Crop Per Drop of Diesel?

Energy Squeeze on India's Smallholder Irrigation

India's smallholder irrigation is in the grip of an energy squeeze and is proving the proverbial last straw on the camel's back. Marginal farmers and sharecroppers are particularly badly hit. Typically, they depend on pump owners for renting pumps, and even as prices have stayed put, the rental rates have risen in tandem with every diesel price hike because of the monopoly power of pump owners in these localised, village-level, informal oligopolies. Pump rentals have also tended to be downwardly sticky – they rise when diesel prices jump but stay put when fuel prices fall. This paper synthesises the results of 15 village studies to understand the impact of the energy squeeze and explores the desperate responses smallholders are forging to cope with or absorb the energy shock, and somehow stay in irrigated agriculture.

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1975-2000 was the golden age of smallholder irrigation in south Asia. Until then, much of the irrigation in the region depended on gravity flow, and was confined to the command areas of canal systems and traditional irrigation structures such as tanks, ponds and ahar-pyne systems. Since 1975, the spontaneous boom in private investment in small boreholes and mechanised diesel and electric pumps revolutionised irrigation agriculture taking it beyond the command areas to every nook and corner of the sub-continent. This happened at a time when growing population pressure made it imperative for marginal farmers to intensify their farming to ensure food for their family and livelihood security. The mushrooming of local, informal and fragmented pump irrigation service markets, through which the poor could access irrigation from pump owners, vastly expanded the productivity and equity impacts of this irrigation boom. Government policies supported the pump irrigation revolution through the expansion of institutional credit, a variety of subsidy schemes on borings and pumps, and support to farm electrification and electricity subsidies. While pumps and boreholes emerged as the mainstay of smallholder irrigation, new concerns about the threat of groundwater depletion, and adverse impacts of electricity subsidies on the viability of the electricity industry emerged. How to cool this overheated pump irrigation economy has emerged as one of the trickiest water policy issues in the region.

Since 2000, however, all available evidence suggests that the region's groundwater economy has begun shrinking in response to a growing energy squeeze. This energy squeeze is a combined outcome of three factors: (a) progressive reduction in the quantity and quality of power supplied by power utilities to agriculture as a desperate means to contain farm power subsidies; (b) growing difficulty and rising capital costs of acquiring new electricity connections for tubewells; and (c) an eightfold increase in the nominal price of diesel during 1990-2007, a period during which the nominal rice price rose by less than 50 per cent. In a 2002 survey of over 2,600 tubewell owners we carried out in India, Pakistan, Nepal terai and Bangladesh, our respondents unanimously ranked "energy cost and availability" as the top challenge to their farming, far above "groundwater depletion", "high rate of well failure", and "rising groundwater salinity" [Shah et al 2006]. Since the time of our survey, diesel prices have jumped over 70 per cent; there is no surprise then that the diesel price squeeze on small-scale irrigation is heading towards a crisis in all the countries of south Asia but this is particularly visible in eastern India and the Nepal terai where the ratio of rice to diesel price has turned particularly adverse as evident in Table 1.

Of even greater significance for the poor is the response of pump rental prices to the rise in diesel prices because the poorest strata of India's peasantry depend on water markets to secure their irrigation. Because water markets are natural oligopolies [Shah 1993], pump owners use diesel price increases to raise their pump rental rates in tandem with every major rise in diesel prices despite the fact that pumps themselves have become cheaper during 1990-2007. Figure 1 shows the changes in the nominal price of diesel versus the price of pump irrigation in Mirzapur, Uttar Pradesh. Between 1990 and 2007, diesel prices here have risen from Rs 46/l to Rs 34.8 but the rate buyers incur per hour of pump irrigation has increased from Rs 23-25 to Rs 90-95 per hour, far larger than that needed to cover the increase in fuel cost. Another characteristic of this relationship has been the downward stickiness of pump irrigation prices. Every time there is a big increase in the diesel price, the pump irrigation price tends to jump. However, the reverse is never the case.

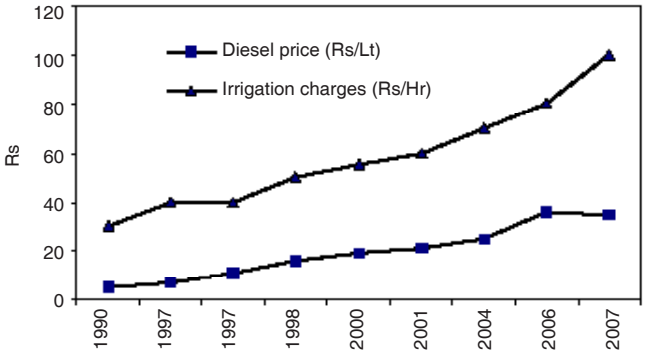
As a result, pump rentals relative to farm produce prices – which is what matters to the marginal farmers and sharecroppers – have risen even faster than diesel prices relative to rice and wheat prices. In Deoria, eastern Uttar Pradesh, a marginal farmer could buy an hour of pump irrigation for the farm gate price of a little over 3 kg of rice and wheat in 1990. Today, this ratio is 10 kg of wheat and 12 kg of rice (Figure 2).

Table 1: Farm Gate Rice Price Relative to Diesel Price in South Asia

	Diesel Price: February 2007	Farm Gate Rice Price: February 2007	Kg of Rice Needed to Buy a Litre of Diesel
India (Indian Rs)	34.0	6.4	5.7
Pakistan (Pak Rs)	37.8	11.8	3.2
Bangladesh (Taka)	35.0	9.0	3.9
Nepal terai (Nepal Rs)	57.0	10.0	5.7

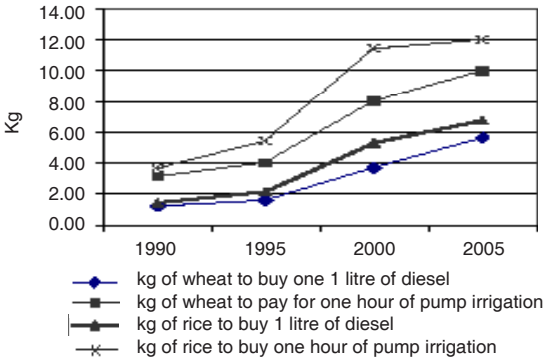
Source: Field research results by IWMI researchers.

Figure 1: Diesel Price Rise and Pump Irrigation Price: Mirzapur, UP



Source: From the Mirzapur case study.

Figure 2: Deoria: Relative Price of Diesel and Diesel Pump Irrigation with Respect to Farm Gate Food Prices



Source: The Deoria case study.

Electric tubewells, subject to flat horse-power linked tariff are cheaper to operate than diesel pumps; their owners also sell pump irrigation at much lower rates compared to diesel pump owners. Therefore, new electricity connections are avidly sought after. However, most states – which in the early 1960s gave district collectors monthly targets for a minimum number of tubewells to be electrified – now have an embargo on new electricity connections to tubewells and where they are issued, the entire cost of taking the power line to the tubewell (of poles, cables and transformers) is charged to the farmer. This has made new electricity connections scarce as well as prohibitively costly. Even so, existing electric tubewell owners, and marginal farmers who are close enough to tubewells to buy pump irrigation from them are luckier compared to diesel pump owners and their buyers as is evident from Table 2. Since farmers who can buy pump irrigation from electric tubewell owners incur lower costs than when using their own diesel pumps, diesel pump owners in Uttar Pradesh today prefer purchased irrigation from electric tubewells rather than irrigating with own diesel pump.

Table 2: Cost of Irrigating Acre of Sugarcane in Village Akataha, Deoria, Eastern Uttar Pradesh

(Rs per acre)

	Diesel Pump	Electric Pump
Own irrigation source	1,620	37
Purchased pump irrigation	3,780	1,080

Source: Case study of the Akataha village.

This paper summarises the results of 15 village studies carried out in different parts of India – with the participation of location-based researchers – to evolve a first-cut assessment of the variegated impacts of the energy squeeze on small-holder irrigation with groundwater that has come to dominate Indian agriculture during the recent decades. The aim of the studies was to explore, identify and document rather than to measure and quantify these impacts. The only way we can analyse whether some impact is more widespread than others is by enumerating the number of case study villages where these occurred (in the opinion of our research partners). This enumeration is set out in Table 3, which suggests that the groundwater economy in many parts of India, especially in the east, is shrinking; that marginal farmers and sharecroppers have taken the brunt of the energy squeeze, and these are struggling to survive in irrigation by fashioning a variety of desperate responses to the energy squeeze.

Table 3: Three Most Important Responses of Farmers to Energy Squeeze in Study Villages

	Village Study Location	Most Important Response	Second Most Important Response	Third Most Important Response
1	Kendradangal, Birbhum, West Bengal	Decline in pump irrigated boro rice area	Marginal farmers and share croppers exit farming	Kerosene/crude as a diesel substitute
2	Kaya, Murshidabad, West Bengal	Shift to low-water using crops	Chinese pumpsets	Kerosene as a diesel substitute
3	Ferozpur Ranyan, Haryana	Give fewer irrigations; same crop pattern	Water conveyance through pipes	Exodus of marginal farmers from farming
4	Purana Pradhan, Khurda, Coastal Orissa	Install electric pump or buy from electrified borewells	Switch to high-value crops	Move out of pump irrigated agriculture
5	Badhkummed, Ujjain, Madhya Pradesh	Turned to electric pumps	Decline in diesel pump irrigated area	Irrigate fewer times
6	Berkhedakurmi, Sehore, Madhya Pradesh	Increase in irrigation with electric pumps	Decline in area under diesel pump irrigation	Switch from sugarcane to wheat and gram
7	Lilapur, Rajkot, Gujarat	20-25 per cent decline in rabi irrigation	Increased irrigation interval	Small bed and alternate furrow irrigation
8	Jawrabodi, Vidarbha, Maharashtra	Increased irrigation interval	Optimising on rainfall/life-saving irrigation	Reduced irrigated area
9	Keotkuchi, Barpeta, Assam	Diesel pumps run on kerosene	Decline in pump irrigation	Farmers quitting farming
10	Dharamgarh, Kalahandi, Orissa	Increased use of canal irrigation and manual lifting	High-value crops	Longer irrigation interval
11	Shergarh, Hoshiarpur, Punjab	Farmers lease out lands to Bihar labourers	Distress shift to off-farm livelihoods	Optimising water application
12	Veerpur, Banswara, Rajasthan	Kerosene used to run diesel pumps	Longer irrigation interval	Pump irrigation concentrated on vegetables for market
13	Simra, Phulwari, Bihar	Return to rainfed paddy in kharif and pulses in rabi	Pump irrigation concentrated on summer onion for market	Sharecropping with purchased irrigation declining
14	Akataha, Deoria, Eastern UP	Increased dependence on flow irrigation	Pump irrigation concentrated on high-value crops	Longer irrigation interval
15	Abakpur Mobana, Mirzapur, Uttar Pradesh	Pump irrigation concentrated on cash crops	Irrigation interval longer	Water saving crops

Source: From the case studies carried out by the author and his research partners.

I
Withering Water Markets?

Most social impacts of the energy squeeze on smallholder irrigation (and the agrarian poor) work out through groundwater markets. Around 1990 and before, when diesel was one-eighth its price today, and farm power supply better than today, electric tubewell owners were natural oligopolists forced to behave in a highly competitive market [Shah 1993]. Flat electricity tariff, which reduced their marginal cost of pumping to near-zero levels created a powerful incentive for them to maximise pump irrigation sales, and in the process, pare down the prices. Diesel pump operators were able to offer some competition because diesel prices were low and their portability allowed diesel pumps to irrigate areas that electric tubewells could not reach. Numerous field-based studies showed that such local groundwater markets emerged as the mainstay of ultra-marginal farmers and share croppers, especially in eastern India and Bangladesh. In Bangladesh, Fujita and Hussain (1995) noted that thanks to pump irrigation markets, "the economic value of land...has decreased in a relative sense" in farm income generation and "opportunities for the landless and near-landless to climb the social ladder [have] expanded greatly". In Uttar Pradesh, Niranjan Pant (2005) wrote: "...the smallest farmers with land-holdings up to 0.4 ha are the largest beneficiaries of the ground-water markets as 60 per cent of the farmers of this category irrigated their wheat crop by water purchased from the owners of private water extraction devices..." Shah and Ballabh (1997), based on a study of water markets in six villages of north Bihar, concluded that these had opened up new production possibilities for the poor, which left them better off than before, and thereby imparted a new dynamism to the region's peasant economy. Even Wilson (2002), otherwise critical of profiteering by water sellers in Bihar, wrote: "extension of irrigation through hiring out (mobile diesel pump sets) to small and marginal holdings is in fact the major factor accounting for the further increase since 1981-82 in cultivated area irrigated at least once to approximately 73 per cent in 1995-96. Those hiring in pump sets are overwhelmingly small and marginal cultivators; they cultivate an average of 1.35 acres (compared with an average of 3.89 acres cultivated by pump set owners)..." Most recently, Mukherji (2006) in an extensive study of water markets in West Bengal reaffirmed their myriad benefits to the agrarian poor. Water markets, and indeed groundwater irrigation itself, have been a source of much succor to the agrarian poor. Studying rural poverty ratios across the Indian states over five points between 1973-74 and 1993-94, Narayanmorthy (2007) concluded that, "there is a significant inverse relationship between the availability of groundwater irrigation and the percentage of rural poverty..."

With soaring diesel prices and shrinking power supply to tubewells, this happy situation has rapidly changed for the worse. Pump irrigation markets, which boomed during the 1980s and 1990s and probably served more area than all public irrigation systems in India [Mukherji 2005] are shrinking rapidly, and so is the size of the groundwater irrigation economy itself. During the 1980s and 1990s millions of farmers in northern and eastern India purchased diesel pumps often as stand-bys for their increasingly unreliable electric pumps. Now these have come full circle; diesel becoming unaffordable, especially for water buyers, the preference for electric tubewells has increased. However, electric tubewells are unable to meet these expectations because electricity supply as well as connections are dwindling.

In eastern India, Nepal terai and Bangladesh, electric tubewells are few and far between. Where we find some, two impacts follow: first, their owners find their monopoly power enhanced, which they use to increase their share in groundwater markets and irrigation surplus. Second, they are able to moderate the energy squeeze on marginal farmers, especially when the power supply situation is good and tubewell owners pay flat electricity tariff. We found this to be the case in Uttar Pradesh (UP), West Bengal and Orissa. Where they are found in significant numbers, electric tubewell owners have driven diesel pump owners out of business. So unequal is the competition that even owners of diesel pumps prefer to purchase irrigation from electric tubewell owners rather than use their own diesel pumps (ibid). In UP, a 5 hp electric tubewell connection is a cash-cow for its owner: it entails a monthly charge of Rs 410 but can generate up to Rs 9,000 per month as gross income from water sale, a highly profitable proposition. In Birbhum, West Bengal, our researcher wrote, "...by charging such a high price for electric pump irrigation, the submersible owners are getting their own irrigation free of cost and, on top of that, they make some profit as well." Here, the flat tariff paid by electric submersibles increased from Rs 5,460 to Rs 8,950 per year between 1990 and 2007. In response, irrigation rates charged for boro rice too doubled from Rs 450 to Rs 900 per bigha. This rise was much smaller than the rise in the cost of purchased diesel pump irrigation. This has diverted the diesel pump owners' business to electric tubewell owners and served to strengthen their monopoly power. While electric submersible owners make merry, it is also increasingly the case that marginal farmers of Bengal can grow boro rice only if they can tie up irrigation with an electric shallow/mini-deep tubewell owner.

The succor private electric tubewells can provide to the poor is limited by West Bengal government's policy, which seems designed to minimise new connections for electric tubewells and ensure that the poor do not get them. To promote boro irrigation, the government initiated a scheme to issue temporary seasonal connections. In 2003, temporary connections were offered to Birbhum farmers for boro rice at Rs 7,000 for three months. In our study village, seven diesel pump owners took advantage of this. The next year, the tariff was jacked up to Rs 18,000, which put paid to the boro season electrification. Permanent connections are preferred by all but take three to four years to get approved and cost a prohibitive Rs 1.25-1.3 lakhs for poles, 11 KV cables, a 10 KW transformer and an electronic metre. The only farmer in our study village could afford such a mini-deep connection had seven acres of his own land and five acres of neighbouring land to command.

The ability of flat-tariff paying electric tubewells to moderate the impact of the diesel price squeeze is undermined by three factors: (a) inadequate supply of new electricity connections for irrigation; (b) the prohibitively high cost of installing new connections; and (c) low amount and quality of power supply to agriculture. We found new electricity connections easily and quickly available in Uttar Pradesh but the demand was subdued because the farmer had to pay for the cost of laying the cable, poles and transformer, too – which may add up to Rs 1,00,000 or more. In Kalahandi villages in Orissa, we found electricity supply plentiful, and electric tubewell costs one-seventh of what it costs to operate a diesel pump of comparable output. However, an electric pump 500 m away from the village may cost Rs 40,000 in cables and poles besides the cost of the well, pumpset pump house, starter, etc. As a result, in our study village, we found that only six large farmers owned electric pumps while small farmers

managed with either their own or rented diesel pumps. The large farmers are able to earn Rs 30,000-35,000 per year (net) from their tubewell in crop-sharing contracts, which implies a decent rate of return on their capital investment. However, the entry-barrier in the form of high capital costs keeps smallholders from this benefit. In West Bengal, even if the farmers were willing to incur such high costs, connections were hard to come by in many areas primarily because of the state water investigation department (SWID)'s sometimes exaggerated concern about over-exploitation of the groundwater resource.

In Bihar, all the three disabling factors were in full play. In a rare exception, in Simra village in the Patna district, we found over 100 electric tubewells in operation. But since the uncertain, halting and mostly nightly power supply in the village never exceeds six hours/day, and that too with a dozen or more trips, the water buyers had to depend heavily on renting diesel pumps at Rs 35/hour (excluding fuel and Mobil) as electric pump owners had hardly enough electricity to irrigate their own crops.

The only location – out of the 15 we studied across India – where the energy squeeze left farming unperturbed was water-abundant Kerala. Diesel pump irrigation disappeared from Kerala in the 1970s as the government set up electricity infrastructure in the nook and corner of the country. However, Kerala agriculture and its irrigation are in the throes of profound change. The state invested large sums in creating paddy irrigation infrastructure, but thanks to labour and land shortages, soaring farm wage rates, and a roaring money order economy, land use in Kerala is rapidly shifting away from paddy and toward plantation crops, mainly rubber, banana, areca nut and coconut. Much of the plantation economy is built around homesteads where dug-wells, augmented by bores at the bottom double up for domestic use as well as for watering the home garden. Farmers lift the small quantity of water needed to water their trees manually or by using small electric motor-pumps. The village we covered, Thekkamkara in the Trichur district, was an atypical Kerala village with proliferation of kerosene pumps. Energy squeeze is not a serious issue here, yet, the government has a scheme to supply three litres/month of subsidised kerosene per acre to smallholders to soften the energy shock. A 1.5 hp kerosene pump can lift 25 cubic m of water and irrigate an acre in four hours. The energy cost of irrigation here must be less than 5 per cent of the value of output it supports compared to 25-35 per cent in northern and eastern India. Yet, we found a small political economy woven around kerosene distribution in Thrichur.

II
Return to Rainfed Farming

Leaving aside Kerala, elsewhere in India the energy squeeze is folding up the pump irrigation economy. Way back in the 1970s, economist Ishikawa (1967) called "irrigation" the leading input in agricultural growth. Post-1975, India's smallholder agriculture boomed with supplemental irrigation made possible by diesel and electric pumps. However, all evidence we have suggests that the energy squeeze is forcing farmers, especially the marginal farmers and share croppers, to economise or even give up on this leading input. In groundwater-rich eastern Uttar Pradesh and Bihar, marginal farmers are withdrawing from wheat and sugarcane cultivation because they cannot afford the cost of supplemental irrigation with rented diesel pumps. In Gujarat as well as Vidarbha, our case studies showed that farmers dependent on rented diesel pumps are replacing cultivation of rabi wheat with that of rainfed gram and other pulses. In West Bengal (and Bangladesh), all available evidence suggests that small farmers are compelled to give up boro rice cultivation, which has served as their food security passport for over two decades. In the Kaya village of Murshidabad, we found the most important result of rising diesel prices has been a decline in boro rice area from about 50 per cent of village farm land in the early 1990s to 20 per cent or less today.

There is a strong scale-bias in the shrinking of boro rice area, with the agrarian poor hit the hardest. This was put in bold relief by the case study of the Kendradangal village in the Birbhum district in West Bengal. Electric tubewells, generally owned by influential, upper caste farmers, covered most of the village lands barring a small pocket of 70 ha with small parcels owned by schedule caste (SC) families. Post-1985, when the boro rice revolution overran Bengal, the electrified parts of the village experienced a productivity boom but the SC families irrigated boro rice with the help of 25 diesel pumps. Come 2005, thanks to soaring diesel prices, only nine SC diesel pumps were in use; in the summer of 2006, the number dwindled to three. While the electrified part of Kendradangal continues with its boro rice binge, the SC farmers we interviewed lamented, "diesel pumps are fit to be thrown into compost pit". Between 1990 and 2006, boro rice irrigated with diesel shallows in the SC lands in Kendradangal fell from 60 ha to 16 ha. In the Kaya village of Murshidabad, SC farmers told us, "For us, the positive effect of the green revolution has been nullified due to diesel price hikes... boro paddy played a great role so far in feeding our families; in 'amon', it is impossible to grow the family's rice requirement without cultivating a large field, but in boro because of very high yield, we could lease small plots and grow enough food for the family. But now boro paddy is beyond the reach of us marginal farmers."

In the canal villages we covered in Kalahandi in Orissa, with diesel pump irrigation rates soaring from Rs 25 per hour in 1995 to Rs 60 in 2007, pump rental markets have shrunk. Many mali farmers in this high-water table area took to the manual irrigation of vegetables by pots or by lifting water using dhenkuli from a depth of 10 feet in their four feet diameter open wells. Moreover, farmers renting diesel pumps shifted to diesel-saving watermelons on river banks besides taking to more diversified rainfed crops. In general, turning to rainfed cultivation of field crops like groundnut and black gram while expanding vegetable cultivation with pump irrigation for the nearby town – brinjal, cabbage, potato and watermelon, all of which are capital intensive and risky but produce high cash per unit of land – are the twin elements of the dominant livelihood strategy by small and marginal farmers in these wet villages.

A similar transition from pump irrigated crops to rainfed crops was noted in drier areas. In our Gujarat village in the Rajkot district, we found poor farmers giving up winter wheat to take to gram and pulses, besides some Bt cotton. In Ujjain, Madhya Pradesh, we found them switching from irrigation-dependent sugarcane, cotton and groundnut to rainfed soybean and gram. In gram, too, we found farmers taking to a drought-resistant "dollar" variety, giving up traditional varieties that gave better yield but needed irrigation.

III
Sharecropper under Siege

The groundwater boom had powerful labour absorption impacts on agriculture but these are on the wane. In the Murshidabad village of Kaya, the decline in boro paddy and jute cultivation

depressed demand for labour. Boro paddy especially was much valued by marginal farmers since it absorbed family labour in productive subsistence farming. With boro paddy on the decline, menfolk of landless and marginal farmer households have been looking for work in brick kilns, National Rural Employment Guarantee Programme work or rickshaw-pulling and disguised unemployment among women has risen. In the Simra village of Patna, Bihar, farm wage rates were Rs 15 in cash and two kg of rice, about the lowest in all the villages we covered. In onion fields, the wages offered were five kg of onion; and for 'masoor' harvesting, it was one bundle for every 18 bundles harvested. To make matters worse, highly elastic labour supply from neighbouring villages kept Simra's farm wage rates depressed.

Leasing small parcels of land for a fixed annual rent has been an important way for the landless to employ family labour to ensure food security. In Simra, in such 'nagdi batai' (or cash tenancy) contracts, a landless family leases in a hectare of land from an absentee land owner for a cash rent of Rs 14,000-20,000 per year, and cultivates it with purchased pump irrigation. But this form of tenancy is on a decline because the landless and marginal farmers, 75 per cent of Simra's households, find it increasingly difficult to make their tenancy viable. In Kendradangal, our Birbhum village, we were told that for marginal farmers with diesel pumps, leasing in land for boro rice cultivation was very common until 2000. However, with rising diesel prices, this practice has all but disappeared; in 2006 only three marginal farmers leased only six or seven bighas for boro cultivation. In the Kaya village of Murshidabad, similarly, until a few years ago, it was common for landless or marginal farmers to lease small parcels of land for an annual rent of Rs 1,800-2,000/bigha (Rs 13,500-15,000 per ha). For crops like boro rice or vegetables, they could still manage by buying diesel pump irrigation. With present prices of diesel pump irrigation, however, this practice has almost ended, what with half or more of the boro production claimed by the providers of land and water alone.

Instead of cash tenancy, crop-sharing for water is on rise in some parts. In the Rajkot village of Saurashtra, Gujarat, water buyers depend on renting diesel pumps only for supplemental irrigation in kharif. Renting diesel pumps for rabi crops, once widespread, has completely disappeared. Electric tubewell owners, who under Gujarat's new Jyotirgram Scheme get eight hours of uninterrupted, full voltage power under a fairly high flat charge of Rs 850/hp/year, have moved in as aggressive sellers of pump irrigation service during rabi [Shah and Verma 2007]. The common arrangement is crop-sharing rather than cash sales: the land owner provides land and labour and the tubewell owner provides pump irrigation service. Both parties share other costs and output on a 50:50 basis. In this deal, then, the value of pump irrigation is equivalent to both land as well as labour.

The rise in diesel prices has increased the rental value of surface irrigated land wherever surface irrigation is reliable. At the tail end of the upper Indravati system in the Kalahandi district of Orissa, Nayak reported that annual rent charged by command area farmers for one-tenth of a hectare rented for vegetable cultivation is Rs 1,000, while the rent for the a similar sized plot outside the canal command is just Rs 250 per year.

In the Kalahandi villages we covered in Orissa, electric pump owners generally provide irrigation services on a sharecropping basis and earn Rs 30,000-35,000 annually from selling water. In a standard contract, the pump owning large farmer usually contributes land and irrigation for groundnut while the tenant contributes labour. Both the parties share other costs and output on a 50:50 basis. If a small farmer contributes land and labour and the pump owner contributes just irrigation, then the latter absorbs all costs of other inputs – mainly seeds and fertiliser, and both share the output equally.

In coastal Orissa's Purana Pradhan village, the cost price squeeze has forced many landless and marginal farmers to move to off-farm occupations. This has made more land available for the remaining landless to lease in for short-term crops like summer paddy as well as round the year vegetable cultivation. Even some women of the landless families now work on crop-share contracts rather than as casual farm workers.

IV
Hierarchy of Exit

In many of our case study villages, we discerned a curious hierarchy of exit from diesel pump irrigated farming – in which small and medium farmers migrate out of unviable irrigated farming but even poorer households reverse-migrate into irrigated farming. This was evident in Keotkuchi, our Assam village. In this flood prone village, kharif paddy, always at the risk of a wash out, is a low-input-low-output affair. But farmers grow mustard, potato or vegetables soon after kharif paddy and then grow their main crop of summer paddy. This input and irrigation intensive crop of summer paddy with an assured yield of around 7 mt/ha had a strong fillip during the 1990s when the government supplied a large number of diesel pumps at subsidised rates. But now, summer paddy is on a decline, primarily thanks to soaring diesel prices. No matter how farm budgets are worked out, summer paddy does not generate any surplus for a farmer who views his farm as an economic enterprise. Therefore, most farmers in Keotkuchi who could find off-farm work have gone ahead and found it, sold off their diesel pumps at throw-away prices, and left farming to either large farmers or sharecroppers. The village is surrounded by villages full of hard-working landless Bangladeshi Muslims whose priorities are two: food security by growing their own rice; and putting their free family labour to productive use. They bought up the diesel pumps from Keotkuchi's yesterday farmers at throw-away prices, leased their paddy land in the summer, and irrigated their summer paddy with kerosene or a kerosene-diesel mix. The other classes of farmers who have survived the energy squeeze are large farmers who can invest in electric pumps, diesel pumps, tractors and gensets and optimise on irrigation cost as well as quality.[1]

A similar hierarchy of exit from farming was noted in the more mechanised agriculture of Punjab, Haryana and Madhya Pradesh. Here, soaring diesel prices have been affecting smallholder farming through its leveraged impact not only on pump irrigation but also on the hiring rates of other machine services, mainly ploughing and threshing. With water tables down to 60-70 feet, 150-300 feet deep tubewells with submersible pumps are needed to access groundwater irrigation. The investment required may exceed Rs 1.2 lakh, and only large and some medium farmers are able to afford such investments. Since tractors are often used to run generator sets, farmers who have tractors and deep tubewells with submersible pumps enjoy economies of scope in the agrarian economy. Small farmers who depend on rentals of all machines find the going tough. Since electric tubewell owners hardly get enough electricity to irrigate their own fields, their customers have to contend with "gen-set irrigation" which may cost up to Rs 1,100 per day to water four to five hectares. In our study village in Malwa, giving five irrigations to a bigha of wheat with a

tractor-powered gen-set can cost upwards of Rs 3,500, at which cost wheat cultivation becomes an unviable proposition. So only those farmers that have electric pumps or can crop-share with electric pump owners grow wheat. The rest turn to "rainfed" crops or quit farming. In response to squeezed margins in farming, many smallholders in Punjab and Haryana have been leasing out parts or all of their holdings to even poorer migrant labourers from Bihar and Madhya Pradesh at Rs 8,000-9,000 per acre of flat rent, while they themselves move to off-farm jobs. The migrant labourers, whose first concern is to receive full-employment wage rates, rather than profit, make their farming viable through substituting muscle power for machine power and through super-intensive cultivation of high value crops for the market. It is these reverse migrants into farming and marginal farmers unable to find off-farm livelihoods who are bearing the brunt of the energy squeeze.

At the bottom of the agrarian pyramid, the energy squeeze (and the cropping pattern changes it is bringing about) is influencing women's role in the agrarian economies in myriad ways. In Murshidabad, we found that the decline in boro cultivation curtailed the rice-boiling cottage industry that is dominated and controlled by poor women. In the Deoria village, decline in paddy area reduced demand for female labour for transplanting work; women here took to goat rearing. In Abakpur Monga in Mirzapur, Uttar Pradesh, expansion in vegetable crops, especially peas, has increased demand for labour and created new employment opportunities and higher wage rates for poor women labourers. And almost everywhere, we found the energy squeeze on irrigated agriculture increasing the role of livestock and dairying, further transforming the position of women in the household economies of the poor.

V
Chinese Pumps to Aid of Bengal's Agrarian Poor

In West Bengal, help has come to the "energy squeezed" farmer from unlikely quarters: Chinese kerosene-cum-diesel pumps. Boro rice is far more intensive in working capital, labour and irrigation but it is land-saving and therefore appealing to marginal farmers and sharecroppers. It offers 7 mt/ha of rice yield against barely 1-1.5 mt/ha rainfed amon (kharif) rice. Growing a small parcel of boro rice may liberate a farming family from subsistence worries for the whole year, and it is therefore prized by the poor. For the want of better alternatives, such as electric pumps, West Bengal's marginal farmers have been switching to Chinese pumps with gusto. They are cheap, costing Rs 7,000 and Rs 8,500 for 3.5 and 5 hp against Rs 16,000 for a 5 hp Kirloskar. The Chinese 5 hp pump runs for two hours from a litre of diesel, which a Kirloskar 5 hp burns up in an hour or less. Finally, while a Kirloskar needs a bullock cart to move around, the Chinese pump can be easily carried by a farmer on his shoulders.

In just five years, Chinese pumps have captured the irrigation pump market in West Bengal. In Murshidabad, all 30 diesel run shallows in Kaya, our study village, used Chinese pumps. The boro rice boom here was originally fed way back in the 1970s and 1980s, by cooperative tubewells with electric pumps founded by an NGO; the co-ops failed, as they elsewhere did [Pant 1984; Ballabh 1989]. But the boro rice boom continued during the 1990s with the help of Kirsloskar pumps. But at ruling diesel price, the Kirloskar is considered "fit for a compost pit"; and the Chinese pump is riding a wave of popularity.

How the Chinese pumps made in-roads into West Bengal's irrigation scene remains something of a mystery. Apparently, some second-hand Chinese pumps smuggled across the Bangladesh border caught the farmers' fancy, and soon enough, there followed a deluge of Chinese pumps smuggled across the Bangladesh border. It was only a matter of time before official imports began in 1998. Now, out of every 100 new diesel pump assemblies purchased in these parts of West Bengal, over 90 have Chinese engines. Kolkata has emerged as the epicentre of Chinese pump diffusion. Several brands of Chinese and Chinese-Indian pump assemblies are on offer here (Greeves China, Tricircle China, GK200, Chhanta China, Zenith China, Changfa China, ZL 175 China, etc). All these are selling at 35-40 per cent of the price of Kirloskar 4 and 5 hp engines, which remained market leaders for decades, and Honda 4 hp pumps. Interviews with pump dealers in Kolkata confirmed that farmers preferred these for their low price, their much higher fuel efficiency (0.35-0.4 l/hour), ability to work on kerosene, and easy portability. Chinese pumps suffer more wear and tear and have a shorter life, but Chinese pump mechanics have come up in every village, and their spare parts are cheaper and easily available.

VI
PDS Kerosene: For Kitchen or Farm?

Close on the heels of Chinese pumps, a new trend has emerged throughout India – that of using subsidised public distribution system (PDS)[2] kerosene meant for cooking for running irrigation pumps. Against the fact that it reduces the life of the engine, poor farmers see two advantages in using kerosene: first, PDS kerosene, subsidised as a cooking fuel, is cheaper than diesel; and second, when used with Chinese pumps, it yields more water per litre, ceteris paribus. Extensive use of kerosene and crude oil to run diesel pumps is the litmus test of how hard the energy squeeze pinches pump irrigators. Some engines, particularly Chinese ones, are designed to use diesel as well as kerosene. In Kalahandi (Orissa) villages, we found that marginal mali farmers, traditional vegetable growers, have disposed of their diesel engines and taken to 1.5 hp kerosene pumps for irrigating an onion crop through 3'*2' kyari's on a 0.25-0.5 ha parcel of land. But we found scheduled caste marginal farmers in Birbhum running even Kirloskars on kerosene, "In what way can you call this a diesel pump?", they said about their pumps.

In many parts of eastern India, collecting PDS quota subsidised kerosene meant for cooking and storing it for irrigating a rabi or summer crop has increasingly become a standard operating procedure for many poor households. Sharecroppers and marginal farmers with large families have special advantages as well as compulsions: large family means more kerosene allotment from fair price shops. It also means freedom from using hired labour at peak wage rates. A large family also means urgency in growing boro rice for family subsistence.

PDS kerosene has emerged as a key player in West Bengal's political economy of boro rice cultivation. Increasingly, the task of storing PDS kerosene for boro rice irrigation has been taken over by operators of PDS outlets themselves, who wait for the onset of the boro season to release their stockpile of PDS kerosene. With this, switching to kerosene too has ceased to be of much help since it is the traders who have begun to skim the cream in the black markets for PDS kerosene: between 1990 and 2006, diesel prices went up from Rs 4/l to Rs 34.30/l in Murshidabad villages but kerosene prices in the black market rose from Rs 8/l to Rs 25/l, wiping out some of the cost advantage kerosene offered to the poor in fending off the energy squeeze.

VII
Diesel-efficient Irrigation Options

Expectedly, the rise in pump irrigation costs has forced farmers to search for diesel-efficient irrigation options including crop choices, irrigation techniques and fuel options. In the Rajkot villages in Gujarat, we found farmers adopting small-bed irrigation in winter crops such as cumin, gram and wheat, and alternate furrow irrigation for cotton. They told us that these can save 20-25 per cent diesel usage but reduce crop yield/bigha by a quintal in cotton as well as wheat. In our UP village in the Mirzapur district, to save on irrigation costs, farmers have begun applying four irrigations to the rabi wheat crop rather than the five that they have been giving all these years. In our Birbhum village of West Bengal, we found many share croppers leasing in parcels just below their own land so as to use the water drained out of their boro paddy in raising another rice crop in the lower field. Many who were forced to give up boro cultivation all together due to high diesel costs increased their area under mustard crop during winter when water can be pumped or manually lifted, for a supplemental irrigation from ponds. In this new trend of replacing boro rice by rabi crops, irrigation cost relative to crop value has been a prime consideration for small farmers choosing between mustard, wheat and potato. Mustard fetches better prices and requires less irrigation. Purchased diesel pump irrigation for rabi mustard may cost Rs 200-250/bigha against Rs 1,500/bigha for boro rice.

In our study village from Vidarbha, the system of rice intensification (SRI) was introduced some years ago as water-saving technology but after trying it for a few seasons, farmers found its labour requirement in weeding daunting and the SRI disappeared without a trace. However, many small farmers did switch to the practice of dividing their farms into small basins, roughly of 200 sq m, at different heights for more efficient water, and diesel usage. In coastal Orissa's Purana Pradhan village, the soaring diesel price has induced farmers to convey water from well-head to their fields either by flexible pipes or by masonry channels.

How the energy squeeze is heralding wholesale cropping pattern changes from diesel-intensive to diesel-saving crops was striking in the Simra village of Patna district, Bihar. In 1990, this was a wholly rice-wheat village with little diversification away from this age-old rotation. Now, kharif paddy continues with or without irrigation but during rabi and summer, of its 300 ha, Simra has 150 ha under rainfed masoor, 50 ha under lightly irrigated gram, 40 ha under wheat, and 75 and 20 ha respectively under intensively irrigated onion and corriander, the last fetching them the highest return per acre as well as per litre of diesel/kerosene. In the eastern UP village, Akataha, farmers have switched from long duration to short duration paddy, and some irrigated paddy area has given way to diesel-saving groundnut and high-value potato crops.

VIII
Gambler's Choice

Curiously, in several of our study areas, small farmers have responded to the diesel price squeeze by adopting even more diesel-intensive crops, mostly vegetables and sugar cane. In the eastern UP village, the highly profitable sugar cane cultivation has replaced some of the wheat and paddy area. This reflects farmers moving from a low-input-low-output strategy to a high-input-high-income one to survive the rising cash-intensity of farming. This was most evident in the Abakpur Mobana village of the Mirzapur district in UP, where low-value rainfed kharif crops are being increasingly replaced by high-value, lightly irrigated vegetable and groundnut crops. Here, 90 per cent of the farmland was under food crops (jowar, bajra, maize, gram, tun, wheat) in 1990. Today, 80-90 per cent of farmland is under cash crops, high-value vegetables and diesel-efficient groundnut. The vegetables most widely grown here are chilli, tomato, brinjal, onion and potato.

The primary driver of the high-risk, capital-intensive cropping strategy is the need to maximise the crop (and cash) per drop of diesel. In the Purana Pradhan village in Khurda district of coastal Orissa, Manas Satpathy computed that vegetables cost a lot more to cultivate in cash inputs than kharif or summer paddy but these also offer greater cash returns (Table 4). Some years ago, sugar cane was widely irrigated by diesel pumps but now vegetables are the most important crop irrigated by diesel pumps in this village because they yield the highest income per drop of diesel. Poorer farmers, whose main concern was foodgrain security for the family were cajoled into learning new skills of vegetable cultivation and of marketing it to maximise their household income. Such a family typically uses their family labour intensively – of men, women and children, on 1.5-2 acres of leased in low-land and purchased pump irrigation from kerosene or electric pumps. Cooperation among low-land vegetable growers here is of paramount importance; if one of them chose to grow paddy, the water draining out of his field might ruin the near-by vegetable crop.

Another example of marginal farmers turning to risky high value crops was found in the Simra village (Patna, Bihar). Here, forced to give up winter wheat, share croppers and marginal farmers took to intensive cultivation on small plots of fully irrigated onion crop during the summer; it required a good deal of capital but its higher cash returns justified the investment. Initially, intensive onion cultivation in the summer began as a strategy to beat the rising cost of diesel pump irrigation of wheat and other crops but now, with the area under summer onion rising to a quarter of the village's farmland, the crop stimulated more diesel pump purchases. Onion requires 13 irrigations to mature and diesel pump owners charge Rs 3,000/bigha (Rs 12,000/ha) as a fixed charge for onion irrigation. This high rate makes investment in a diesel pump highly attractive. Simra's onion revolution looked like a way to beat the energy squeeze.

Often, however, such desperate risky choices have ended up as sure ways of getting nothing out of something. This happened to Simra's onion economy, too. After some years of bumper returns, untimely summer rains ruined Simra's onion crop in 2005 and 2006, leaving the small tenants in a huge debt trap. While some gutsy smallholders will still keep experimenting with onion, chances are that most will steer clear of the high value but risky onion crop or choose some mix of onion and low-risk masoor to diversify the risk of being wiped out.

Similar was the experience in Birbhum. Struggling to survive, marginal farmers in Kaya, and surrounding villages took to vegetable cultivation for the market to make up for boro rice

Table 4: Costs and Returns from Paddy and Vegetables, Khurda, Coastal Orissa
(Rs per acre)

	Cost of Cultivation	Net Return
Kharif paddy	3,500	2,500
Summer paddy	6,000	3,000
Vegetables	30,000	50,000

Source: From the Khurda case study.

that they had to give up. The switch proved highly remunerative for small farmers with large families and a Chinese pump. At one stage, 25-30 per cent of Kaya's farmlands were under vegetables. More recently, vegetable prices have been dropping due to a glut, and the rising cost of road transport, another result of hikes in diesel prices. In 2006, Kaya produced a surfeit of cabbage that nobody was willing to lift, and many frustrated farmers ploughed it back into their fields. Kaya farmers are now coming full circle and experimenting with an admixture of two extreme crop groups: one, consisting of hardy, water-saving crops like oilseeds, wheat and pulses that offer low but risk-free returns; and the other, including onion, coriander, black cumin that may offer better returns as cash crops but are full of price as well as output risks.

IX
Conclusion

Smallholder irrigation in India is under siege from an energy squeeze with three sides: (a) deteriorating farm power supply; (b) embargo on new electricity connections; and (c) an eight-fold increase in diesel prices since 1991. The government of India's Accelerated Irrigation Benefits Programme is investing tens of thousands of crores annually in surface irrigation, which is shrinking. But the real challenge Indian agriculture faces today is that of helping smallholder irrigators out of the energy squeeze. This paper summarised 15 village studies from different parts of India to explore the immiserising impacts the energy squeeze is causing at the bottom of India's agrarian economy.

What could be done to counter the energy squeeze? Several ideas emerge from farmers' struggles. Promoting fuel-efficient diesel/kerosene pumps of the Chinese variety can ease the cost-price squeeze. Making PDS kerosene allocation to poor farmers, as in Kerala, too might help. The idea of providing subsidised diesel to farmers, as is done for trawler-operating fisherfolk in some states, too is doing rounds. Improving manual irrigation technologies and better management of surface water bodies for gravity flow irrigation too can relieve the stress from the energy squeeze. Helping marginal farmers own pumps can help save them from the monopoly rents contained in prevailing pump irrigation prices.

However, all these must be treated as short-term patchwork. The real answer probably lies in improving electricity supply to agriculture. A 2004 IWMI-Tata study in eastern UP showed that increasing diesel pump density helps the poor water buyers a little but increasing electric pumps under flat tariff can "improve the net returns [from farming] of poor water buyers by 20-25 per cent even if no yield gains are realised. Such a shift will have a huge impact in UP since 57 per cent of all food crop cultivators are water buyers here" [Kishore and Mishra 2004]. This is true not only for eastern UP but for all of eastern India. However, realising these gains for the poor requires a mindset-change. The invidious political economy of power subsidies that have emerged in India over the past three decades have encouraged state governments and power utilities to view agriculture as a pariah. This needs to change. If Indian agriculture is to thrive and our agrarian poor to prosper, it is critical that farm power supply is managed proactively. The challenge here is to manage farm power subsidies to acceptable levels in a manner which relieves the stranglehold of the energy squeeze on smallholder irrigation. Perhaps, Gujarat's Jyotirgram Yojana points at the way to go [Shah and Verma 2007]. Under this scheme, Gujarat electricity board offers eight hours daily of three phase, full voltage power supply to tubewells along a predetermined schedule. With some modification, this has the potential to contain power subsidy to manageable levels but beat the energy squeeze with which smallholder irrigation in India is waging a losing battle today. By creating a regime in eastern India such as created by the Jyotirgram Yojana in Gujarat, the energy squeeze can be eased in a positive and proactive manner. Moreover, by giving marginal farmers priority in issuing new electricity connections for shallow and submersible tubewells, it is possible to generate equity benefits comparable to deep land reforms. Today, irrigation contributes as much to farm value creation as land, and giving the agrarian poor preferential control over electricity connections and groundwater, the last frontier, a bold policy can give them the opportunity land reforms could not. EPW

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Notes

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1 In Keotkuchi, the archetype of this latter class was Nirmal Chandra Das, who added 100 bigha of leased land to his own 60 bigha farm, gave up diesel-intensive summer paddy altogether and developed a diversified cropping patter in rabi to make his farming operation viable.

2 Public distribution system which issues kerosene as cooking fuel to ration card holders.

References

Ballabh, V (1989): 'Decline of a Novel Experiment: A Case Study of Group Irrigation Tubewells in Deoria District', presented at the at a workshop on efficiency and equity in groundwater use and management held at Institute of Rural Management Anand during January 30-February 1.

Fujita, K and F Hossain (1995): 'Role of Groundwater Market in Agricultural Development and Income Distribution: A Case Study in a Northwest Bangladesh Village', *Developing Economies,* Vol 33, No 4, pp 442-63.

Ishikawa, S (1967): *Economic Development in Asian Perspective,* Economic Research Series 8, Kinokuniya Bookstore Co, Tokyo.

Kishore, Avinash and Keshari Nandan Mishra (2004): 'Cost of Energy for Irrigation and Agrarian Dynamism in Eastern Uttar Pradesh', IWMI-Tata Water Policy Programme, Anand.

Mukherji, A (2005): 'The Spread and Extent of Irrigation Rental Market in India, 1976-77 to 1997-98: What Does the National Sample Survey Data Reveal?', IWMI-Tata Water Policy Research Highlight 7, Anand, India.

– (2006): 'Groundwater and Agrarian Change in West Bengal, India', Ph D thesis, Cambridge University, London, UK.

Narayanamoorthy, A (2007): 'Does Groundwater Irrigation Reduce Rural Poverty? Evidence from Indian States', *Irrigation and Drainage*, Vol 56, pp 349-61.

Pant, Niranjan (1984): 'Community Tube Wells: An Organisational Alternative to Small Farmers' Irrigation', *Economic and Political Weekly,* Vol 19, No 26, A59-A66.

– (2005): 'Control and Access to Groundwater in UP', *Economic and Political Weekly,* Vol 40, No 26, pp 2672-80.

Shah and Verma (2007): 'Real-time Co-management of Electricity and Groundwater: An Assessment of Gujarat's Pioneering, Jyotirgram Scheme', IWMI-Tata Water Policy Programme, Anand.

Shah, Tushaar (1993): *Groundwater Markets and Irrigation Development: Political Economy and Practical Policy*, OUP, Bombay.

Shah, Tushaar, O P Singh and Aditi Mukherhi (2006): 'Some Aspects of South Asia's Groundwater Irrigation Economy: Analyses from a Survey in India, Pakistan, Nepal Terai and Bangladesh', *Hydrogeology Journal*, Vol 14, No 3, pp 286-309.

Shah, T, V Ballabh (1997): 'Water Markets in North Bihar: Six Village Studies in Muzaffarpur District', *Economic and Political Weekly*, Vol 32, No 52, A183-A190.

Wilson, Kalpana (2002): 'Small Cultivators in Bihar and 'New' Technology', *Economic and Political Weekly,* Vol 37, No 13, pp 1229-38.