

# Patterns of Rural Mechanisation, Energy and Employment in South Asia: Reopening the Debate

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During the 1970s, major policy debates on the role of mechanisation in agricultural and rural development in south Asia took place; by the early 1990s, such debates had largely faded. Yet today, countries such as Bangladesh possess some of the most productive, mechanised and labour-intensive agricultural industries in south Asia. This paper reopens these debates in the light of: (1) the highly diverse patterns of rural mechanisation that have taken place in Bangladesh, India and Nepal since the 1980s; (2) current renewed interest in rural employment and rural economic growth; and (3) changes in global trade patterns.

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During the 1960s and 1970s, rural development was viewed as a central issue in economic policy. Sustained rural development was seen as an important policy goal. Issues such as agricultural mechanisation, rural-urban linkages, multiplier effects and decentralised rural economic growth were key themes.<sup>1</sup> Since then, the dominance of neoliberal economic policy agendas has somehow pushed issues of rural mechanisation and rural employment into the background. Agriculture became a technical discussion, mainly revolving around the role of seeds and other inputs such as irrigation, fertiliser and pesticides. Departments of agricultural engineering in western universities and the centres of the Consultative Group on International Agricultural Research (CGIAR) faced declining resource flows and in some cases closure. In 2007, the Food and Agriculture Organisation's (FAO's) agricultural engineering directorate was closed. While there has been a renewal of interest in rural development and engineering issues in some Asian universities, for example, with the promotion of alternative energy initiatives – improved cooking stoves, small-scale food processing, biogas and mini or meso hydropower – such areas have, since the 1980s, been seen as largely peripheral to mainstream policy concerns.<sup>2</sup> The decline of interest in policy discussions about rural employment and mechanisation is illustrated by the minimal coverage of these issues in recent key documents such as the International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD 2008), the Global Conferences on Agriculture Research for Development (GCARD 2010) and World Development Report (WDR) on agriculture for development (World Bank 2008).

Yet, globally, the greatest number of poor people globally are still to be found living in rural areas. Under some demographic projections, neither local urban development nor the growth of the international remittance economy will provide adequate employment for rural people. The role of engineering, energy and trade policy in influencing patterns of agricultural and rural mechanisation and employment remains central. If we return to the subject of mechanisation today, we find that despite the neglect from policymakers, there have been far-reaching changes on the ground in many parts of east and south Asia, leading to diverse, locally-determined patterns of transformation and outcomes. As Akram-Lodhi et al (2010: 279) recently argued, such processes of rural transformation

are subject to a substantive diversity that is rooted in the contingent and conjectural complexity that arises out of a historically-embedded process of variable incorporation of rural economies and societies into capitalism operating on a world scale.

Our purpose here is to reopen the policy debate on mechanisation and rural livelihoods in south Asia. We concentrate on the spread of single-cylinder, diesel engine-based agricultural mechanisation, as this has been a key component in the mechanisation patterns of south Asian countries that we briefly review here. First, we discuss the way mechanisation is conceptualised and measured. For example, problems in data collection have a significant effect on the content of policy debates in terms of what is included and what is left out. We follow this by highlighting the spread of small-scale Chinese diesel engines that have been crucial to local level mechanisation processes. Finally, we provide short overview discussions on issues from India, Bangladesh and Nepal that highlight this diversity of mechanisation processes and outcomes.

## Conceptual Problems and Data

Definitions of agricultural mechanisation are not straightforward, and they also make the development of suitable indicators a difficult task. The distortions that result can lead to an overemphasis on certain

types of technologies at the expense of others. For example, this problem is well-illustrated by the FAO's definition of tractors. The FAO's definition of agricultural tractors specifies four-wheel tractors (4wts)<sup>3</sup> but does not include 2wts or "power tillers", even though they perform the same tasks as 4wts. The result is that Bangladesh's agriculture appears as hardly mechanised at all, even though since the 1980s, there has been a dramatic spread of small-scale Chinese single cylinder diesel engines to power 2wts, irrigation pump-sets and many other types of rural equipment across the country. In reality, Bangladesh has one of the most mechanised agricultures in Asia.

All definitions of mechanisation have their strengths and weaknesses, as well as their associated measurement problems. These are compounded by the prevalence of linear "ladders of mechanisation" theories found in some engineering and social science literature. For example, one influential theory is based on the idea that as the agricultural sector develops, the use of larger-scale equipment on large holdings enables the sector to become more "efficient". Within such a view, the use of large tractors, complex cultivation equipment, seeding drills and combine harvesters are activities that signify the "top of the ladder". Another manifestation of linear thinking is the idea that mechanisation of operations takes place within a specific sequence, with tillage operations becoming mechanised before other operations. The evidence however, often shows that such general linear paths do not exist, and that it is local contexts that are the key determinants of what actually happens in practice.<sup>4</sup>

The second problem is one of measurement, even when there is an agreement on what constitutes a useful indicator of mechanisation. In practice, it is often difficult to estimate the number of items being used at a given time in a given place, let alone to find out who owns an item and their nationality.<sup>5</sup> In the case of tractors, one might get an estimate of numbers by studying registration and importation documentation, but tractors are remarkably mobile and may not be kept where they were registered or used for the purposes under which they were registered. In addition, engines and equipment can be repainted and relabelled in ways that

conceal its origins. In countries where there are donor- or government-led projects, there may also be the familiar problems of agencies monitoring and evaluating the spread of their own hardware and making claims of success that may often be difficult to substantiate on the basis of hard evidence. Since the 1970s, few efforts have been made to establish reliable national or regional figures to inform national and international rural mechanisation policy debates. This means that the empirical basis for policies relating to mechanisation is often inadequate, and remains open to the speculative use of figures for a wide range of reasons.<sup>6</sup>

### The Spread of Small Chinese Engines

Small Chinese-made diesel engines for powering pump-sets, 2wts, threshers, trailers and other equipment have proved central to mechanisation processes in Bangladesh, Sri Lanka and Nepal. Yet their importance went largely unnoticed at the time. Some observers might have predicted that Japanese and South Korean power tillers would be the main way forward for countries with small landholding patterns and high levels of land fragmentation. Others might have thought that the subsidised Indian agricultural machinery sector would have developed appropriately scaled equipment for conditions in eastern India and that these would spread to neighbouring countries such as Bangladesh, Nepal and Sri Lanka where there were similar "minifundist" conditions. Few people foresaw that it would be the Chinese agricultural engineering industry that was to make the most significant engineering contribution to the reduction of human drudgery and rural poverty and to agricultural growth in these countries.

By the late 1970s, small-scale mechanisation was taking place in China in ways that were very different from those occurring in Japan and South Korea. In China, the government initially prioritised the production of small horsepower pump-sets and tractors, at lower levels of technical efficiency and at significantly lower cost than elsewhere. When China began exporting this equipment in the mid-1980s, it was possible for them to undercut the

price of equivalent Japanese equipment by over half. Although Japanese and Korean manufacturers and agricultural engineers could point to the superior quality of their equipment, it was priced out of the reach of the majority of small farmers and rural entrepreneurs who provided the potential market. Lower quality Chinese equipment turned out to be "good enough" to meet the basic economic and technical needs of small farmers with small fragmented plots and of the small-scale entrepreneurs who bought equipment to hire out as part of the increasing growth of rural agricultural service industries (Qiuqiong et al 2007).

### India's Large-Scale Agricultural Mechanisation

India has a long history in the development, production and promotion of tractors.<sup>7</sup> India is now the number one producer of 4wts in the world, with growing exports to markets such as the United States (Radjou 2009). Today, there are over 20 factories producing nearly 3,00,000 4wts per year. The estimated total population of 4wts in India is 2.8 million (Singh and Roy 2008). Interestingly, India's agriculture is far less mechanised than in Bangladesh and Sri Lanka. While India has 22% of its area under mechanised tillage (Kulkarni 2009), Bangladesh and Sri Lanka both have about 80% mechanised.<sup>8</sup> India's agricultural conditions are, of course, far more diverse than those in Bangladesh and Sri Lanka. Yet, this lower level of mechanisation can also be explained in considerable part by India's relatively small number of 2wts – 1,10,000, a third of the number found in Bangladesh. The small number is despite joint venture projects with Japan and South Korea (Varshney et al 1995) and a policy of providing 20-30% subsidies for 2wts over nearly three decades.

Within India, the extent of mechanisation is extremely varied and there are large regional disparities, with Punjab and Haryana possessing the highest levels of mechanisation and eastern states such as Bihar and Orissa, with some of the lowest. Policies have tended to favour larger-scale equipment such as 4wts, combine harvesters and large pump-sets, and have focused less on the mechanisation needs of farmers with

smaller holdings or those of rural labourers, particularly in the major poverty quadrangle of eastern Uttar Pradesh, Bihar, West Bengal, Orissa and the Deccan plateau.<sup>9</sup> These are rural areas with high population densities, some of which are approaching those of Bangladesh and the terai of Nepal.

### **Bangladesh: Highly Mechanised and Labour-intensive**

The history of agricultural and rural mechanisation in Bangladesh could not be more different from that of India. The history of mechanisation in Bangladesh is in many ways a remarkable one, in which both the government and the private sector played important roles. In the early 1970s, when Bangladesh was commonly seen as a “basket case” by many international development specialists, few people foresaw that by 2010 the country would possess one of the most mechanised agricultural economies in south Asia (Mandal 2002; Islam and Shirazul 2009). Significantly, while most of the wheat and rice crop is threshed by machines, there are no combine harvesters.<sup>10</sup> Eighty per cent of primary tillage operations are now mechanised and performed mainly by 3,00,000 small 2WTS and only around 3,000 4WTS. There are highly developed markets for a range of agricultural services (including tractors, pump-sets, and threshing) derived from the use of the small Chinese diesel engines discussed earlier. Around 55% of the land that is cultivated is now under irrigation. Most of this is irrigation from groundwater and surface water sources using small Chinese pump-sets. In 2006, it was estimated that of the 4.62 million hectares irrigated from groundwater sources, 68% was from shallow tube wells, 17% from low lift pumps and 15% from deep tube wells (Singh and Roy 2008).<sup>11</sup>

Although small Chinese pump-sets had been spreading since the mid-1980s, the key reason for the subsequent rapid spread of 2WTS in the 1990s was a sudden major change in policy as a result of a national food crisis. A series of major floods and cyclones hit Bangladesh in the late 1980s, taking a major toll on human life, and also affecting the draught oxen population. In 1988, when military ruler President Ershad asked what machinery would be most

appropriate for the quick replacement of the lost animal draught power, he was told by his agricultural policy advisers that Chinese 2WTS would be ideal – but that these could not be imported, due to restrictions by the national standards committee. In response, Ershad simply disbanded the committee. What had started with the import of small Chinese irrigation (diesel) pump-sets in the 1970s and 1980s was now quickly followed by the imports of 2WTS in the mid-1990s. Also important was the fact that the World Bank was promoting market liberalisation and the lowering of tariffs in Bangladesh. The result was that imports of small engines, tillers and pumps grew rapidly.

The result is that Bangladesh has a highly mechanised, labour-intensive agricultural and rural economy, with substantial employment and other growth linkages to other sectors in the national economy. Today there are over one million small horsepower diesel irrigation pump-sets and nearly 4,00,000 diesel 2WTS. There are also tens of thousands of small-scale mechanised rice, wheat and maize threshers, mainly powered by the Chinese diesel engines. Without this small-scale mechanisation via shallow tubewells-pumpsets and 2WTS, there would have been no

significant growth in agriculture and no “green revolution” in Bangladesh. Two other factors have also been crucial in this transformation. The first was that Bangladesh was able to capitalise on its large energy resources, mainly in the form of gas deposits used for urea production. The second was the fact that, the local private sector, unlike in Nepal or India, played a key role, a fact that still requires more research.

### **Nepal: Mixed Agricultural Mechanisation**

Despite its small size, Nepal contains extensive agro-climatic variation, cultural diversity and inequalities in landownership and access. Much of Nepal’s wheat crop is now threshed by machine, generally powered by the diesel engines of Indian, and increasingly Chinese pump-sets. Around 15-20% of tillage is now mechanised.<sup>12</sup> The total number of tractors is around 42,000, with 30,000 4WTS (71%) and 12,000 (29%) 2WTS. From the 1970s onwards, 4WTS were promoted as key symbols of a modern, commercial and efficient agriculture. All the major Indian tractor companies established sales outlets across Nepal. More recently, multinational companies such as John Deere and New Holland, with manufacturing bases now in India, have also

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entered the market. From the mid-1990s onwards, large Indian combines were seen in Nepal, and today many Indian and Nepali combine owners work on a contract basis across the terai.

2WTS were promoted during the mid-1970s, and early 1980s, with two Japanese aid programmes leading to the subsidised private sector imports of approximately 2,000 Japanese, South Korean, and occasionally Indian and Chinese machines. Once the subsidies to farmers finished, the less expensive Chinese ones came to dominate. Initially, the spread of 2WTS was limited to the Kathmandu and Pokhara valleys, where they were used for transport and tillage. In 1993, the city governments of both valleys banned further registration of two-wheelers in the valleys, as they were contributing to growing traffic congestion. An old stock of Japanese, Korean and other two-wheelers was maintained by the local informal sector engineering industry, and one can still see some of the Japanese tractors in use even after 30 years. Since the late 1990s, there have been some small donor projects promoting 2WTS on a non-subsidised basis (Gurung et al 2008). Today, sales of Chinese two-wheelers are estimated to be about 1,200 per year.

Donor-supported programmes for subsidised pump-sets and shallow tube wells were introduced in the late 1970s and continued through the 1990s until the 2000s. Until recently, the sole source of the large heavy pump-sets was India, where they are still manufactured. The largest change in groundwater irrigation technology has been the recent appearance of lightweight, inexpensive Chinese diesel pump-sets used with cheap, easy-to-handle locally-produced “lay flat” irrigation pipe technology.<sup>13</sup> In 2003, there were two programmes run by two NGOs with extensive experience in Bangladesh. These NGOs supported Nepalese importers, who by 2004, had begun selling the cheaper Chinese pump-sets in Nepal.<sup>14</sup> The official estimate of shallow tube wells (with a pump-set) in 2001 was close to 80,000. However, the statistics do not include pump-sets bought outside the official government programmes. If we take these into account, there are probably now over 1,20,000 working pump-sets in Nepal with Chinese models rapidly gaining ground. The number of

small-scale electrically powered engines for pump-sets are few, but growing.

### Reflections on Recent Agricultural Mechanisation

To conclude, we draw attention to four themes that provide entry points into a renewed debate about agricultural mechanisation in south Asia: (1) the important role played by public policy and its diverse outcomes; (2) the significance of increasing markets for technology-based services; (3) the importance of revisiting income and asset distributional outcomes produced by technological change; and (4) the need to link up “old” themes around technology with current realities.

First, the diversity in the patterns of mechanisation in the south Asian countries, we have briefly looked at, is striking – both between and within countries. It is clear that a linear “scaling up” of one model of mechanisation in a standard “sequence” has not taken place. Instead, variations in local conditions, national government policies and farmer and small-scale rural industry adaptation processes have generated a range of different outcomes. In Bangladesh, trade liberalisation gave rise to the import of Chinese pump-sets and 2WTS. International trade in tractors has also played a central part in these transformations. Nepal, on the other hand, had pursued a *laissez-faire* policy since the 1990s, with mechanisation largely excluded from subsequent major policy documents and debates. Today, as we have seen, the large Indian (and Chinese) tractor industries are exporting 4WTS to the western countries. At the same time, India is gradually importing small-scale equipment such as 2WTS and small diesel engine pumpsets from China.

Second, there has been a significant expansion of markets in small-scale technological services based around diesel engines – for tillage, transport, water, pumping, threshing and other tasks. These service markets of small-scale equipment need to be more fully taken into account within policy debates. Those who favour large-scale equipment tend to argue that surplus capacity is hired out on a commercial “contract” basis, whereas small-scale equipment is primarily used on single “stand alone” small farms. Yet, we have

frequently observed that the opposite can be true: that owners of 4WTS decline to hire out their equipment when it is not in use on their own holding. While contract combine harvesting is common on some parts of the Indian and Nepal terai, contract threshing of wheat and rice by farmers with holdings of all sizes is more common, often by rural entrepreneurs using threshers attached to small mobile diesel engines used to power pump-sets.

Third, more attention needs to be paid to the income and asset distribution causes and effects of mechanisation. We have not considered these issues in this short paper, but it is important to revisit the evidence that mechanisation *per se* contributes to the concentration of land into larger holdings. Nor have we covered the very serious health and safety dimensions of rural machinery that especially affect rural labourers, nor the implications of environmental effects, such as groundwater depletion and arsenic contamination in drinking water and food chains as a result of intensification of groundwater development. Further, research is needed in order to inform new public debates on rural mechanisation. However, while there is currently a shortage of such studies, there is evidence that some academic and commercial interest groups continue to promote the idea that large-scale commercial farming remains more “efficient” than small-scale operations. Some mainstream growth-centred economists suggest that there is a natural process of a movement towards larger, more efficient landholdings as a result of economies of scale. Such assumptions need to be subjected to closer scrutiny, not only in terms of technical and commercial rationales, but also from a planning perspective in which national economic, social and environmental goals are also taken into account.<sup>15</sup>

### Old and New Debates

Finally, we argue that the challenge now is to bring together “old” and “new” elements of mechanisation debates. Concerns with rural poverty reduction, rural employment, rural development and national technology policy were central to the mechanisation discussions of the 1970s.<sup>16</sup> Some issues were framed too simply in technical or economic perspectives that were out of step with local realities. For

example, unhelpful binary oppositions included “tractors versus bullocks” for land preparation, “hand versus machine milling” for rice, “deep tube wells versus shallow tube wells” or manual irrigation pumps. At the institutional level, policy options were represented by such stark alternatives such as “private versus public ownership”, or “government tractor hire schemes versus cooperative management”. While some of these debates were simplistic, there is a chance that we have gone too far in closing down the debates altogether. Similarly, research on the ways “interest groups” influence technology policy remains as relevant today as it was in the 1970s (Thomas 1975; Burch 1980). The use and misuse of “standards” policies and regulations remains a live issue, particularly as complex value chains increasingly operate at the global level. The use of Keynesian macroeconomics, Leontief input-output models and social-employment accounting each remain relevant.

However, today there are three new sets of factors. First, the array of available mechanical equipment has increased dramatically. While in the 1970s, there might have been diesel and electric engines available only in a very limited range of sizes, today there is almost no limit to the possible variations in scale of this machinery, plus other new engineering technologies that promise to reduce rural poverty. Second, we must recognise the hitherto neglected but central role of energy policy for rural mechanisation. In the past, 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” drew attention away from its dependence on cheap energy, whether for urea, pumping water or the marketing and supply of inputs and outputs. We now have a whole range of alternative sources and uses of energy, and new issues around land use for biofuels and other energy sources. The landscape of agricultural and rural development debates has shifted dramatically, and each country and region has specific actors and contexts to consider. Third, we need to rethink the importance of rural employment and worthwhile rural livelihoods for achieving goals of long-term poverty reduction,

equity and sustainable economic growth, both locally and globally.

## NOTES

- 1 We do not aim here to provide a systematic review of the large applied policy literature on mechanisation, and provide only selected references and data to illustrate our arguments. Figures used represent our best judgments based on empirical sources from many places. We are happy to supply further details to interested readers.
- 2 Irrigation is commonly and unhelpfully addressed as a separate sector from agriculture. In this paper, we treat irrigation technology as one of the key components of agricultural mechanisation.
- 3 2WTs are mistakenly termed “pedestrian controlled tractors” by FAO. In most situations, the driver rides on an attached seat.
- 4 In recent years, large-scale mechanised farming has been shown to have a very chequered history as regards “efficiency” in both the short- and long-term use of scarce national resources, and in relation to environmental indicators and distribution of incomes and wealth.
- 5 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 are to be understood.
- 6 Needless to say, adequate estimates for policy analysis could be obtained using a variety of empirically-based research methods. These would not necessarily involve large sums of money or large-scale data collection.
- 7 Bhatt (1978) gives a description of the role of the public sector in supporting the development of the Indian four-wheel Swaraj tractor.
- 8 Even when other comparison criteria are used, such as kilowatt availability per hectare, the mechanisation disparities between India, Bangladesh and Sri Lanka remain very large. In Sri Lanka, 80% of land preparation is done mechanically and performed by 1,00,000 2WTs and 25,000 4WTs (Tilakaratra 2003).
- 9 There is an extensive empirical literature that discusses small versus large farm efficiency. Fragmented small holdings in places like Bangladesh can be seen as providing effective ways of managing local micro-level variations and conditions.
- 10 4WTs were also promoted at various times in Bangladesh. For example, a tractor cooperative scheme in the 1960s at Bangladesh Academy of Rural Development (BARD), Comilla, failed for reasons of elite capture, but some renovated tractors were subsequently deployed privately and used for small-scale contract ploughing services (Lewis 1996). 2WTs were initially promoted in Bangladesh in the early 1970s by a Japanese aid programme.
- 11 Chinese engines on boats also replaced gangs of labourers for pulling sail boats upstream.
- 12 Figures for Nepal are difficult to find, an exception being Pariyar et al 2001, who gave estimates of agricultural machinery in Nepal.
- 13 It is estimated that there is a 30%-50% saving in water as compared with conventional field canals.
- 14 By the early 2000s, these low cost pump-sets were also becoming popular in India.
- 15 See Falcon (1967) for an early discussion of these issues using a national Leontief input-output framework.
- 16 For example, for India, see Dandekar and Rath (1971) and Rudra (1979).

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