Crop per Drop of Diesel! Energy-Squeeze on India's Smallholder Irrigation

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Introduction

1975-2000 was the golden age of smallholder irrigation in South Asia. Until then, much irrigation in the region was gravity flow, and 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 investments in small boreholes and mechanized diesel and electric pumps has revolutionized irrigation agriculture, taking it beyond the command areas to the nook and corner of the sub-continent. This happened at a time when growing population pressure had made it imperative for marginal farmers to intensify their farming to ensure their families had food and to improve the security of their livelihoods. 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, support to farm electrification and electricity subsidies. While pumps and boreholes emerged as the mainstay of smallholder irrigation, new concerns emerged about the threat of groundwater depletion, and about the adverse impacts of electricity subsidies on the viability of the electricity industry. How to cool this overheated pump irrigation economy 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 cost of acquiring new electricity connections for tubewells; and (c) an eight-fold increase in the nominal price of diesel during 1990-2007 (a period during which the nominal rice price rose by less than 50 %). In a survey we carried out in 2002 interviewing over 2,600 tubewell owners in India, Pakistan, Nepal terai and Bangladesh, who 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'. Since the time of our survey, diesel prices have jumped over 70 %. Hence, it is no surprise that the diesel price squeeze on small-scale irrigation is heading towards a crisis in all the countries of South Asia in general, and is particularly visible in eastern India and Nepal terai, where the ratio of rice to diesel price has turned particularly adverse as evident in Table 1.

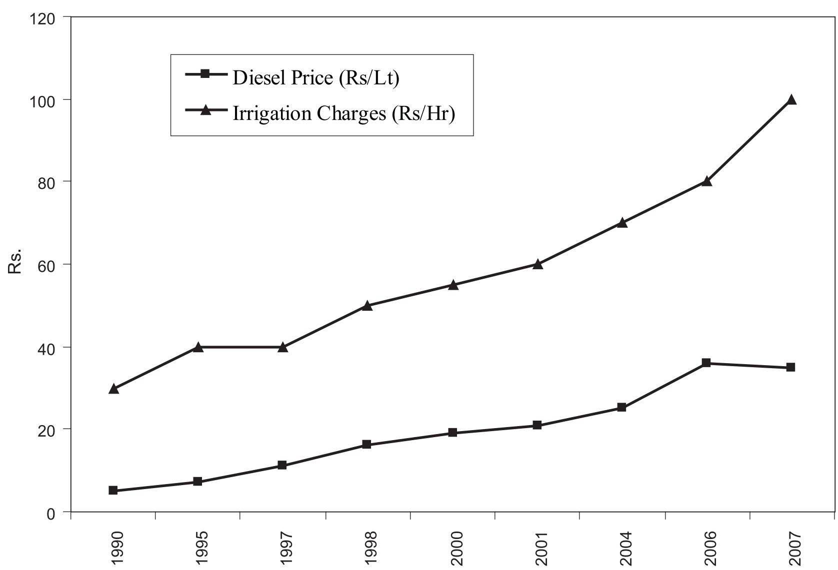
Table 1. Farm-gate rice price relative to diesel price in countries of South Asia.

	Diesel price: February 2007	Farm-gate rice price: February 2007	Kg. of rice needed to buy a liter of diesel
India (Indian Rs.)	34.0	6.4	5.7
Pakistan (Pakistan. 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

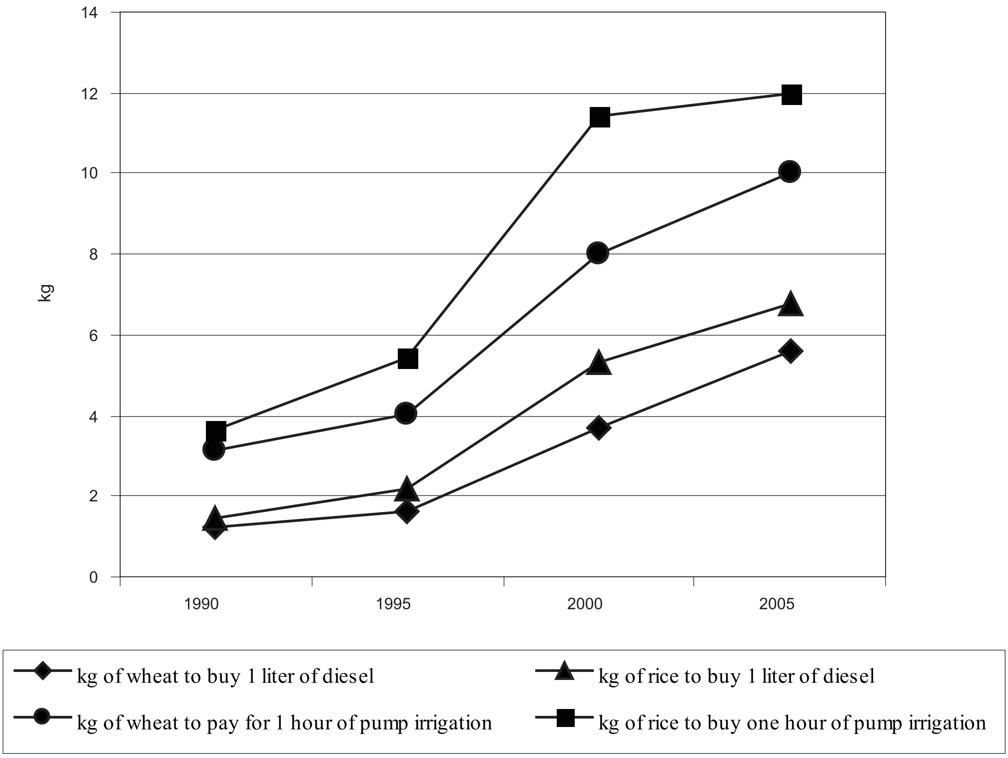
Of even greater significance for the poor is the increase of pump rental prices consequent to the rise in diesel prices. The poorest strata of India's peasantry depend on water markets for securing their irrigation, but because water markets are natural oligopolies (Shah 1993), pump owners use diesel price increases to raise their pump rental rates in tandem with every major rise in diesel price, 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 (Singh, O.P.). Between 1990-2007, diesel prices have risen from Rs. 4.6 to Rs. 34.8 per liter; but the rate incurred by buyers of pump irrigation has been an increase from Rs. 23-25/hour to Rs. 90-95/hour, far more than what is needed to cover the increase in fuel cost. Another characteristic of this relationship between diesel an pump irrigation prices, is the downward stickiness of pump irrigation prices; although every time there is a significant increase in the diesel price, pump irrigation prices tend to jump high, the reverse is never the case.

Figure 1. Diesel price rise and pump irrigation price: Mirzapur, UP.



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

Figure 2. Deoria: Relative price of diesel and diesel pump irrigation with respect to farm-gate food prices.



Electric tubewells, subject to flat horse-power linked tariff, are cheaper to operate than diesel pumps because their owners sell pump irrigation at much lower rates than 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 the minimum number of tubewells to be electrified—now operate an embargo on new electricity connections to tubewells. And where they are issued, the entire cost of taking the power line to the tubewell i.e., 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 their 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 a lower cost than using their own diesel pumps, diesel pump owners in Uttar Pradesh, too, prefer purchased irrigation from electric tubewells than irrigating with their own diesel pumps.

Table 2. Cost of irrigating an acre of sugarcane in the Akataha Village, in the Deoria District of eastern UP (Singh, Yashwant).

	Diesel pump	Electric pump
Own irrigation source	Rs. 1,620/acre	Rs. 37/acre
Purchased pump irrigation	Rs 3,780/acre	Rs. 1,080/acre

This paper summarizes the results of studies we carried out in 15 villages, located in different parts of India. These studies were conducted with the participation of location-based researchers and are aimed at developing a first-cut assessment of the varied impacts of the energy squeeze on smallholder irrigation with groundwater, which has become a dominant factor in 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. In the opinion of our research partners, the only way we can analyze whether certain impacts were more widespread than others is by enumerating the number of case study villages where these occurred. 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. Furthermore, marginal farmers and sharecroppers are seen to have borne the brunt of the energy squeeze, and are fashioning a variety of desperate responses in order to survive in irrigation.

Table 3. The three most important responses of farmers in the study villages to the energy squeeze.

	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 sharecroppers exit farming	Kerosene/crude as a diesel substitute
2.	Kaya, Murshidabad, West Bengal	Shift to low-water using crops	Chinese pump-sets	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% decline in rabi irrigation	Increased irrigation interval	Small bed and alternate furrow irrigation
8.	Jawrabodi, Vidarbha, Maharashtra	Increased irrigation interval	Optimizing on rainfall/ life-saving irrigation	Reduced irrigated area

	Village study location	Most important response	Second most important response	Third most important response
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 laborers	Distress shift to off-farm livelihoods	Optimizing 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 rain-fed paddy in kharif and pulses in rabi	Pump irrigation concentrated on summer onion for market	Share-cropping 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: Farm survey in 15 villages

Withering Water Markets?

Most social impacts of the energy squeeze on smallholder irrigation—and the agrarian poor—are felt through groundwater markets. Before and around 1990, when diesel was one-eighth its price today and farm power supply better than today, electric tubewell owners, in spite of enjoying natural oligopolies**,** were forced to behave in a highly competitive market (Shah 1993). Flat electricity tariffs, which reduced the marginal cost of pumping to near-zero levels, created a powerful incentive for electric tubewell owners to maximize pump irrigation sale, and in the process pare down the prices. Diesel pump operators were able to offer some competition because of a) low diesel prices b) portability of diesel pumps facilitating the irrigation of areas that could not be reached by electric tubewells. Numerous field-based studies showed that such local groundwater markets emerged as the mainstay of ultra-marginal farmers and sharecroppers, especially in eastern India and Bangladesh. In Bangladesh, Fujita and Hussain (1995) noted that owing to pump irrigation markets, 'the economic value of land... has decreased in a relative sense' in the 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 landholdings of up to 0.4 ha are the largest beneficiaries of the groundwater markets, as 60 % 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 in North Bihar, concluded that the markets had opened new production possibilities for the poor that left them better off than before, and that 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 % 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 a 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 areas 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 this situation has come full circle; with diesel becoming unaffordable, especially for water buyers, the preference for electric tubewells has increased, but it is a preference that is largely unmet because electricity supplies as well as connections are dwindling.

In eastern India, Nepal terai and Bangladesh, electric tubewells are few and far between. Where we find them, 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 tariffs. We found this to be the case in Uttar Pradesh, 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 (Mukherji 2005). In UP, a 5-hp electric tubewell connection is a 'cash-cow' for its owner as it entails a monthly charge of only Rs. 410 but can generate up to Rs 9,000/month as gross income from the sale of water, which is a highly profitable proposition (Singh. O.P.). 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"(Chowdhury). Here, the flat tariff paid by electric submersible pump users increased from Rs. 5,460/year to Rs. 8,950/year between 1990 and 2007. In response, irrigation rates charged for boro rice too doubled from Rs. 450/bigha to Rs. 900/bigha. This rise was much smaller than the rise in the cost of purchased diesel pump irrigation, which has diverted the diesel pump owners' business to electric tubewell owners and strengthened their monopoly power. While electric submersible owners make merry, it is also increasingly the case that the 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 the West Bengal government's policy, which seems to be designed to minimize new connections for electric tubewells and ensure that the poor do not get them. To promote boro irrigation, the government had a scheme to issue temporary seasonal connections. In 2003, temporary connections were offered to Birbhum farmers for boro rice at Rs. 7,000 for 3 months; and in our study village, seven diesel pump owners took advantage of this offer, but the next year, the tariff was increased to Rs. 18,000, which put paid to the boro season electrification scheme. Permanent connections are preferred by all, but take 3-4 years to get approved and are prohibitive in cost, e.g., Rs. 1.25 – 1.3 lakhs for poles, 11 KV cables, a 10 KW transformer and an electronic meter. The only farmer in our study village who has so far been able to afford such a mini-deep connection had 7 acres of his own land and 5 acres of neighboring lands 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; (we studied 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 has to pay for the cost of laying the cable, poles and transformer, too—which may add up to Rs. 100,000 or more (Singh, O.P.). In the Kalahandi villages in Orissa, we found electricity supply in plentiful and electric tubewells costing one-seventh of the cost of operating 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, pump-set pump house, starter, etc. As a result, in our study village, we found only six large holding farmers owned electric pumps while small farmers managed with their own or rented diesel pumps. These large holding farmers are able to earn Rs. 30-35 thousand net/year from their tubewells in crop-sharing contracts, which implies a decent rate of return on their capital investment. However, the entry-barrier of high capital costs prevents smallholders from availing themselves of this benefit (Nayak). 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 the State Water Investigation Department (SWID) expressed a 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 the study village Simra in the Patna District, we found over 100 electric tubewells in operation. But since the uncertain, halting and mostly night-time supply of power in the village never exceeds 6 hours/day, and that too with a dozen or more power-interruptions, 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 (Chaube).

The only location—out of the 15 we studied across India—where the energy squeeze left farming unperturbed was water-abundant Kerala (Raphael). Diesel pump irrigation disappeared from Kerala way back in the 1970s as the government laid electricity infrastructure in every 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 due to labor and land shortages, soaring farm wage rates, and a roaring money-order economy, the land use in Kerala is rapidly shifting away from paddy cultivation and towards 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 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 use small electric motor-pumps. The village we covered, Thekkamkara from the Trichur District, was an atypical Kerala village with a proliferation of kerosene pumps. Although the energy squeeze is not a serious issue here, the government has a scheme to supply 3 liters/month of subsidized kerosene per acre to smallholders to cushion the energy shock. A 1.5 hp kerosene pump can lift 25 m^3 of water and irrigate an acre of land in 4 hours. The energy cost of irrigation here must be less than 5 % of the value of output it supports, compared to the 25-35 % of northern and eastern India. Yet, we found a small political economy woven around the kerosene distribution in Trichur.

Return to Rain-fed Farming

Leaving aside Kerala, elsewhere in India, the energy squeeze is folding up the pump irrigation economy. Way back in the 1970s, economist Ishikawa called ‘irrigation’ the leading input in agricultural growth (Ishikawa 1967). Post-1975, India’s smallholder agriculture boomed with supplemental irrigation made possible by diesel and electric pumps. However, all the evidence we have suggests that the energy squeeze is forcing farmers, especially the marginal farmers and sharecroppers, to economize 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 using rented diesel pumps for supplemental irrigation. In Gujarat (Talati) as well as Vidarbha (Mardikar), our case studies showed that farmers dependent on rented diesel pumps are quitting rabi wheat cultivation, replacing it with the cultivation of rain-fed gram and other pulses. In West Bengal (and Bangladesh), all available evidence suggests that smallholding 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 that the most significant impact of rising diesel prices was the decline in the boro rice area from constituting about 50 % of the village’s farm land in the early 1990s to 20 % or less today (Banerjee).

There is a strong scale-bias in the shrinking of the boro rice area, with the agrarian poor being the hardest hit. This was put in bold relief by the case study of 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 the Schedule Caste (SC) families. Post-1985, when the boro rice revolution overran Bengal, the electrified parts of the village experienced a productivity boom, however, the SC families too were able to irrigate boro rice with the help of 25 diesel pumps. Come 2005, as a result of soaring diesel prices, only nine SC diesel pumps were in use, and 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 the 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 (Chowdhury). In the Kaya village of Murshidabad, SC farmers told us: “For us, all the positive effect of 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 the 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" (Banerjee)..

In the canal villages we covered in Kalahandi in Orissa, with diesel pump irrigation rates soaring from Rs. 25/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 4 feet diameter open wells. Moreover, farmers renting diesel pumps shifted to diesel-saving water melons on river banks besides taking to more diversified rain-fed crops. In general, turning to rain-fed cultivation of field crops like groundnut and black gram while expanding vegetable cultivation with pump irrigation for the nearby town —brinjal, cabbage, potato and water melon, all of which are capital intensive and risky but produce high cash per decimal 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 rain-fed crops was noted in drier areas as well. In the 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 rain-fed 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 an irrigation or two (Sharma).

Sharecropper Under Siege

The groundwater boom had powerful labor absorption impacts on agriculture, but these are now on the wane. In the Murshidabad village of Kaya, the decline in boro paddy and jute cultivation depressed the demand for labor -especially boro paddy was much valued by the marginal farmers since it absorbed family labor in productive subsistence farming. With boro paddy on the decline, men folk of landless and marginal farmer households have been looking for work in brick kilns, NREGP 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 2 kg of rice, about the lowest in all the villages we covered. On onion fields, the wages offered were 5 kg of onion; and on masoor harvesting, it was one bundle for every 18 bundles harvested. To make matters worse, the highly elastic labor supply from neighboring villages kept Simra's farm wages at these depressed rates (Chaube).

Leasing small parcels of land for a fixed annual rent has been an important way for the landless to employ family labor to ensure food security. In Simra, in such *Nagdi Batai* (or Cash Tenancy) contracts, a landless family leases a hectare of land from an absentee land owner for a cash rent of Rs. 14,000-Rs. 20,000/year; and cultivates it with purchased pump irrigation. But this form of tenancy is on the decline because the landless and marginal farmers, 75 % of Simra's households, find it increasingly difficult to make their tenancy viable. In Kendradangal, a Birbhum village, we were told that marginal farmers with diesel pumps shared a common practice until 2000 of leasing land for boro rice cultivation. However, with rising diesel prices, this practice has all but disappeared; in 2006 only three marginal farmers leased land, and that too only six or seven bigha's for boro cultivation. In the Kaya village of Murshidabad, similarly, until a few years ago, it was common practice for the 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/ha), and they would still manage to grow crops like boro rice or vegetables by buying diesel pump irrigation. With the present prices of diesel pump irrigation, however, this practice has almost ended 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 the rise in some parts of India. In the Rajkot village of Saurashtra, Gujarat, water buyers depend on renting diesel pumps only for supplemental irrigation in the kharif and renting diesel pumps for rabi crops, once a widespread practice, has completely disappeared. Electric tubewell owners (who under Gujarat's new Jyotirgram Scheme get 8 hours of uninterrupted, full voltage power under a fairly high albeit flat charge of Rs. 850/hp/year [Shah et. al. 2007]) have moved in as aggressive sellers of pump irrigation service during the rabi. The common arrangement is crop sharing rather than cash sales: the land owner provides land and labor; 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 labor.

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

In the Kalahandi villages that we covered in Orissa, electric pump owners generally provide irrigation service on a share-cropping basis and earn Rs. 30-35 thousand annually from water selling. In a standard contract, the pump owning large holding farmer contributes land and irrigation usually for groundnut, while the tenant contributes labor; both parties share each others' costs and output on a 50:50 basis. If a small farmer contributes land and labor and the pump owner contributes just irrigation, then the latter absorbs all the costs of other inputs—mainly seeds and fertilizer; 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. Happily, this has made more land available for the remaining landless to lease 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 (Satpathy).

The Hierarchy of Exit

In many of our case study villages, we discerned a curious hierarchy of exit from diesel pump irrigated farming i.e., small and medium farmers migrate out of unviable irrigated farming while poorer households 'reverse-migrate' back into irrigated farming. This was evident in Keotkuchi, study village of Assam (Dasgupta). 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 the 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 got a strong fillip during the 1990s when the government supplied a large number of diesel pumps at subsidized rates. But now, summer paddy is on the decline, primarily due to the soaring diesel prices. No matter how the 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 done so, selling their diesel pumps at throw-away prices, and leaving their farming to either large farmers or sharecroppers. The village is surrounded by villages full of hard-working landless Bangladeshi Muslims whose priorities are two fold: a) food security by growing their own rice; and b) put their free family labor to productive use. These people bought the diesel pumps from the 'yesterday's' farmers of Keotkuchi at throw-away prices, and lease their paddy land in the summer, irrigating their summer paddy with kerosene or a kerosene-diesel mix. The other classes of farmers who have survived the energy-squeeze are the large holding farmers who could invest in electric pumps, diesel pumps, tractors and 'gensets' and optimize on the irrigation cost as well as quality.[1]

A similar hierarchy of exit from farming was noted in the more mechanized agriculture of Punjab (Misra[a]), Haryana (Misra[b]) and Madhya Pradesh (SRIJAN). Here, soaring diesel prices have been affecting smallholder farming through its leveraged impact not only on pump irrigation but also on the rental 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 lakhs and, as such, only large and some medium farmers would be able to afford such investments. Since tractors are often used to run generator sets (gensets), farmers who have tractors and deep tubewells with submersible pumps enjoy economies of scope in the agrarian economy. Small farmers however, who depend on the rentals of all machines find the going to be tough. Since electric tubewell owners get hardly enough electricity to irrigate their own fields, their customers have to contend with 'genset irrigation' which may cost up to Rs. 1,100/day to water 4-5 hectares. In our study of a village in Malwa, giving five irrigations to a bigha of wheat with a tractor-powered genset can cost Rs. 3,500 upwards, at which cost wheat cultivation becomes an unviable proposition (Sharma). So only those farmers who grow wheat and have electric pumps or can crop-share with electric pump owners irrigate farming; the rest turn to 'rain-fed' crops or quit farming altogether. 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 laborers from Bihar and Madhya Pradesh at Rs. 8,000-9,000/acre/year of flat rent, while they themselves move to off-farm jobs. The migrant laborers, whose first concern is to get full-employment wage rates, rather than secure a profit, make their farming viable by substituting muscle power for machine power and through the super-intensive cultivation of high-value crops for the market. It is these reverse migrants into farming— the marginal farmers who are unable to find off-farm livelihoods— are bearing the brunt of the energy squeeze.

At the bottom of the agrarian pyramid, the energy squeeze and the cropping pattern changes it brings about are influencing women's role in the agrarian economies in a myriad of ways. In Murshidabad, we found that the decline in boro cultivation has a curtailing effect on the rice-boiling cottage industry, which is dominated and controlled by poor women. In the Deoria village, decline in the paddy area affected a reduction in the demand for female labor

[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 all together and developed a diversified cropping pattern in the rabi to make his farming operation viable.

for transplanting work. Hence, women in this village took to goat rearing. In Abakpur Monga in Mirzapur, UP expansion in vegetable crops, especially peas, has increased the demand for labor and created new employment opportunities and higher wage rates for poor women laborers. And almost everywhere, we found the energy squeeze on irrigated agriculture increased the role of livestock and dairying, further transforming the position of women in the household economies of the poor.

Chinese Pumps to the 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, labor and irrigation than other rice crops, but it is effective in land-saving and, therefore, appealing to marginal farmers and sharecroppers alike. It offers 7 mt/ha of rice yield against barely 1-1.5 mt/ha rain-fed *amon* (kharif) rice. Growing a small parcel of boro rice may liberate a farming family from subsistence worries for the whole year and, therefore, it is prized by the poor. For want of better alternatives, such as electric pumps, West Bengal's marginal farmers have been switching to Chinese pumps with gusto. They are cheaper to buy, costing Rs. 7,000 and Rs. 8,500 for 3.5 and 5 hp pumps respectively, when compared with Rs. 16,000 for a 5 hp diesel pumps made in India. The Chinese 5 hp pump runs for 2 hours from a liter of diesel, which a local pump of 5 hp burns in an hour or less. Finally, while a local pump needs a bullock cart to move around, the Chinese pump can be easily carried by a farmer on his shoulders.

Within approximately only 5 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. Boro rice boom here was originally fed way back in the 1970s and 1980s, by co-operative tubewells with electric pumps founded by an NGO. However, the co-ops failed, as they did elsewhere also (Pant 1984). But the boro rice boom continued during the 1990s with the help of Indian pumps. The rising diesel price however, has led the Indian pumps to be considered 'fir for composit pit', and led the Chinese pumps to become one of the most popular alternatives to the Indian pump.

How did the Chinese pumps make in-roads into West Bengal's irrigation scene remains somewhat of a mystery. Apparently, certain second-hand Chinese pumps smuggled across the Bangladesh border found 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 epicenter of Chinese pump diffusion. Several brands of Chinese and Chinese-Indian pump assemblies are on offer here and are selling at 35-40 % less than the price of Kirloskar 4 and 5 hp engines, which remained market leaders for decades. Interviews with pump dealers in Kolkata confirmed that farmers preferred these Chinese pumps for their low price, their much higher fuel efficiency (0.35-0.4 l/hour), their ability to work on kerosene, and their easy portability. Chinese pumps, however, suffer more wear and tear and have shorter life span. Nevertheless, Chinese pump mechanics have emerged in every village; and their spare parts are cheaper and readily available.

PDS Kerosene: For the Kitchen or the Farm?

Close on the heels of Chinese pumps has emerged a new trend throughout India, of using subsidized PDS[2] kerosene, usually meant for cooking, to run irrigation pumps. Against the fact that it reduces the life of the engine, poor farmers see two advantages in using kerosene: first, PDS kerosene, subsidized as a cooking fuel, is cheaper than diesel; second, used with Chinese pumps, it yields more water per liter, *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 chucked aside their diesel engines and taken to 1.5 hp kerosene pumps for irrigating their onion crop, with 3'*2' *kyari's* on a 0.25-0.5 ha parcel of land. But we found that scheduled caste marginal farmers in Birbhum, would run Kirloskars also on kerosene: "In what way can you call this a diesel pump?" they mocked about their pumps.

In many parts of eastern India, collecting the PDS quota of subsidized 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 labor at peak wage rates. Large family also means urgency in growing boro rice for family subsistence.

PDS kerosene, then, 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 price went up from Rs. 4/l to Rs. 34.30/l in Murshidabad villages; but kerosene price in the black market too rose from Rs. 8/l to Rs. 25/l, wiping out some of the cost relief offered by kerosene to the poor in fending off the energy squeeze (Banerjee).

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 these can save 20-25 % of diesel but reduce crop yield/bigha by a quintal in cotton as well as in 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 usual five they have been applying all these years. In our Birbhum village of West Bengal, we found that many sharecroppers leased parcels just below their own land so as to use the water drained out of their boro paddy to raise another

[2] Public Distribution System which issues kerosene as cooking fuel to ration card holders.

rice crop in the lower field. Many, who were forced to give up boro cultivation altogether due to the high diesel cost, increased their area under mustard crop cultivation during the winter - when water can be pumped, or manually lifted for 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 for example, fetches a better price and requires much less irrigation. The 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 a few years ago as a water-saving technology; but after trying it for a few seasons, farmers found its labor requirement in weeding to be daunting and SRI disappeared without trace. However, many small farmers did switch to the practice of dividing their farm in to small basins, roughly of 200 m^{2}, at different heights for more efficient water, and diesel, use. In coastal Orissa's Purana Pradhan village, the soaring diesel price has induced farmers to convey water from the 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 a striking feature in the Simra village of the Patna District, Bihar. In 1990, this was a wholly rice-wheat village with little crop diversification and that rarely moved away from this age-old rotation. Now, kharif paddy continues with or without irrigation; but during the rabi and summer, of its 300 ha, Simra has 150 ha under rain-fed masoor, 50 ha under lightly irrigated gram, 40 ha under wheat, and 75 and 20 ha, respectively, under intensively irrigated onion and coriander, the last fetching them the highest return per acre as well as per liter of diesel/kerosene. In the eastern UP village, Akataha (Deoria dist), farmers have switched from long duration to short duration paddy; and some of the irrigated paddy area has given way to diesel-saving groundnut and high-value potato crops.

The 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 sugarcane. In the eastern UP village, some parts of the wheat and paddy area have been replaced by highly profitable sugarcane cultivation. 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 rain-fed kharif crops are increasingly replaced by high-value, lightly irrigated vegetable and groundnut crops. Here, 90 % of the farm lands were under food crops (*jowar*, *bajra*, maize, gram, *tun*, and wheat) in 1990, but today, 80-90 % of the farm lands are 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 maximize the crop (and cash) per drop of diesel. In Purana Pradhan village in the 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 on the other hand vegetables also offer greater cash returns (see Table 4). Some years ago, sugarcane was widely irrigated by diesel pumps, but now vegetables are the most important irrigated crop by diesel pumps in this village. The

Table 4. Costs and returns from paddy and vegetables, Khurda, Coastal Orissa (Satpathy).

	Cost of cultivation (Rs./acre)	Net return (Rs./acre)
Kharif paddy	3,500	2,500
Summer paddy	6,000	3,000
Vegetables	30,000	50,000

Source: Authors' estimates based on farm survey

likely reason for this is because they yield the highest income per drop of diesel. Poorer farmers, whose main concern was food-grain security for the family, were cajoled into learning the new skills of vegetable cultivation and of marketing it to maximize their household income. A typical family in this scenario would intensively use their family labor (including men, women and children), on 1.5-2 acres of low-land and irrigate with either kerosene or electric pumps, whichever they have purchased. Co-operation among low-land vegetable growers here is of paramount importance. For example, 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)—(Chaube). Forced to give up winter wheat, sharecroppers and marginal farmers in the Simra village took to intensive cultivation of fully irrigated onion crops on small plots during the summer. This practice 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 cultivation increasing to a quarter of the village's farm land, the crop stimulated an increase in the purchases of diesel pumps. Because onion requires 13 irrigations to mature, and diesel pump owners levy a fixed charge of Rs. 3,000/bigha (Rs. 12,000/ha) for onion irrigation, the investment in a diesel pump is a very lucrative proposition. Simra's onion revolution therefore, 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 a few 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, the chances are that most will steer clear of the high-value but risky onion crop, or choose a mix of onion and low-risk masoor to mitigate the risk of getting wiped out.

Similar was the experience in Birbhum. Struggling to survive, marginal farmers in Kaya and the surrounding villages took to marketing vegetable cultivation to replace the boro rice cultivation that they had to give up and at one stage, 25-30 % of Kaya's farm lands were under vegetable cultivation. The switch proved highly remunerative for small farmers with large families who owned Chinese pumps. More recently however, vegetable prices have been dropping due to: a) glutting the market; b) the rising cost of road transport (a result of hikes in diesel prices). In 2006, Kaya produced a surfeit of cabbage that nobody was willing to lift, and many frustrated farmers had to plough 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 crops like onion, coriander, black cumin that may offer better returns as cash crops, but are full of price and output risks (Banerjee).

Conclusion

Smallholder irrigation in India is under siege from an energy squeeze with three sides: (a) deterioration of farm power supply; (b) embargo on new electricity connections; and (c) an 8-fold increase in diesel prices since 1991. The Government of India's Accelerated Irrigation Benefits Program is investing tens of thousands of crores annually in surface irrigation, which is shrinking. But the real challenge Indian agriculture faces today is helping smallholder irrigators out of the energy squeeze. This paper summarized 15 village studies from different parts of India to explore the immiserizing impacts of the energy squeeze at the bottom of India's agrarian economy.

What could be done to counter the energy squeeze? Several ideas emerge from the struggles of farmers. For example, promoting fuel-efficient diesel/kerosene pumps of the Chinese variety can ease the cost-price squeeze or making available a PDS kerosene allocation to poor farmers, as in Kerala, too might help. The idea of providing subsidized diesel to farmers, as is done for trawler-operating fisher folk in certain states, is also gathering reception. Improving manual irrigation technologies and the better management of surface water bodies for gravity flow irrigation too can relieve the stress from the energy squeeze. Helping marginal farmers to own pumps can help relieve them from the monopoly of rents found in the prevailing pump irrigation prices.

However, all these must be treated as short- term patchwork. The real answer probably lies in improving the 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 a flat tariff can improve the net returns (from farming) of poor water buyers by 20-25 % , even if no yield gains are realized. Such a shift will have a huge impact in UP since 57 % of all food crop cultivators are water buyers here (Kishore et. al. 2004). This is true not only for eastern UP but for all of eastern India. However, realizing these gains for the poor requires a mindset-change. The invidious political economy of power subsidies that has emerged in India over the past three decades has 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 that relieves the stranglehold of the energy squeeze on small- holder irrigation. Perhaps, Gujarat's *Jyotirgram Yojana* points at the way to go (Shah et al. 2007). Under this scheme, the Gujarat electricity board offers 8 hours daily of three-phase, full voltage power supply to tubewells along a pre-determined schedule. With some modification, this has the potential to contain the power subsidy to manageable levels and still beat the energy-squeeze with which smallholder irrigation in India is waging a losing battle today. By creating in eastern India a regime 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 by 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 provide.

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