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Rural Development & Energy Policy

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Abstract

The purpose of this paper is to reopen policy debates on the role of agricultural mechanisation in rural development. The paper examines very different and diverse patterns of agricultural mechanisation in some South Asian countries over the last 30 years. In Bangladesh, Nepal and Sri Lanka the process was facilitated by the import of inexpensive Chinese diesel engines that powered small two-wheel tractors, pumpsets, threshers, trailers and other rural equipment. Bangladesh now has one of the most mechanised and labour intensive agricultural sectors in South Asia. The spread of small scale equipment was accompanied by the spread of very diverse market institutions for the buying and selling of tractor, pumpset, transport and other services. India followed a different path. The paper concludes with a discussion of old and new themes in the debate. These include a discussion of the remarkable diversity in recent patterns of mechanisation; the central role of a cheap energy policy for understanding patterns of mechanisation and agricultural growth in general; the influence of special interest groups (commercial, bureaucratic and profession/academic) in policy debates; and the need for economic/technical input output and social accounting models in rural development policy analysis and planning.

Introduction

The purpose of this paper is to reopen policy debates on poverty reduction, mechanisation, worthwhile jobs and livelihoods in rural areas. In particular, to highlight the critical role of engineering, energy and trade policy in influencing agricultural and rural mechanisation processes that can help rural poverty reduction. As such, the paper is concerned with the welfare of poor people living in rural areas and the rural engineering and mechanisation dimensions of this. This concern is based, in part, on the recognition that globally, it is in rural areas that the greatest numbers of poor people live and, on the demographic projections and propositions that no amount of "urban" development or the promotion of international "remittance economies" to provide employment for people from rural areas, has the capacity to provide worthwhile jobs, safety nets and services for rural people.

This concern with rural development takes us back to the central issues of development policy debates of the 1960s and 1970s, where sustained rural development was seen as an important goal of public policy. In those debates rural and agricultural mechanisation, employment, inter sector linkages, multiplier effects, and decentralised rural economic growth were central themes to the discussions.

However, since then we have seen the selective promotion of a neoliberal agenda by international agencies and governments and the debates on mechanisation have declined[1]. Where agriculture has been discussed, policy and academic attention has been given to the past role of seeds and associated agricultural inputs such as pesticides, fertiliser and, sometimes, irrigation and the role of rural and agricultural mechanisation and energy policy receiving far less attention.

In the West, departments of agricultural engineering were going through challenging times. Institutes in universities and engineering departments in the centres of the Consultative Group for International Agricultural Research (CGIAR) were closed, the latest, in 2007, the FAO's Agricultural Engineering Directorate. The lack of mechanisation policy analysis is illustrated by the exclusion of agricultural and farm mechanisation issues in the International Assessment of Agricultural Science & Technology and Development (IAASTD, 2008) and the Global Conference for Agriculture Research for Development (GCARD March 2010). While there was some support for alternative engineering interests in Universities in Asia and promotion of alternative energy initiatives around such things as cooking stove improvements, small scale food processing, biogas, and mini/meso hydro, general interest in these types of alternatives declined, especially as regards being integrated in a substantial way into mainstream policy support[2].

Notwithstanding the lack of policy debates in South Asia during this time, there have been great transformations in agricultural mechanisation in different regions. As we will see, this has taken place in very diverse ways and helped give rise to widely different outcomes.

The structure of this paper is first to describe, briefly, some major agricultural mechanisation changes in South Asia. Then, to look in more detail at Nepal to illustrate the importance of the location specificity of contemporary mechanisation policy debates not only for the more obvious agro-climatic reasons, but also for the equally, if not more, important economic, historical, political, cultural and other institutional dimensions of policy practice. We conclude the paper by referring back to some of the debates of the 1970s to see what issues are old and what are new. This paper concentrates on diesel based patterns of mechanisation as these are the dominant power sources for the machinery currently in use. In the future, alternative sources of energy for powering agriculture and rural machinery will become more important. National and international energy policies and agreements will play a major role in influencing these patterns and how benefits and costs are distributed[3].

Before we start we need, briefly, to discuss data problems, as this is an area where indicator and data collection problems abound.

Data Problems

The problem of what to count as an indicator of agricultural mechanisation is well illustrated by the FAO's definition of "tractors". The FAO's definition of agricultural tractors only includes 4-wheel tractors (4WTs)[4] and does not include 2-wheel tractors (2WTs), although they perform all the same tasks as 4WTs. Consequently by this 4WT definition of agricultural mechanisation, Bangladesh's agriculture is hardly mechanised. The reality is that Bangladesh has one of the most mechanised agricultures in Asia, as a result of the spread of small-scale Chinese single cylinder diesel engines that power 2WTs, pumpsets and many other types of equipment. Of course, there are many other indicators of mechanisation, but they all have their strengths and weaknesses and associated measurement problems. The indicator problem is compounded by the "ladder of mechanisation" theories found in some engineering and social science literature that promote the idea that as the agricultural sector develops, it uses larger scale equipment on large scale holdings. Large tractors, complex cultivation, seeding drills and combined harvesters are at the top. Indeed, mechanisation of this type is seen in some regions of some countries but as we will see, this linear model is not often reflected in the diverse patterns of mechanisation and service markets found in recent mechanisation transformations in South Asia[5].

The second problem is one of measurement even when there is agreement on a useful indicator for mechanisation. It is really difficult to estimate the number of pieces of equipment being used at a given time in a given place, let alone to find out who owns it and their nationality[6]. For example, the number of irrigation pumpsets and tractors working in a particular region. Some might exist but need repair, some might be in working order but spare parts are not easily available, etc. In the case of tractors, one might get an estimate of numbers by studying registration and importation documentation; but tractors of any size and combine harvesters are remarkably mobile and do not always stay where they are registered. In addition, engines of diverse origins can be repainted, relabelled in a whole variety of ways. In countries where government/donor projects are present, all of the familiar problems exist of agencies monitoring and evaluating the spread of their own hardware and sometimes making claims of success; this cannot be reconciled when all the numbers of the competing claims are added up. With the promotion of neoliberal policies, few efforts have been made to establish reliable national or regional figures for mechanisation policy debates. This means that the empirical basis for policies relating to mechanisation is often inadequate, open to the speculative use of figures and open to criticism of the use of data[7].

Overview of the Diversity of Recent Agricultural Mechanisation in Asia

The spread of small Chinese engines in South Asia

Central to the transformations in Bangladesh, Sri Lanka and Nepal have been Chinese engines powering pumpsets, 2WTs and their attachments, threshers, various transporters (motorized three-wheelers, etc) and other equipment. In the 1970s, some might have thought that 2WTs and engines from Japan and South Korea would have been the way forward for some countries/regions with smaller farms and/or land fragmentation. Others might have thought that the subsidised Indian agricultural machinery sector would have developed suitable smaller scaled equipment for such conditions in Eastern India and this might have spread to neighbouring Bangladesh, Nepal and Sri Lanka. No one was thinking about engines from China. As it has turned out, it has been the Chinese agricultural engineering industry that has made the most significant engineering contributions, as regards rural poverty reduction and agricultural growth in Bangladesh, Sri Lanka and, lately, Nepal.

In the late 1970s and early 1980s, small scale mechanisation was taking place in China in a very different way from Japan and South Korea. In China the initial focus was on producing small horsepower pumpsets and tractors, at lower levels of technical efficiency and at significantly lower cost. When China began exporting this equipment, in the mid 1980s, they could undercut the price of the Japanese equipment by over half. However, as many Japanese and Korean manufacturers and agricultural engineers in Asia pointed out, although the Japanese and Korean products were of superior quality, this quality came at a price and, essentially, this priced the equipment out of the reach of the majority of small farmers and rural entrepreneurs, who might have bought this equipment. While the Chinese equipment can be termed as of lower quality, it was 'good enough' and relevant to the economic circumstances faced by farmers with fragmented/small plots and rural entrepreneurs who bought the equipment and hired it out[8]. These features help to explain the continuing spread of Chinese engines in many parts of the world.

India's Dominantly Large Scale Agricultural Mechanisation

India has a long history in the development and promotion of tractors and a tractor industry[9]. India is now the number one producer of 4WTs in the world, and its exports are growing with markets in the USA expanding (Radjou, 2009). Today, there are over 20 factories producing nearly 300,000 tractors per year with an estimated total population of 4WTs of 2.8 million (Singh and Roy 2008). Interestingly, India's agriculture is far less mechanised than its neighbours Bangladesh and Sri Lanka, where Chinese engines and equipment are used. While India has 22% of its area under mechanised tillage Bangladesh and Sri Lanka both have about 80% mechanised (Kulkarni 2009)[10]. While India's agricultural conditions are far more diverse than Bangladesh and Sri Lanka, some of this lower level of mechanisation can be explained by the small numbers of 2WTs in India. There are only 110,000, which is a third of the number in Bangladesh.

Even support for joint venture projects with Japan and South Korea and a policy of 20-30% subsidies for 2WTs, offered over nearly three decades, has not resulted in the major spread of 2WTs in India. Some importers and manufacturers suggest that past protectionist policies and subsidies for the 4WT tractor industry may explain some of this (Justice and Gurung 2003).

Within India the incidence of mechanisation is extremely varied with large regional disparities (highest mechanisation in the Punjab and Haryana). Past policy emphasis on larger equipment (4WTs, combines, large pumpsets) appears to have contributed less to the mechanisation needs and service markets of small/fragmented farmers[11] and labourers, especially in the major poverty quadrangle of eastern UP, Bihar, West Bengal, Orissa and the Deccan plateau. These are rural areas with high population densities, some of which are approaching those of Bangladesh and the Terai of Nepal.

Bangladesh's Highly Mechanised and Labour Intensive Rural Economy

The history of agricultural and rural mechanisation in Bangladesh cannot be more different from that of India. By many criteria, Bangladesh has a remarkable history of mechanisation. In this the Bangladesh Government and the Bangladesh private sector both played important roles.

In the early 1970s, when Bangladesh was characterised as a "basket case" by some international development specialists, no one was forecasting that Bangladesh would, in 2010, have one of the most mechanised agricultural economies in South Asia (Mandal, 2002, Islam, 2009). Significantly, while most of the wheat and rice crop is threshed by machines, there are no combine harvesters[12]. 80% of primary tillage operations are mechanised, performed mainly by 300,000 small 2WTs and a few (3,000) 4WTs. There is a highly developed market for tractor services, pumpset services, threshing and other services derived from the use of small engines. 55% of land cultivated is under irrigation. Most of this is from ground water and surface water sources using small pumps. In 2006 it was estimated that of the 4.62 million hectares (mha) irrigated from groundwater sources, 3.12 mha (68%) was from shallow tubewells, 0.80 (mha 17%) from lowlift pumpsets and, 0.7 mha (15%) from deep tubewells (Singh and Roy 2008)[13].

Perhaps the main reason for the rapid spread of 2WTs in the 1990s was a major change in policy in the late 1980s as a result of a national food crisis. After a cyclone hit Bangladesh in 1988 within two-and-half years of a previous one, taking not only a major toll on human life, but also on the oxen population, President Ershad asked what machinery would be most appropriate for their quick replacement.

He was told that the Chinese 2WTs tractors could do this, but due to the standards committee they could not be imported. To overcome this problem, Ershad simply disbanded the committee. This action, combined with market liberalisation and the lowering of tariffs, resulted in what could be termed as a flood of small engines and associated tillage, pumping and other equipment. What had started with the import of small Chinese irrigation (diesel) pumpsets in the 1970s and 1980s was quickly followed by the major imports of 2WTs in the mid-1990s. Furthermore, for as yet not well understood reasons, the Bangladesh private sector (as compared to the private sector in Nepal or India) focused on the imports of smaller scale machinery. This has led to the present numbers of over one million small horsepower diesel irrigation pumpsets and nearly 400,000 diesel 2WTs. Coupled with the more recent spread of tens of thousands of small scale mechanised rice, wheat, and maize threshers, mainly powered by the Chinese diesel pumpsets, this makes Bangladesh possibly the most mechanised, labour intensive agricultural sector in South Asia, with substantial employment and other growth linkages to other sectors. Without this small scale mechanisation, there would have been no significant growth in agriculture and no "Green Revolution" in Bangladesh. During this period, Bangladesh was also able to capitalise on its large energy resources, namely the extensive gas deposits that have been used for, amongst other things, urea production.

Nepal's Mixed Agricultural Mechanisation

In this section we look at the spread of some specific types of agricultural equipment in Nepal. We could have picked any number of examples, but have selected ones in which we have worked over the years and which reflect some important lessons as regards pro poor mechanisation, production efficiency, and innovation processes. The examples are 2WTs, diesel irrigation pumpsets and flexible delivery pipes, and the biomass stove.

1960 1970 1980 1990 2000 2010

Traditional water mills (ghattas) .... Improved water mills ....

4-wheel tractor/trailers ....

Small hp Indian irrigation pumpsets .... Chinese diesel pumpsets ....

Two-wheel tractors/trailers Kathmandu & Pokhara Valleys ....

Wheat Threshers- powered by pumpset's diesel engine ....

Hand-cranked winnowing fans ....

Combine Harvesters ....

Two-wheel tractors-rest of Nepal

Rice threshers-eastern Nepal

Reapers, 2 & 4 WTs

Figure 1. Start of the Spread selected Agro-Machinery in Nepal

Nepal has great diversity of agroclimatic conditions, the more obvious represented by the flat lands of the Terai (Gangetic plains), valleys of the hills, and the lands of the high Himalayan mountains. It also has an incredible diversity of cultures, ethnic groups, inequalities in ownership of land and other resources, and other economic conditions. It has a long open southern boarder along the Terai with India.

Before the 1970s, there was little mechanisation in Nepal except for such things as traditional methods for using the power of gravity (falling water, ropeways, etc). There are thousands of traditional water mills (*Ghatta*) in use, primarily used for grinding grain. Their technical efficiency has increased over the years with new and locally produced turbine blades fitted to the existing mills.

Since the 1970s the mechanisation picture[14] has changed significantly and it is now estimated that most of the wheat in theTerai is threshed by machines, generally powered by the engines of Indian and now Chinese pumpsets[15]. Rice threshers are beginning to spread in Nepal's eastern Terai which borders eastern Bihar. 15-20% of tillage is mechanised, and there are at least 100,000 small scale irrigation pumpsets. In addition, the rapidly growing horticultural, poultry, dairy and animal feed industries and other “value added chains”, based on agricultural and other rural resources, are using mechanical equipment of one type or another in production, processing, transport and marketing activities.

The first agricultural mechanisation project in Nepal was the early introduction and promotion of 4WTs, on the Terai, in the 1960s and 1970s (Pudasaini 1976). This came about not only as a result of government and donor support policies but also because of the long open border with India, where 4WTs and combined harvesters were being promoted as “the” symbol of a modern, commercial and efficient agriculture. From the 1970s onwards all the major Indian tractor companies established sales agencies across Nepal, the latest including multinational companies such as John Deere and New Holland, with manufacturing bases now in India. Current estimates of the total number of 4WT's in Nepal, with an average HP of over 30, are thought to be in the range of up to 30,000. From the mid-1990s onwards large combine harvesters with Indian licence plates began entering Nepal and, today, there are many, Nepali owned, operating on a contract basis across Nepal's Terai.

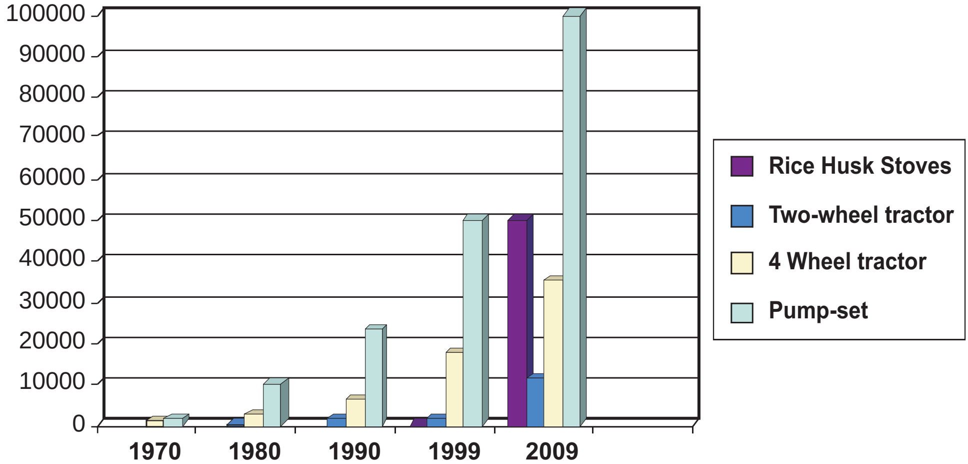

Figure 2. Number of 2 wheel tractors, 4 wheel tractors, pump-sets and biomass stoves in Nepal 1970-2009.
(Source Pariyar, Shrestha and Dhakal, 2001, authors estimates)

While the sale of 4WTs continues to grow, several authors have noted that the relevance and potential for 4WTs in Nepal is quite low. This is due to the widespread fragmentation of holdings, and the low average holding size (national average of 0.98 hectare). One of the reasons for the continued sales of 4WTs is that all tractors are multifunctional and their engines can be used for a wide range of activities. In Nepal a large number of 4WTs are used, primarily, as road transport vehicles. This is partly due to the tractor import tariffs being only a small fraction of those for transport trucks. An understanding of the spread of 4WTs in Nepal would require an analysis of the ownership of tractors (on both sides of the boarder), the way tariffs and other regulations in Nepal and India are actually implemented, and the various uses of tractors and transport vehicles on the Indian and Nepali Terai. While such analysis would be necessary for policy prescriptions to be made, it is beyond the scope of this paper.

The spread of 2-Wheel Tractors in Nepal

In the mid-1970s and early 1980s there were concerted efforts to promote 2WTs. Two projects of the Japanese International Co-operation Agency promoted the importing of Japanese 2WTs. This promotion along with subsidies from the Nepal Agricultural Development Bank in the 1980s led to the private sector importing approximately 2,000 Japanese, South Korean and occasionally Indian and Chinese 2WTs. Once the subsidies for the Japanese 2WTs finished they were rarely imported and, slowly, the less expensive Chinese ones became popular. Initially the spread of all 2WTs was limited to the Kathmandu and Pokhara valleys. The 2WTs were used in multiple ways and markets developed for tractor services. They were used, primarily, for agricultural operations and transport services in the construction industry. Generally, agricultural labourers would operate the 2WTs and negotiate the hiring out of the equipment on a contract basis. Agricultural demand was seasonal and especially high for land preparation.

The 2WTs were particularly suitable for the urban construction industry, as they could negotiate the very narrow and winding streets of urban areas. However, due in part to a steady or even increasing sale of

2WTs, in 1993, the city governments of Kathmandu and Pokhara banned further registration in the valleys, as city administrations perceived that the tractors were being used primarily for construction haulage and not for agriculture, and were aggravating growing traffic congestion. Although not the intent, the “urban” ban on 2WTs resulted in the farmers in the larger zones, surrounding Kathmandu and Pokhara, not getting access to the services of more 2WTs. What happened was that the old stock of Japanese, Korean and other 2WTs were maintained and even after 30 years some of the Japanese 2WTs are still in use. As a result of the ban other things happened as well: for example, 2WTs being registered in other zones in the country and then used in Kathmandu.

By 2000, the only 2WTs in Nepal, more or less, were the ageing populations in the Pokhara and Kathmandu valleys, which had been imported before the 1993 ban. However, by this time there had been a number of small donor supported R&D projects in the mid 1990s that had promoted the cheaper Chinese 2WTs on Nepal's flat land (Terai). This succeeded in getting Nepal's agro-machinery merchants to re-start importing 2WTs and marketing them in the areas where the projects were operating on the Terai. Since the 2000s, there has been an increase in 2WT sales, with numbers approaching 1000 per year in 2002. Sales during the Maoist insurgency dropped to 500 per year. Since the Maoists joined the government, sales have climbed back and now are estimated to be at over 1200 in the past year. The national total in 2009 is estimated to be 11,000 2WTs (NAEF 2009). The financial economic rates of return (even without government subsidies) on 2WTs have always been very high. Many rural entrepreneurs have become service providers to surrounding villages. They sell a range of tillage, haulage and other services.

Spread of Pumpsets and flexible pipes

Subsidised programmes for pumpsets and shallow tube wells (STWs) involving the Agricultural Development Bank, Nepal (ADBN) were introduced by the government in the late 1970s. They were designed to promote and expand year-round irrigation for farmers, mainly on the Terai. The sole source of the pumpsets was India which still manufactures these very heavy, expensive old model diesel pumpsets. While some argue that the present spread of pumpsets has come about as a result of the earlier ADBN programmes, others argue that the largest change in the STW sector, in recent years, is the appearance of the light weight, inexpensive Chinese diesel pumpsets combined with the locally produced “lay flat” delivery pipe (NAEF 2009). In 2003, there were two separate but semi coordinated efforts by two NGOs[16] to promote the Chinese pumpsets. Both had extensive experience in Bangladesh and had seen the huge impact that these irrigation pumpsets had had there. Both NGOs supported separate Nepalese importers who, by 2004, had begun selling the cheaper Chinese pumpsets in Nepal[17]. Estimating the current number of pumpsets in Nepal is difficult. The official estimate of shallow tubewells (with a pumpset), in 2001, was close to 80,000[18]. However, the statistics do not include pumpsets that were bought outside official government programmes. If we take all purchases into account, and the promotional activities of NGOs, it is likely that there were over 100,000 working pumpsets in Nepal by the end of 2009. In most cases the pumpset engines are used also for powering wheat and rice threshers, mills and other rural engineering equipment.

Alongside the expansion of the Chinese pumpsets, there has been the rapid spread of equipment that has increased the efficiency of field level water management. This is the locally produced flexible “lay flat” hose pipes. These are flexible, easy to move plastic pipes that take water from the pumpset to where it is needed in the field. They can be rolled up for transport when not in use. It is estimated that there is a 30%-50% saving in water as compared with conventional field canals - as there is no canal infiltration loss nor the need for digging tertiary ditches in the fields. Alongside the spread of pumpsets and lay flat hose pipes, have been the spread of many market institutions for the buying and selling of water, threshing, transport and other services, arising from the spread of the small scale engines.

Spread of Biomass stoves

Most of Nepal's 25 million population lives in rural areas and relies on wood and other rural biomass for cooking. This is putting pressure on forest resources. There is a long history of engineers trying to improve stoves in Nepal and elsewhere that goes back to the 1960s. We are not going to review those activities here. We concentrate on one type of stove; the biomass stove (also known as rice husk stove) that relies on the principles of pyrolysis to convert biomass into gas, which then burns to give heat. The stove produces a very hot flame and produces little or no smoke. The stove originally came from Vietnam and was developed and promoted across Asia by the International Rice Research Institute (IRRI) in the 1970s.

In the 1990s, there were two small government initiatives to develop and promote the biomass stove which had come from the International Rice Research Institute in the Philippines, in the 1970s. One was in the Nepal Academy of Science and Technology; and the other, in the Agricultural Engineering Division (AED) of the Nepal Agricultural Research Institute. Both met with little or no success.

In 2000, a member of a local NGO saw the stove demonstrated and in discussions with the staff of AED they thought that, with increasing prices for fuel, perhaps the time for the biomass stove had come. Thus, they decided to demonstrate and test market the stove on the Terai. The NGO fabricated 25 pieces for training, demonstration and sales purposes in its workshop, on the Terai, using the heavy duty design from the AED. Initial reaction by rural households was very positive but nearly everyone complained that the cost (approximately $12.00 - 13.00) was too high. The formal promotional work on the Terai stalled soon after, in 2003, due to the increasing conflict in Nepal. The NGO and AED staff were unable to get to the villages where the 25 stoves had been distributed.

In the summer of 2006, the conflict ended and the NGO found as many as 200 pieces in use. Several blacksmiths in the area had reduced the costs by changing to a lighter design (the Vietnamese 'Lo Trau' stove) that one of them had seen at a nearby industrial fair after the NGO and AED had introduced the stove into the area, in 2004. The lower cost stove used scrap sheet metal hereby reducing the cost by half, to about $5.00 to $6.00. Since then the NGO has helped train small and medium manufacturers, one of which has scaled up its production to over 150 units per day and in March 2009, was planning to produce a similar number across the boarder in Gorakpur, India. Recent accounts from two other districts in Nepal report there are other NGOs and many manufacturers now promoting and making stoves in eastern Nepal. Conservative estimates put the current number of agricultural biomass stoves at the end of 2010 at nearly 100,000 pieces.

When the stove was first introduced, rice husk was generally obtained free from rice mills in the area, as the millers would often just burn it.

Since then rice husk has increased in value and is now being carted away along with the milled rice by the owners. In response, households, especially poorer households, have been finding alternative fuel for the stoves, such as chopped wheat and rice straw.

The recent spread of the biomass stove is interesting as it appears to follow an often theorised about, but rarely seen, "S" shaped "adoption curve", which many research and development groups would like to be associated with. The effective demand for the stove, especially by poorer households and the increases in fuel prices (and other energy sources), have been the main economic reasons for its spread over the last 10 years. The long history and the nature of its introduction into Nepal are instructive. How the less expensive Vietnam Lo Trau model turned up, unsolicited, at the fair in Nepal around 2005 is still a mystery being investigated. It is worth speculating that perhaps the spread curve of the Vietnam biomass stove in Nepal might have started earlier, and been of a different shape, if there had been direct contact and exchange of information between Nepal and Vietnam earlier.

Reasons for the Spread of Agricultural Engineering Technologies in Nepal

The examples of the spread of different types of agricultural engineering technology in Nepal all illustrate the importance of their usefulness in the eyes of users in the specific socio-economic contexts in which they live. In all our cases, specific market institutions for the dissemination of information, for services, purchase, repair, manufacture, etc. co-existed with the "hardware". The biomass stove sat on a shelf in an agricultural engineering department for many years until poor households on the Terai got to see it working. It appears that the government and international engineers who drew up shallow tubewell irrigation programmes, for many years for Nepal, were unaware of, or chose to ignore, relevant engineering information on the suitability of Chinese pumpsets that had already spread for many years in Bangladesh. The information, and the ability to promote the information on their use, and the associated market institutions came with NGOs. Interestingly, in all three cases, we had situations where one piece of "hardware" was introduced, but it was a cheaper design that subsequently spread. In our cases these less expensive designs that spread (the Lo Trau stove, the Chinese pumpsets, and the Chinese 2WTs) were not local adaptations, but were, themselves, new introductions at a later time, again from outside. It would appear that the early more expensive equipment helped with the introduction of new ideas. Some theories of innovation portray a general linear process whereby local adaptation of an original design takes place as the technology spreads from the original centre. While these types of local adaptation certainly takes place often, as in the case of poorer households creating new sources of biomass, our case studies reflect innovation processes which are rarely linear in the conventional sense with designs coming from and spreading from designated R&D centres.

Poverty reductions implications

We have selected case studies that appear to have benefited poorer households, cultivators, rural labourers, small scale manufacturers, and rural artisans. The equipment has reduced human drudgery, improved the efficiency of production, and increased rural employment in agriculture and linked sectors. We have not looked at the implications of the spread of larger equipment, such as 4WTs and combine harvesters and other larger scaled equipment. Serious studies would be needed before any claims could be made, about the types of agricultural and other rural engineering equipment which are associated with pro poor rural growth[19].

Policy Implications for Nepal

In the broader context we see that the policies and actions of government, donor and NGO organisations have been important. For example although the less expensive Chinese diesel engines and irrigation pumpsets have been spreading since the late 1980s, in Bangladesh, in agro-climatic conditions similar to Nepal, it has taken years for this information to spread to Nepal. In the meantime, the Government of Nepal and donors have been promoting other more costly and more cumbersome engines and pumpsets from India. The long open border with India poses a particular agricultural engineering policy challenge for Nepal. The lack of policy analysis in this area, going back to the exclusion of agricultural mechanisation from the Agricultural Perspective Plan of the late 1990s, has meant, in effect, a policy of facilitating an Indian agricultural mechanisation policy in Nepal. As we have seen, commercial and engineering interests of India have been promoting their technology in Nepal for years. Whether 4WTs, combined harvesters, large heavy pumpsets are the best choices, from a national development perspective needs investigating. The recent experiences of the spread of Chinese engines and equipment, and the spread of other technologies from other countries, almost by chance, rather than as a result of government and donor policies to investigate and promote a wide range of relevant engineering options suitable for Nepal, leads us to conclude that agricultural engineering and rural engineering more broadly, needs to come into the centre of Nepal's energy and development policy debates. Policies and regulations to promote decentralised hydro electric generation and other alternative energy sources will be important for rural development. (NCVST 2009).

Overall Reflections on Recent Agricultural Mechanisation in South Asia

Tremendous Diversity and the Major Influence of Public Policy

First, what stands out, strikingly, is the extent of the diversity of different patterns of mechanisation in different regions of Asia, and within different countries. While compared to the 1970s there has been little academic debate on mechanisation, the extent and diversity has been very large indeed. Paradoxically, we are now in a situation where the large Indian and Chinese tractor industries are exporting small 4WTs to the USA, as they are relevant to today's US economic, policy and social contexts. At the same time, India is now importing the cheaper small scale engines and accessories from China as they are more relevant to many Indian rural economies with smaller/fragmented holdings than the equipment from the Indian 4WT orientated industries.

Appropriate and Intermediate Technology

Our review highlights a couple of other issues concerning appropriate/intermediate technology. First, a feature of the spread of very diverse patterns of mechanisation is the diversity of market institutions for the services of small scale engines. These are markets in tillage, transport, water, pumping, threshing and many other services. In the 1970s, there were strong “appropriate”, “alternative” and "intermediate" technology movements, with the writings of Fritz Schumacher (Small is Beautiful) prominent in the debates. The onus of these discussions was on small equipment for small farms and small rural businesses. Rarely mentioned was the idea that small scaled equipment would be hired out to others. This reality needs to be taken on board in policy debates as the proponents of large equipment sometimes like to suggest that large equipment is often used efficiently as it is hired out on a commercial "contract" basis, while small scale equipment is just used on the single small farm. If anything, we have found the opposite to be true, with the owners of 4WTs not hiring out their equipment when not needing to use it themselves, although a service market exists.

The second issue of appropriate technology movements concerns effective contributions to macro economic policy practice. To some extent, it could be argued that the "alternative/appropriate" schools of thought were "allowed" to continue, in fact promoted, and got government and donor money to experiment, to develop alternatives, to conduct "action research", just so long as they did not, effectively, challenge dominant policy practice. It appears, from our review, that changes in policy practice on agricultural engineering have come from within mainstream national political arenas. Even today, in Nepal, there continue to be hundreds of projects promoting alternative energy use; however, the effective mainstreaming of some of the ideas into policy practice appears remarkably difficult[20].

What's old and what's new.

Concerns with rural poverty reduction, rural employment, and national choice of technique analysis were central to the debates on mechanisation in the 1970s[21]. Some of the issues were stylised in an overly simplistic engineering/economic way. We now realise the issues are more complex: partly as a result of the availability of a wider range of technical and institutional choices. For example, choice of technique was presented as either/or alternatives: tractors vs. bullocks for ploughing; hand pounding rice vs. machine milling; large scale deep tubewells vs. small scale shallow tubewells vs. manual irrigation pumps. On institutional options the debate was represented by such alternatives as private ownership vs. public ownership and government tractor hire schemes.

The way special vested interests (whether donor interests, bureaucratic interests, academic interests) could dominate in national choice of technique decisions, was well recognised and documented, such as the promotion of deep tubewells and canal systems in Bangladesh when shallow tubewells were far more relevant (Thomas, 1975). Furthermore, the promotion of British 4WTs in Sri Lanka under an aid programme to stimulate the British tractor export market is another example (Burch 1980). Thus, such issues of commercial and bureaucratic interest groups influencing national technical choice are not new. To some extent, the promise of neoliberal, structural adjustment was to do away with such "market distortions". However, the neoliberal agenda was only selectively implemented and some commercial and bureaucratic interests continued to influence national economic "choice of technique" debates.

What is emerging now is the importance of the role of different academic and research groups/alliances and their "schools of thought", in promoting themselves as the authoritative voice for informing policy debates in agriculture and rural development. First, within this debate and decision-making, agricultural rural engineers are often not present. Second, within the debates is the pervasiveness of the model that 4WTs, large combine harvesters, deep tubewells, with lined channels, etc. is "the main" way forward to a modern, productive, efficient agriculture. This narrow conceptualisation continues in spite of the evidence to the contrary, coming from the many different mechanisation paths we have seen taking place in Asia, over the last 40 years. These ideas are narrowing policy analysis at a time when the policy debates need opening up.

Perhaps the most important issue emerging today for agriculture and rural development is energy policy and the role of rural engineering and mechanisation in development. In the dominant agricultural policy framing, it was taken for granted that the agricultural sector would be subsidised with cheap energy. The preoccupation with high yielding varieties as the key technological component in the "Green Revolution" helped detract attention away from the importance of this policy of cheap energy (including urea) for agriculture. Of course now, alternative sources of electricity, the use of land for bio fuels, etc. add new dimensions and options to agricultural/energy policy debates.

Interestingly, in the late 1960s and early 1970s macro economic input output models, social accounting models, models of agrarian structures and other holistic economic frameworks, that take into account interdependencies and intersector linkages, feedbacks, positive and negative multipliers, direct and indirect effects, etc. of different policies were used in planning and policy analysis[22]. However, these broader frameworks were replaced by models concerned mainly with economic growth. In the context of agriculture and the rural sector the experiences of neoliberal models were critically reviewed (Hart 1993). It is interesting to speculate, that some of the recent food, energy, and financial crisis would have come as less of a surprise if public sector planners and policy analysis had still been using the earlier holistic input output model. We suggest that there is a need to return to the use of these more holistic planning frameworks if the policy concern is to be with rural poverty reduction, rural employment, and economic growth. In this context this paper has highlighted the need for location specific analysis.

Conclusion

In terms of agricultural and rural mechanisation, a great deal has happened on the ground since the debates of the 1970s. The diversity of South Asia's mechanisation experiences can be used to help open up today's policy debates, concerning rural and agricultural development. Today, energy policy together with policies concerning rural and agricultural mechanisation, will play a major role in determining whether agricultural growth will also give rise to rural employment and broad based rural development.

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Endnotes:

1. As this is not a review of the sizeable applied policy literature on mechanisation we only include a few selected references to illustrate our arguments. Many of the figures used in this article are our best judgements based on empirical sources from many places. We are happy to supply details to interested readers. We would like to thank Sunari Senaratne for assistance, and editing and reducing a longer version of this paper.
2. Irrigation technology is commonly addressed by a different sector analysis. This separation of a key area of agricultural mechanisation and its energy sources from agricultural sector analysis has always given rise to intrinsic problems for policy debates.
3. For example the significance of electrical pumpsets for irrigation in China are discussed by Qiuqiong, Roselle & Hu, 2007)
4. 2WTs are strangely and mistakenly termed by the FAO as "pedestrian controlled tractors". Mistakenly so, because in most of the uses the driver rides on an attached seat.
5. Also see the later footnote on the significance for policy purposes, of classification systems based on "size of organisation" in economic models (Falcon, 1967).
6. The nationality issue is relevant as regards who can access policy benefits and how economic benefits are distributed. These issues would need to be examined if the equity-ownership of assets and sustainability effects of mechanisation processes were examined.
7. Needless to say, adequate estimates for policy analysis could be obtained using a variety of empirically based research methods and need not be large scale date collection exercises. .
8. Central to this discussion is the question of who defines standards and regulation for what purpose and whose benefit.
9. Bhatt (1978) gives a description of the role of the public sector in supporting the development of the Indian Swaraj tractor.
10. Even when other comparison criteria are used, like kilowatt availability per hectare, the mechanisation disparities between India, Bangladesh and Sri Lanka are still very large. In Sri Lanka 80% of land preparation is done mechanically and performed by 100,000 2WTs and 25,000 4WTs. (Tilakaratna, 2003).
11. There is extensive empirical literature that discusses whether, and under what conditions there is any economic efficiency of large over small scale farms. Fragmented and/or small holdings in places like Bangladesh are often the more effective way of managing micro differences in agronomy, soil and local market institutions.

12. 4WTs have been promoted at different times in Bangladesh. For example, in the 1960s at Bangladesh Academy of Rural Development, Comilla (Lewis1996). 2WTS were promoted in Bangladesh in the early 1970s by a Japanese aid programme, which amongst other things established a training and service centre just outside Dhaka.
13. Engines also replaced gangs of labourers for pulling sail boats upstream.
14. This paper is concerned with a small set of agricultural engineering and mechanisation issues and not with covering the recent spread of equipment associated with the growth of the horticultural, poultry and dairy industries and other rural based value added chains; nor are we looking at the spread of other rural engineering equipment such as mini and meso hydropower, household solar water heaters, biogas plants, ropeways, rural road and bridges and other technologies with an engineering component.
15. This figure does not include the very small manual treadle pumpsets that are spreading fast.
16. National Agricultural Engineering Forum (NAEF) and the International Development Enterprises (IDE), Nepal.
17. By the early 2000s these low cost pumpsets were also becoming popular in India.
18. The figure is based on a calculation of the estimated area irrigated by STWs and using an assumption that on average 2.5 hectares is irrigated by a STW.
19. This analysis would also need to look at the actual safety in use of agricultural and rural equipment. This is a particularly difficult area to monitor in the field, and to insure minimum health and safety practices.
20. In the early 1990s some appropriate technology groups in Nepal engage in national energy policy practice. They effectively challenged World Bank supported Arun 3 project; a very large scale hydro electric project. This opened up space for assessing alternatives and the subsequent development of micro and meso hydro schemes (Pandey 1993).
21. For example for India see Dandekar and Routh (1971) and Rudra (1979).
22. For example see Falcon (1967) where he used a Leontief input output model to explore the significance of inter sector linkages and how by reclassifying agriculturally based small scale businesses into the industrial sector, rather than agricultural sector, the Pakistan economy more closely resembled the structure of the USA economy.

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