DIESEL PRICE HIKES AND FARMER DISTRESS: THE MYTH AND THE REALITY

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Abstract

The issues being addressed in this paper are as follows. Has there been significant change in cost of groundwater pumping due to diesel price shock in regions where it matters? If so, how that has impacted millions of irrigation water buyers? How farmers respond to increase in irrigation costs? Such responses include: how the well owning farmers change their farming enterprise, including the farming system itself; how their willingness to take risk changes, and finally, how the economic prospects of irrigated farming itself changes as a result?

It is found that the impact of diesel price on irrigation cost incurred by diesel well owners is not significant. One reason for this is that the regions which are heavily dependent on diesel pumps for irrigation have shallow groundwater table. Also, this burden is not passed on to the water buyers owing to increasing competition and reducing monopoly power of pump owners. The analysis of the farming enterprise of irrigators under differential cost (irrigation) regimes presented here shows that farmers would be able to cope with very high rise in irrigation costs through irrigation efficiency improvements and allocating more area under crops that give higher returns per unit of land and water, that enhance the farming returns from every unit of water and energy used. By doing this, they are able to maintain almost the same net returns from farming as in the past. This means, that the rise in cost of diesel in real terms had not made any negative impact on economic prospects of diesel well irrigators, including water buyers.

1. INTRODUCTION

While in many arid and semi-arid regions of India, the water management issue is of growing physical shortage of water, and in some water-abundant regions, it is economic scarcity of water. Here, due to poor state of rural electrification, high cost of diesel engines, and the small size of land holdings, investment in irrigation is very poor. The resource poor, small and marginal farmers pay exorbitant prices for the water they buy from well owners, making irrigated agriculture an unattractive proposition.

Many scholars argue that the recent hikes in diesel prices across the country had badly hit the regions with poor rural electrification facility.. Their argument is that growing economic scarcity of water, occurring due to this, cause sweeping changes in agriculture, especially of small and marginal farmers in India. This they attribute as a cause of widespread farmer distress in the countryside. This is based on the premise that regions such as eastern UP, West Bengal, Assam and Bihar depend heavily on diesel power for lifting groundwater, and increase in price of diesel is likely to impact on cost of irrigation and also millions of rural livelihoods in these regions, as agricultural productivities are already very low. Over the period of 17 years, the price of diesel has also gone up from Rs. 5 per litre to Rs. 34.84 per litre.

The available empirical works on impact of energy price hike on irrigated farming are based on respondent surveys. Such works have little relevance for practical policy formulation in the sense that the perceived

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"impacts of price changes" are an outcome of the whole range of changes happening with the farming system level, including that on the market front. Such analyses fail to segregate the response of farmer to input price changes, and their subsequent implications for prospects of farming, especially by small and marginal farmers.

In this paper, certain fundamental questions are raised concerning Indian agriculture. First: has there been significant change in cost of groundwater pumping due to diesel price shock in regions where it matters? If so, how that has impacted on millions of irrigation water buyers? How farmers respond to increase in irrigation costs? Such responses include: how the well owning farmers change their farming enterprise, including the farming system itself; how their willingness to take risk changes, and finally, how the economic prospects of irrigated farming itself changes as a result?

2. A CONCEPTUAL FRAMEWORK FOR ANALYZING THE IMPACT OF ENERGY PRICE ON FARMING ENTERPRISE

The rise in diesel price might affect the diesel well owners and water buyers in diesel well commands in different ways. First of all, the rising diesel price (Rs/litre) would raise the marginal cost of using irrigation water for crop production unless the farmers put in systems to improve the efficiency of the pump that reduce the diesel consumption per hour of pumping, and increase the well outputs. This would encourage the well owners to improve the efficiency of use of irrigation water in the field to cut down the cost of irrigation. This can result in lower irrigation dosage, higher yield, higher physical productivity of water (kg/m^3), and perhaps higher water productivity in economic terms also (Rs/m^3), with net returns remaining the same.

But, there might be crops where the cost of irrigation itself would be a significant chunk of the production cost. In such situations, with diesel price hike, the irrigation cost could become so high even with efficiency improvement, when compared against the gross returns from the crop. This would eventually make the net returns too low, making the crop itself unviable. In such situations, the farmers might respond by replacing the existing crops by new crops that yield much higher income returns (Rs/ha of land) so as to offset the increase in cost of irrigation water. This can also include crops that are highly water-intensive. Hence, analysis should be based on farming system returns rather than return from crops.

On the other hand, the impact of rising diesel price on water buyers would be a little more complex. The reason is that over time, along with increasing cost of production of water, the monopoly price of water itself could also change in favour of water buyers with increasing number of privately owned wells as found in Muzaffarpur in Bihar (Kumar, 2007). If that happens, then the water price may not increase in proportion to the cost of production of water. Hence, taking the actual price paid by water buyers would nullify the impact of real change in diesel prices in areas where situation had not improved. To sum up, while diesel price hike can impact on cost of groundwater irrigation, the price fluctuations are not true reflections of the actual impact of diesel price increase.

While this can happens on the cost front, on the price front, the market price of many agricultural produce also can change significantly over time. For instance for many cereals, the prices in real terms had not increased in real terms, and on the contrary, had reduced in certain cases. Hence, comparing the time series data on income returns from farming would distort the picture with respect to impact of input prices by wrongly attributing the declining returns to the increase in input costs. This means for capturing the "response to and impact of input price changes", it is essential to compare the farming systems under different price regimes for irrigation water. The major attributes to be covered in such analysis include: 1] irrigation dosage; 2] physical productivity of water in crops; 3] net returns from crops and livestock; 4] net water productivity in economic terms for crops and livestock; and, 5] the returns and water productivity in farming.

2.1 Differential Cost of Groundwater for Irrigation across Different Categories of Farmers

The average cost of pumping irrigation water for the diesel pump owners is $Rs.1.38/m^3$ and the range is $Rs.0.99/m^3$ to $Rs.2.04/m^3$. The average price at which diesel well owners sell water is $Rs.2.81/m^3$ and the

individual values range from Rs.2.07/m^3 to Rs. 3.63/m^3. Against this, the average price of at which irrigation water is sold by electric pump owners is Rs 0.65/m^3 and the individual values range from Rs 0.52/m^3 to Rs 0.84/m^3.

The average price at which groundwater is being sold by electric well owners is Rs 0.70/m^3 and the individual values range from Rs.0.31/m^3 to Rs 0.92/m^3. The average cost of pumping groundwater using diesel pump is Rs.1.87/m^3 and individual values range from Rs. 1.41/m^3 to 2.93/m^3. The average price at which groundwater is being sold by diesel pump owners is Rs 2.15/m^3 and the individual values range from Rs.1.84/m^3 to Rs.2.42/m^3 (Table 1).

Table 1: The Average Costs and Cost Range in Irrigation Water for Diesel Well Owners, and Water Buyers in Diesel and Electric Well Commands

Name of the Region	Cost of Irrigation Water					
	For Diesel Well Owners		Water Buyers in Diesel Well Command		Water Buyers in Electric Well Command	
	Average	Range	Average	Range	Average	Range
South Bihar	1.87	1.41-2.93	2.15	1.84-2.42	0.70	0.31-0.92
Eastern UP	1.38	0.99-2.04	2.81	2.07-3.63	0.65	0.52-0.84

3. OBJECTIVES

The overall objective of the study is to analyze how the small and marginal farmers in water abundant regions respond to diesel price hike, and to assess the overall impact on the economic prospects of farming. The specific objectives are:

- To analyze the actual change in cost of irrigation water for diesel well owners and water buyers due to rise in diesel prices
- To analyze the response of diesel well owners to potential hike in irrigation costs and its overall impact on economic prospects of farming
- To study the response of water buyers in diesel well commands to diesel price hike and its overall impact on economic prospects of their farming;

3.1 Hypothesis

Increase in cost of diesel would encourage farmers to use water and other inputs for crop and livestock production more efficiently; but might also adopt high valued crops which require more water, to sustain the net returns from crop production.

4. METHODOLOGY

4.1 Geographical Coverage

The geographical coverage of present study includes eastern plain region of Uttar Pradesh and south Bihar plains .

4.2 Climatic Condition of the Study Area

The average annual precipitation in the eastern plain region of Uttar Pradesh is about 1025 mm. The region's climate is dry sub-humid to moist sub-humid. The soil types in this sub-zone are light alluvial and calcareous clay. Patna district falls under the south Bihar plains region of Bihar state receives average normal annual rainfall of 1103mm and climate condition of region is dry to moist sub-humid. The soil types found in the region are old alluvium sandy loam to clayey and the larger areas under the *Tal* and *Diara*.

4.3 Methodology

4.3.1 Overall Methodology

At the outset an analysis is made here, of the actual increase in cost of irrigation water for the diesel well owners and water buyers over time on the basis of the time series data on cost of diesel; energy (diesel) use per hour of pumping; and the well outputs. This is adjusted to inflation. The price water buyers pay in hourly terms is converted into unit charges using data on well outputs, and then adjusted to inflation to obtain the prices in real terms.

The potential response of diesel well owners to increase in irrigation cost is analyzed by comparing the cropping pattern; irrigation water dosage; and productivity of irrigation water in crops, dairying and at the farm level of the diesel well owners with that of water buyers from electric well owners. This is in view of the fact that the water buyers in electric well commands are incurring much lower cost for irrigation water as compared to diesel well owners, and water buyers in diesel well command. Whereas overall agro-climatic conditions governing the demand for water for a particular crop, and the ecological viability of crops would remain the same. Subsequently, the potential response of water buyers to rise in irrigation cost is analyzed by comparing the above attributes and compared with water buyers in electric well commands.

The overall economic impact of rise in irrigation cost on farming enterprises is analyzed by estimating the net return from the entire farm for diesel well owners and their water-purchasing counterparts, and then comparing it with that for water buyers from electric well owners in the same region. Further, based on the actual rise in cost of irrigation water felt by diesel well owners over the years due to diesel price hike, and the potential response of the irrigators to irrigation cost rise, the actual impact of diesel price hike on farming enterprises of diesel well owners and their water buyers is assessed.

4.3.2 Sampling Plan

Sixty well owners and water buyers from electric and diesel well commands in Eastern Uttar Pradesh (Varanasi and Mirzapur) and South Bihar plain (Patna) were selected for the study.

4.3.2 Analytical Procedure

The net economic return from farming would be assessed by adding up the net return from crops and dairy production.

The net return from crop production NI_{crop} for those crops which by-products does not used for the dairying will be estimated as:

$$NI_{Crop} = \left[\left(Y_{MP} * FHP_{MP} \right) + \left(Y_{By-p} * FHP_{By-p} \right) \right] - C_{Input} \quad \ldots\ldots\ldots (1)$$

For the estimation of net return NI_{cropi} for those crops, which by-product is used as an input of milk production (dry fodder) , in such situation we will allocate total cost of production between the main product and by-product using their ratio of market value. The net return from such crops we will be estimated as:

$$NI_{Crop\,i} = \left[\left(Y_{MP} * FHP_{MP}\right) - C_{Main\ product}\right] \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Here, Y_{MP} is the yield of main product (Quintal); FHP_{MP} is the farm harvest price of main product (Rs/kg);Y_{By-P} is the yield of by-product (Quintal) and FHP_{BY-P} farm harvest price of by-products (Rs/kg); C_{input} is the cost of all inputs used for crop production and is the cost of inputs for main production.

The net income from livestock NI_{Dairy} production based on life cycle we will estimate as:

$$NI_{Dairy} = \left[\left(Y_{milk} * P_{milk}\right) + \left(Y_{Dung} * P_{Dung}\right)\right] - \left[\left(P_{gf} * Q_{gf}\right) + \left(P_{df} * Q_{df}\right) + \left(P_{cf} * Q_{cf}\right) + P_{oi}\right] \ldots \quad (3)$$

Here, Y_{milk} is the milk yield per animal per annum; Y_{Dung} is the yield of dung per animal per annum; P_{milk} and P_{Dung} is the price of milk and price of dug received by the farmer; Q is the quantum of inputs used per cattle unit per annum. The suffixes , *gf, df, cf* and *oi* stand for green fodder, dry fodder, cattle feed, and other expenses respectively. The price of *gf* and *df* will be the unit cost of production (total input costs divided by total production). The price of *cf* and *oi* is the actual market price.

The net income at farm level (Rs) would be estimated as:

$$NI_{farm} = \sum_{i=1}^{m} NI_{crop\,i} + \sum_{j=1}^{n} NI_{Dairy} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.. \quad (4)$$

Where, $\sum_{i=1}^{n} NI_{Crop\,i}$ is the net income from all the crops grown by the farmers on his farm and $\sum_{n=1}^{n} NI_{Dairy}$ is the net income from dairy farming.

The detailed methodology for estimating water productivity in crops, dairying and farm level water productivity are discussed in Singh and Kumar (2008).

Table 2: The Cost of Pumping and Sale Price of Groundwater in Diesel Well Commands of eastern UP and south Bihar villages

Name of the Region	Price Details	Cost of Pumping Groundwater (Rs/m^3)				Selling Price of Groundwater (Rs/m^3)			
		1990	1995	2000	2006	1990	1995	2000	2006
South Bihar Plans	Average	0.41	0.51	0.95	1.60	1.16	1.40	1.75	2.11
	Minimum	0.22	0.31	0.75	1.38	0.90	1.10	1.44	1.81
	Maximum	0.95	1.04	1.46	2.09	1.67	1.88	2.08	2.50
Eastern UP	Average	0.47	0.56	1.00	1.64	0.98	1.31	1.63	2.67
	Minimum	0.14	0.21	0.54	1.02	0.84	1.11	1.39	1.96
	Maximum	1.51	1.62	2.10	2.82	1.62	2.34	2.52	3.51

Assumption: We assume that the diesel consumption, discharge rate of the pump and hours of diesel pump running per year is same for 2006

5. RESULTS AND DISCUSSIONS

5.1 Actual Impact of Diesel Price Hike on Cost of Pumping Well Water and Water Prices in the Market

The actual cost of groundwater pumping and the price at which water is traded in the diesel well commands of eastern UP and south Bihar are given below. It shows that in the case of south Bihar villages, the average cost of pumping went up by nearly 300 per cent from Rs. 0.41/m^3 to 1.16/m^3, whereas the selling price of water went up by only 90% from Rs.1.16/m^3 to Rs. 2.11/m^3. This means that the monopoly price ratio had declined from 2.8 to 1.3. In the case of eastern UP villages, the average cost of pumping went up by nearly 280% from Rs.0.47/m^3 to Rs.1.64/m^3, where as the sale price of water went up by 170%. This means, the decline in monopoly price of water is (from 2.1 to 1.6) is not as sharp as in the case of south Bihar. This is quite understandable, as the rate of growth in number of diesel wells and pump sets has been much higher in south Bihar than in eastern UP. In nutshell, the impact of diesel price change on the water buyers is different from that of eastern Utter Pradesh.

But, the price increase shown above does not mean that the actual price of irrigation water has gone up. If one wants to see how the price has changed in real terms, one should correct the price to the inflation rates. We have used an annual inflation rate of 7% to estimate how the cost of pumping and cost of irrigation water (sale price) have changed over the years from 1990-2006. It shows that in the case of eastern UP, the cost of irrigation in real terms has gone up by 18%, whereas the actual price of irrigation water from diesel well owners had gone down by 7.5%. In South Bihar while the cost of irrigation in real terms has gone up by 32%, the price of irrigation water had gone down by 38%.

5.2 Cropping Patterns in the Study Area under different Energy Pricing Regimes

Cropping patterns of farmers in electric and diesel pump command area under different crops in different seasons for eastern Uttar Pradesh is dominated by the paddy and wheat. During summer, most of the agricultural lands remain fallow, farmers grow only green fodder. The water buyers in diesel well commands allocate some portion of their land for pulses viz., arhar, black gram and green gram, which are normally rainfed, but require one or two irrigations in case of long dry spells, thereby cutting down the cost of irrigation.

The cropping pattern of water buyers in electric well commands and farmers in diesel well commands in south Bihar plans is similar to that obtaining in the eastern Uttar Pradesh viz., paddy and wheat cropping system. Due to high rainfall and poor drainage of land in the region, the agricultural land remains waterlogged during monsoon, and in this situation farmers are forced to take paddy. Farmers allocate a very small area for fodder crops to sustain dairy farming. During winter, they allocate larger area for wheat followed by potato, which gives high returns. During summer, farmers allocate larger are for onion, which again provides cash income

5.3 Irrigation, Net Return from Crops and Crop Water Productivity

The estimates of irrigation dosage, water productivity in physical and economic terms for selected crops for diesel well owners and their water buyers in eastern Uttar Pradesh are presented in Table 3 Comparison of the estimates for diesel well owners and their water buyer counter parts (Table 3) shows the following: 1] the average depth of irrigation is slightly lower for water buyers in diesel well command as compared to their well-owning counterparts; and, 2] the water buyers in diesel well commands secure higher physical productivity of water and water productivity in economic terms for all the crops.

Comparison between diesel well owners and water buyers in electric well commands however shows a different trend. The average dosage of irrigation is much lower for farmers who buy water from electric well commands as compared to diesel well owners, in spite of the fact that they are confronted with much lower

Table 3: Water Use, Physical and Net Water Productivity under Diesel Pump, Eastern Uttar Pradesh

Name of the Crops	Diesel Pump – Owner			Diesel Pump –Water Buyer			Electric Pump –Water buyer		
	Depth of irrigation (mm)	WP (kg/m^3)	Depth of irrigation (mm)	WP (kg/m^3)	Net WP (Rs/m^3)	Net WP (Rs/m^3)	Depth of irrigation (mm)	WP (kg/m^3)	Net WP (Rs/m^3)
Paddy	15.53	1.86	9.09	2.39	2.92	2.62	3.61	2.29	3.64
Sesamum	2.29	0.89	1.14	0.88	17.72	17.39	0.57	1.25	9.58
Sugarcane	-	-	-	-	-	-	0.57	10.62	8.11
Bajra	2.29	3.43	1.33	4.41	17.83	7.47	1.43	4.05	10.52
Wheat	12.74	2.57	8.33	3.50	7.80	6.22	2.93	2.63	7.57
Potato	3.70	7.23	2.29	7.40	-	17.87	2.91	5.96	9.58
Pea	3.40	1.56	1.67	1.74	12.36	12.19	1.33	2.14	14.95
Gram	4.16	1.58	1.99	1.82	17.78	15.33	0.36	1.62	31.12
Mustard	2.70	1.56	1.44	1.15	11.99	10.87	1.20	1.39	11.44
Linseed	3.43	1.36	1.03	1.53	16.77	13.70	-	-	-

GF: Green fodder
Source: Author's own estimate based on primary data

Table 4: Water Use, Physical Productivity of Water and Net Water Productivity in Economic Terms under Diesel Pump, South Bihar Plain

Name of the Crops	Diesel Pump – Owner			Diesel Pump –Water Buyer			Electric Pump –Water buyer		
	Depth of irrigation (cm)	WP (Kg/m^3)	Net WP (Rs/m^3)	Depth of irrigation (cm)	WP (Kg/m^3)	Net WP (Rs/m^3)	Depth of irrigation (mm)	WP (kg/m^3)	Net WP (Rs/m^3)
Paddy	8.96	2.40	7.50	5.41	2.98	9.56	4.67	2.69	8.35
Wheat	5.88	1.98	5.97	3.16	2.27	6.80	3.51	1.76	5.78
Potato	3.89	12.93	44.57	1.81	13.92	49.83	2.00	11.74	41.78
Mustard	3.89	1.54	16.18	1.92	1.60	16.25			
Onion	3.70	5.84	21.50	3.06	5.34	21.27	2.18	5.40	23.15
Maize	2.24	5.26	17.05	1.64	7.65	31.84	1.76	6.86	19.05

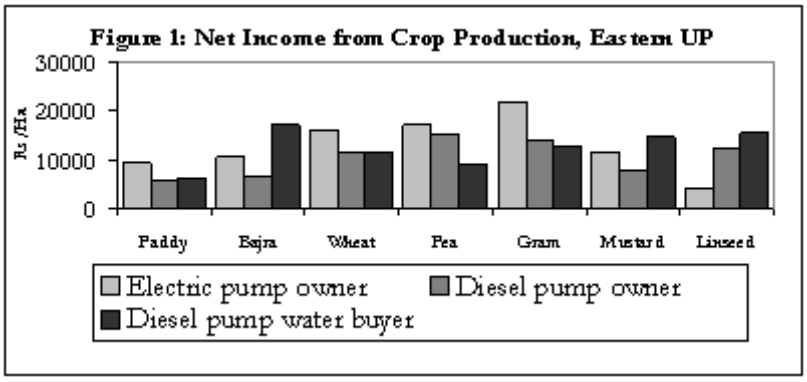
GF: Green Fodder
Source: Author's own estimate based on primary data

marginal cost of irrigation. Further, the water buyers in electric well command secure much higher values of water productivity in both physical and economic terms as compared to diesel well owners. This is due to the fact that the electric well commands are located in the flood plains of the river, with high soil moisture content, fertile soils. These reduce not only the irrigation water requirement of the crops, but also the need for fertilizer inputs also, minimizing the input costs. As a result, the irrigation dosage and water productivity values are higher for water buyers in electric well command.

As regards the net income from crop production, the comparative figures for eastern Uttar Pradesh are presented in Figure 1. Here, the electric well owners secure higher income per ha in paddy, wheat, pea and gram as compared to farmers in diesel well commands. Whereas, the diesel pump water buyers secure higher net income in bajra, mustard and linseed.

The estimates of irrigation dosage, water productivity in physical and economic terms for selected crops for diesel well owners and their water buyers, and water buyers in electric well commands in south Bihar plains are presented in Table 4. Comparison of the estimates for diesel well owners and their water buyer counterparts shows a similar trend as that of eastern Uttar Pradesh. Comparison of corresponding figures between diesel well owners and water buyers in electric well command show a similar trend. The figures of irrigation dosage and water productivity (in both physical and economic terms) are higher for diesel well owners who have to pay a much higher price for irrigation water in volumetric terms, as compared to those who buy water from electric well owners.

As regards the net income from different crops, the comparative figures are presented in Figure 2. In south Bihar plans, the electric well owners obtain higher net income per ha in wheat, potato, mustard and onion crops whereas, diesel pump water buyers get higher net income per ha in maize cultivation. The diesel pump owners are receiving second highest per hectare net income from onion, mustard, potato and wheat and highest per hectare net income from the paddy crop.



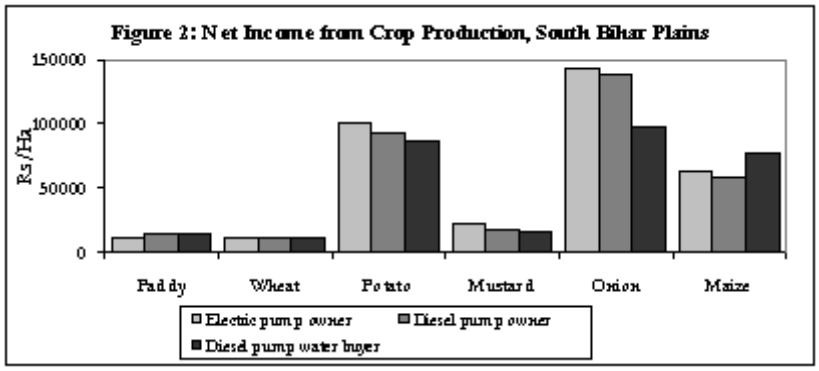


Table 5: Average Feed and Fodder Used Based on Lifecycle of Animal, Diesel Pump, Eastern Uttar Pradesh

	Feed and Fodder Use (kg/day/animal)								
	Diesel Pump – Owner			Diesel Pump – Water Buyer			Electric Pump-Water Buyer		
	Buffalo	CBCow	Ind. Cow	Buffalo	CBCow	Ind. Cow	Buffalo	CBCow	Ind. Cow
G. Fodder	19.6	24.3	17.1	19.2	16.7	13.4	13.8	19.5	14.8
Dry Fodder	15.1	17.5	13.2	17.1	19.6	19.1	8.9	12.7	9.3
Concentrate	1.5	1.5	1.4	1.3	1.8	1.3	1.0	1.8	1.2

Note: CBCow implies Cross Bred Cow; Ind. Cow implies Indigenous Cow

5.4 Net Income and Water Productivity in Milk Production

The net income from milk production is dependent on the amount of fodder and feed provided to the dairy animals; cost of production of these inputs, and milk yield and the price of these outputs. Whereas the determinants of water productivity in milk production are: the milk yield and its price; the total amount of water embedded in the animal feed and fodder; and the cost of production of animal feed and fodder.

Table 6: Average Feed and Fodder Used Based on Lifecycle of Animal, Diesel Pump, South Bihar Plains

	Feed and Fodder Use (kg/day/animal)								
	Diesel Pump – Owner			Diesel Pump – Water Buyer			Electric Pump-Water Buyer		
	Buffalo	CBCow	Ind. Cow	Buffalo	CBCow	Ind. Cow	Buffalo	CBCow	Ind. Cow
G. Fodder	14.85	15.29	10.77	9.87	11.46	9.82	9.90	8.19	6.18
Dry Fodder	18.68	9.13	9.49	14.70	14.86	18.07	10.36	23.15	12.36
Concentrate	1.81	1.40	0.79	1.74	1.24	1.11	1.66	2.03	1.27

5.4.1 Feed and Fodder Use

Table 5 presents the estimates of average quantum of green fodder, dry fodder and animal feed provided to the three different types of livestock, viz., buffalo, cross bred cow and indigenous cow for diesel well owners; the farmers who purchase irrigation water from them; and those who purchase water from electric pump owners for eastern UP villages. Comparison across the different categories of farmers shows that generally, the dairy inputs are highest for water buyers of diesel well owners, followed by diesel well owners and lowest for water buyers in electric well command. The exception is for cross bred cow in which case the green fodder input is much lower for water buyers of diesel well command as compared to other categories of farmers.

Table 6 presents the estimates of average quantum of green fodder, dry fodder and animal feed provided to the three different types of livestock, viz., buffalo, cross bred cow and indigenous cow for diesel well owners and the farmers who purchase irrigation water from them; and farmers who purchase water from electric well owners for south Bihar villages. Comparison across the different categories of farmers shows no general trend unlike what has been found in the case of eastern UP. Nevertheless, for buffalo, the quantum of green and dry fodder input is highest for diesel well owners.

5.4.2 Water Use for Milk Production, Physical Productivity of Water and Gross Water Productivity in Economic Terms

The water required for milk production includes that embedded in the dry and green fodder and cattle feed provided to the animals, in addition to the direct water use by cattle for drinking. They are estimated for the

Table 7: Water Use for Milk Production in Diesel Pump Command Area, eastern UP (m^3/day)

	Diesel Pump – Owner			Diesel Pump – Water Purchaser			Electric Pump – Water Buyer		
	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow
Total Water Use (m^3)	3.02	3.48	2.68	3.00	3.21	2.64	2.19	3.35	2.38
Milk Production (litres)	2.08	4.01	1.95	2.23	3.23	2.01	2.64	4.08	1.89
WP (Lt/m^3)	0.69	1.15	0.73	0.75	1.00	0.76	1.20	1.22	0.79
Gross WP (Rs/m^3)	11.03	16.13	10.95	11.93	14.06	11.38	12.97	12.31	7.35

entire animal life cycle by using the standard formula used in Singh (2004) and also in Kumar (2007). Using the figures of average daily milk production per animal per day, the gross return from dairying was worked out. The physical productivity of water in milk production (litres/m^3) and the gross water productivity in economic terms (Rs/m^3) were estimated using the figures of total water use per animal per day and the gross returns. The estimates for eastern UP are presented in Table 7.

Comparison of the figures of physical productivity of water in milk production shows that the figures are highest for water buyers in electric well commands. Between diesel well owners and water buyers in their

Table 8: Water Use for Milk Production in Diesel Pump Command Area, eastern UP (m^3/day)

	Diesel Pump – Owner			Diesel Pump – Water Purchaser			Electric Pump – Water Buyer		
	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow
Total Water Use (m^3)	4.88	3.93	2.73	3.62	3.18	3.04	4.09	5.36	3.37
Milk Production (litres)	1.69	3.53	1.37	1.68	2.30	1.18	1.86	2.97	0.88
WP (Lt/m^3)	0.35	0.90	0.50	0.46	0.72	0.39	0.45	0.55	0.26
Gross WP (Rs/m^3)	4.85	10.60	7.00	6.50	8.52	5.45	6.35	7.69	3.6

command, no major differences were noticeable. As regards gross water productivity in economic terms, the water buyers in electric well command obtain the highest values in buffalo milk production. Again, no major differences were noticeable between diesel well owners and those who buy water from them in gross water productivity. But, in case of cross bred cows, diesel well owners secure the highest water productivity, followed by water buyers in diesel well commands and lowest by water buyers in electric well commands. In the case of indigenous cows, the water buyers in diesel well commands obtain highest water productivity in rupee terms.

The estimates for south Bihar are presented in Table 10. Comparison of the figures of physical productivity of water in milk production shows that the figures are highest in case of water buyers in diesel well commands for buffalo milk; and highest in case of diesel well owners for cross bred cow, and indigenous cow. The water buyers in diesel well command secure highest gross water productivity in economic terms in buffalo milk production, while diesel well owners secure highest gross water productivity in cross bred cow and indigenous cow milk production. The farmers in electric well commands obtain the lowest figures of physical productivity of water and gross water productivity in economic terms in cross bred cow and indigenous cow milk production.

5.5 Expenditure, Net Income and Net Water Productivity in Milk Production

The total average expenditure for milk production per animal per day was estimated using the standard formula provided in Singh (2004) and Kumar (2007). Table 9 contains total expenditure in dairy production and net income from dairying per animal per day, and net water productivity in economic terms for different types

Table 9: Physical Water Productivity and Net Water Productivity in Economic Terms in Milk Production, Diesel Pump, Eastern Uttar Pradesh

	Diesel Pump – Owner			Diesel Pump – Water Purchaser			Electric Pump – Water Buyer		
	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow
Total expenditure (Rs/day)	17.71	20.12	17.71	20.02	22.73	18.43	12.73	19.80	14.03
Milk production (Lt)	2.08	4.01	1.95	2.23	3.23	2.01	2.64	4.50	1.89
Income (Rs)	33.34	56.18	29.32	35.74	45.17	30.09	28.44	45.48	17.51
Income from dung (Rs/day)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Gross income (Rs/day)	33.84	56.68	29.82	36.24	45.67	30.59	28.94	45.98	18.01
Net income (Rs/day)	16.13	36.56	12.10	16.22	22.94	12.15	16.21	26.18	3.98
Net WP (Rs/m^3)	5.33	10.50	4.52	5.41	7.14	4.60	7.39	7.82	1.67

Table 10: Net Water Productivity in Milk Production, Diesel Pump, South Bihar Plain

	Diesel Pump – Owner			Diesel Pump – Water Purchaser			Electric Pump – Water Buyer		
	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow	Buffalo	CBCow	Ind.Cow
Total expenditure (Rs/day)	20.57	16.52	20.57	17.05	14.95	14.38	19.35	11.20	16.77
Milk production (Lt)	1.69	3.53	1.37	1.68	2.30	1.18	2.36	0.79	1.86
Income (Rs)	23.65	41.60	19.11	23.53	27.06	16.57	32.76	11.11	25.98
Income from dung (Rs/day)	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Gross income (Rs/day)	24.15	42.10	19.61	24.03	27.56	17.07	33.26	11.61	26.48
Net income (Rs/day)	3.58	25.57	-0.96	6.98	12.61	2.69	13.91	0.41	9.70
Net WP (Rs/m^3)	4.98	4.06	2.84	3.62	3.18	3.04	4.92	2.81	4.09

of livestock. Comparing the estimates for the three different categories of farmers show some definite trends. For instance, the expenditure on dairy production is highest for water buyers in diesel well command, who are confronted with highest marginal cost of irrigation water, followed by diesel well owners and lowest for water buyers in electric well commands. The net income from milk production does not show any definite trends. Water buyers in electric well commands secure highest net water productivity in milk production in buffalo milk production; diesel well owners obtain highest water productivity in cross bred cow milk production; and water buyers in diesel well commands obtain highest water productivity in production of indigenous cow milk.

The estimates of daily expenditure on dairying; the net income from milk production per animal per day; and the net water productivity in rupee terms for different categories of livestock are provided for the three different categories of farmers in south Bihar villages in Table 10. Comparing the figures, no definite trend vis-à-vis expenditure, incomes and water productivity is seen to emerge.

5.6 Impact of Differential Cost of Irrigation on Water Productivity at the Farm Level

Table 11: Comparison of Water Productivity at the Farm Level at Different Irrigation Costs in Eastern UP and south Bihar

Name of Region	Farmer Category	Overall Water Productivity in Crops(Rs/m^3)	Water Productivity in Dairying (Rs/m^3)	Farm level Water Productivity (Rs/m^3)
Eastern UP	WB in Electric well	16.72	2.84	9.78
	Diesel Well Owner	10.35	3.03	6.73
	WB in Diesel well	20.06	0.17	10.20
South Bihar	WB in Electric well	17.97	1.64	9.81
	Diesel Well Owner	21.62	0.90	11.27
	WB in Diesel well	22.59	0.30	11.45

Source: authors' own estimates

Having estimated water productivity values for crops and dairying, the water productivity values for the entire farming system were worked out using the estimates of the total volume of water annually allocated to different crops and the estimated volume of water used up in dairy production as per the equations provided in Methodology. The final figures for water productivity for the crop combinations; water productivity in dairying and farm level water productivity for the locations, viz., eastern UP and south Bihar are provided in Table 11. It shows that water productivity figures are higher for the farmers who are confronted with the higher cost of irrigation water, i.e., the water buyers in diesel well commands. The exception is the water buyers in electric well commands. This is due to the inherent advantage with the location.

The higher values of farm level water productivity for water buyers in diesel well commands is mainly due to the reduced application of irrigation water for the crops, which enhances both physical productivity and

Table 12: Net Income from Crop and Milk Production, Eastern Uttar Pradesh

Type of pump	Type of farmer	Gross cropped area (Ha)	Net income from crop production (Rs)	Net income from milk production (Rs/annum)	Farm level net income (Rs)	Farm level net income (Rs/Ha)
Diesel Well	Well owner	5.29	124587.3	7152.3	131739.6	24880.2
	Water buyer	2.21	54637.6	6165.0	60802.6	27570.1
Electric Well	Well owner	5.66	74764.5	7429.5	82193.9	14528.1

Source: Authors' own estimate based on primary data.

Table 13: Net Income from Crop and Milk Production, South Bihar Plains

Type of pump	Type of farmer	Gross cropped area (ha)	Net income from crop production (Rs)	Net income from milk production (Rs./day)	Farm level net income (crop + milk) (Rs.)	Farm level net income (Rs/ha)
Diesel Well	Well owner	3.14	111736.7	10292.6	130769.5	210345.8
	Water buyer	1.70	61517.7	8130.89	76023.9	190031.1
Electric Well	Well owner	2.49	140105.5	9958.09	150063.6	191387.5

Source: Authors' own estimate based on primary data.

water productivity in economic terms for the crops. But, the improvement in physical productivity of water does not get converted into higher water productivity in rupee terms in dairy production. This is because the cost of production of dairy inputs is higher for water buyers in diesel well commands and diesel well owners.

5.7 Impact of Differential Cost of Irrigation on Farm Incomes

Overall impact of electricity and diesel price change on the farming system is analysed by considering the net return from crop and dairy farming is discussed in subsequent section. Analysis shows that the impact of cost of irrigation on farming prospects is not at all significant. While in the case of eastern UP, the water buyers in diesel well commands, who incur the highest cost of irrigation water, are earning highest income per unit of land, the electric well owners, who incur the lowest cost of irrigation water, obtain the lowest net return from unit of land (Table 12). In south Bihar, the diesel well owners are found to be obtaining highest income from every unit of land, even higher than what the water buyers in electric well commands obtain (Table 13). The difference in net returns between diesel well owners and their water purchasing counterparts is also not significant.

6. MAJOR FINDINGS

1. The impact of rising cost of diesel on the diesel well owners (in terms of cost of diesel well irrigation in real terms) is nearly 32% in south Bihar and 18% in eastern UP. But, this did not have any positive impact on the price at which water is sold by diesel well owners due to the reducing monopoly power of diesel well owners over time. The actual price at which water is available to the water buyers came down by 38% in south Bihar and 7.5% in eastern UP. The fact that the cropping pattern of diesel well owners and water buyers did not undergo any significant change over the past one and a half decade testifies this.

2. In order to analyze the potential impact the rise in diesel price would have on the farming enterprise of diesel well owners and water buyers in their command, a comparative analysis of irrigation water use, income from crops, dairying and entire farm; and water productivity in crop and milk production and at the farm level of three different categories of farmers, viz., water buyers in electric well commands, diesel well owners and water buyers in diesel well commands was carried out. It shows that higher cost of irrigation water motivates farmers to use irrigation water more efficiently from a physical point of view to minimize the cost of irrigation.

3. Ever since the Green revolution period irrigated farming has been getting transformed as a commercial proposition by the farmers. Farmers prefer crops yielding more returns and in the process reasonable price hikes in diesel do not find much importance by the farmers in their farming economies.

4. Further, the farmers who are paying higher cost for irrigation water use it more efficiently also from agronomic and economic points of view, as reflected by higher values of water productivity in both physical and economic terms they obtain.

5. The farmers who are paying higher cost for irrigation water use it more efficiently from economic point of view at the farm level than those who pay lower cost, by optimizing crop and dairy inputs; and allocating more area under crops that give higher returns. This is reflected in the highest cropping system water productivity and farm level water productivity in economic terms for the water buyers in diesel well commands.

6. The net income return farmers obtain from irrigated farming is found to be inelastic to the cost of irrigation water. The water buyers in diesel well commands, who pay the highest cost for irrigation water, get as much net returns per ha of land as the water buyers in electric well commands, who incur the least cost for irrigation water in volumetric terms. They manage to sustain the net returns by minimizing the input costs and maximizing the returns, and selecting crops that give higher returns per unit land.

7. It is clearly found that the impact of diesel price on irrigation cost incurred by diesel well owners is not significant. Also, this burden is not passed on to the water buyers due to the increasing competition, and lowering monopoly power of pump owners. Further, the analysis of the farming enterprise of irrigators under differential cost (irrigation) regimes shows that farmers would be able to cope with steep rise in irrigation costs through irrigation efficiency improvements and allocating more area under crops that give higher returns from unit of land and water, that enhance the farming returns from every unit of water and energy used. By doing this, they are able to maintain almost the same net returns from farming as in the past. This means, that the rise in cost of diesel in real terms cannot make any negative impacts on economic prospects of diesel well irrigators, including water buyers.

7. CONCLUSIONS AND POLICY IMPLICATIONS

An attempt is made to answer two important questions concerning India's farm livelihoods in this paper. They are: 1] what has been the actual impact of the rising price of diesel on millions of India's small and marginal farmers in water abundant regions who depend on irrigation pumps energized by diesel directly or indirectly vis-à-vis the cost of irrigation water?, and 2] what is likely to be the potential impact of rise in cost of irrigation water on the farming enterprise of small and marginal farmers, who are either well owners or water buyers?

Contrary to the popular perception and belief that diesel price rise causes a lot of distress among farmers, it is found that the impact of diesel price on irrigation cost incurred by diesel well owners is not significant. One reason for this is that the regions which are heavily dependent on diesel pumps for irrigation are having shallow groundwater table. Also, this burden is not passed on to the water buyers due to the increasing competition and lowering monopoly power of pump owners. One needs to keep in mind the fact that over the past two decades, there has been an explosion in irrigation pump sets in eastern India, and this had drastically reduced the monopoly power of diesel pump owners.

The analysis of the farming enterprise of irrigators under differential cost (irrigation) regimes presented here shows that farmers would be able to cope with very high rise in irrigation costs through irrigation efficiency improvements and allocating more area under crops that give higher returns from unit of land and water, that enhance the farming returns from every unit of water and energy used. By doing this, they are able to maintain almost the same net returns from farming as in the past. This means, that the rise in cost of diesel in real terms had not made any negative impact on economic prospects of diesel well irrigators, including water buyers.

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