PEDAL PUMP AND THE POOR
Social Impact of a Manual Irrigation Technology in South Asia

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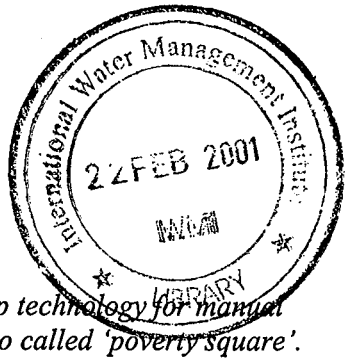

Abstract

This paper offers an assessment of the social impact of the treadle pump technology for manual irrigation in Eastern India, Nepal terai and Bangladesh, South Asia's so called 'poverty square'. The region packs 400 m of Asia's 900 m poor; but it also has among the world's best groundwater resources. Treadle pump technology can be a powerful tool for poverty reduction in this region. It self-selects the poor; it puts to productive use the region's vast surplus family labour, and is claimed to raise the annual net household income by US $ 100 on the average.

The paper reviews evidence from a variety of studies—including our own--designed to test these claims; and concludes that: [a] the treadle pump technology does 'self-select' the poor, although the first-generation adopters tend to be the less poor; [b] it transforms small-holder farming systems in different ways in different sub-regions; in North Bengal and Bangladesh, adopters take to cultivation of HYV rice in boro season; elsewhere, adopters turn to vegetable cultivation and marketing;[c]it results in increased land-use intensity as well as 'priority cultivation'; adopters provide crop-saving irrigation in a large part of their holding but practice highly intensive farming in the 'priority plot';[d], average crop yields on 'priority plots' tend to be much higher than obtained by farmers using diesel pumps or other irrigation devices;[e] income impact varies across households and regions; but $100/year as average increase in annual net income seems a conservative estimate. Less enterprising adopters achieve fuller employment at 'implicit wage rate' that is 1.5-2.5 times the market rate. The more enterprising take to intelligent commercial farming and earn substantially more.

For a marginal farmer with $ 12-15 to spare, there could hardly be a better investment than a treadle pump which has a benefit:cost ratio of 5, IRR of 100% and pay-back period of an year. It thus ideally fills the need of the marginal farmers. The challenge lies in its marketing; exceptional ingenuity seems required to put the treadle pump in the hands of millions of rural poor. In Bangladesh, where this has become possible, over a million pumps so far sold probably do not account for a large proportion of irrigated area but have certainly reached a significant proportion of Bangladesh's rural poor. In Eastern India and Nepal terai, the technology was introduced only in the 1990's; therefore total sales have been in the neighbourhood of 100,000 against an ultimate potential of 9-10 million. For significant impact on the poverty in the region, treadle pump sales need to quickly cross the 100,000 per year barrier in Eastern India and Nepal

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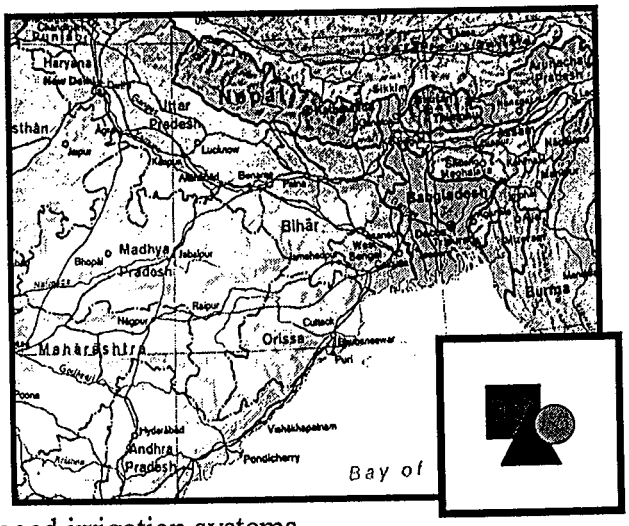
terai, possibly by recreating here the conditions that led to Bangladesh's three-year long sales boom during the early 1990's which very nearly saturated its treadle pump market.

1. Irrigation against Poverty

The Context

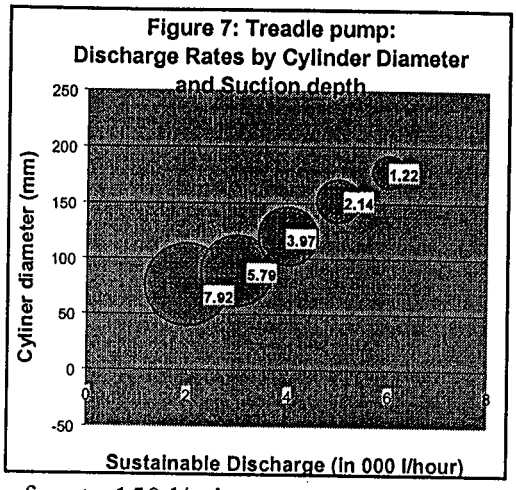
This research is set out in Eastern India, Nepal terai and Bangladesh—the heartland of the Ganga-Brahmaputra-Meghana basin, and South Asia's so called 'poverty square'. The region packs 400 m of Asia's 900 m poor; but it also has among the world's best groundwater resources, available at a depth of 1.5-3.5 m.[1] The population density is over 500/sq. km; well over half of the total farm lands are operated by marginal and small farmers owning average holdings of 0.8-0.9 ha compared to the all-India average of 1.55 ha and Punjab's average of 3.61 ha; (GOI: 1999); marginal and small holdings have increased in number and have been halving in average size every 15 years since 1960. Moreover, barring Uttar Pradesh where some consolidation of holdings took place during the 1960's, the average holding is fragmented in 4-5 postage-stamp sized parcels; the average parcel size was 0.11 ha in Bihar and West Bengal in mid-1980's (Rao N.D.). The development of the industrial and service sectors—which could have absorbed some of the growing labour force—is slower than elsewhere in South Asia. After an initial surge in yields and total farm production during the 1980's, agricultural productivity in Eastern India has stagnated or even decelerated during the 1990's (Bhalla and Singh 1999 [forthcoming]; Saxena, pers.com). Overall, then, the region is stuck in a low-productivity quagmire that perpetuates its rural poverty and agricultural stagnation.



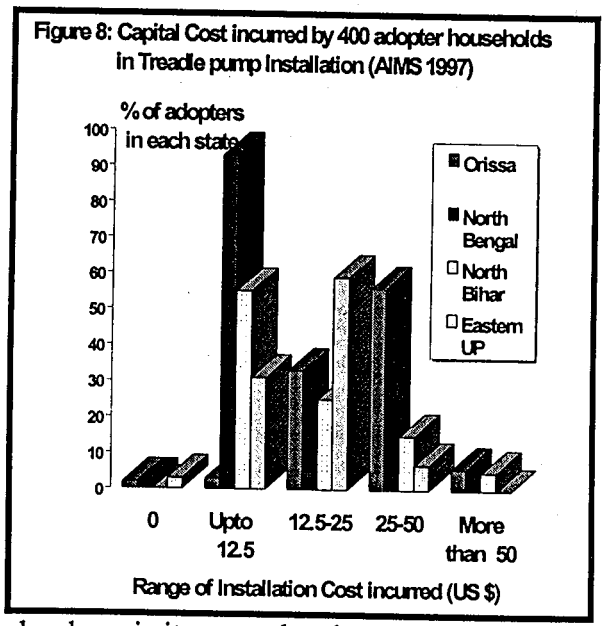
Development of groundwater irrigation has for long been held out as the answer to Eastern India's socio-ecological malaise. Irrigation improves rural livelihoods in direct and indirect ways; good quality irrigation—as with privately owned pumps--does this better than poor quality irrigation. A growing body of evidence shows that support to small-scale, privately managed groundwater irrigation targets poor rural households better than other poverty-reduction interventions and creates more livelihoods compared to large agency-managed irrigation systems (Chambers, Saxena and Shah 1987; Shah 1993; Rao N.D.). In the context of the G-B-M basin, this offers big opportunity for concentrated attack on rural poverty in an environmentally sustainable fashion. Besides relieving its flood-proneness, intensive groundwater development can serve as a powerful 'trigger' to catalyze a Green-Revolution-based rural economic upsurge in this region, as it did in Haryana and

require significantly more strenuous work than [treadle] pump which delivers up to 150 liters/minute..' (Dixit 1993:11). This seems plausible; however, farmers we interviewed who have used different devices think differently. A group of farmers we met in Puri district, coastal Orissa ranked the treadle pump, *tenda* and *shenna (taar-balti)* in terms of ease of operation, water output, capital cost, maintenance cost as in Fig. 6.

The treadle pump's main advantages are relatively greater ease of operation and high water output besides low maintenance and repair cost; the *tenda* costs a good deal--Rs 200-300-- to set up and as much per year to maintain; the *shenna* is cheaper to make and maintain and also has very good water output[3] but is laborious and requires two persons to operate and therefore does not offer the independence the other two offer.



Variety of claims has been made about what the technology can deliver relative to the hand pump, which is popular in the entire region. It is claimed for example that 'the treadle pump can have an output of up to 150 l/minute compared to the standard hand pump's output of 20 l/minute..' (Dixit 1993). But in actual practice, the treadle pump output is less than claimed (Figure 2,4) and the hand pump output far more..(Figure 3). In field conditions, depending upon whether the operator is a man, woman or a child, the treadle pump output is probably in the range of 0.6-0.8 l/s and the hand pump delivers about 0.5-0.6 l/s, substantially more than 20 l/minute (fig 2). Even in test conditions, results do not show treadle pump discharge to be more than 1-1.1 l/s. A World Bank commissioned study in Bangladesh found the treadle pump's 'comfortable discharge rate'—that is at a power input rate of 30 watts over the Basic Metabolic Rate of 62 watts (expended while lying in bed doing nothing)—to be 50-55 liters/minute at a pumping head of 3 m; beyond 3.5 m, the discharge dropped off and at 5 m, it was down to 28 liters/minute at 30 watts over BMR (Orr et al 1991:14). Water output tends to be significantly higher for larger cylinder pumps at shallow pumping heads; as the pumping head increases, the 'optimal' cylinder size decreases, and so does the discharge per unit of effort (see fig:7).



The best part of the treadle pump technology is its cost; the cheapest bamboo treadle pump is installed for less than US $ 12; the more expensive metal and concrete pumps cost US $ 25-35 complete with a bore

and a frame. Cost estimates provided by manufacturers and marketers vary widely and are sometimes misleading; but Figure 8 reports on the actual amounts spent by 400 small farmers in installing treadle pumps in Eastern India during 1994-96; very few except in coastal Orissa—where salinity requires the costlier concrete pumps to avoid corrosion of the metal pump-head—spent more than $ 25 on the treadle pump assembly and bore; by far the majority spent US $ 25 or less. The going rate for the capital cost of new canal irrigation potential in South Asia is US $ 4000-4500; new tubewell irrigation potential costs the society US $ 800-1000/ha to create; treadle pump technology creates new irrigation potential at US $ 100-120/ha and targets it to the poorest.[4]

The Organization

The technology is developed and promoted by International Development Enterprises, a US NGO that abhors subsidies but revels in taking up a technology and paring its cost down to half[5], and reaching it to the poor through mass-marketing in a professional manner. In each country where it works, IDE is registered as an independent national organization; while operating styles can vary somewhat across countries, the core philosophy remains the same. IDE claims its approach to be unique; unlike the general NGO-propensity to work with a large portfolio of activities, IDE believes in focusing its energies on a 'core business'; it believes in professionalism, and in achieving scale in its work and impact. Instead of expending energies and time on mobilizing communities and forging collective action, IDE focuses on the individual poor household as its customer and tries to reach it through the market institution. In India as well as Bangladesh, IDE has built medium-sized organization of 250-300 mostly professional and field staff; in Nepal, IDE is smaller but growing rapidly. In Bangladesh, where IDE played an instrumental role in popularizing treadle pump technology, a variety of NGOs and private entrepreneurs got in to the manufacture and marketing of a variety of branded and unbranded treadle pumps independently of each other, and largely, of the IDE. Today, between 80-90 private manufacturers produce treadle pumps in Bangladesh and market them through the normal trade channels. Prices are fixed by them; and so are marketing margins. IDE, Bangladesh tries to stipulate pricing and quality standards; but these do not seem to stick. The generic technology promotion that occurs through the IDE's aggressive promotion of *Krishak Bandhu* brand creates a public good that benefits all those involved in the treadle pump business.

IDE India learnt important lessons from the experience of IDE, Bangladesh and, over the years, evolved a strategy and organization for promoting the treadle pump, which is distinct from the later. In India, IDE has licensed a small number of manufacturers to manufacture treadle pump to their specifications and market them under *Krishak Bandhu* brand name owned by IDE. IDE has also appointed distributors and dealers who market *Krishak Bandhu.* IDE's entire field organization down to the *mistries* is oriented to promotion and marketing. In India, all strategic marketing decisions are made by the IDE *viz.*, the retail price of treadle pump, marketing margins at each level, what design to promote where. IDE assumes direct responsibility of quality control by deploying its own QC staff at the manufacturing facilities.

In Bangladesh, where the treadle pump was introduced in mid-1980's, some 1.3 m pieces have been claimed to be sold including replacement demand. Eastern India and Nepal terai have an ultimate market potential for some 10 m treadle pumps (Ananda Mohan De quoted in Bhanot 1999)[6]; but the sales here have just hit 100,000; and the IDE has a long way to go. It has been claimed that every treadle pump sold results in an annual increase of US $ 100 in the net income of an ultra-poor household (Polak N.D.); at this rate, if and when IDE does saturate this market potential, it will have accomplished one of the most powerful—and best targeted—poverty-alleviation interventions the world has even seen, by increasing net annual income of South Asia's poorest rural households by a billion dollars, and that, at little cost to the public exchequer. No wonder, Paul Polak, the chairman of IDE wrote: 'The treadle pump is the harbinger of a new agricultural revolution greening millions of postage stamp sized plots in the heart of the world's poorest and hungriest areas.. a treadle pump installed on a tubewell costs thirty-five dollars, less than one-tenth of the cost of a diesel pump..' (Polak nd:4).

Research Issues

Despite the treadle pump's run away success in Bangladesh—and a variety of claims made about its beneficial impacts—there is surprisingly little research on it, barring two early studies in the end of the 1980's by Orr et al (1991) and Alam (1997). A good deal of writing on treadle pump has been anecdotal. Some of it is based on PRA techniques which—in the hands of the casual or the overly committed—often runs the risk of 'selective perception' and have doubtful credibility. As a result, the treadle pump's potential—as well as that of the approach evolved by IDE—remains largely unascertained and unknown either among irrigation professionals or in the development establishments.

In some ways, the treadle pump technology is an unusual subject for a social impact assessment. After all, the treadle pump is promoted as a 'private good', available off the shelf without any explicit subsidy. One can, therefore, argue that the proof of the pudding is in the eating; if the farmers find the product attractive relative to its price, they will invest in it, maintain it, replace it after its economic life is over. And the sales figures of the treadle pump are the best evidence of its social impact. However, at least four reasons make the study of social impact of treadle pump technology interesting *and* important. First, the claim is not merely that the investment in treadle pump is financially and economically viable but that its income impact (claim: US $ 100/year) is *disproportionately high* compared to its capital cost (US $ 20/piece). Second, the technology has unique property of 'self-selecting the poor' which makes it ideal as a poverty-reduction intervention. Third, the potential that the treadle pump technology offers for substituting muscle power for fossil fuel—and the positive 'externality' that so results-- does not enter the market calculus; this is the potential gain that will not be revealed by the 'treadle pump buyer behavior'.[7] Fourth, indirect impacts of a growing treadle pump economy too would fail to get reflected in market valuation. For example, producing, marketing, replacing, and servicing a large population of treadle pumps itself would create new employment and livelihoods; and these are important social benefits in conditions of large-scale open o disguised unemployment. All these questions are

important; yet, the central research question is about its direct impact on net incomes of poor farmers: 'Is the treadle pump capable of raising the net income of its South Asian adopters a billion dollars an year?'

2. *Evidence*[8]

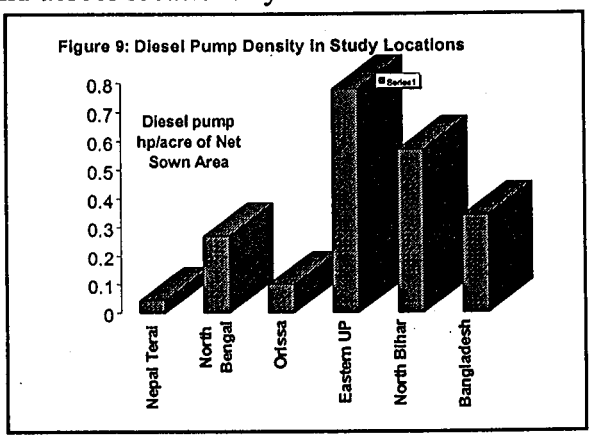
Foundation Study: Background

Besides a number of mostly unpublished earlier studies that we have drawn upon, the evidence we have used in this paper is derived from the six location studies that were commissioned for this study in North Bihar, North Bengal, Eastern Uttar Pradesh, Coastal Orissa, Nepal Terai and Bangladesh. In each of these locations, a *study* village with high treadle pump density (i.e., number of treadle pumps/hectare of net sown area) was compared with a *control* village where treadle pump was yet to be introduced but which was otherwise as similar to the study village as possible. All households of the two villages were interviewed in all six locations. Table 1 provides a profile of some 2400 households that were met in these six locations. Only 300 of these had purchased treadle pumps; just over 150 had diesel pumps; 550 households were landless and 1360 were land-owning pump-less; in some ways, the pump-less in this region are worse off compared to the landless.

Table 1: Profile of the Sample Surveyed

	Treadle Pump Owners	Diesel pump owners	Pump-less small holders	Landless House-holds	All house-holds
Jaipur, Nepal Terai	11	2	56	13	82
33-Bigha, Nepal Terai	54	1	76	11	141
Haldimohan, North Bengal	43	30	321	80	474
Salajunga, Orissa	23	7	101	23	154
Tharuwadih, Eastern UP	28	51	417	109	604
Dostpur-Khairabi, North Bihar	31	47	320	160	558
Khamer-Taherpur, Bangladesh	89	11	22	47	169
Sreepur, Bangladesh	21	9	47	107	175
Total	300	158	1360	550	2357

The variations in the diesel pump density found across locations symbolize a wider interplay between the deepening of machine culture and agrarian dynamism and growth in this part of South Asia. Nepal terai, North Bengal and parts of Orissa are way behind Eastern Uttar Pradesh and North-West Bangladesh in terms of the deepening of machine culture and of the Green Revolution technology; and the latter areas are in their turn far behind Western Uttar Pradesh, Haryana and South West Bengal which have enjoyed full-fledged Green Revolution now for 15 years or more. It is as if local agrarian economies are traversing in time along



a well-defined trajectory from an early stage marked by high use of human and animal power, pre-HYV technologies, and low output per acre and worker to a late-stage marked by high use of machines, HYV technologies, high output per acre and worker and a new array of institutions that somehow find a fit between intensive use of machines and conditions of excess labour and disguised unemployment.

Table 2: Overall Patterns Across Locations

	Nepal Terai	Coochbehar, North Bengal	Puri, Orissa	North Bihar	Eastern Uttar Pradesh	Bangladesh
Breadth of spread of TP Technology:	Moderate; 1/3rd of the target households	Low; 1/7th of the target households	Low; 1/8th of the target households	Low; 1/15 the of the target households	Low; 1/20th of target households	High in Khamer; ½ of target households
Length of experience with TP technology	Short-2-3 years	1-2 years	1-2 years	2-3 years	2-3 years	10-12 years
Deepening of Machine-culture in irrigated agriculture	Low; only 3 diesel pumps in two villages for 200 house-holds and 340 acres	Moderate; 30 diesel pumps for 400 households and 550 acres	Low; 7 diesel pumps for over 200 households and 350 acres	High; 47 DPs for 560 households and 300 acres	High; 51 DPs for 600 households and 450 acres; threshers and tractors widely used	Moderate; 11 DPs for 170 households and 160 acres
What did the newly introduced treadle pump technology replace:	Rainfed farming; manual irrigation devices like *dhenkul* and *karin*	Rainfed farming; swing-basket; purchased pump irrigation	Rainfed farming; *tenda* irrigation; purchased pump irrigation	Rainfed farming; hand-pump irrigation of vegetables; Purchased DP irrigation;	Rainfed farming; purchased pump irrigation	Rainfed farming; swing basket; purchased pump irrigation

Dominant institutions of exchange we find in early-stage locations are labour markets and land-tenancy; but striking new institutions one finds in late-stage areas—such as Eastern Uttar Pradesh, North Bihar and North West Bangladesh have to do with machines: in the latter, diesel pump irrigation markets are wide and deep; but thresher and tractor hire markets are common too; while bullocks are rapidly disappearing from the scene, a few households of poor farmers in every village emerge as specialist providers of bullock labour. These new form of machine-labour markets are common in Eastern Uttar Pradesh and North Bihar but unheard of in North Bengal, Nepal Terai and Orissa. The dynamic of treadle pump impact in these locations then needs to be explored against the wider backdrop of deepening machine culture and its interplay with agricultural change (table 2).

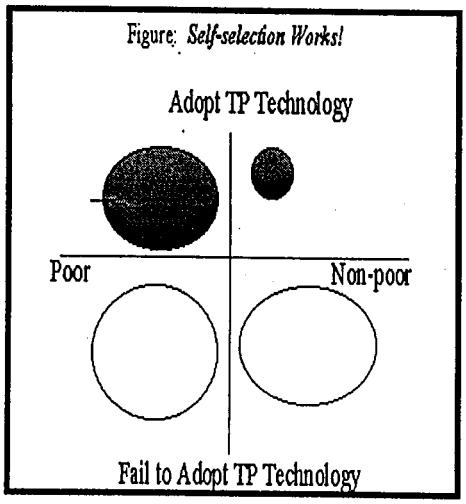


Figure: *Self-selection Works!*

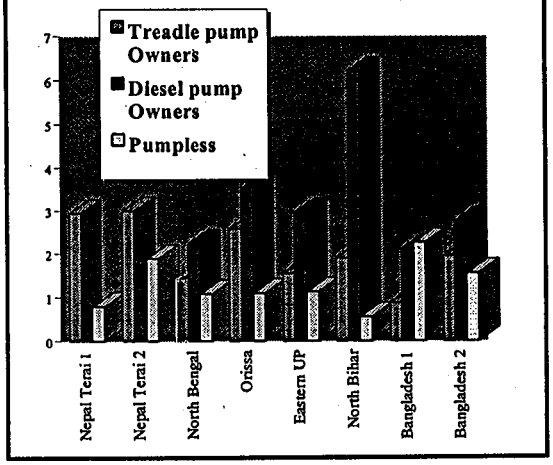
Who Are Treadle Pump Adopters: The Poorest?

One of the many such claims made for treadle pump technology is its capacity to 'self-select' the poorest; that is, in a random selection of treadle pump owners, poor would dominate, and in a random selection of the non-poor, non-adopters of the treadle pump technology would dominate (Fig

10). The 'self-selection' hypothesis has important policy implications, for the bane of official programs to help the poor is the problem of targeting, of minimizing the proverbial α and β-errors[9] in managing poverty alleviation programs[10]. If treadle pump technology is indeed self-selecting the poor, then, we know for sure that public policy support to it would successfully target the poor. Even before we deal with the productivity and income impacts, then, we need to question this unquestioned assertion. And in a random selection of farmers, if we find that poor dominate the adopter group and non-poor, the non-adopter group, that is a good test of the 'self-selection' hypothesis.

Figure 11, which shows a plot of the average land-holding owned by treadle pump owners, diesel pump owners and the pump-less households suggests a pecking order: diesel pump owners invariably have largest land holdings; however, the treadle pump adopters are only the next best in terms of land-ownership; they are not the poorest land owners, and certainly not the landless. And in our total sample of 2357, the pump-less are far more numerous—and in some ways, worse off--than landless.

Figure 11: Average Land holding (acres)



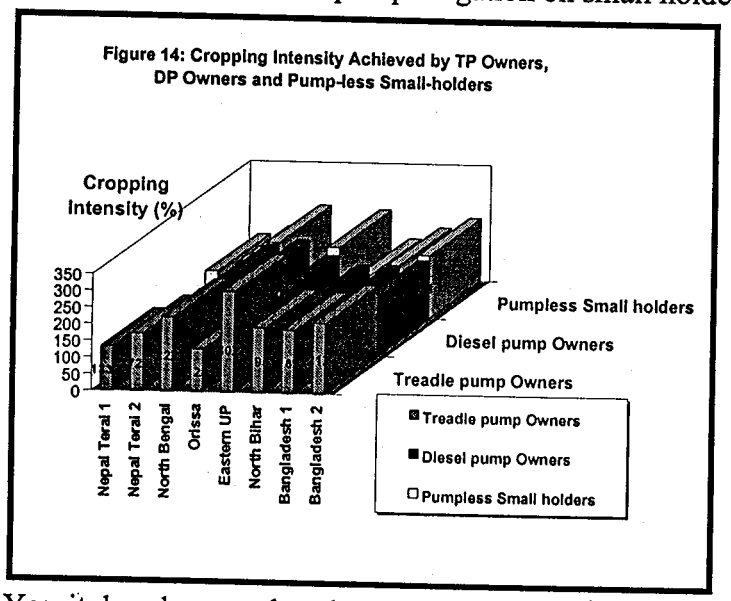
This general pattern of the 'treadle pump trickle down'—that is, for the early adopters to be the less poor amongst the poor—is corroborated by earlier studies. The AIMS (1997:204) study found that land holdings of treadle pump adopters were uniformly higher in a survey of 400 adopters and 200 potential adopters: by 15% in Orissa, 66% in Bihar, 55% in North Bengal and 17% in Eastern Uttar Pradesh. Similarly, a survey of a sample of early treadle pump adopters in Balasore district of Orissa suggested that 88% were from upper castes, over half were in 30-50 age group, over half had a family size of 5-10 members, 92% were literates; and equal proportion had agriculture as their main occupation (RCDC 1994:4). The Orr et al (1991:35) study found that early adopters of treadle pump in Bangladesh were the ultra-marginal farmers with less than 0.25 ha but they cite earlier studies which showed the average holding size of adopters to be much higher at 0.64 ha. A 1995 survey of 20 respondents each from TP users, Pump Irrigation Buyers, Diesel Pump Owners and Non-irrigators in Puri district by R M Mallik, a Bhubaneshwar-based economist and a 1995 survey of Gorakhpur mandal by Shah, Indu and Paleja (1996) also confirmed this trend (see, table 3). They show that treadle pump adopters are not the poorest; households, which have the smallest holdings, are non-irrigators; they probably have farm labour as their main occupation and cultivate their fields for rain-fed paddy during kharif. Diesel pump owners--who are also pump irrigation sellers--have distinctly larger operated holdings.

embraced by these communities is in some fundamental ways different from the 'grass-based' farming systems. In contrast to the land-oriented value creation in the latter, the vegetable growing communities consider the size of the holding *per se* as a peripheral variable in their farming, but combine enormous amount of family labour and care with Green Revolution inputs on small amounts of land as a livelihood strategy. Much of our latter analysis suggests that there is little sense for the land poor to ape the grass-based farming systems that large land-holders do; and if the treadle pump irrigation can enable small-holders in the Ganga-Meghna-Brahmaputra basin to find a way out of the grass-based farming in favor of land-saving, water and labour intensive high-value crops, it can provide a big answer to rural poverty in this region.

3. *Evidence: Treadle pump Irrigation's Direct Impacts*

Is treadle pump technology land-augmenting?

On the impact of treadle pump irrigation on small holder farming, a major claim often made is straight forward: since it opens up their access to high quality irrigation, the technology confers on them all the benefits that irrigation provides, the most important of which is freedom from rain-fed farming and capacity to raise crops in winter and summer. For the poor farmers constrained by their postage-sized holdings, treadle pump technology can work as a land-augmenting intervention. Does this really happen?



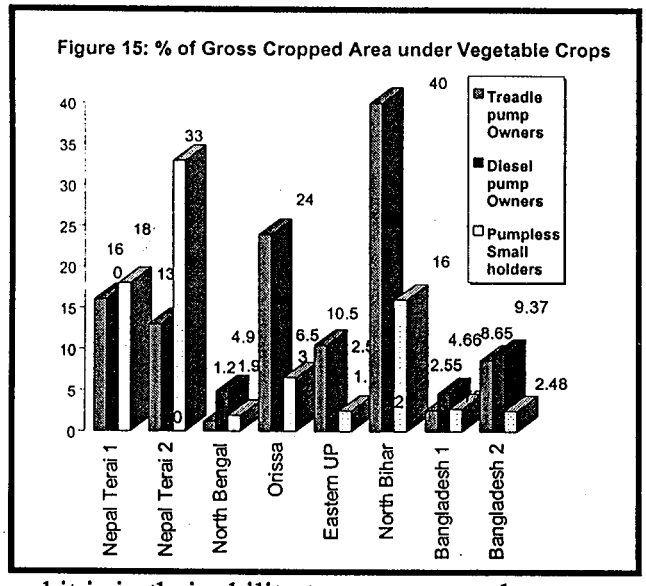
Yes, it does happen, but the gains in cropping intensity seem far from significant and the patterns vary greatly across locations. And this emerges more clearly from table: 4 than figure:14. In Nepal terai and North Bengal, land use intensities of adopters are comparable to non-adopters and even diesel pump owners; thus the land-augmenting impact of irrigation *per se* seems doubtful in these regions. In Orissa, land use intensity of adopters and non-adopters is comparable and significantly lower compared to diesel pump owners; and our conjecture is that this is because all marginal farmers in the Orissa villages close to towns place a great deal

Table 3 Land use Intensity (%)achieved by Different Groups

	Treadle pump Owners	Diesel pump Owners	Pump-less Small holders
Nepal Terai 1	133.4	0	131.8
Nepal Terai 2	172.9	0	157.8
North Bengal	222	217.4	222
Orissa	128	233	123
Eastern UP	302	187	211
North Bihar	195	160	126
Bangladesh 1	189	158	161
Bangladesh 2	212	176	191

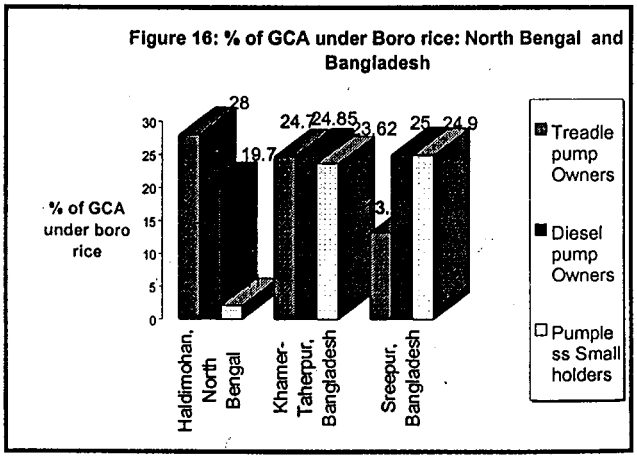
more emphasis on vegetable growing using a variety of traditional muscle driven irrigation devices; where as diesel pump owners rely more on grass-based cropping patterns. And as alluded earlier, vegetable-based smallholder farming systems are driven not by the size of the area under plough but by intensive use of Green Revolution inputs and family labour. In Eastern Uttar Pradesh and North Bihar, land-augmenting impact of treadle pump irrigation is significant. Also relevant seems to be the aspect that in Eastern UP and North Bihar—with their hyper-active diesel pump irrigation markets—treadle pump adopters use a skilful mix of purchased diesel pump irrigation and treadle pump labour to get the best of both the worlds: they use treadle pump exclusively for vegetables but use a mix for grass-crops. So effective seems to be this combination that in both the regions, larger farmers with diesel pumps too have taken to treadle pump, not as the mainstay of their farming but as an ingenious manner of optimizing between cash and food crops. [11]

Other studies provide clearer evidence on land-augmenting impact of treadle pump adoption. The Orr et al study (1991: 45-46) found that 31% of the land which was previously left fallow in boro/rabi seasons was brought under cultivation; more low-lands came under plough than up-lands; more previously fallow land was brought under boro/winter cultivation in Pirganj where adopter focus was on modern boro rice cultivation rather than Aditmari where adopters grew more vegetables.



Cropping Pattern

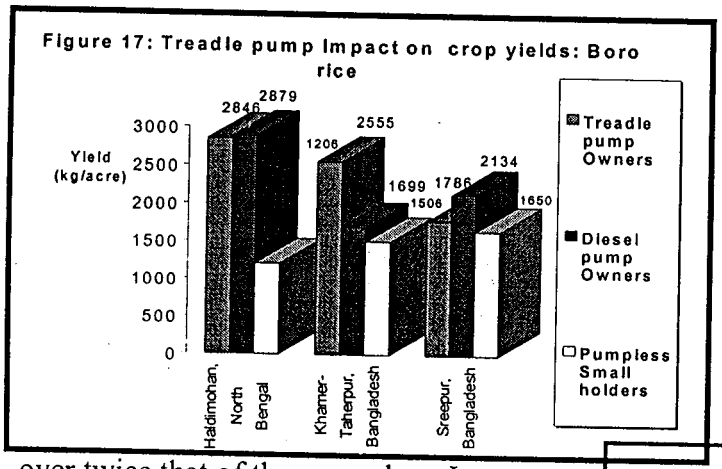
Treadle pump adoption however results in more significant changes in the cropping patterns and farming systems adopted by small-holders; and it is in their ability to grow crops they were not able to grow hithertofore that potential adopters identify the USP (Unique Selling Point) of the treadle pump technology. In North Bengal, the prize crop that small holders without irrigation are denied is what is locally known as '*china boro*', a high yielding rice variety hugely popular with the resource-rich in North Bengal and Bangladesh that performs best with intensive input application and deft water management (Fig 16). In Nepal terai, Eastern Uttar Pradesh, the treadle pump is perceived primarily as a specialist 'vegetable pump' so much so that many

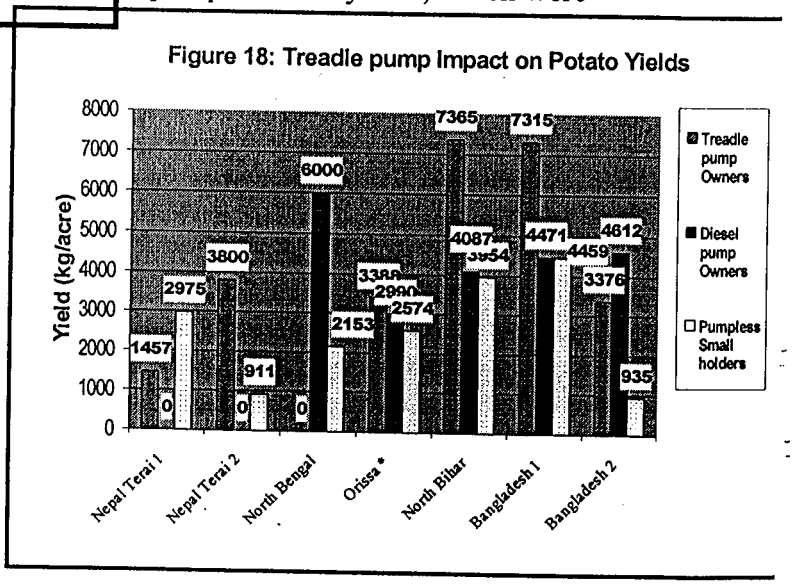


diesel pump owners maintain a treadle pump on the side to water their vegetable plots (Fig 15). In Bangladesh, although the 'vegetable pump' stereotype propagated by the IDE is well entrenched, the uses of treadle pump irrigation are more diversified, including for cultivation of *china boro.* And these patterns get amply reflected in the cropping patterns that emerge from our Foundation Study survey. In North Bengal, treadle pump impact on increased *china boro* cultivation is most striking; however, in the Bangladesh villages, the pump-less irrigate *china boro* with purchased irrigation at a huge cost as we presently examine. In Sreepur, the village where treadle pump has just arrived, the impact on the adopters is to take to vegetable cultivation in a major way.[12] In Orissa, Eastern Uttar Pradesh, North Bihar and Bangladesh control village, the cropping patterns adopted by adopters is significantly titled in favour of vegetable crops. In the two villages of Nepal terai, there is no significant difference between adopters and non-adopters in their cropping patterns, presumably because water table is so close to the ground that most non-adopters irrigate from artesian springs[13]; as a result, treadle pump irrigation does not ameliorate irrigation-deprivation in any significant sense, at least in the villages studied.[14, 15]. Other studies we came across showed that Nepal terai has highly variable conditions and that treadle pump technology has brought about bigger change than our two-village study suggests.

Intensive Cultivation as an 'art-form'?

Treadle pump irrigation's most significant impact is probably through is impact on crop yields. Adopters harvest 4.5-8 mt/ha of *china boro,* 9-50 mt/ha of green vegetables and, 8-18 mt/ha of potato. The yields they harvest are almost invariably and significantly higher than the pump-less and often so, compared even to diesel pump owners. Take *china boro,* for instance; in North Bengal, adopters matched the diesel pump owners' yields, which were over twice that of the pump-less. In Bangladesh study village, adopters outdid diesel pump owners as well as the pump-less by a factor of 1.6; in Bangladesh control village, diesel pump owners obtained higher boro rice yields; but as we noted earlier, their focus was on vegetables of which they harvested 20 mt/ha. In the North Bihar site, the *koiri* adopters of treadle pumps, with generations of vegetable growing experience, harvested a whooping 45 mt/ha of green vegetables; not surprising then that many *Thakurs*





large land owners took to treadle pump irrigation just for their vegetable plots. The story was repeated again with potato, which became a treadle pump adopters' preferred crop across locations. Barring Nepal terai, adopters harvested significantly higher yields compared to the pump-less as well as diesel pump owners; in Eastern Uttar Pradesh and North Bihar, treadle pump owners harvested average potato yields in the neighborhood of 16-17 mt/ha—which was 60-70% higher than diesel pump owners managed. When it came to production per farming household, then, the treadle pump owners did not seem as badly off compared to medium sized land owners; what they did not have in terms of large size of land holding, they more than made up from various combinations of higher crop yields, better cropping intensity and more of high-value crops such as boro rice, vegetables and potato.

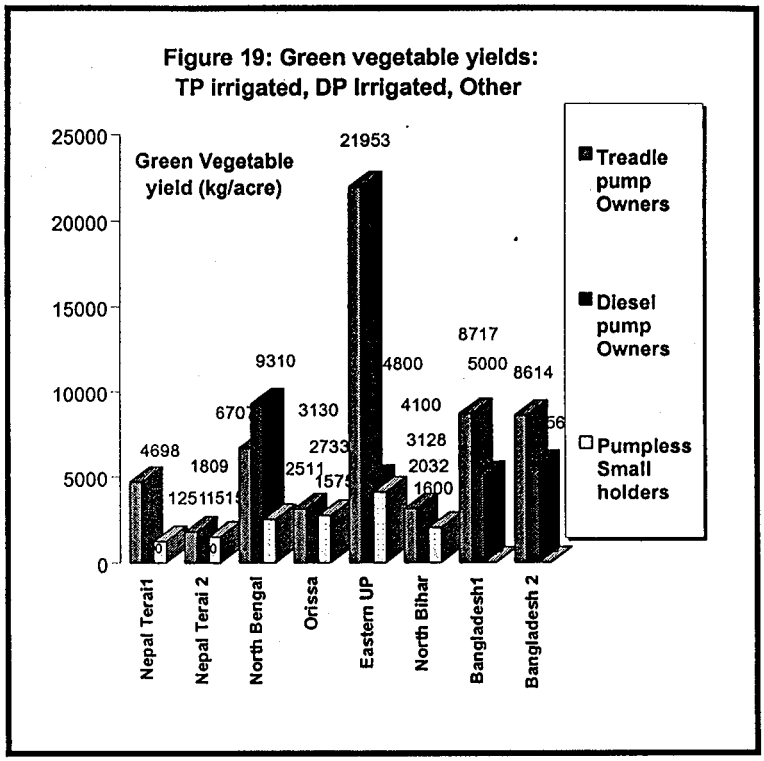


Table: 4 *Results of a 1995-96 Unpublished Survey by T. Shah, R Indu and S Paleja*[1]

Variable	Diesel Pump Owners	Water Buyers	Treadle pump Owners
Sample size	134	151	95
Average operated area (acres)	4.23	1.65	2.014
Cropping intensity (%)	178.7	203.0	199.5
% of area under vegetables: rabi	2.23	1.89	11.7
% of area under vegetables: summer	23.5	82.32	80.48
% of cropped area under vegetables: kharif	0.50	1.39	4.58
Gross cropped area in vegetables/ farmer acres	0.13	0.10	0.46
Average yield/acre (kg): wheat	772.5 (33.6%) *	698.5 (37.3%)	832.9 (30.9%)
Average yield/acre (kg); Kh.paddy	1138 (44.95)	897 (44.9%)	1096.5 (36.5%)

* Figures in brackets refer to the area under the crop as % of GCA

Indeed, in the farming strategy adopted by treadle pump owners, land holding size became largely irrelevant to income generation; everywhere, we came across adopters who practiced some form of 'priority farming'; since it was not possible to handle more than 0.5-0.7 acres with treadle pump irrigation, they showered enormous amount of Green Revolution inputs, care and family labour on their treadle pump irrigated crops while growing low-risk crops on the rest of their holding or at times leaving it fallow.[16] For those located close to vegetable markets, this strategy paid off handsomely; but it paid off even for adopters in North Bengal and Bangladesh who used treadle pump to grow china boro. [17]

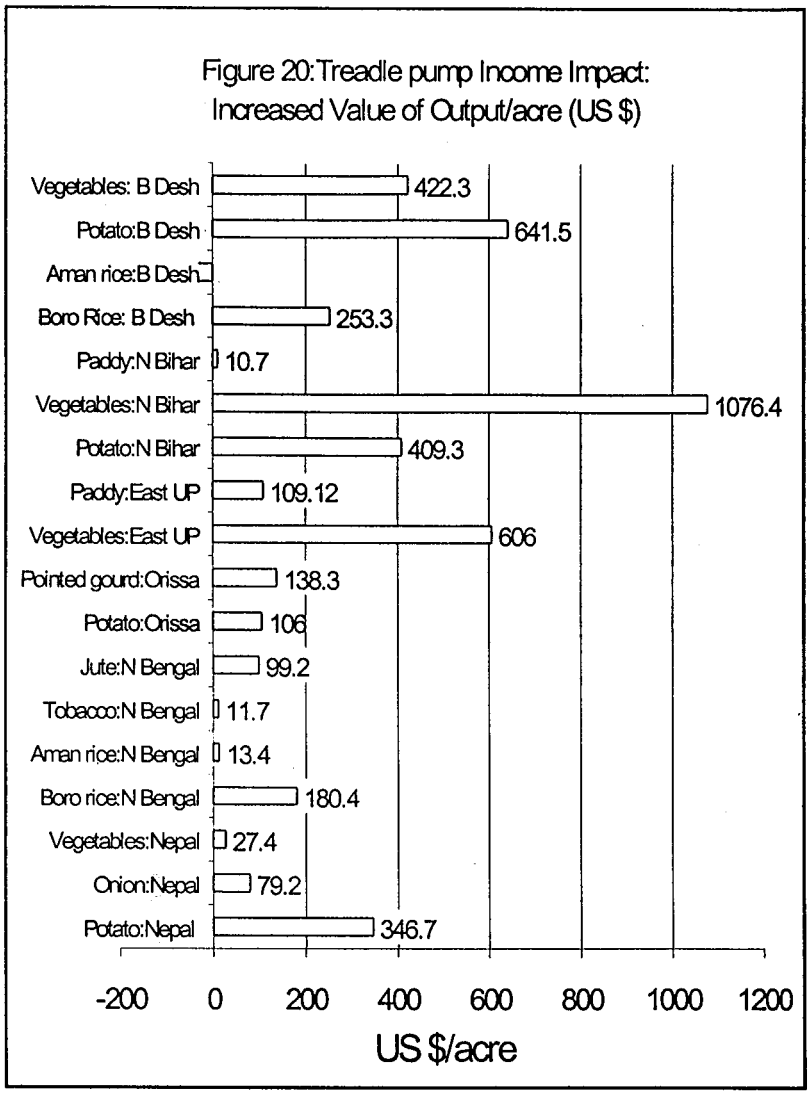
Earlier studies too found the treadle pump's beneficial impact to vary according to the regional contexts. The central benefit treadle pump adoption offers, according the Mallik survey of farmers in Puri district of Orissa in 1995, is a significantly higher land-use intensity compared to both diesel pump owners as well as pump irrigation buyers. In this sense, treadle pump technology can be viewed as land-augmenting technology. The GCA of treadle pump adopters at 5.8 acres is significantly larger than water buyers' at 4.9 acres. The most surprising finding emerging from Mallik's survey is that treadle pump users' stress on vegetable cultivation is not different from water buyers' any significant way; in absolute terms, diesel pump owners grow vegetables on substantially larger area. For all groups, vegetables account for 10-12% of total GCA; the main crop is still paddy in all three seasons.

The 1995 survey of Gorakhpur mandal by Shah et al (1996) showed, as our more recent study in Gorakhpur mandal does, that adopters grow much more vegetables in relative and absolute terms compared to others. However, this survey did not capture higher cropping intensity as a significant treadle pump impact in Eastern UP. On crop yields, adopters do distinctly better than pump irrigation buyers; and this might well be because of the greater irrigation-independence that adopters enjoy; moreover, it is likely that water buyers end up over-economizing on their costly purchased pump irrigation which adopters probably are not forced to. Interestingly,. however, all adopters surveyed were also water buyers; and in wheat, they actually applied more purchased irrigation/acre than even pure water buyers did. This probably means that adopters do not necessarily save a lot on irrigation cost, as the Mallik-survey of Orissa showed; the main gain of TP adoption here is

Table: 5
Impacts of Treadle pump Adoption:
R M Mallik's 1998-96 Survey for Salajunga, Puri District, Orissa

Hypothesis	TP Users	Pump Irrigation Buyers	Diesel Pump Owners	Non-irrigators
Sample size	19	20	20	20
Backward castes	17	19	18	20
Operated holding (acres)*	3.2	3.07	4.69	1.94
Land use intensity %**	181	160	160	99
Gross cropped area (acres))	5.8	4.9	7.5	1.92
% of sown area under vegetables: Kharif +	10.9 (0.29)	3.6 (0.10)	6.4 (0.56)	0.0 (0.00)
% of sown area under vegetables: Rabi +	52.0 (0.55)	85.0 (0.87)	82.4 (0.99)	0.0 (0.00)
% of sown area under vegetables: summer +	13.3 (0.27)	10.7 (0.19)	14.8 (0.28)	0.0 (0.00)
Average total area under vegetables (acre)	1.11	1.16	1.83	0.00
Kharif paddy/acre (kg)	931	992	822	893
summer paddy/acre(kg)	1024	1292	1413	
Irrigation expenditure/ acre: (selected crops)				
Rabi paddy	346	NA	1406	
potato	44	865	773	
brinjal (rabi)	0.0	912	1493	
Lady's finger (rabi)	356	1000	1775	
Summer paddy	72	2397	1650	
Lady's finger (summer	0.0	544	865	
Brinjal (summer)	0.0	544	865	

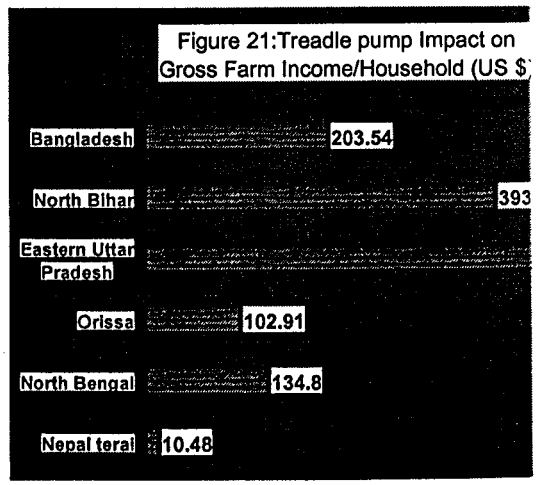
* Operated holding = (Own land) + (land leased in) - (land leased out)
** Land use intensity is computed here by computing the area sown in each season as a % of total area and summing the percentage figures for the three seasons.
+ Figures in brackets refer to average area (in acres) per sample household under vegetables.



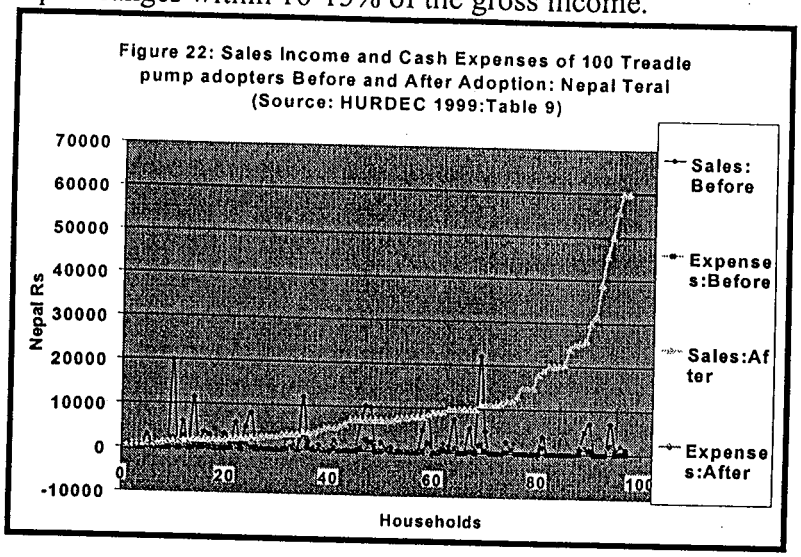
substantially higher crop yield in wheat and paddy and a lot more vegetable cultivation.

Income Impact.

Measuring increased income *as a result of* treadle pump technology is a tricky affair entailing comparative analysis of farm budgets. Our study was not designed to doing that; we worked on the premise that if treadle pump adoption significantly influences intermediate variables—such as cropping intensity, cropping patterns, and crop yields, then the income impact hypotheses gets simultaneously tested, albeit, indirectly. And all the evidence we have analyzed on these variables suggests that adoption results in significant increase in these intermediate variables and hence adopter household's net income. The Orr et al (1991) study estimated net benefits/ crop/hectare to range from US $ 120-440; it also estimated the return on treadle pump irrigation high: the benefit:cost ratio at 3.4 and IRR at 50.9%; pay-back period, one season (ibid.: p58). 93% of the 151 farmers surveyed recovered their capital investment in one season. A figure of US $ 100/household as a rough estimate of value of annual benefit stream (which includes cash income plus improved home consumption), first suggested by Paul Polak has been in currency as a sort of 'income-impact hypothesis'. Our analysis suggests that while there are wide variations across households as well as regions, US $ 100 is probably a conservative estimate of the average net benefit/ household created by treadle pump adoption. There are many indications that the *average* is probably significantly higher. One indication is the substantial increase in yields of high-value crops under treadle pump irrigation as figure: 20 shows. Gross income per acre of



US $300-400/acre is common, especially since the post-adoption cropping patterns get reoriented towards high value crops. True, the cash costs on Green Revolution inputs too increase very substantially compared to the pre-adoption situation; however, cash costs of inputs ranges within 10-15% of the gross income.



Per acre gross income however is only a distant relative to per household net income since most adopters irrigate much less than an acre with treadle pump. Figure 21 constructs the increase in gross income per household *because of* treadle pump adoption. This takes into account changes in cropping pattern, cropping intensity and even loss of crops resulting from super-intensive cultivation of treadle pump-irrigated crops—such as *aman* and *aush* rice and jute in Bangladesh and North Bengal. And even if we take 25% as the input costs (excluding the imputed value of family labour), the net income estimates in all locations except Nepal terai and Orissa would be around or substantially greater than US $ 100/ adopter household.

A study recently completed in Nepal terai (HURDEC 1999) which uses a more appropriate 'before-and-after' methodology offers more categorical evidence on the income impact of treadle pump adoption. The HURDEC analysis is based on comparing farm budgets of 100 adopter households before and after they adopted treadle pump. Although attractive from many angles, this method relies on farmers' recall of past decisions and is often considered open to measurement problems. However, given that the with-and-without method we deployed too has problems of measurement and comparative analysis, it is as well that one might use before-and-after method based on recall. The HURDEC results are interesting and are shown in Figures :22 and23.

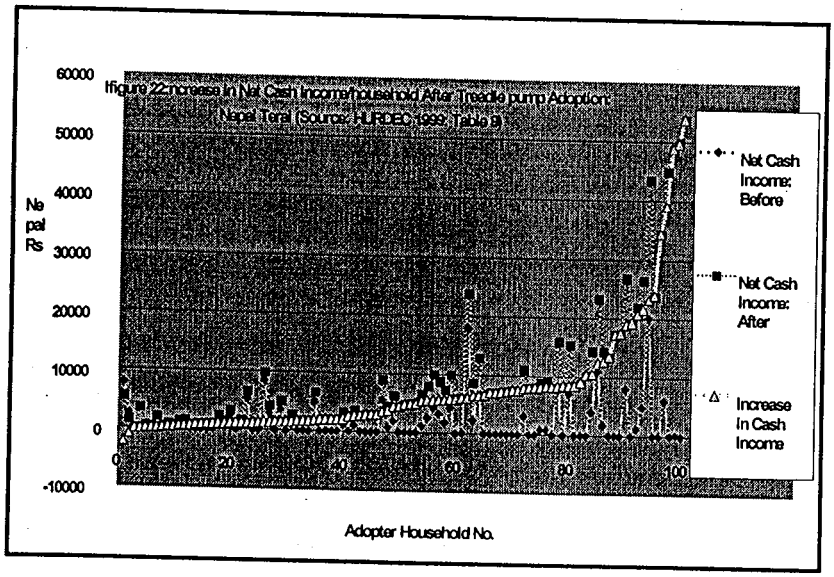


Figure22 shows gross income and expenses before and after the treadle pump adoption for 96 households; Figure 23 shows net income figures before and after adoption. In both the figures, household data is arranged in ascending order of the net income after adoption.

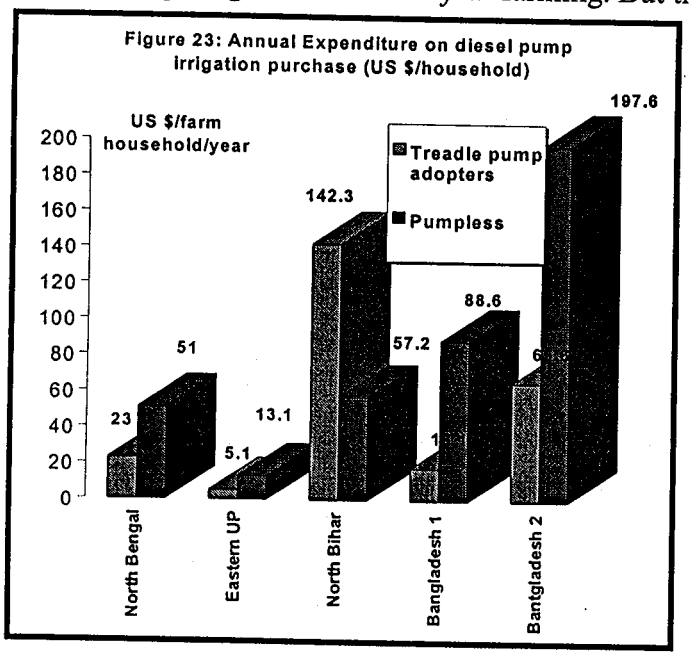
The HURDEC study provides further insight into the pattern of income impact of the treadle pump technology. It shows that for nearly 40% of the adopters, treadle pump impact on net household income is in the range of NRs 3000-4000 (US $ 50-70) or less; for another 40%, it is in the range of N Rs 4000-8000 (US $ 70-110) but for 20% of the enterprising adopters, it is substantially in excess of N Rs 8000 (US $ 110) /household. This is a pattern we came across in all our location studies too. Household level impact of treadle pump adoption takes two forms: less enterprising among the poor use it to bring their surplus family labour under productive use; their gain is an 'implicit wage' on family labour that is 1.5-2.5 times the market wage rate. In contrast, the more enterprising among the poor use treadle pump irrigation to make a transition from 'subsistence farming' to *intelligent commercial farming;* it is these who evolve and use new ideas like early planting to beat the market-glut, husbanding hired diesel pump irrigation with treadle pump irrigation, priority application of inputs, building market linkages, growing new types of vegetables, and so on; these earn much more from treadle pump irrigation—only a small part of their increased earning is return to their labour; the bulk of it is return to their entrepreneurial effort—innovating, risk-taking, searching for new market opportunities, and so on.

Everywhere, we came across such examples of 'smart small-holder farming'. In a field trip in Bangladesh, we interviewed Abdul Rahim of Morjal village (Thana Raipura, Dist: Narsindhi), one such exemplar who is probably met by all IDE visitors as demonstration of the best that treadle pump technology has to offer. When we met him in early September 1999, Rahim had already grossed US $1200 from selling bringal grown on one *bigha* over 8 months. On inputs, he had spent $ 250 so far; but 10-12 hours of pedaling/day (by two men taking turns) every day for 6-7 months is what took to produce a steady weekly supply of 150-160 kg of brinjal for the market. By the time the present crop is replaced in the following two months, Rahim will have grossed $1600, spent $350 on inputs and invested some 400 person days of mostly family labour on a plot of what was earlier wasteland.

In many locations, we found indicative evidence of large-scale emulation by adopters of such remarkably successful entrepreneurial farmer—at times, with disastrous effects. In the North Bengal study village, many treadle pump adopters took to tomato and cabbage cultivation in a big way without developing any understanding of the market dynamic; and all of them burnt their fingers in the glut that ensued. In Coochbehar town, cabbage began selling at less than half a rupee per kg; many farmers fed cabbage to their livestock; and, a stage came when even bullocks refused to eat cabbage. The farmers we met were a frustrated lot who swore they would never try vegetables again. But they sure would; and next time around, they will think hard about how to beat the market glut.

Where small farmers have been using the treadle pump for some time, there is some faint evidence that in this process of 'creative destruction', the treadle pump helps the average adopter also to become 'market suave'. For example, based on a survey of farmer perceptions, the AIMS (1997:207) study found that 46% of the adopters in Orissa, 65% in North Bengal, 34% in North Bihar and 39% in Eastern Uttar Pradesh confirmed that they were able to sell their crop early which helped them to beat the market glut. Moreover, except in North Bihar—where only 56% thought so, more than 90% of the responding adopters confirmed that the use of the treadle pump helped them plan their farming strategies better. Again except in North Bihar, over 80% of adopters felt that treadle pump adoption has 'increased their incomes' and over 90% confirmed that it 'improved their economic well-being'.

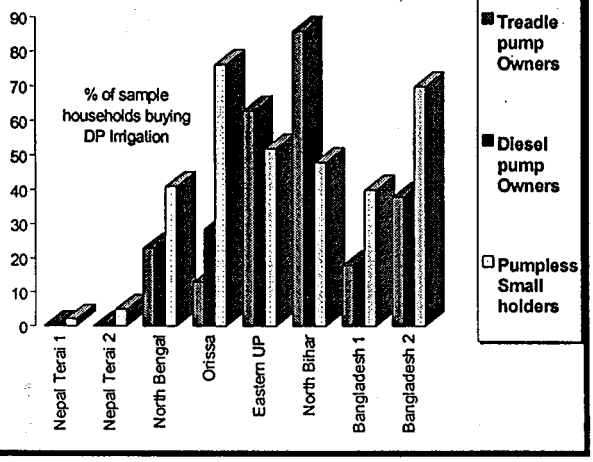
There is another aspect to the income impact of treadle pump that is often ignored. Most studies estimate income impact of treadle pump irrigation by comparing income under treadle pump irrigation with *rain-fed* farming. But this is clearly inappropriate especially because the treadle pump technology is being promoted in flood-plains where there really is no pure rain-fed farming as we find in semi-arid areas of South Asia. And as most studies—including ours—show adopters did not come into irrigated farming from rainfed farming; most came from inferior or less suited or more laborious or more time-consuming--manual irrigation technologies—such as hand pump, *tenda, shena,* bucket-irrigation, *taar-balti (*swing-buckets), etc--to treadle pump. Our study in Nepal terai and Orissa show unexpectedly low income effect because non-adopters mimic the treadle pump adopter farming strategies with great finesse and earn comparable incomes. If we were to estimate income impact in our studies by comparing adopter households with a small sample we have of pure rain-fed farmers, our estimates of increased income would be much higher--but wrong.



Where mechanical pump irrigation markets are active, the economics of treadle pump irrigation are closely aligned with those of irrigating with purchased pump irrigation which in turn depend critically on a variety of factors but particularly the marginal energy cost of pumping. In Bangladesh, the cost of diesel is marginally higher --at US $ 0.26/litre compared to India's US $ 0.21/litre (before India hiked diesel prices in September 1999). But the cost of electricity in Bangladesh is much higher at US $ 6.4 for 100 kWh and its availability for agricultural pump sets is much better. In contrast, in Eastern India, almost all state electricity boards charge for power at a flat rate which

includes a heavy element of subsidy; however, power supply to agriculture is woefully poor in quantity and quality. As a consequence, whereas in Bangladesh, diesel and electric pump owners compete for increasing their market shares, in India, diesel pump owners rule the roost in localized pump irrigation markets. In a field visit to village Majarchan (Thana Polash; Dist: Narshingi, Bangladesh), we figured that the village had 85-90 treadle pumps and some 25 diesel and electric pumps with intensely competed pump irrigation markets especially for *boro* HYV rice. Unlike in Eastern India, where diesel pump irrigation sells on a hourly basis @ US $ 0.6-0.85/hour, Bangladesh has several charging systems but the cost of pump irrigation of *boro* HYV rice is around US $ 60-65/acre. Marginal farmers manage 0.35-0.5 acre of boro HYV paddy irrigation with a treadle pump; however, it is common to raise some more with supplementary purchased pump irrigation. For Jalaluddin, a diesel pump owner who was our main informer, *boro* is the peak business season, operating his pump 15-17 hours/day, irrigating all of 1 acre of his own paddy crop but 30 acres of his clients' *boro* rice. No surprise, then Jalaluddin changes his diesel pump every two years, and still makes more money as a water seller than as a farmer.

Figure 24: Dependence on Purchased Diesel Pump Irrigation



For the treadle pump adopter, ruling diesel pump irrigation price is a crucial determinant of the implicit wage rate on pedaling the treadle pump. With good estimates on the technical rate of substitution between the pedaling a treadle pump versus using diesel pump irrigation, one could work out the implicit wage rate on pedaling under different conditions. Regrettably, one aspect on which most treadle pump users hesitate to hazard even 'guesstimates' is the labour use in treadle pump irrigation, no matter how one formulates the question. In Majarchan village of Bangladesh, different farmers explained to us differently the amount of work involved in treadle pump irrigation of boro rice. Average of 4 hours/day for 45-50 days (that is a total of 180-200 hours or 25 days full-time work equivalent) per *bigha* of boro HYV rice was however, the common refrain; at this level of effort, treadle pump irrigation offers an implicit wage rate of US $ 0.8-1/day just in the form of saving of mechanized pump irrigation cost. This does not compare well with the going farm wage rate in *boro* season at US $ 1.4/male worker day; but treadle pump irrigators harvest at least 0.2/mt more rice per *bigha* than diesel pump irrigators (the average boro *HYV* yields in Narshindi being 0.9-1.1 mt */bigha* or 6.7-8.1 mt/ha).

Variations in patterns of income impact across regions are in some ways far more interesting that the absolute magnitude of impact *per se.* In dynamic local agrarian economies with hyperactive pump irrigation markets —such as in North Bihar and Bangladesh—where treadle pump adoption is driven by the need to break out of the paralyzing and total dependence on pump irrigation sellers, the saving in irrigation cost

itself is a significant gain, especially in Bangladesh and North Bengal (see figure:23). In Eastern Uttar Pradesh, where pump irrigation markets are active, our estimates of average costs of purchased pump irrigation are unbelievably low; however, the counter-intuitive result that treadle pump adopters spend *more*—and not less—on purchased pump irrigation compared to non-adopters is easier to explain. In these locations, we found treadle pump impact on cropping intensity as well as yields to be exceedingly high; achieving these entailed intelligent combinations of treadle pump irrigation and purchased pump irrigation; therefore, it is not surprising that that adopters in North Bihar spend US $ 90 more on pump irrigation because they gross US$ 400 more compared to the non-adopters.

In emerging pump irrigation markets dominated by few oligopolistic sellers, total dependency on water sellers is often more crippling than the cost, especially for ultra-small holders whose purchases are in small lots. For ultra-marginal farmers, freedom from dependency on pump irrigation markets is an important non-price benefit. And as figure: 24 shows, barring the Bangladesh villages where non-adopters are larger farmers compared to adopters—fewer treadle pump operators buy pump irrigation compared to non-adopters.

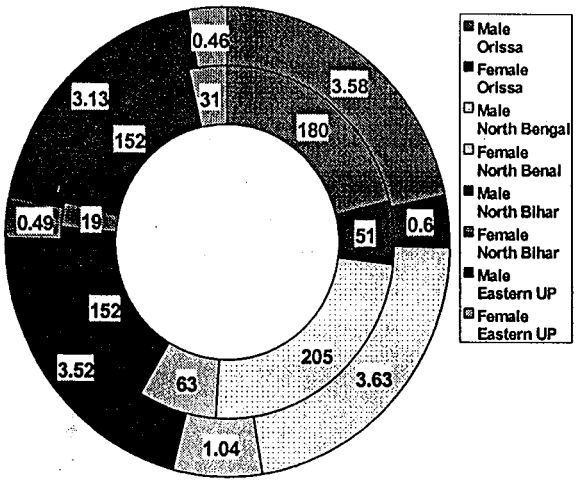
Gender Dimensions

Perhaps, one of the most profound—and the least understood—is the impact of treadle pump adoption on the intra-family dynamic, not only in terms of the reallocation of labour but also of decision making 'roles' in general. A major reason why the (diesel) pump-less marginal farmers are locked into low 'value added' farming is that man's labour becomes the limiting factor on the amount of irrigation the pump-less can give using traditional manual devices. Although women's role in agriculture is well-established, their role in manual irrigation is limited. Except in some tribal communities in Orissa and in Nepal terai, operating *tenda, lathakari, shenna, taar-balti* and other such manual devices have been the largely the preserve of adult men, by tradition and, in some ways, by necessity; and women were on the margin of irrigation. The treadle pump is beginning to change this scenario.

Many 'normal' studies have failed to capture the important qualitative changes that the treadle pump technology is producing on gender relations and, instead, have focused exclusively on the sharing of treadle pump labour. Most of these have concluded that adult men still provide the bulk of the pedaling labour. For example, the AIMS (1997) survey of 400 treadle pump households in Eastern India asked their respondents about the gender patterns of treadle pump labour; in particular, it sought information on number of males and females who contribute to pedaling labour and also the average hours contributed per day during the irrigation season. Key results of the study are summarized in figure: 25 . It suggests that male members of the household contribute the bulk of the pedaling labour –in terms of heads as well as hours. It also suggests that women are far more involved in treadle pump irrigation in North Bengal and Orissa than in North Bihar and Eastern Uttar Pradesh. The MARG (1996:V) study of treadle pump buying behavior also noted that 'In the case of most of the owners, the pump was being operated mainly

by the farmer himself, though in some cases, the wife was also helping the farmer..' Similarly, the early Orr et al (1991:50) study based on a survey of 151 adopters in Pirganj and Aditmari in Bangladesh found that men contributed 3/4th to 4/5th of the treadle pump labour. Women contributed more as the land holding size declined; children contributed less than 1/10th. [18] These studies have all tried to show that, for once, the woman has *not* been at the receiving end of new forms of drudgery; however, they have also failed to reveal that in those 20-30% of 'smart-farming' adopter households, the new found, 'treadle pump-induced' prosperity is founded on a brand new partnership between man and woman and other members of the household, a partnership in which the woman has a larger role and greater importance than she ever had in farming.

Figure 25: Men and Women contributing to Treadle Pump Labour: Heads and Hours/day/household based on a Survey of 400 adopters (AIMS 1997)



The Ramaswami and Sengupta (1999) study focuses on these subtle, qualitative changes that the treadle pump technology is producing in intra-family dynamic. They begin by suggesting that despite IDE's gender-sensitivity and its heavy projection of women in its visual messages, its promotional approach by and large fails to 'include' women; women are unable to participate in its public demonstrations at *haats* and meetings which are typically dominated by men; and women are totally absent in the marketing channel, where new jobs and livelihoods are created by the day. Yet, they conclude that the expansion of the woman's role in irrigation farming is amongst the most significant impacts of the treadle pump technology. The touchstone of this impact, Ramaswamy and Sengupta (ibid.) argue, is the role of women in treadle pump *purchase* decisions. If one asked 100 diesel pump buyers whether they consulted their wives about the purchase, it is highly unlikely most would say they did; but if the same question were asked to 100 treadle pump buyers, it is highly unlikely that many—or, any--would say they didn't. Diesel pump owners do not need their women to rally around; treadle pump buyers do. Ramaswamy and Sengupta (1999) conclude: in many poor households, the treadle pump purchase marked a new collaborative relationship between man and wife based on greater mutuality, co-operation, respect and fusion of roles. In adopter households, certainly the woman's work on the farm has increased; but for many of these women, it is small price for their increased importance, her enlarged role in household decision making, and above all, in participating actively in a change process that will catapult her family into a new era of prosperity. 'So what if there is more work? Would you rather have me idle and starve? My family eats better and clothes better. I am not scared of work', was the sentiment shared by a tribal woman about her role in treadle pump irrigation (Ramaswami and Sengupta 1999:17). Earlier too, they labored on the fields but

their toil counted for little or nothing; now, their toil has got them significance—before their men, their families, in their world.

There is perhaps a great deal more to how the treadle pump technology changes gender relations in adopter households than we know. And the Ramaswami-Sengupta (1999) study offers some interesting hypotheses: women tend to get more involved in treadle pump irrigation before they are 30 than after they are 40; many young women feel they will be able to participate less and less in it as they grow old; women tend to be more active in it if their irrigated plots are closer to their homes; by implication, in households in which treadle pump induces greater vegetable cultivation which typically takes place near homestead, women's participation tends to be higher than where treadle pump irrigation is used for grain-fiber crops where constant watch is not paramount. The Ramaswamy-Sengupta (1999) study provides some support to the finding of other surveys that women participation in manual irrigation tends to be less in Eastern Uttar Pradesh and North Bihar than in Bangladesh, Orissa and North Bengal. However, their study also hints at deeper—and probably more profound--change process in motion in the former regions where *khushwaha* and *koiri* adopters are turning intensive vegetable cultivation with treadle pump irrigation into an art-form; Ramaswamy-Sengupta suggest a different pattern of role-definition that is emerging in which women are taking increasing responsibility of marketing while men guard the 'farm-front' implying more treadling labour. Mahendra Singh too alludes to this new allocation of work but thinks the gender roles are the opposite; it is the men who go in search of distant markets and better prices while women work in the fields.

Be that as it may, after all is said and done, there still are unsettled issues of gender-equity that result from the persistence of a certain 'mindset'; and it is this aspect of the Ramaswamy-Sengupta conclusion that makes one wonder about the upshot of all that we have learnt about what treadle pump technology has done to gender roles and relations. "Despite the tiny empowering processes that have accompanied women's treadling and their active involvement in farm activities, *men continue to be in charge of critical decisions* regarding what crops to grow, selling the farm produce and managing the family finances..' [emphasis from the original] (ibid:18). More, the treadle pump has done little to shake the 'the idea (a mindset) that women are only capable of simple manual tasks... that women can not cope with technological sophistication.' The persistence of this mindset acts as a self-fulfilling prophesy, 'forcing [women] to emotionally distance themselves from such [new] technologies (such as wetland weeder, diesel pump, mechanical winnower or thresher). In this otherwise gloomy picture, Ramaswamy-Sengupta conclude: 'treadle pump is one of the few technologies to have broken the rigid gender division of labour, rudimentary and simple as it is..' (ibid:20).

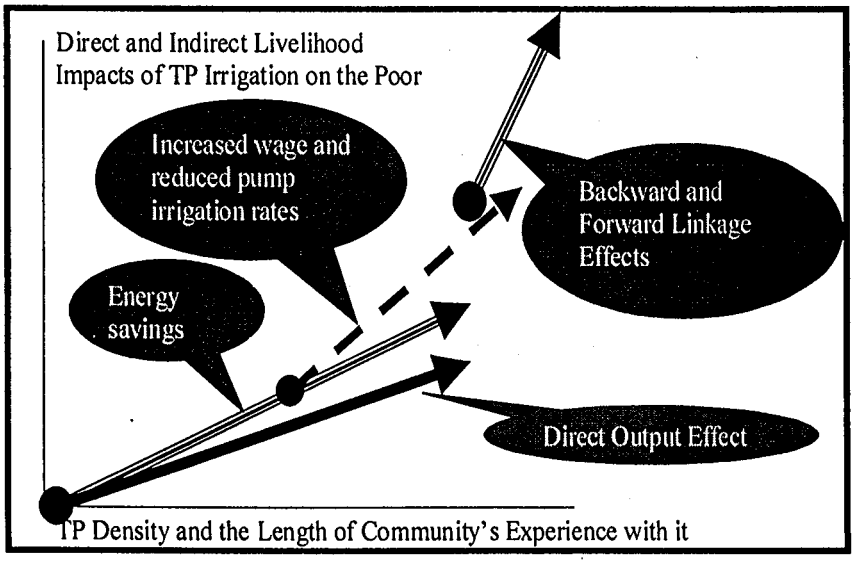
4. Second Generation Impacts.

We have suggested earlier in this report that asking whether or not the treadle pump--an unsubsidized private capital good-- confers benefits on its buyers is a trivial exercise if the product is selling; for, if it did not, the product would die for the lack of a market. There can be no better proof that the treadle pump is 'value for money' for marginal

farmers than the fact that it has sold over a million pieces without a direct subsidy on its cost. All that the studies reviewed so far in this paper including our own have done, then, is to validate and detail a conclusion that was otherwise evident.

Yet, there is need to study a variety of long term and indirect impacts of the treadle pump technology because many of these are neither evident nor are they likely to enter the market-calculus. Of particular importance are the ways in which treadle pump adoption transforms small-holder farming as a 'socio-technical' system, and how farmers with varying levels of dynamism and enterprise deal with the new opportunities that the technology offers to them. There are also questions of the health impacts of long-term use of treadle pump which have not been explored. Then, treadle pump irrigation--and manual irrigation in general--also seems to result in high water use efficiency. As Dixit argued (1993:10) ,'..over-watering is rarely observed with manual irrigation, since the delivery of water is a function of work and people generally will not 'over-work'.. [Moreover,] field workers have observed that farmers using manual irrigation spend more time and effort contouring their land to minimize the water needed for irrigation... [Indeed,] all aspects of farming, from weeding to proper timing of pesticides...are done better on farms using manual irrigation..[because] the farmer spends many hours on a manual pump with nothing to do but observe his field and think about it..'. Besides others, then treadle pump may also have appeal in maximizing 'crop-per-drop' especially as it becomes popular for low-lift surface water irrigation in water-scarce areas.

There is also the related issue of environmentally 'clean' irrigation. The region comprising Eastern India, Nepal terai and Bangladesh has probably over 10 m diesel pumps of various horse power ratings; and this number is growing at a rate of around 0.8-1 million a year; even if each of these operates for only 400 hours every year, diesel pump irrigation uses up a billion liters of diesel every year, costing US $ 0.25 billion mostly in foreign exchange. If treadle pump irrigation can replace even a small part of the growing diesel pump irrigation, it can mean a great deal of social benefit, in terms of environment, conserving fossil fuels, saving in foreign exchange—besides, of course, the direct income gains for the adopters.



Most important to study however are the second-generation welfare impacts of treadle pump technology, which may be large and significant, especially if the sales of treadle pump are likely to grow at anywhere near the rate at which they grew in

Bangladesh during the early 1990's. A treadle pump population of a few hundred thousands in Eastern India and Nepal terai would not warrant such study; but if it is going to be in a few millions, the treadle pump program can produce huge indirect beneficial impact. In this respect, three hypotheses are of interest:

[a] What we have examined are direct, short-term impacts of treadle pump adoption on adopter households. In the long term, several adjustment processes will have time to work out. Adopters who are slow to take up the 'smart options' for increasing incomes tried out by front-runners will gradually take to them. Increased income and cash flows will result in greater investment in fixed and working capital in smallholder agriculture. It will also result in other investment as in HRD. Better food and nutrition security will produce health benefits that in turn will enhance the household capacity to earn. In sum, with the magnitude of short-term income impacts that seem evident from our study, chances are that in medium to long run, many treadle pump adopter households will move to a significantly higher income trajectory through a variety of 'knock-on' effects of better income and cash flows.

[b] Indirect impacts in the long run are directly related to the *density of treadle pumps* in a village or an area (measured as number of treadle pump/hectare of net sown area). As the density increases to 0.5-1.00 in an area, local markets for farm labour and diesel pump irrigation are likely to be affected. Our studies show that the treadle pump adopter households withdraw fully or largely from the local farm labour markets because of increased labour demand of their treadle-pump-irrigated crops at higher implicit wage rates; similarly, adopters also reduce significantly their dependence on diesel pump irrigation markets than before. In areas with high treadle pump density, then, farm labour markets will face declining supply resulting in higher real wage rates; similarly, pump irrigation markets will face declining demand, causing a 'buyers' water market' with lower prices and improved quality of service. Both these will directly benefit the marginal 'non-adopter' farmers who are net sellers on the labour market and net buyers on the pump irrigation market.

[c] The third hypothesis about long-term impact has to do with backward and forward linkages. As the treadle pump economy expands, we expect that a growing number of people would be engaged in supporting it in a variety of ways, including manufacturing, marketing, maintenance and repair. According to some estimates, already some 25000 people may well be employed directly or indirectly in the treadle pump business in the region. As the population of treadle pumps grows, such 'upstream' jobs and livelihoods supporting the treadle pump economy will increase from backward linkages. Similarly, forward linkages—through processing and marketing of treadle pump induced output--too will create indirect employment effects, especially because a mt of additional vegetable output involves more processing and marketing effort than a mt of grain and fiber crops. If treadle pump irrigation results in increased vegetable cultivation, new jobs would be created in its transport, processing and marketing since post-harvest value-addition is larger in vegetables than in grain crops. In an economy with near-full employment, these impacts would mean little since it would only result in transfer of resources from one productive use to another. However, the central problem of

Bangladesh, Nepal terai and Eastern India is open and disguised unemployment of labour. Here, each new job created is net additional to human welfare.

It is important to reiterate that the *indirect* impacts we have hypothesized are contingent upon high *density* and long experience with treadle pump in a community or an area. In point of fact, the design of our study—which involved comparing household and village level variables between two villages with and without high density and long experience—was geared to capture the short term as well as long term, direct as well as indirect impacts of treadle pump irrigation in six locations. Regrettably, in none of our locations, did we find treadle pump density to be high enough to begin to influence village-level variables; neither did we find the experience with the technology long enough for the long term household level impacts too to become visible. [19] Thus while it would be too early to look for long-term direct and indirect impacts of treadle pump irrigation in Eastern India and Nepal terai, the presence or absence of these impacts should be evident especially in North West parts of Bangladesh where the treadle pump was first introduced and became immensely popular.

5. Conclusion: The Billion Dollar Question

This study has been largely about assessing the livelihood and income impact of treadle pump technology in South Asia. The core hypothesis has been IDE Chairman Paul Polak's oft-quoted claim --that every treadle pump sold increases annual net income of a marginal farmer in South Asia by US $ 100 (Polak N.D.; Postel 1999). Our own field research—and our review of other research—have found support for this claim and have suggested that Polak's might even be an underestimate. The implications of this finding are significant for the role treadle pump technology can play in the region. Eastern India and Nepal terai have an ultimate market potential for some 10 m treadle pumps which has subsequently been revised downward to a more modest 2.5 m. If and when IDE does saturate this market potential, it will have probably accomplished one of the most powerful—and best targeted—poverty-alleviation interventions the world has even seen, by increasing net annual income of South Asia's poorest rural households by a billion dollars, if the original estimate of market potential is considered! The question is if it will, and when.

All evidence indicates the technology has established its value; the real challenge now is marketing. To make any worthwhile impact in Eastern India and Nepal terai, treadle pumps have to sell not in ten thousands but in hundreds of thousands every year for many years. The total up-take in India and Nepal so far has been around 100,000; this is, by all means, good but it is not good enough to make regional impact either in absolute or relative terms. But for Bangladesh's million treadle pumps, socio-economic impact of treadle pumps in South Asia would be a non-issue.

Why are treadle pump sales not picking up more than they have so far is a source of endless of charm and frustration for IDE and its friends. It is certainly not for the want of effort; IDE marketing organization seems worked to its limits. Neither is it for the lack of professionalism and marketing capability; few development organizations in these parts

are as marketing-suave and as well-packed with talent and professional competence as IDE is.

It is a neat little poser: here is a product which, study after study has shown, substantially benefits its buyer. The private benefit: cost ratio on treadle pump investment is in the neighbourhood of 5; the Internal Rate of Return (IRR) is variously estimated to be around 100%; the payback period is less than an year(CES 1997:19)[20]. For a marginal farmer with US $ 12-15 to spare, there are few 'capital investment propositions' more attractive than a treadle pump. Considering these, the amplified East-Indian version of Bangladesh's three-year treadle pump sales boom in early 1990's –when it sold over 100-130 thousand pumps every year—should have been in place already or should be just around the corner. But nothing of this description seems anywhere on the horizon, as treadle pump off-take in Eastern India and Nepal terai keeps trotting trend-lessly in tens of thousands, refusing to cross the 100,000/year barrier. Why? Why in Bangladesh but not in Eastern India and Nepal terai, in each according to its market potential? This is the billion-dollar question facing the IDE. And until there is an answer to this, the treadle pump technology in Eastern India and Terai Nepal will have great potential but limited impact.

Naturally, no body is exercised by this question more than the IDE itself, where virtually everyone, especially in marketing, has a theory of her own on why the Bangladeshi treadle pump sales boom is not crossing into India and lower Nepal: 'Bangladesh introduced treadle pump in mid-1980s; in India, IDE began in the real sense only in 1995-96, and Nepal, even later; after all, it takes time to establish a new product!'; 'Bangladeshi farmer is far more hard-working; the East Indian farmer is lazy'; 'why, they don't have *Thakurs* and *Bhumihars* in Bangladesh'; 'why should a small farmer want to buy a treadle pump for Rs 1200 if he can get a diesel pump under loan subsidy scheme at Rs 6000 and with no cash-down as in Eastern Uttar Pradesh?'; 'marginal farmer's purchase decisions are governed by circumstances outside his control; when we decide sales targets, we do not know that Bihar will have a drought (as in 1997) and North Bengal will have floods(as every second year) and Orissa will have a cyclone (as in 1999).. man proposes, God disposes..".

Theories galore; and each of these may have grains of truth; the question is if individually or together, these still constitute a *complete* explanation to the riddle: why do we not see on the horizons of Eastern Indian and Nepal terai any inkling of the kind of sales boom that Bangladesh experienced in 1990's and which made social impact of treadle pump technology a subject worthy of serious study. If several things went 'right' for Bangladesh, many also went wrong: in Bangladesh, treadle pump had to compete with micro-diesel pumps whereas in Eastern India, treadle pump is amply protected from competition because nothing less than 5 hp diesel pumps are available. Bangladesh had nowhere to go and learn about how to promote a technology to the poor on such a massive scale; IDE India and Nepal have Bangladesh's experience to learn from. Partly as a consequence, IDE Bangladesh's approach to marketing treadle pump might even appear primitive and amateurish compared to IDE India's highly professional and strategic approach. The organization that IDE has built up in India for promotion and

marketing of treadle pump provides it a high degree of control over strategic marketing policy variables such as the quality, prices, manufacturing and marketing margins; IDE Bangladesh controls virtually nothing in Bangladesh's treadle pump economy, much as it would want to.

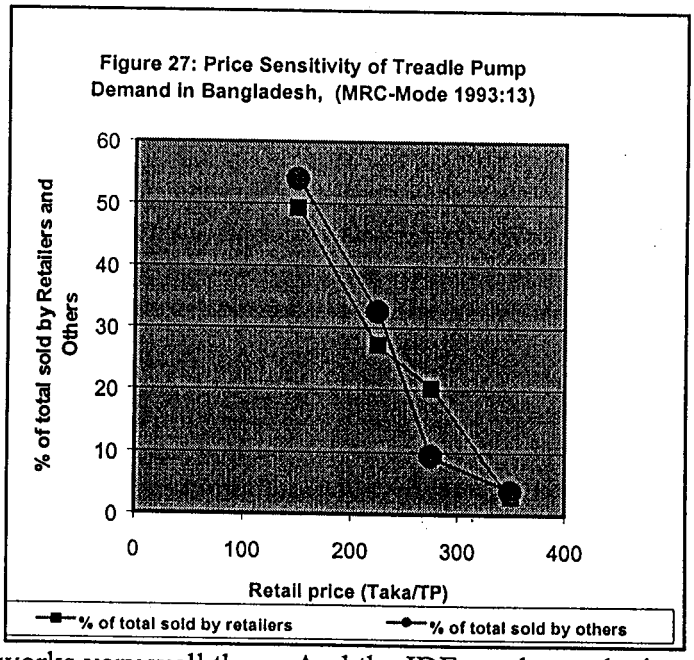
A companion study in progress on exploring the 'IDE Approach' will no doubt find a more complete answer to this 'billion dollar question'; and our guess is that whatever answer it comes up with will have something to say on at least four aspects that struck to us as significant in course of our numerous interactions with farmers, dealers, *mistry*'s and the IDE field staff. The first issue is about *quality*. In India, IDE's marketing strategy has placed enormous emphasis on quality control, so much so that its policy on brand-building, channel management, pricing and marketing margins is directly driven by the goal to ensure high product quality. The quest for high quality has also been the primary driver of product costs. Indeed quality control through its own specialist staff is one of the several ways IDE India differs from IDE Bangladesh; and it is a significant empirical question if: [a] the concept of 'quality' that IDE has pursued matches the buyer's aspirations from the product; and [b] if this 'investment' in quality has yielded dividends in terms of product acceptance and sales. However, this issue will be best addressed by the 'marketing study' in progress. Our impression is that the few studies that exist in Bangladesh suggest general satisfaction with quality of the whole range of branded and unbranded treadle pumps available (MRC-MODE 1993:52); however, despite such extra-ordinary emphasis, problems of quality have always been a major treadle pump marketing issue in India; almost every study has commented on quality problems as a source of buyer dissatisfaction. Earlier, the quality problems were in the pump itself; more recently, it has had to do with the quality of washer. The problems with check valves bewitched the treadle pump program in all Indian locations and it is not clear if the problem is satisfactorily resolved even now. [21]

The second issue is about the *stake* of the distributors and dealers in the treadle pump. At the present volumes, it is difficult to understand why distributors, dealers and *mistry*'s would have great incentive to push treadle pumps at IDE-fixed margins. The problem is not that margins are low; the problem is that at current volumes, the total expected earnings from treadle pumps at the dealer and lower levels are so small that the product can not get much importance from them, except for a handful of dealers who are able to sell a thousand or more pieces in a season. A 1998 study of treadle pump marketing dynamics in North Bengal (Shah 1998) estimated that over 80% of dealers sold less that 50 treadle pumps per year each; compare this with Bangladesh where the 1993 MRC-Mode (1993) study found that the *mistry*'s sold an average of 50 treadle pumps in a season. In the early years of a new product-launch, dealers are willing to invest in the hope of making good in future as volumes build up; but if volumes do not build up at expected rates, they begin losing interest. There is thus a catch-22 situation: at much larger volumes, present margins would probably be adequate to drive the channel incentive-structure; but those volumes can not be reached unless the distributors, dealers and *mistry*'s have better over all earnings from their treadle pump business at present. In that sense, IDE India should look forward to a day when *Krishak Bandhu* is pitted against *Kishan Bandhu*[22], and it has to deal with the problem of mushroom growth of

local manufacturers of treadle pumps who rebel against IDE standards and rule in their little market segments, as has happened in Bangladesh. That will be the first sign that the treadle pump is ready to cross the 100,000/year barrier in India. [23] For creating significant socio-economic benefit, IDE needs to blend the Alfred Marshall's idiom of 'market structure' with the marketing management notions of Philip Kotler.

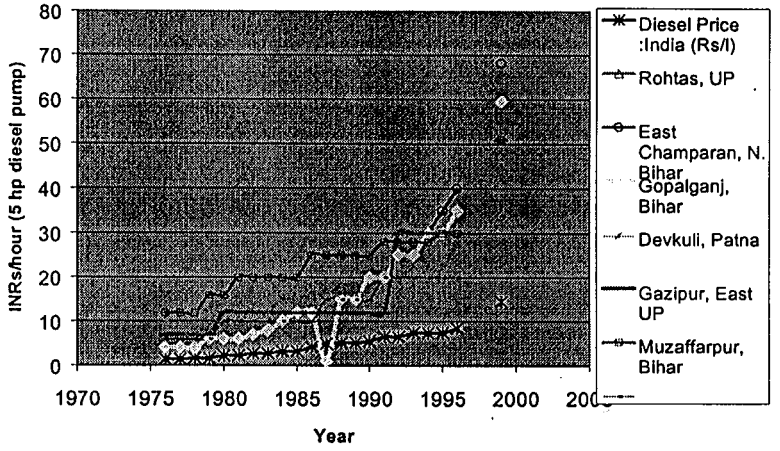
The third important—and related--issue is *pricing*. In our assessment, the market for treadle pumps is far more responsive to price and far less responsive to quality than is generally believed. In Bangladesh, where around 85 manufacturers make and market treadle pumps in a huge array of price-quality combinations, this has been evident; a 1993 study commissioned by the Swiss Development Co-operation showed that the bulk of the buying activity was concentrated in the lowest priced treadle pumps; less than 5% of the sale of the numerous treadle pump products available in Bangladesh were from the price range of Tk 350 or more; over 50% of the sale was of products costing Tk 150 or less. To make doubly sure, MRC-MODE (ibid:45) asked their sample of farmers to weigh the factors that drive their purchase decisions: and price turned out to be the most important factor. There are also other indications that demand may be much higher if prices can be cut to Rs 150-200. In course of a field visit to North West Bangladesh, we found that treadle pump dealers there have a brisk business selling second hand and low-priced unbranded treadle pumps in North Bengal where IDE India has been aggressively marketing *Krishak Bandhu*. In Eastern Uttar Pradesh, IDE has been pushing the sturdier but costlier metal pedal pump without notable success. However, during 1999, the field team introduced the cheaper, if less long-lasting and less sleek-looking bamboo treadle pump; and if the early reports are to be believed, the bamboo pump is doing very well and may be the first major marketing break-through in that region .

The fourth—and related-- aspect to consider is the IDE's response to the issue of *subsidy*, not on the treadle pump to which the IDE is ideologically opposed, but its competition, the diesel pump. In East Indian states there already are in place subsidy and loan schemes under which marginal farmers in Eastern India can get a diesel pump and a bore at 25-40% lower than market cost with a loan facility thrown in. These would have reduced the treadle pump's appeal greatly, had these schemes been working better than they are. In our surmise, a major reason why treadle pump sales are struggling in Eastern Uttar Pradesh is that the diesel pump subsidy scheme works very well there. And the IDE needs to take into account the fact that there is



increasing pressure on governments at central and state levels to enhance small holder irrigation through various means including making the subsidy schemes work better. In a recent personal communication, Dr N C Saxena, Secretary of India's Planning Commission, wrote: "we would be very keen to mount new policies which can increase agricultural productivity in Eastern India. Water is one resource, which is available in abundance, and, therefore, the new policies should perhaps focus on its exploitation. However, the sum total of the evidence suggests a large number of diesel pumps are working on very low capacity utilization and the spread of treadle pumps is still very low. This is an anomaly which is difficult to explain." It may not be long before the 'anomaly' is better understood, where upon the governments might do either or both of the following: make diesel pump subsidy schemes work better; and impose a subsidy on treadle pump. IDE needs to formulate an appropriate response to this eventuality.

Figure 28: The Impact of 35% Diesel Price Hike on Pump Irrigation Prices (INR/hour: 5 hp diesel pump)



The upshot of our analysis is: the treadle pump technology is a super-performer in the marginal farmer context of G-B-M basin; it has great potential for socio-economic impact; however, whether this potential translates into significant impact will depend squarely upon how rapidly can IDE put the pump in the hands of the millions of the region's poor, especially in Eastern India and Nepal terai. A big opportunity to push the sales of the treadle pump is offered by the recent 35% increase in the diesel price in India which will put marginal farmers throughout India to great misery because they will now have to pay US $ 1.5-1.6/hour of pump irrigation (18-20 m^3 of water) compared to US $ 0.8-1.00 they have been paying so far (see figure: 28).[24] To those marginal farmers who were depending upon purchased pump irrigation so far, the appeal of the treadle pump will become stronger than ever since the water price they pay to private pump owners drives the implicit wage rate they earn on pedaling on their own treadle pump.

IDE needs to make an opportunity out of this adversity facing the marginal farmer. Thomas Hemphill, IDE, India's Director has recently asserted, rightly, that: "There is no question that our commitment is not to the product, our commitment is to improving the socio-economic conditions of farm families.. We're not just product hustlers, we are in this for long term socio-economic benefit.." (Bhanot 1999:9). Right, and the only way IDE can produce noteworthy socio-economic benefit is by pulling off the marketing miracle of the millennium. And nothing can be more respectable—and rewarding for the

poor of Eastern India and Nepal terai--than 'product hustling' if excelling in it can help IDE sell a million pumps in Eastern India and Nepal terai in the coming 3-5 years.

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