and Shah et al.). Downing and Polack (2000) conclude that KB belief in the need for quality control simply misread the demand in the market. Given IDE's record of innovation in response to the market, one can only explain this by suggesting it was a result of the perceptions of the individuals involved. This episode is worth noting as KB-branded pumps took on a lead role in the India part of this case study.

The final point worth mentioning on the Bangladesh programme are developments in recent years arising from the introduction of cheap ((US$175) Chinese diesel pump sets. As the purchasing power of farmers has increased those who can have shifted to these -- although used and low quality treadle pump sets are still a thriving part of the market. Polack (undated) argues that one of the effects of the introduction of treadle pumps was the strengthening of water markets among the poor – treadle pump owners also tended to

buy irrigation water. This market has helped farmers purchase diesel pumps sets as they rent them out or sell water as well as using them for their own crops. This progression seems likely continue as the latest twist in the small scale irrigation innovation story in Bangladesh. To be continued!

3.3. Treadle pump programme in North Bengal, India.

For the case of treadle pumps in India we concentrate on IDE's activities in North Bengal undertaken from 1995 onwards. IDE's activities did in fact start earlier in India from 1992 as it started to replicate its successful experience of Bangladesh in 1992. During this phase IDE introduced the treadle pump with the help of AFPRO (an established apex level NGO). AFPRO identified 20 of its local NGO partners in Uttar Pradesh and Bihar to introduce the pumps. Between 1993 and 1995 the IDE team developed a new pump using the basic treadle technology. The new pump was called the Metal Pedal Pump (MPP), since it was made of prefabricated metal -- the original Bangladesh pump used locally available bamboo for the treadle.

In 1995 Euroconsult, a development funding agency identified treadle pumps as a technology worth promoting in North Bengal. North Bengal (confusingly part of the Indian state of West Bengal) is adjacent to North Bangladesh, and it is therefore agro-climatically and socio-economically similar to North Bengal. It also has the highest concentration of treadle pumps in Bangladesh. Euroconsult contacted IDE-India and provided funds for promotion of treadle pumps. The IDE approach in India was based on the same under lying principles as that in Bangladesh – i.e. facilitating the development of a private sector supply chain for treadle pumps.

However what is apparent in retrospect is that many of the early lessons from the Bangladesh programme about quality versus price had not been noted. In fact the interpretation of the IDE approach in India seems to have been more influenced by the KB approach and indeed this brand was adopted in India. Steenbergen (undated) explains that while designing the promotion campaign, a number of decisions were taken:

- a high quality treadle pump would be promoted at a fixed non-subsidized price; the idea was to set a standard and create a reputation for the treadle pumps, hence avoiding in this initial stage a market spoiled by spurious models;
- to safeguard the quality of the pump, a purchaser would receive a one-year warranty card and each pump would have a punch plate with a unique number;
- this decision, basically the choice for a quality product, had strong implications for manufacturing and the marketing strategies; quality production and quality control implied the central manufacture of the pump.
- in its turn the central manufacture of the pump implied a long single marketing chain from a limited number of central manufacturers to a large number of remote rural customers.

At this early stage IDE had to play the role of main distributor as well, supplying the dealers and the installers. Efforts were started to build up local manufacturing capacity. The production of the treadle pumps to the quality standards stipulated in the project, however, required a pressing machine, a shearing machine, electricity supply and working capital. No manufacturer in North Bengal was found possessing all these assets

and interested to start a manufacturing line. Instead a Calcutta-based manufacturer was identified that was making high quality drinking water pumps for UNICEF programmes. This placed the manufactures 5 to 10 hours drive from treadle pump retailers and users. IDE's own market analysis predicted that it once its direct marketing and supply system was fully functioning it would sell 11,000 pumps per year

In the first season the direct marketing effort was supported by two marketing teams, each consisting of three promoters, whose task was to build up installer-networks in the blocks in which the marketing efforts concentrated. The results of the first year were better than expected with 903 Treadle pumps were sold.

In the second season confusion over government subsidies caused private sector distributors and retailers to hesitate about whether or not to get involved in the IDE programme. What in effect this meant was that IDE had to continue to play a role in the market chain as both a wholesaler and as a distributor. Sales at the end of the season were 2400 branded KB pumps and 1253 non-branded pumps.

The third season consolidated the strategy of the previous year with some minor changes. But increasingly rather than the dealers or mistri's (local pump installers and mechanics) taking a lead in sales, the fifteen marketing assistants engaged by IDE became the anchor point in sales promotion. Sales remained at the 2500 level for branded pumps, again well below the predicted 11,000. Before the fourth season there was a complete revamp of the dealer network prior to the season. The number of distributors increased from 3 to 7, while IDE continued to play the role of link between the manufacturer (whom they made subject to quality control) and the distributor-dealer network (who were expected to sell the branded KB pumps).

Another major limitation encountered was the prevalent system of sales-on-credit coupled with the modest working capital of most dealers. To stimulate sales, IDE therefore decided to relax its earlier insistence on payment by cash and instead advanced credit-on-sales to the distributors and dealers. This amounted to approximately INR US$ 4000 in credit or close to 20% of the total turnover of that season. It is interesting to note that the Bangladesh programme had also face a similar issue and experimented with credit services, but quickly withdrew.

By the fourth season the IDE promotion team was seriously concerned by its less than expected levels of pump sales. To counter this is came up with a range of imaginative promotional activities – such as selling coupons that gave buyers discounts on the pumps. At the end of the season sales of the branded treadle pumps were 2584 and an estimated 500 non-branded pumps. This was achieved at the price of an intensive promotion campaign, consisting of more than 1600 promotional events (market demonstration, village demonstrations and short campaigns), including 67 widely attended video shows.

In the fifth season (1999-2000) a withdrawal strategy was initiated. Sales dropped from the previous year, but not dramatically (only 15%) and a safe platform seemed to have been reached. IDE also gradually withdrew from the marketing chain. Up to this point, IDE served as the link between treadle pump manufacturers and distributors and also provided trade credit to the system. In the final season a start was made with establishing links directly between the manufacturer and the distributors of pumps. After the end of

the Euroconsult-funded project, IDE still continued to work in North Bengal with funds from other sources, but at a much reduced scale. By the end of the project in 2000 total sales of treadle pumps in the project area were about 13,000 branded pumps and 2500 non-branded pumps. In contrast to the Bangladesh experience, the spread of treadle pumps in West Bengal has been relatively slow with sales actually falling quite dramatically after the withdrawal of IDE.

A field visit to the project area in 2002 (Naik) noted that no pumps were active there, and this in an area where apparently more than 13,000 treadle pumps had been sold previously. The contrast with Bangladesh is striking. North Bangladesh had nearly 900,000 operational treadle pumps at the time of the study (Naik 2002). Sales of treadle pumps in Bangladesh at the time of the study were in the range of 30,000 units per year, even though active promotion of the treadle pump has stopped at that time. Steenbergen makes the following concluding comments in his assessment of the North Bengal programme.

> *"The rural private sector, as it exists in North Bengal, is weak. Where people are poor, the domestic private sector is equally poor. Given this weakness, how well conceived was the strategy that was followed? The question is particularly relevant, since projected sales were substantially higher than actual sales. The high expectations were based on the popularity of the treadle pump in adjoining districts in Bangladesh and confirmed in the marketing survey during the beginning of the campaign. The high response to the subsidy package in 1997 also suggests a much larger latent demand."*

Steenbergen goes on to highlight factors in IDE's strategy that seemed problematic:

- it aimed to introduce a high quality product to a poor clientele, and tried to maintain a fixed and reasonable price at the same time;
- it worked with a long retail chain, consisting of Calcutta-based manufacturers, distributors, local dealers, mistris – no such chain existed earlier;
- The IDE, moreover, (had to) insert itself into this long chain of command; and occupy a commanding position in it, as it was doing the quality control of the manufacturers, the licensing of local dealers and mistri's and providing trade credit;
- though it did not finance the product, it subsidized an extremely intensive promotion campaign with the promotion costs exceeding the treadle pump turnover.

This long retail chain was justified by the desire to guarantee quality. It was motivated by the tactic of approaching a new market with an assured product and building up a solid reputation. It led to the branding of the product, emphasis on quality control and a warranty system, which in the context of rural Bengal was extraordinary. The consequence of this desire to guarantee quality was however, a long retail chain that started with a manufacturer that was not based locally. A drawback of this long chain and the reliance on Calcutta-based manufacturers was that local spin-off was limited. This has had an effect on R&D and product innovation, which could not develop into a spontaneous process, driven by customer feedback, but instead became a complementary service provided by the IDE.

It has to be said that efforts were undertaken by IDE to find a manufacturer, closer to the North Bengal market. This never materialized for lack of entrepreneurs with the resources

and the conviction that this was a risk worth taking as well as the general underdeveloped industrial climate in the region. But the 'no candidates' also had to do with the high quality requirements of the product. This excluded small producers, such as those in the border villages, who have been manufacturing the pump for a number of years. Experience showed, however, that small producers came back in the picture in the fourth and fifth promotion season. This suggests that if sales increase to a certain density such workshops may find their way into the market on a small scale, producing a lower quality, but lower price product.

While these ex-post observations made in the review of van Steenbergen, seem an accurate diagnosis of the limited success of IDE's North Bengal programme in India, it leaves a bigger question unanswered: Why was it that after the success of its Bangladesh programme, and all the lessons generated there, could IDE get it so wrong in India?

4. Comparative Analysis: supply chain or innovation capacity?

What then have been the main distinguishing features of the two stories? It is perhaps important to start by stating that the Bangladesh experience has had a number of in-built advantages. The Bangladesh treadle pump programme has been operational for some 7 years before the India programme began. The Bangladesh programme was being promoted by two big agencies RDRS and IDE (though RDRS was only limited to North Bangladesh). Though the total resource deployed by both the country programmes were in the order of US$8-10 million each, the Bangladesh programme had started at a time when technology competition for manual irrigation was much weaker. Finally the India programme started at a time when mechanisation in agriculture had already begun and the treadle pump had thus to compete with subsidised diesel pump sets. Indeed economic conditions generally had changed a over this comparatively short time, and this combined with the different competitive structures in the two regions must have had some effect on diffusion rates. Nevertheless it might be expected that given IDE's previous experience there must also have been considerable learning, so that by 1996 there was much to build on. Table 2 contrasts the two cases.

Table 2 Similarities and differences between the Bangladesh and India case.

Parameters	Bangladesh Programme	India Programme
Product focus	Began with a totally different product, the rower pump, but later switched.	Treadle pump only.
Product range	Multiple products in price range US$3.5 to US$25.00.	Single branded and quality controlled product at regulated price
Manufacturer profile	Decentralised and autonomous. Mainly small rural fabricators closely connected to retailers and consumers.	Centralised in one medium sized manufacturer disconnected from retailers.
Product brand	Briefly promoted its own brand KB during mid 1990's, but very soon disowned it after floating the KB company. IDE then went on to promoting all forms of treadle pumps.	IDE India only promoted KB brand of treadle pumps. IDE India also very deliberated did not encourage non-KB pumps. Later IDE introduced joint branding, but only with KB manufacturers.
IDE role	Supply chain facilitator.	Supply chain facilitator and service provider in the market – wholesaler and distributor.
Types of innovation	**Institutional innovations**: Removal of all pump subsidies in the manual irrigation sector as a way of	**Institutional innovations:** Limited success in removing subsidies on manual irrigation. **Incremental innovations:** R&D by IDE

	encouraging the private sector. The shift in strategy from rower to treadle pump. Shift from single quality to multiple quality models as a way of responding to the different purchasing power of clients. **Radical technical innovations**: Shift from Rower to Treadle pump **Incremental technical innovations.** Innumerable design changes to reduce cost and make use of locally available material. **Marketing innovations:** The introduction of low cost low quality models	changed design in search of better quality
Culture or institutional setting of country programme	Willing to learn and listen to others. Flexible enough to abandon defining features of the programme when found to no longer be useful	Rigidly adhered to defining feature of programme – manufacturing quality standards – even when this was undermining the success of the whole programme.

Although in both countries IDE set out to establish a supply chain for a specific piece of equipment, the Bangladesh case illustrates that IDE succeeded – probably unintentional -- in creating a very different sort of capacity that lead to both institutional and technological innovation that in turn underpinned programme success. The critical institutional innovations in IDE's programme were central to its ability to respond to successes and failures and feed back from technology users. In contrast, in the India case the programme seem to be more rigid in its out look and concentrated (unsuccessfully as it turned out) on developing tightly controlled a supply chain. The programme policy of high quality branded pumps had implications both for where these where manufactured and by who (centrally and distant from users) and for price (relatively high). With user / manufacture interaction absent and a weak market demand for the relatively high priced pump providing few incentives for new manufactures, options for both technical and institutional innovations need to put the technology failed to emerge.

So despite the similar environments in Bangladesh and North Bengal in India, outcomes have been markedly different. What seems to be clear is that something about the institutional setting of the two programmes on the one hand help learning and innovation in Bangladesh and other impede it in India. One is also left with the sense that lessons from Bangladesh were not transferred to India. What then were the lessons from this case? A useful way to present these is to summarise the features of the capacity that IDE succeeded in creating and which the conceptualisation in section 2 discusses in terms of innovation capacity.

Based on these empirical finding from the Bangladesh case key elements of this capacity include:

1. **Sector coordination.** The presence of an organisation such as IDE that can facilitate interaction and coherence between not just actors in the supply chain, but other development and policy actors engaged in sector support. For example, IDE set a coordination committee to discuss issues that affect small scale

irrigation and succeed in getting all government and non government agencies to remove subsidies. Research organisation played no role in this case (although one could argue that the NGOs that developed the rower and treadle pump technologies were playing this role rather than public R&D organisations). However, it could be anticipated that a role of a coordinating organisation would include facilitating links to sources of science and technology. It needs also to be noted that sector coordination may be a catalytic role needed to stimulate sector take off at which point the sector then takes on its own self organising dynamic as new opportunities and incentives emerge.

2. **Non-technological focus of organising principle for sector coordination.** The use of a non-technical sector development theme is important as it prevents getting locked into particular technological dead-end. For example, IDE stated its mission as improving access of poor households to irrigation water. Its focus was on creating supply chains and markets for low cost irrigation technology. As a result it was not wedded to any particular technology, although after the initial focus on the rower pump, the treadle pump (in its various forms) emerged as the front runner. Similarly such as widely defined mission provided common ground for negotiation and coordination with other initiatives in the sector which could other wise have been viewed as competitors.
3. **Interaction as a learning and information gathering and transmission mechanism**. Interaction was used by both IDE and manufactures to gather information about consumer demands and to use this information to develop new products and strategies – copy cat pumps in the case of manufactures; new quality/ price strategies in the case of IDE. These mechanism also allowed IDE to develop pro-poor institutional innovations, in this case its change to a strategy to promoting differently priced models that allowed it to more accuratly address the needs of its target customer – rural households with weak purchasing power. Underpinning these mechanism were patterns of interaction that go beyond those solely associated with the supply chain and which network together all the actors with interests in the sector – village mechanic, development agencies, manufactures, farmer and mirco-finance organisations. Some of these networking activities involve formal partnering in joint activities, other a looser type of links more akin to social capital.
4. **Habits and practices (institutions) of key organisations are central**. The way organisations work determines whether they innovate and whether the system that they are part of innovates. For example, the attitude of IDE in terms of listening to different ideas, learning from mistakes and adjusting strategies was critical in this case. Not only did IDE interact with others, its was willing to use this as a way of gathering information on what sorts of pumps were preferred (treadle rather than rower) and latter on collecting market information on the price sensitivity of consumers and the need to introduce a range of differently priced models. Further more it was willing to act on this information and alter its strategy, sometimes radically, with a view to succeeding in establishing a self sustaining supply chain. The different habits and practices of the two IDE country programmes in India and Bangladesh illustrate impacts different institutional contexts can have on innovation and consequently programme performance.
5. **Market demand.** An important element of innovation capacity comes from the incentives and information markets create for manufactures to first produce and then later produce new products in response to changes in that market. IDE succeed in developing this level of market demand and then adapted its own

approach based on technical innovation observed in the market. The market it created for water and related service in rural areas has allowed further technical innovation through the opportunities created for the introduction and use of diesel pumps.

6. **Policies and institutional innovations to provide incentives for stakeholder participation**. Multi stakeholder participation in sector development is important both because some stakeholders have critical roles – for example the private sector; But also because the needs of specific stakeholder particular poor ones needs special attention. In this case a key policy affecting innovation capacity was the use of price subsidies by some agencies -- this was discouraging the private sector from manufacturing pumps.

5. Policy implications.

This paper began by suggesting that viewing technological change not in terms of technological scarcity, but in terms of innovation capacity could help tackle the conundrum of how to organise technology development and promotion. The relatively successful case of IDE's treadle pump programme in Bangladesh provides evidence that that recent systems conceptualisations of innovation capacity can be empirically supported. Ironically, the of IDE's efforts in India demonstrates precisely why linear approaches to technology transfer rarely work. What then are the policy implications of this?

5.1 The role and relative importance of research in technical change and rural innovation strategies needs to be reassessed.

If the treadle pump case is typical it suggests that the key challenge is not the creation of new ideas, but rather adaptation and use of existing one. Knowledge scarcity is greatest at the knowledge frontier and it is here where research is important as a way of generating new ideas and information. However, most rural develop challenges and opportunities are not situated at the knowledge frontier. The capacity for creative imitation and adaptation to local conditions therefore assumes much greater importance than research. A related point is that even where research and technology development are required, this is only a relatively minor component of the innovation process and there are a whole range of activities and processes that also need to be invested in -- these centre on strengthening networks and learning rather than transferring technology per se.

5.2 Interventions to promote self organising systems.

There is now growing recognition that the networks of interaction and learning that give rise to innovation are most often self organising. That is to say they do note arise from specific interventions but by the response of actors to market and other signals -- a recent World Bank (2006) study describes this as an opportunity driven innovation trajectory, in contrast to an orchestrated innovation trajectory. Of course in many case this process of self organisation becomes limited for one reason or another, or as in the treadle pump case simply fails to occur unless an external agent like IDE intervenes.

This suggests the important role that organisations like IDE could play in helping establish networks when the market is not sufficiently developed to provide the incentives to do so. Similarly such coordinating organisations are also important in strengthening networks and interactions that market incentives will never be able to create. An other way of looking at IDE's role here is to see it building the capacity for self organisation, both by developing new types for market demand (for pumps or water supply services) and by building the social capital needed to make self organisation easier.

Biggs et al (2002) exploring the spread of power tillers in Nepal noted that because of this process of self organisation many processes of mechanisation are now underway with a wide range of technical and socio economic outcomes. The parallels with the micro-irrigation technology in Bangladesh are obvious. Biggs and his colleagues argues that policy can only start to contribute and strengthen these process of innovation by monitoring them, especially from a socio-economics and sustainable innovation systems perspective, so as to inform government policy or inform the activities of projects and programmes where mechanization is a component.

5.3 Existing pro-poor institutional innovations in technology development and promotion can provide lessons for wider practice.

The IDE story in Bangladesh is an obvious example of an institutional innovation in technology development and promotion has had tangible and widespread poverty reducing impacts. There are surely many other cases that policy could learn from. Judging by the India part of this story, however, even learning and sharing lessons within one organisation can be difficult. Two issues that need to be dealt with if more is to be made of lessons from practice. Firstly, there is not a strong tradition of systematically learning lessons from development programmes. In contrast to the management literature where the case study is king, evaluations tend to focus on quantitative measures of performance and have limited diagnostic ability in learning lessons on process. Where qualitative approaches are used, funding imperatives tend to encourage success story documentation. Biggs 2005 identifies methods such as appreciative enquiry as a way of identifying promising institutional innovations and suggests that governments should use this to scan for opportunities.

Secondly, far too few programmes rigorously monitor the poverty reduction impacts and as a result evidence for policy change is weakened. Even in the IDE case, no systematic monitoring of poverty impacts was undertaken by IDE. It is only because a number of reviews and surveys by different agencies provide sufficient triangulation that a pro-poor label be given to their approach with some degree of confidence.

5.4 The new innovation capacity strengthening agenda.

The above points taken together suggest that dealing more effectively with technology promotion is a question of strengthen innovation capacity. This means that policy needs to focus on building networks of interaction and learning to enable new and existing knowledge to be put into use. This may be achieved through coordination or by providing stronger incentives and help for self organisation. Policy also needs to strengthen learning at all level – in organisations, in sectors and between different development domains and countries. Finally institutional change is critical and ways of

stimulating this and identifying new sources of institutional innovation is the most presses task in strengthening this capacity

.

The donor community needs to pay particular attention to this point as long term investments are needed to create the capacity to make productive use of science, technology and knowledge in the development process. A focus only on research, technology development and transfer will not satisfy this need and will not bring about the social transformations that international development assistance wishes to achieve. As science and technology is once again moving up the agenda of a number of donors, great care must be given to ensuring that the same mistakes of the 1960' and 1970's of building scientific infrastructure with no operational links to the actors and process that bring about innovation are not repeated. Its hoped that the story of IDE treadle pumps will help guide how to move ahead in what are still very much uncharted waters.

6. Conclusion.

The conundrum of how best to organise technology development and promotion remains at the heart of the quest to make more effective use of science, technology and other sources of knowledge in the development process. The case of the two contrasting programme of IDE in India and Bangladesh suggests that shifting towards a systems view of innovation and innovation capacity are justified and would help policy make long overdue corrections in approach.

V Some Concluding Remarks

The lessons for technology development more generally are equally clear. Donor interventions that do not make serious attempts to build long-term capacity will always represent an inefficient use of scarce resources. The evidence is abundantly clear that such interventions are all too common in many parts of the developing world. What is sad about the IDE case in India is that an organisation set up precisely to deal with this issue directly (to meet it head-on as it were), has been unable to follow through in practice despite having had success before in a cognate area. One would hope that international bodies concerned with technology development for the rural poor would pay close attention to cases such as this and draw appropriate lessons. If they do not the waste if resources will certainly continue.

References

Bell. M (2006) Background paper for the L20 workshop on Furthering Science and Technology, March 2006 UNU-MERIT Maastricht http://www.l20.org/publications/21_sY_Sci_background_Bell.pdf>

Biggs, S., and Clay. E (1981) Sources of Innovation in Agricultural Technology World Development, Vol 9, No 4, pp. 321

Biggs, S. (2005). Learning from the positive to reduce rural poverty: Institutional innovations in agricultural and natural resources research and development. Paper prepared for the Impact Assessment Workshop organized by the CGIAR Systemwide Program on Participatory Research and Gender Analysis for Technology Development and Institutional Innovation (PRGA) and the International Maize and Wheat Improvement Center (CIMMYT) on 19–21 October 2005 at CIMMYT Headquarters, Mexico.

Biggs, S., Justice S, Chanda Gurung, J. Tripathi, and Ganesh Sah (2002) The Changing Power Tiller Innovation System in Nepal: An Actor-Oriented Analysis. Paper prepared for a workshop on Agricultural and Rural Mechanization, Bangladesh Agricultural University, Mymensingh, Bangladesh. 2nd November 2002.

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

Byerlee, D and Echeverria, R.G 2002 Agricultural Research Policy in an Era of Privatization: introduction and overview. In Byerlee, D. and R.G. Echeverria (eds) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI. pp300

Chambers, R. and Ghildyal, B (1985) Agricultural Research for Resource Poor Framers - the Farmer First and Last Model. Agricultural Administration 20: 1-30.

Clark N G (2002) Innovation Systems, Technology Assessment and the New Knowledge Market: Implication for Third World Development. Economics of Innovation and New Technology, Vol. XI, Nos. 1 & 2.

Clark, N, G., Hall, A.J., Rasheed Sulaiman V., Guru Niak (2003) Research as capacity building: the case of an NGO facilitated post-harvest innovation system for the Himalayan Hills. World Development 31(11): 1845-1863.

Collinson, M.P, (1987). "Farming systems research: procedures for technology development" Experimental Agriculture, Vol. 23, pp 365-386.

Douthwaite, Boru, (2002), *Enabling Innovation: A Practical Guide to Understanding and Fostering Technological Change*. Zed books

Downing, J and Polack, P. (2000) The development and commercialisation of the treadle pump in Bangladesh: A case of product marketing on a mass scale.

Edquist, C. 1997. Systems of Innovation Technologies, Institutions and Organizations. London: W.W. Norton.

Freeman, C. 1987. Technology Policy and Economic Performance: Lessons from Japan. London: Frances Printer.

Gass, G. and S. D. Biggs, 1993, "Rural Mechanisation: A Review of Processes, Polices, Practice and Literature", Project Appraisal, Vol. 8(3), pp. 157-187

IDE undated. Action plan-4, NBTDP phase-III Inception report: Promotion of private sector involvement in manual irrigation

Hall, A.J. 2005. "Capacity Development for Agricultural Biotechnology in Developing Countries: An Innovation Systems View of What It Is and How to Develop It. Journal of International Development 19(5): 611-630.

Hall, A.J. 2006. "Public-Private Sector Partnerships in a System of Agricultural Innovation: Concepts and Challenges." International Journal of Technology Management and Sustainable Development 5(1).

Hall, A.J., M.V.K. Sivamohan, N. Clark, S. Taylor, and G. Bockett. 2001. "Why Research Partnerships Really Matter: Innovation Theory, Institutional Arrangements, and Implications for Developing New Technology for the Poor." World Development 29(5): 783-797.

Hall, A.J., Rasheed Suliaman V., N.G Clark MVK Sivamohan and B Yoganand. (2002) Public–private sector interaction in the Indian agricultural research system: An innovation systems perspective on institutional reform. Chapter in Byerlee, D. and R.G. Echeverria (eds) Agricultural Research Policy in an Era of Privatization: Experiences from the Developing World. CABI.

Hall, A.J., Rasheed Suliaman V., Clark, N.G. Yoganand B. (2003) From measuring impact to learning institutional lessons: an innovation systems perspective on improving the management of international agricultural research. Agricultural Systems 78 (2003) 213-241

Hall, A.J., B Yoganand, Rasheed Sulaiman V., Raina, R, Prasad, S, Niak, G and N.G Clark. (Eds) (2004) Innovations in Innovation: reflections on partnership and learning. ICRISAT, Patancheru, India and NCAP New Delhi, India 238pp

Hall, A. J (2007) Building agricultural innovation capacity in developing countries: requirements and lessons. Panel paper presented at the Global Science, Technology and Innovation Forum, 14 -16 February 2007, World Bank, Washington DC.

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

Polak P (Undated) How IDE installed 1.3 million treadle pumps in Bangladesh by activating the private sector: The practical steps. Access at http://www.its.caltech.edu/~e105/readings/cases/IDEtreadle.pdf

Schumacher E F (1973) Small is Beautiful London, Sphere Press

Shah T, Alam, M., Dinesh Kumar M., Nagar, R.K and Singh, M. (2000) Pedling out of poverty: Social Impact of a Manual Irrigation Technology in South Asia. Research Report No 45, International Water Management Institute, Colombo, Sri Lanka. 36 pp

Spielman, D. J. and von Grebmer, K. 2004 Public-private partnerships in agricultural research : an analysis of challenges facing industry and the Consultative Group on International Agricultural Research 2004.. 53 p. -- Washington, D.C. International Food Policy Research Institute (IFPRI). EPTD Discussion Paper No.113.

Rasheed Sulaiman, V. and Hall, A (2005) Extension Policy at the National Level in Asia. Plant Production Science Vol 8. No 3.: 308 -319

Richards, P. (1985) Indigenous Agricultural Revolution. Hutchinson, London

Srinivas, S.N. and Jalajakshi, C.K. (2004) Alternatives to Micro-irrigation: Evaluation of the treadle pump. Economic and Political weekly, September 18 2004

Starkey, P., (1987), Animal-drawn Wheeled Tool Carriers: Perfected Yet Rejected, Berlin: G/T/Z

F. van Steenbergen (undated) The market for the poor: treadle pump promotion in India, Water Praxis Document, Land & Water Product Management Group, Archadis Euroconsult, the Netherlands 16 pp

World Bank (2006) Enhancing Agricultural Innovation: How to go beyond the Strengthening of Research Systems. Economic Sector Work report. The World Bank: Washington DC pp149

The UNU-MERIT WORKING Paper Series

2007-01 *Developing science, technology and innovation indicators: what we can learn from the past* by Christopher Freeman & Luc Soete

2007-02 *The impact of innovation activities on productivity and firm growth: evidence from Brazil* by Micheline Goedhuys

2007-03 *Estimations of US debt dynamics: Growth cum debt and the savings glut in Kouri's model* by Thomas Ziesemer

2007-04 *States and Firms on the Periphery: The Challenges of a Globalising World* by Gabriel R.G. Benito & Rajneesh Narula

2007-05 *How Do Consumers Make Choices? A Summary of Evidence from Marketing and Psychology* by *Zakaria Babutsidze*

2007-06 *Inter-firm Technology Transfer: Partnership-embedded Licensing or Standard Licensing Agreements?* by John Hagedoorn, Stefanie Lorenz-Orlean & Hans Kranenburg

2007-07 *The Behavior of the Maximum Likelihood Estimator of Dynamic Panel Data Sample Selection Models* by Wladimir Raymond, Pierre Mohnen, Franz Palm & Sybrand Schim van der Loeff

2007-08 *Location and R&D alliances in the European ICT industry* by Rajneesh Narula & Grazia D. Santangelo

2007-09 *How do social capital and government support affect innovation and growth? Evidence from the EU regional support programmes by Semih Akcomak & Bas ter Weel*

2007-10 *The Micro-Dynamics of Catch Up in Indonesian Paper Manufacturing: An International Comparison of Plant-Level Performance* by Michiel van Dijk & Adam Szirmai

2007-11 *Financial Constraint and R&D Investment: Evidence from CIS* by Amaresh K Tiwari, Pierre Mohnen, Franz C. Palm & Sybrand Schim van der Loeff

2007-12 *The Spatial Hierarchy of Technological Change and Economic Development in Europe* by Bart Verspagen

2007-13 *The origins and implications of using innovation systems perspectives in the design and implementation of agricultural research projects: Some personal observations* by Andy Hall

2007-14 *Technology supply chain or innovation capacity?: Contrasting experiences of promoting mall scale irrigation technology in South Asia* by Andy Hall, Norman Clark and Guru Naik