DETERMINANTS OF CHOICE OF IRRIGATION TECHNOLOGY AND FARM INCOME

A. Conceptual Framework

For the purpose of the study, it is important to analyse the determinants of irrigation technology choices and farm incomes. Fig. 1 below illustrates how the past condition of power supply and the expectations regarding the future along with farm and region specific characteristics affect the choice of irrigation technologies. The choice of a specific irrigation technology, in turn, together with current conditions of power supply affect input choices, and consequently farm incomes.

Figure 1 - Conceptual Framework: Determinants of Technology Choices and Farm Incomes

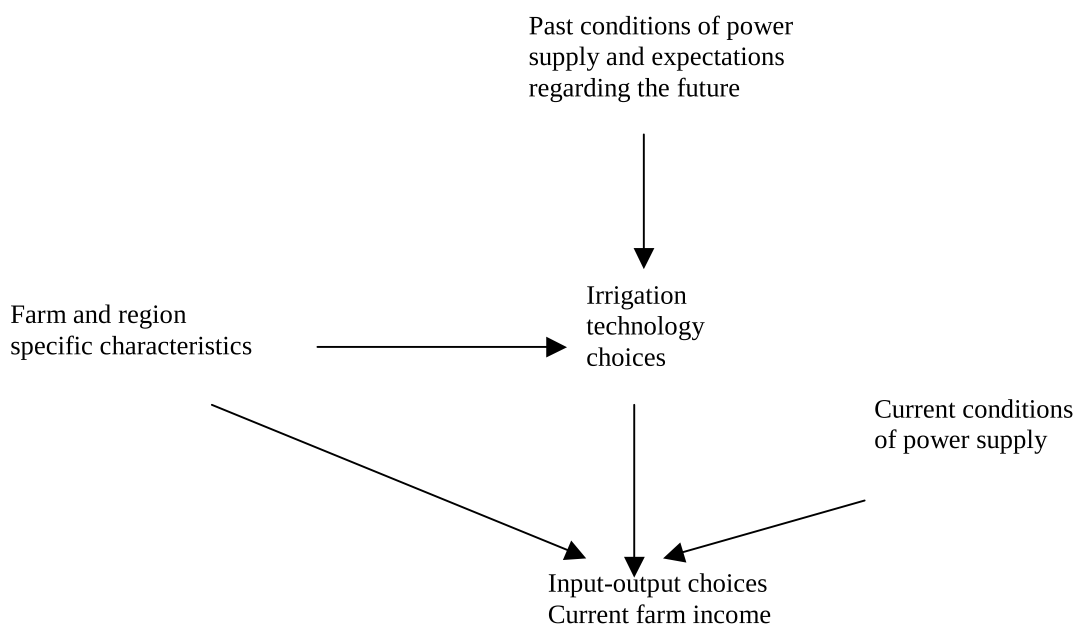
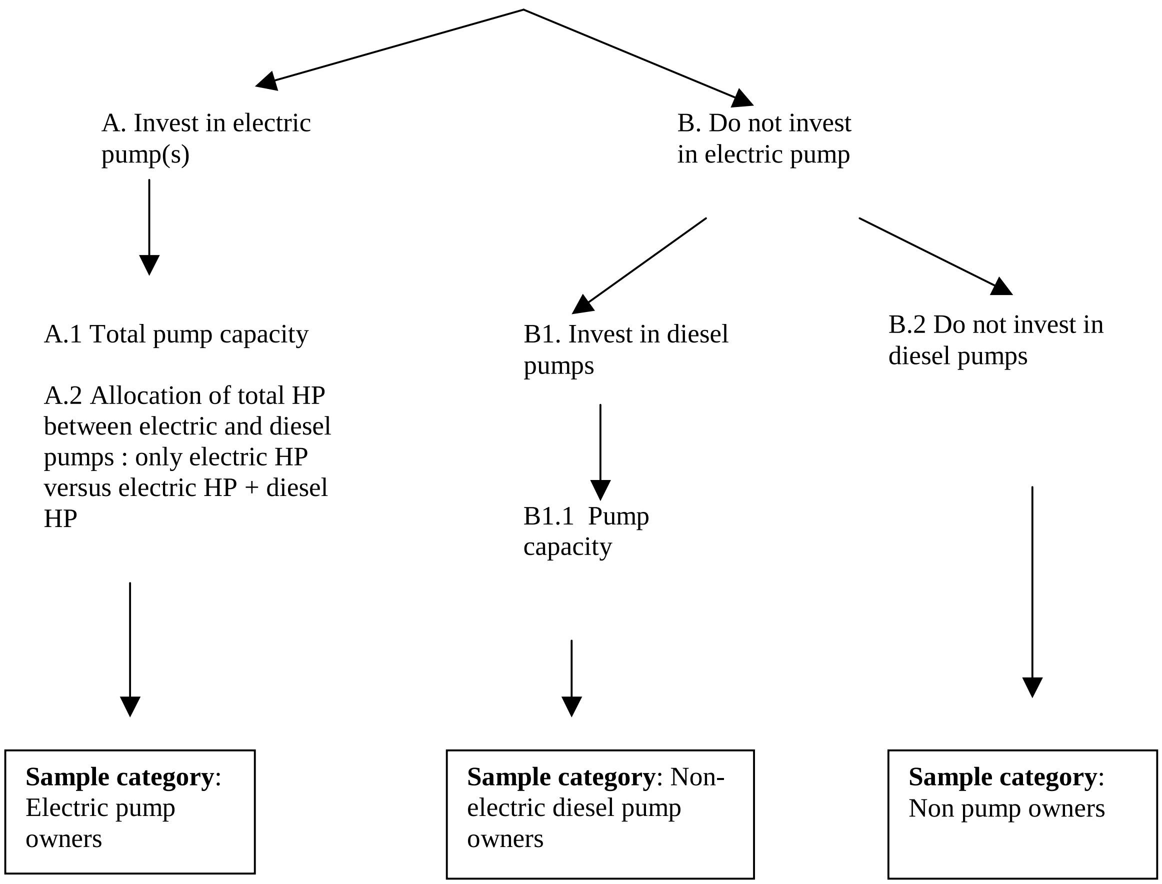


Fig. 2 presents a simplified decision tree to analyse how the decision regarding the technology choices are made. According to this decision structure, farmers first decide whether to invest in an electric pump or not.[1] Once the decision to invest in an electric pump is made (left branch of Fig. 2), farmers will have to choose pump capacity (HP) and its allocation to either electric pumps alone or to have supplemental diesel pumps. Farmers who do not invest in electric pumps (right branch of Fig. 2), may choose to invest in either diesel pump or no pumps.

Figure 2 - Decision tree regarding technology choices



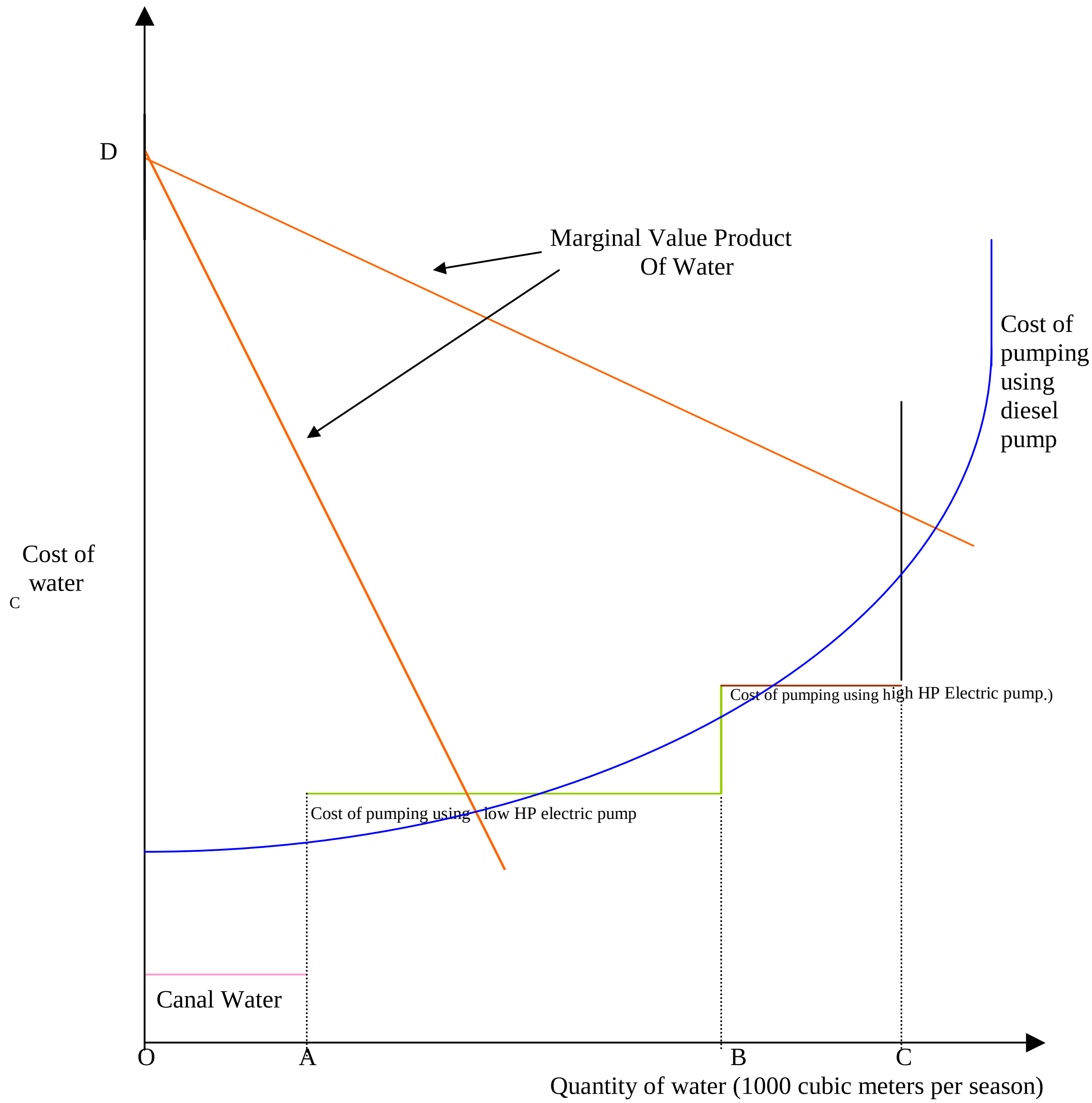
[1] It is possible that some farmers may have wanted to invest in an electric pump but could not do so because a connection was not available. This possibility is explored in the discussion of the results from the technology regressions.

The relative costs of different sources of water available to a farmer through investment in different irrigation technologies is illustrated in Figure 3. The figure is based on the relative irrigation cost calculations done in the previous chapter. Canal water is highly subsidized and its use requires minimal investment on part of farmers (generally in the form of digging and maintaining field channels), relative to groundwater irrigation which requires a large prior investment in well and pumps. However, canal water is available in only a few places and there are quotas on the amount available for use at each farm level (such as OA shown in figure). Given that canal water is almost free to farmers, it seems reasonable to assume that farmers use it to the fullest extent possible where it is available and thus there is no real issue of technology choice involved here.

All farmers, irrespective of whether they own a well or not, also have the choice of purchasing water from other well owners in their neighborhood. In general, purchase of water also requires very little prior investment, mostly in the form of rubber pipes and/or field channels. Thus this choice will also not be regarded as a technology choice. However, availability of canal water and the decision to purchase water in any season is likely to have an impact on farm incomes and thus this choice is analyzed in the farm income regressions in the second step. Purchased water in general entails the highest variable costs as discussed in the previous section.

The real technology choice question therefore is whether to invest in a pump and if so ,of what type (electric or diesel) and how much capacity (horsepower). As discussed in the previous chapter, given the flat rate tariff system, farmers face close to zero marginal costs of pumping with an electric pump but are restricted because of power rostering on the number of hours they can pump (as shown by the vertical segments of the electric pump cost curves in Figure 3). They are also subject to the poor reliability and quality of electric power supply. Thus the cost of pumping through an electric pump resembles a mirrored L shaped curve, where the horizontal part shows the zero tariff and the vertical part shows the quantity constraint that farmer faces. A higher HP pump as opposed to a lower HP pump costs higher in terms of initial fixed investment costs and tariff costs, but can pump larger amount of water in any given unit of time (OB units of water can be pumped with low HP pump and OC with higher HP pump in Figure 3). The irrigation technology choice of farmers is likely to depend on these costs together with their long term demand for water (as shown in Figure 3).

Figure 3 - Marginal value product of water and cost of water from various sources



B. Who invests in electric pumps?

Following the technology choice tree in Figure 2, the issue of who invests in electric pumps is examined first. The dependent variable is defined as a binary variable (=1 if invested in electric pump, zero otherwise). Given this binary choice, a probit model is preferred over the ordinary least squares estimator since it gives unbiased estimates. Amongst the explanatory factors, the electricity supply indicators explained in detail above together with some region and farm specific factors shown in Table 1 were considered.

Table 1 - Technology Choice Regression: Determinants of Choice of an Electric Pump
(Probit Estimates)

Dependent Variable = 1 if farmer has an electric pump, zero otherwise

Variable Description	Variable name	Parameter Estimate	T-statistic	Marginal effect
I. Power supply factors				
Connection constraint (Percentage of sample farmers in a district who reported being unable to get a connection)	connect	-0.01	-0.31	-2.E-05
Day lost in Transformer Burnout	burndayp	-0.10	-1.49	-3.E-04
Power availability (hrs/day: Rabi Kharif mean)	schssRK	6.59**	4.90	0.02
Power availability (hrs/day: Rabi Kharif mean)* Land owned		-0.27**	-7.16	-1.E-03
Unscheduled powercuts (hrs/day: Rabi-Kharif mean	uschssRK	-20.94**	-4.68	-0.07
Unscheduled powercuts (hrs/day: Rabi-Kharif mean))* Land owned		0.81**	5.89	3.E-03
Power availability during period of peak demand in Summer (dummy =1 if available)	peakS	-7.82**	-4.67	-0.03
II. Farm and region specific factors				
Electric Tariff bill rate(Rs./HP/month)- 1978 Rates	flat78a	-0.40	-0.52	-1.E-03
Land owned (hectares)	landownR	0.93**	5.91	3.E-03
Value of Owned Assets (Rs)	assetval	0.01**	5.40	2.E-05
Non-farm Income (Rs/year)	oincval	-0.01	-1.24	-2.E-05
Education of Household Head (dummy =1 if educated)	ifhedu	-0.71**	-2.21	-2.E-03
Household Size	hhsize	-0.09**	-2.24	-3.E-04
Credit Constraint (Dummy = 1, if farmer is constrained)	crconstn	-0.28	-1.27	-1.E-03
Rainfall (mm: Annual Normal)	rainN	0.00	0.19	2.E-06
Coefficient of Variation of Rainfall	covrain	0.06	0.77	2.E-04
Canal availability (dummy=1, if farmer has access to canal water)	canal	-0.28	-0.93	-1.E-03
Groundwater Depth (feet: average annual)	gwSKR	0.01	1.42	3.E-05
Percentage of Fresh Groundwater in Aquifer	fresh	-0.01	-0.46	-3.E-05
Water price (Rs/ha/irrigation)	wsellira	-0.01**	-2.02	-5.E-05
Price of Well (in Rs. 1,000)	wpreDEm	-0.05**	-3.05	-2.E-04
Price of Diesel Pump (in Rs. 1,000)	pumppred	0.04*	1.69	1.E-04
Price of Electric Pump (in Rs. 1,000)	pumpreE	0.09**	3.60	3.E-04
Paddy price (Rs/quintal)	vpaddyp	1.E-03	1.12	4.E-06
Wage rate (Rs/day)	vwage	0.01	0.53	5.E-05
Ferilizer price	vfprice	2.E-03	0.30	7.E-06
Diesel price (Rs/liter)	dprice	0.13	0.32	5.E-04
Constant	_cons	-12.27	-0.98	
Number of obsverations =716, Wald chi2(27) = 203.34 Prob > chi2 = 0.0000				

Notes: * denotes significance at 10% level
** denotes significance at 5% level

C. Determinants of total pump capacity (HP) for electric pump owners

Farmers who decide to invest in an electric pump, also have to decide on much horsepower to invest. Table 2 presents the results of an ordinary least squares regression of natural log of total HP[2]. This equation estimates the farm household's effective demand for total pumping capacity[3].

Table 2 - Determinants of Total Horsepower for Farmers with Electric Pump
(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)

Dependent Variable: Natural Log of Total Horsepower

Variable	Parameter Estimate	T-Statistic	Elasticity
I. Power supply factors			
Days Lost due to Transformer Burnout (Days/year)	-3.E-04	-0.06	-3.E-03
Power Availability (hrs/day: Average Rabi-Kharif)	-0.70**	-4.93	-5.49
Power Availability (hrs/day: Average Rabi-Kharif)* Landowned	0.11**	4.68	3.76
Power Availability (hrs/day:Summer)	0.48**	3.80	3.37
Power Availability (hrs/day:Summer)* Landown	-0.09**	-3.88	-2.74
Unscheduled Powercuts (hrs/day: Average Kharif- Rabi)	0.87**	3.38	1.14
Unscheduled Powercuts (hrs/day: Average Kharif- Rabi)*Landowned	-0.08**	-2.72	-0.47
Availability during period of peak demand (Kharif)	1.66**	2.98	0.38
Availability during period of peak demand (Rabi)	-2.67**	-8.37	-1.15
Availability during period of peak demand (Summer)	0.84*	1.85	0.13
II. Farm and region specific factors			
Electric Tariff bill rate(Rs./HP/month)	-0.04**	-2.32	-0.93
Electric Tariff bill Rate * Groundwater Depth	5.E-04**	2.35	0.80
Canal (Dummy = 1 if farmer uses canal irrigation)	-0.23	-1.29	-0.04
Percentage Fresh Groundwater in Aquifer	0.01**	3.29	0.77
Groundwater Depth (Feet)	-0.01**	-2.32	-0.84
Rainfall (mm: Annual Normal)	-2.E-03**	-2.12	-0.96
Coefficient of Variation of Rainfall	3.E-03	0.19	0.08
Land owned (hectares)	-0.03	-1.11	-0.16
Rental Price of Land (Rs/hectare)	3.E-05**	3.65	0.25
Household size	0.02*	1.66	0.16
Education of Household Head (Dummy =1 if educated)	0.06	0.56	0.04
Constant	3.57**	3.63	
N=334			
Log likelihood = -316.0357			
Wald chi2(21) = 329.44 Prob > chi2 = 0.0000			

Notes: * denotes significance at 10% level
** denotes significance at 5% level

[2] The Hausman two-step procedure was used to correct for sample selection.
[3] Total HP refer to electric plus diesel HP since some electric pump owners may also own diesel pumps.

D. Diesel pumps as a coping strategy by electric pump owners

In Haryana, a number of electric pump-owning farmers also own diesel pumps. It has often been hypothesized that poor conditions of power supply (limited availability, poor reliability and quality) lead farmers to invest in diesel pumps as a coping strategy. To test for this hypothesis, Table 3 presents the results of a probit regression with the dependent variable defined as a binary variable (=1, if invested in diesel pumps, zero other wise).[4] One of the explanatory variables in this regression is total HP. Thus, the regression reported in Table 3 estimates the effect of power supply and other farm and region specific factors on the decision to have supplemental diesel pumps, given a certain demand for total HP.

Table 3 - Determinants of Choice of Supplemental Diesel Pump by Electric pump owners

(Probit estimates corrected for selection, using Heckman two step procedure)

Dependent Variable =1, if farmer has a Diesel pump

Variable	Parameter Estimate	T-Statistic	Marginal effect at sample mean	Elasticity at sample mean
I. Power supply factors				
Connection constraint (Percentage of sample farmers in a district who reported being unable to get a connection)	-0.03**	-2.35	-2.E-03	-0.96
Days Lost due to Transformer Burnout (Days/Year)	0.02**	1.96	2.E-03	0.15
Unscheduled Powercuts (hrs/day: Average annual)	2.42**	3.03	0.18	1.70
Unscheduled Powercuts (hrs/day: Average annual)* Land owned	-0.26**	-3.77	-0.02	-0.79
Power availability (hrs/day: Rabi Kharif mean)	-1.06**	-4.61	-0.08	-4.64
Power availability (hrs/day: Rabi Kharif mean)* Land owned	0.10**	4.98	0.01	1.68
II. Farm and region specific factors				
Log Total Pump Horsepower	0.80**	4.70	0.06	0.67
Canal (Dummy = 1 if farmer uses canal irrigation)	0.14	0.33	**2.E-03**	2.E-03
Diesel Price (Rs.)	0.83	1.17	0.06	5.94
Credit Constraint (dummy = 1 if farmer is constrained)	-0.19	-0.78	**-0.01**	-0.02
Groundwater*Diesel Price	-0.01	-1.51	-1.E-03	-6.66
Past Billrate	1.65**	2.76	0.13	14.62
Percentage Fresh Groundwater in Aquifer	0.03**	2.91	2.E-03	1.25
Groundwater Depth (Feet)	0.16	1.57	0.01	6.64
Rainfall (mm: Annual Normal)	-0.01**	-2.40	-4.E-04	-2.08
Coefficient of Variation of Rainfall	0.09*	1.65	0.01	1.34
Land owned (Hectares)	-0.39**	-4.46	-0.03	-0.89
Household Size	-0.05	-1.46	-4.E-03	-0.19
Education of Household Head (Dummy =1 if educated)	0.02	0.06	**8.E-04**	4.E-03
Predicted value of Diesel Pump price	0.19**	4.14	0.01	-0.02
Predicted value of Electric Pump Price	-0.02	-1.24	-2.E-03	-0.02
Constant	-33.40**	-3.27		
Number of observations = 346				
Log likelihood = -135.1596				
Wald chi2(20) = 321.38 Prob > chi2 = 0.0000				

Notes: * denotes significance at 10% level
** denotes significance at 5% level

[4] The Hausman two-step procedure was used to correct for sample selection.

E. Determainants of Investment in Diesel pumps by non-electric pump owners

In this subsection the technology choice decisions of those who do not invest in electric pumps is examined (the right hand branch B in Figure 2). Basically, the farmers who do not invest in electric pumps have to decide whether to invest in diesel pumps or not. Table 4 presents the results of a probit regression with the dependent variable defined as a binary variable (=1, if non electric pump owners invested in diesel pumps, zero other wise).

Table 4 - Determinants of Choice of Diesel Pump by Non-Electric pump owners
(Probit estimates corrected for selection, using Heckman two step procedure)

Dependent Variable =1, if non electric pump owner has a diesel pump

Variable	Parameter Estimate	T-Statistic	Marginal Effect
Canal (Dummy = 1 if farmer has access to canal irrigation)	-0.74*	-1.89	-0.09
Percentage Fresh Groundwater in Aquifer	0.02	1.27	0.01
Credit Constraint (Dummy = 1 if farmer is constrained)	0.54**	2.06	0.05
Land owned (hectares)	0.11*	1.69	0.03
Groundwater Depth (feet)	-0.60*	-1.79	-0.17
Value of assets owned (Rs)	2.9E-03*	1.68	8.1E-04
Income from other sources (Rs/year)	-0.01	-1.27	-2.6E-03
Education of Household Head (Dummy =1 if educated)	0.55**	2.02	0.08
Household Size	-0.02	-0.35	-4.4E-03
Rainfall (mm: Annual Normal)	-3.7E-04	-0.16	-1.1E-04
Coefficient of Variation of Rainfall	0.01	0.16	1.8E-03
Water price (Rs/ha/irrigation)	6.0E-04	0.11	1.7E-04
Paddy Price (Rs/Quintal)	8.3E-04	0.70	2.4E-04
Wage rate (Rs/day)	-0.04	-1.27	-0.01
Diesel Price (Rs/litre)	-2.97	-1.64	-0.84
Diesel price *Groundwater	0.05*	1.85	0.01
Predicted price of Diesel Well	0.01	0.13	1.8E-03
Predicted price Diesel Pump	-0.11	-1.62	-0.03
Constant	34.59	1.49	
Number of Observations = 172			

Notes: * denotes significance at 10% level
** denotes significance at 5% level

F. Determinants of net income for electric pump owners

Several different specifications of the net farm income equation for electric pump owners were tried to test for the robustness of the results. The results were found to be quite robust across the different specifications. Results of two of the main specifications are reported here. Table 5A and 5B presents the results of these two specifications using the ordinary least squares method with dependent variable as net income[5]. Net income is defined here as gross value of farm production minus annualized fixed cost and all variable costs (except the imputed cost of family labor and land). Thus this income regression estimates the determinants of net returns to own labor and land. Since the effect of power and other farm and region specific factors on net farm incomes are likely to differ across farmers belonging to different size categories, a net farm income equation was estimated separately for a pooled sample of marginal and small farmers and pooled sample of medium and large farmers.[6]

In the first specification of the net income equation, , investment in irrigation technology is controlled for by including the technology variables (total HP and dummy for investment in supplemental diesel pumps) amongst the explanatory variables. Thus this equation estimates the effect of power and other farm and region specific factors on short run incomes (keeping irrigation technology constant). The technology variables may potentially be endogenous. The Hausman test of endogeneity was conducted and it was found that the null hypothesis of exogeneity was rejected only for the case of total HP in the small and marginal farmers' regression. The predicted value of total HP from the regression reported in Table 2 was then used as an explanatory variable in the small and marginal farmers' regression.

In the first specification, gross area cultivated was not included amongst the explanatory variables because it may potentially be endogenous. It is difficult to find instruments that can separately identify the effect of gross area and the technology variables. Variables such as past electricity supply conditions identify both the irrigation technology decisions and gross cultivated area decisions. It can be argued that past input and output prices may more closely influence gross cultivated area decisions than the irrigation technology decisions. However these prices were found to be poor instruments. Thus to identify the returns to a unit of gross cultivated area, a second specification was tried in which gross area cultivated was included amongst the explanatory variables, but technology variables were dropped. The results of the auxiliary regression used to predict gross area are presented in Table 5C.[7]

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[5] The Hausman two-step procedure was used to correct for sample selection in the income regressions.

[6] Separate income equations were first estimated for all the four size categories. The results for small and marginal were found to be qualitatively similar, and so also the results for medium and large farmers. Given the small regression sample size for each category taken separately, two pooled samples were examined finally.

[7] Specifications with both predicted and observed value of gross area were tried. The results, particularly those relating to the effect of power supply factors did not differ much across the two specifications. The Hausman test of exogeneity could not reject the null hypothesis of exogeneity of gross area. Thus only the specification with observed gross area is reported here.

Table 5A: Determinants of Short-Run Net Farm Income of Electric Pump Owners: Specification including Technology Variables

(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)
Dependent Variable: Net farm Income (in Rs. 1,000)

Variable	Marginal-Small	Medium-Large
I. Power supply factors		
Days Lost due to Transformer Burnout (Days/year): Kharif	0.51 (0.44)	-4.60** (-3.84)
Power Availability (hrs/day: Average Rabi-Kharif)	9.47* (1.82)	-1.57 (-0.21)
Unscheduled Powercuts (hrs/day: Average Kharif- Rabi)	5.28 (0.37)	-28.26** (-2.03)
Motor burnout frequency	10.31 (1.43)	1.35 (0.15
II. Farm and Region specific factors		
Diesel dummy (=1, if owns additional diesel pump): observed	-11.67 (-0.39)	29.89 (1.03)
Total HP -predicted	-13.03** (-2.74)	0.23 (0.15)
Canal (Dummy = 1 if farmer uses canal irrigation)	40.42 (1.25)	-13.24 (-0.42)
Credit Constraint (Dummy = 1, if farmer is constrained	-8.92 (-0.61)	26.74 (1.30)
Groundwater Depth (Feet)	0.73 (1.37)	-0.06 (-0.14)
Rainfall (mm: Annual Normal)	0.01 (0.12)	-0.11** (-2.19)
Value of assets owned (in Rs. 1,000)	0.02 (0.22)	0.16** (2.42)
Education of Household Head (Dummy =1 if educated)	-14.84 (-0.96)	-20.19 (-0.87)
Land owned (hectares)	-35.27** (-2.45)	9.05** (3.32)
Diesel price(Rs./litre)	-14.06 (-1.12)	-16.19 (-0.96)
Paddy price(rs./quintal)	0.14 (1.49)	-0.08 (-0.65)
Wheat seed price	-32.90** (-3.57)	23.63** (2.14)
Wage rate (Rs./hour)	3.94 (1.07)	-1.83 (-0.87)
Fertilizer price	-0.73 (-0.52)	-0.57 (-0.57)
Constant	84.99 (0.37)	369.55* (1.77)
Inverse Mills Ratio	146.75** (5.73)	17.19 (0.57)
Adjusted R squared	0.46	0.24
Number of Observations	86	212

Notes: t statistics in parenthesis
* denotes significance at 10% level
** denotes significance at 5% level

Table 5B: Determinants of Short-Run Net Farm Income of Electric Pump Owners- Specification including Gross Cultivated Area

(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)
Dependent Variable: Net farm Income (in Rs. 1,000)

Variable	Marginal-Small	Medium-Large
I. Power supply factors		
Days Lost due to Transformer Burnout (Days/year): Kharif	0.74 (1.15)	-4.28** (-3.73)
Power Availability (hrs/day: Average Rabi-Kharif)	9.63** (2.38)	-4.86 (-0.67)
Unscheduled Powercuts (hrs/day: Average Kharif- Rabi)	-1.13 (-0.13	-21.94* (-1.64)
Motor burnout frequency	-1.27 (-0.26	-4.10 (-0.48)
II. Farm and Region specific factors		
Percentage of area under cotton cultivation (district level)	2.60** (2.34)	-1.73 (-1.49)
Canal (Dummy = 1 if farmer uses canal irrigation)	-23.17 (-0.92)	-23.80 (-0.76)
Credit Constraint (Dummy = 1, if farmer is constrained	-2.42 (-0.25)	28.26 (1.46)
Groundwater Depth (Feet)	0.20 (0.55)	0.20 (0.51)
Rainfall (mm: Annual Normal)	0.01 (0.27)	-0.11** (-2.16)
Value of assets owned (in Rs. 1,000)	0.04 (0.68)	0.09 (1.37)
Education of Household Head (Dummy =1 if educated)	0.84 (0.08)	-23.21 (-1.02)
Gross area cultivated (hectares)	9.87** (5.09)	7.47** (6.07)
Diesel price(Rs./litre)	5.28 (0.66)	-13.40 (-0.83)
Paddy price(rs./quintal)	-0.07 (-0.86)	0.04 (0.37)
Wheat seed price	-11.11* (-1.65)	20.58** (1.97)
Wage rate (Rs./hour)	2.11 (0.92)	-0.60 (-0.30)
Fertilizer price	0.45 (0.47)	-1.38 (-1.40)
Constant	-209.83 (-1.46)	206.64 (1.05)
Inverse Mills Ratio	71.20** (3.83)	35.27 (1.22)
Adjusted R squared	0.43	0.32
Number of Observations	134	212

Notes: t statistics in parenthesis
* denotes significance at 10% level

** denotes significance at 5% level

Table 5C: Determinants of Gross Area Cultivated by Electric Pump Owners

(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)
Dependent Variable: Gross Cultivated Area (hecatres)

Variable	Marginal-Small	Medium-Large
I. Power supply factors		
Days Lost due to Transformer Burnout (Days/year): Predicted	3.1E-03 (0.07	-0.05 (-1.19)
Power Availability (hrs/day: Average Rabi-Kharif)	-0.19 (-0.24)	-0.73 (-0.92)
Power Availability (hrs/day: Summer)	-4.11 (-1.09)	8.50** (3.23)
Unscheduled Powercuts (hrs/day: Summer)	1.47 (1.46)	-0.14 (-0.20)
Unscheduled Powercuts (hrs/day: Average Rabi-Kharif)	-1.39 (-0.67)	-1.14 (-0.74)
Unscheduled Powercuts *land owned (hrs/day: Average Kharif-Rabi)	2.15 (0.89)	-0.73** (-2.49)
Power Availability *land (hrs/day: Average Kharif- Rabi)	-0.80* (-1.90)	0.13** (2.30)
II. Farm and Region specific factors		
Average Normal Rainfall	-0.02 (-0.94)	1.5E-03 (0.16)
Coefficient of variation of rainfall	-0.24 (-0.97)	0.12 (0.75)
Groundwater Depth (Feet)	0.00 (-0.05)	-0.03** (-2.53)
Canal (Dummy = 1 if farmer uses canal irrigation)	5.53* (1.66)	1.62 (0.80)
Rental price of land	0.00 (-1.25)	9.6E-05 (0.85)
Credit Constraint (Dummy = 1, if farmer is constrained	0.53 (1.16)	0.36 (0.53)
Percentage of fresh water in aquifer	0.02 (0.70)	0.06* (1.93)
Past year's fertilizer price	0.02 (0.42)	0.01 (0.20)
Past year's wage	-0.19 (-1.02)	0.01 (0.06)
Past bajra price	-0.08 (-0.89)	5.1E-04 (0.02)
Education of Household Head (Dummy =1 if educated)	0.05 (0.09)	0.22 (0.27)
Household size	0.16 (1.55)	0.13 (1.35)
Value of assets owned (in Rs. 1,000)	0.01** (2.18)	4.6E-03* (1.77)
Land owned (hectares)	4.61 (1.49)	1.71** (4.66)
Inverse Mills Ratio	0.78 (0.51)	1.54 (1.22)
Constant	49.91 (1.29)	-11.93 (-0.59)
R squared	0.41	0.80
Number of Observations	144	238

Notes: t statistics in parenthesis
* denotes significance at 10% level
** denotes significance at 5% level

G Determinants of net income for non-electric pump owners

Among non-electric pump owners, those owing a diesel pump have significantly higher income, as reflected by the significant positive sign on the diesel dummy in Table 6. This table presents the results of an ordinary least squares regression with dependent variable as net farm income of non-electric pump owners. The positive effect for diesel pump owners is lower in areas with greater groundwater depth possibly because of the higher costs of pumping using a diesel pump in such areas.

Variables that have a positive effect on net farm income for non electric pump owners are: size of farm, non-land assets, household size, and the wage rate prevailing in the village. Amongst the various output prices that were tried, only rice price was found to have a positive significant effect. Variables and inputs that have a negative effect are: education of household head and diesel price, None of the other inputs prices such as seed prices of important crops or fertilizer price were found to be significant. The price of water at the village level, as reported by buyers and sellers of water in the village was also not found to be significant. None of the infrastructure variables (road density and market development) were found to be significant.

Table 6 - Determinants of Short-Run Net Farm Income of Non-Electric Pump Owners

(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)
Dependent Variable: Net farm Income (in Rs. 1,000)

Variable	Parameter Estimate	T-Statistic	Elasticity at mean level
Diesel dummy (=1, if owns additional diesel pump): observed	60.69**	2.40	0.42
Household size	4.27**	2.15	0.62
Density of Roads (Kms/1000 ha)	-14.50	-1.31	-1.94
Canal (Dummy = 1 if farmer uses canal irrigation)	-6.60	-0.63	-0.06
Credit Constraint (Dummy = 1, if farmer is constrained)	-5.13	-0.95	-0.05
Groundwater depth * Diesel dummy	-1.08**	-2.61	-0.54
Current Rainfall (mm)	0.07*	1.67	0.67
Value of assets owned (in Rs. 1,000)	0.18**	2.12	0.79
Education of Household Head (Dummy =1 if educated)	-19.44**	-2.19	-0.28
Land owned (Hectares)	16.59**	3.42	0.81
Diesel price(Rs./litre)	-10.40*	-1.73	-3.20
Paddy price(Rs./quintal)	0.06*	1.74	0.90
Cotton price (Rs/quintal)	-0.02	-0.64	-0.45
Wheat seed price (Rs/kg)	-6.17	-1.13	-1.30
Wage rate (Rs/day)	1.84**	2.41	3.12
Fertilizer price (Rs/kg)	-0.44	-1.59	-0.26
Water selling rate (Rs/irrigation/acre)	0.12	1.58	0.48
Constant	61.89	0.44	
Number of Observations = 397			

Notes: * denotes significance at 10% level
** denotes significance at 5% level

H. Determinants of Short Run Electricity Consumption

Two alternative specifications were tried to estimate the short run electricity consumption for pumping purposes. In the first specification reported in Table 7, power consumption measured in terms of total kWh per farmer during the year was taken as the dependant variable. In the second specification reported in Table 8, kWh/HP was taken as the dependant variable. The first specification estimates the determinants of total short run power consumption while the second one estimates the determinants of consumption per load, which roughly corresponds to estimating the hours of electricity use per farmer.

Table 7 - Short run Consumption of Electricity for Pumping
Dependent Variable: kWh

(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)

Variable	Parameter Estimate	T-Statistic	Elasticity at mean level
Power Supply Factors			
Days lost due to transformer burnout (Days/Year)	-157.64**	-3.08	-0.49
Power availability (hrs/day: Rabi)	-9.32	-0.03	-0.01
Power availability (hrs/day: Summer)	869.92**	3.88	1.00
Unscheduled powercuts (hrs/day: Kharif)	1431.62**	2.02	0.52
Unscheduled powercuts (hrs/day: Rabi)	1610.94*	1.82	0.53
Frequency of motor burnouts during the year	41.28	0.14	0.01
Farm and Region Specific Factors			
Diesel dummy (=1, if owns additional diesel pump): observed	-368.31	-0.29	-0.01
Total HP (predicted)	294.76**	3.88	0.29
Gross cultivated area (Hectares)	-34.16	-0.57	-0.04
Value of assets owned (in Rs. 1,000)	-0.15	-0.06	-0.01
Credit Constraint (Dummy = 1, if farmer is constrained)	-850.13	-1.09	-0.05
Canal (Dummy = 1 if farmer has access to canal irrigation)	3858.90*	1.69	0.04
Groundwater depth (feet)	-5.55	-0.32	-0.06
Current Rainfall (mm)	-0.48	-0.24	-0.03
Groundwater quality	-24.39	-0.89	-0.23
Percentage area under oil production (district level)	15542.84*	1.80	0.19
Paddy price(Rs./quintal)	-5.74	-0.59	-0.39
Wage rate (Rs/day)	-128.77*	-1.68	-1.22
Fertilizer price (Rs/kg)	223.96**	3.46	0.80
Constant	1125.08	0.12	
Number of Observations = 132			

Notes: * denotes significance at 10% level
** denotes significance at 5% level

Table 8 - Short run Consumption of Electricity for Pumping
Dependent Variable: kWh/HP

(Ordinary Least Square estimates corrected for sample selection using Heckman two step procedure)

Variable	Parameter Estimate	T-Statistic	Elasticity at mean level
Power Supply Factors			
Days lost due to transformer burnout (Days/Year)	-2.71	-0.25	-0.05
Power availability (hrs/day: Rabi)	15.28	0.20	0.08
Power availability (hrs/day: Summer)	62.65	1.51	0.44
Unscheduled powercuts (hrs/day: Kharif)	-192.85	-1.35	-0.48
Unscheduled powercuts (hrs/day: Rabi)	264.89*	1.62	0.60
Frequency of motor burnouts during the year	106.89**	2.00	0.10
Farm and Region Specific Factors			
Diesel dummy (=1, if owns additional diesel pump): observed	-258.08	-1.10	-0.04
Total HP (predicted)	24.54	1.57	0.17
Gross cultivated area (Hectares)	-16.71	-1.37	-0.14
Value of assets owned (in Rs. 1,000)	1.22**	2.52	0.35
Credit Constraint (Dummy = 1, if farmer is constrained)	-267.24*	-1.88	-0.11
Canal (Dummy = 1 if farmer has access to canal irrigation)	231.65	0.59	0.03
Groundwater depth (feet)	2.02	0.70	0.14
Current Rainfall (mm)	5.00**	2.16	1.87
Groundwater quality	-197.51*	-1.69	-12.33
Percentage area under rice production (district level)	16686.39*	1.72	7.00
Percentage area under oil production (district level)	7320.43**	2.45	0.59
Percentage area under sugarcane production (district level)	34746.23	1.42	1.15
Percentage area under cotton production (district level)	-15243.38**	-2.11	-0.60
Paddy price(Rs./quintal)	17.23**	1.97	8.31
Wage rate (Rs/day)	26.89	1.17	1.70
Fertilizer price (Rs/kg)	35.78**	2.09	0.82
Constant	-9897.57	-2.80	
Number of Observations = 132			

Notes: * denotes significance at 10% level
** denotes significance at 5% level

I. Returns from improvements in reliability and quality of power supply: Comparison of electric and diesel pumps

Diesel pumps are a close technological substitute for electric pumps. As pointed out in chapter 1, about 40 per cent of the farmers interviewed cited the non-availability of electricity connection as the main reason for their investing in diesel pumps. Apart from non availability of electric connection, the other factors cited for investing in diesel pumps were: greater reliability of diesel pumps (21 per cent) and the ready availability of diesel fuel (16 per cent). In this section, the costs and returns of these technological alternatives are compared in order to evaluate the premium farmers associate with the higher quality and reliability of diesel pumps as opposed to electric pumps, and thus to get an alternative estimate for returns associated with power reforms. The results of the econometric analysis are then compared with the willingness to pay analysis described above to test the assumption that electricity tariff reforms will benefit farmers.

Some descriptive background on the differences between electric and diesel pumps is presented first, followed by a more rigorous econometric analysis of their differences.

Several differences between diesel (D) and electric (E) pumps[8] that show electric pumps at a disadvantage at the start up stage (Table 9). First, the initial fixed cost of digging the well/bore and purchasing the pump is on average 41 per cent higher for electric pumps than diesel pumps in all regions.[9] And there is a waiting period from around 3 months to 3 years to get an electric connection.

The higher fixed costs for wells with electric pumps could be explained, in part, by the observation that the average depth of wells/bores where electric pumps are used is higher than that where diesel pumps are used. Diesel pumps seem to be preferred in places where groundwater depth is lower. Lower groundwater depth implies lower digging costs as well as lower requirements for pump HP for wells with diesel pumps. As shown in Table 9 the average horse power associated with diesel pumps used by sample farmers is lower than that for electric pumps, in all regions except regions II and III.[10] In addition, the regression analysis on demand for electric HP in previous chapter showed that farmers tend to over-invest in electric HP as a consequence of limited availability, poor reliability and quality of electricity supply.

The variable costs of operating electric and diesel pumps also differ, largely because of the different pricing structure for electricity and diesel. All the farmers in the sub-sample reported in Table 9, paid for electricity on a flat rate basis while they pay for diesel on a per unit basis. Because of this flat rate pricing structure for electricity, electric pumps are used much more intensively than diesel pumps in every region. On average during the year, the number of hours for which electric pumps are run is about 6 times higher than that for diesel pumps.[11] Due to this higher intensity of use, the per HP per hour cost of operating an electric pump is about 5.6 times lower than that for diesel pumps.[12]

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[8] In constructing table 1, only sample wells which were 5 or less years old were considered. This was done so as to enable a more accurate comparison of costs of the same vintage technology and to avoid problems associated with accounting for depreciation.

[9] In the survey, farmers also reported having paid a connection charge for electric connection as shown in the table. Currently there is no connection charge for agricultural consumers. However, if the connection is disconnected there is a re-connection charge of Rs. 250 per connection.

[10] The HP figures in the table are as reported by the farmer.

[11] The number of hours for which an electric pump is run was estimated from the metering study

[12] The per hour per hp cost of running an electric pump was calculated as: (annual official electricity tariff + annual costs of repair and maintenance of pump)/ number of hours of operation of electric pump. For diesel pump it was

Table 9 - Comparison of costs of electric versus diesel pumps[1]

Particualrs	Region I		Region II		Region III		Region IV		Region V		AverageI	
	D	E	D	E	D	E	D	E	D	E	D	E
Number of pumps in subsample[1]	14	13	15	28	32	27	9	18	28	28	98	114
Depth of bore/well(feet)	97.5	174.6	82.7	167.1	73.3	137.2	75.6	131.7	95.0	131.8	84.6	148.6
HP of pump[2]	8.6	11.6	7.5	6.2	7.8	5.5	7.7	8.0	8.2	11.5	8.0	8.4
Initial cost o f digging and other non-pump expenses (I)	40131.5	61217.9	29907.7	52509.3	37425.9	44219.3	31149.7	59725.3	43014.0	53931.0	37681.9	53027.5
Pump Cost (P)	19607.9	30636.7	17804.2	18282.3	19142.4	20984.1	14719.7	17694.1	18383.2	23033.5	18381.0	21405.1
Connection Charges(C)	0.0	5355.1	0.0	3149.9	0.0	4530.6	0.0	4995.6	0.0	5232.6	0.0	4531.4
Total Fixed cost (I+P+C)	59739.4	97209.7	47711.9	73941.5	56568.3	69734.0	45869.4	82415.0	61397.3	82197.1	56062.9	78964.0
d value of fixed cost[3]	7998.9	13014.3	6388.5	9899.2	7574.3	9335.9	6141.8	11033.6	8220.9	11004.5	7506.7	10571.6
Annual Fuel Cost(F)[4]	3573.9	9048.0	2332.4	4791.4	3126.7	4290.0	4845.4	5798.4	11841.9	6886.2	5653.8	6169.0
Annual Repair and maintenance (R)	2693.9	5717.0	2119.0	3303.2	1666.1	2961.4	1500.0	394.8	1938.9	2988.6	1945.0	3143.1
Total variable cost (V=F+R)	6267.8	14765.0	4451.4	8094.6	4792.9	7251.4	6345.4	6193.2	13780.8	9874.8	7598.8	9312.0
Hours of use (H)[5]	225.7	1449.062	101.1	1416.9	148.3	1093.8	237.0	1564.3	438.0	1731.9	243.0	1496.0
Variable cost /hour/hp	3.2	0.9	5.9	0.9	4.1	1.2	3.5	0.5	3.8	0.5	3.9	0.7

Notes: [1]Only pumps that were 5 or less years old were included.
[2]As reported by the farmer.
[3]The rate of interest was taken to be 7.5% per annum. The procedure for annualization is explained in the annex.
[4]Annual fuel cost was calculated as the annual official tariff charge in case of electric pumps and as total expenditure on diesel for diesel pumps.
[5]Hours of use for electric pumps is based on regional estimates obtained from metering study.

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calculated as: (annual expenditure on diesel + annual costs of repair and maintenance of pump)/ number of hours of operation of diesel pump during the year.

Figure 3 summarizes this structure of relative costs for both technologies. As shown in this figure, diesel pumps have somewhat lower setup costs relative to electric pumps. Therefore, when the demand for pumped water is low, either because an alternate irrigation source (such as canal) is available or because there are constraints on use of other inputs (such as limited amount of cultivable land available or working capital constraints) diesel pumps may be more economical to use.[13] However, since farmers pay on a per unit basis for diesel and flat rate basis for electricity, this initial cost advantage for diesel pumps is overcome by electric pumps at higher levels of use.

The above discussion on relative cost structure of the two technologies has important implications on how these technologies are used (Table 10). As expected, diesel pumps are used more often conjunctively with canal rather than as the sole source of irrigation because of their higher operating costs. The higher operating costs associated with diesel pumps implies that diesel pumps are preferred where canal water is available and thus pumped water requirements are low. Groundwater recharge through seepage from canals also increases the water table and thus lowers the energy requirement for pumping.

Diesel pumps are favored by marginal and small farmers. This may be a consequence of the fact that poorer (and often less educated) farmers find it more difficult to get an electricity connection. Also, for small and marginal farmers who have low pumped water demand (due to constraints on access to complementary inputs such as land or working capital), diesel pumps may be more economical to use.[14] On the other hand, for medium and large farmers who have larger water requirements, a diesel pump becomes desirable to own only when they already have an electric pump and need a supplemental diesel pump to cope with problems of low reliability and quality of electricity supply. Of the total of 318 diesel pumps in the sample, around half are owned by farmers belonging to marginal and small category. In contrast to this, small and marginal farmers own only about 40 per cent of electric pumps in sample. In region II, in particular, marginal and small farmers own 81 per cent of diesel pumps, but only 56 per cent of electric pumps.

Cropping patterns and yields are also quite different under the two technologies. The gross area cultivated under electric pumps is almost double of that under diesel pumps (Table 10). Electric pump owners also tend to grow more water intensive crops, such as paddy and sugarcane, than diesel pump owners. This can be seen in the table on cropping patterns in Annex 1. However, it is interesting to note that the yield of the most important crop in the state, namely wheat, is higher for pure diesel pump owners than the pure electric pump owners in every region. This is in spite of the fact that the average number of irrigations given to wheat is almost the same for electric and diesel pump owners. It is possible that for irrigated crops like wheat whose yields are sensitive to timeliness of irrigation, the better reliability of diesel pumps leads to higher yields. For paddy, the other important irrigated crop of the region, the number of irrigations given by electric pump owners is almost double that given by pure diesel pump owners, but the yield achieved by electric pump owners is only slightly higher. This is a reflection of the higher efficiency of water use associated with diesel pumps.

[13] Figure 1 does not account for the fact that diesel pumps are also more reliable
[14] Unless they can form a partnership with other smaller farmers and jointly invest in an electric pump

Table 10 - Summary table on comparison of electric(E) and diesel(D) pump owners in sample

	I		II		III		IV		V		Average	
	E	D	E	D	E	D	E	D	E	D	E	D
Total number of pumps in sample	85	21	295	45	109	144	130	42	51	66	670	318
Pumps used conjunctively with canal (%)	0	12.5	0.3	3.1	0.1	24.5	6.3	8.3	45.7	69.8	7.6	29.7
Percentage owned by marginal and small farmers	18.1	54.2	56.4	81.2	20.1	59.6	46.1	61.1	15.7	14.3	40.3	50.6
Av. land owned(ha.)	5	2.2	2.8	1.2	2.5	1.9	3.4	2.1	5.2	4.9	3.4	2.2
Gross area cultivated (ha.)	11.8	3.4	7.3	2.3	5.1	3	5.6	4.6	11.9	7.6	7.4	3.7
Paddy yields (quintals/Ha.)	31.3	27.9	31.6	30.6	28.2	31.1	36.3	33.9	29.1	28.4	31.3	30.2
Number of irrigations given to paddy	17.6	11.2	19.8	7.4	27.1	7.7	14.7	4	24.4		19.6	8.3
Wheat yields (quintals/Ha.)	38.9	42.4	38.8	46.4	42.3	44.9	37.8	46.7	41.5	43.5	38.9	45.0
Number of irrigations	9.9	10	9.7	7	7.9	10	9.9	11.3	8.8	9.8	9.6	9.6
Gross income	119,802	65,833	106,431	45,885	112,348	52,728	78,456	53,152	146,582	154,828	102,005	64,463
Gross income per ha.	25,059	30,617	33,240	31,690	46,938	30,717	19,713	24,504	31,990	36,108	29,197	30,328

Notes: The average land owned, land cultivated, yields and income figures are compared between pure electric pump owners and pure diesel pump owners.

Pure electric pump owners have gross incomes about 60 per cent higher than that of pure diesel pump owners because they have larger farms. However, on a per hectare basis, the gross income of diesel pump owners is somewhat higher. The net income of pure electric pump owners is about 72 per cent higher than that of pure diesel pump owners. However, again on a per hectare basis, the net returns are almost same for the two categories and this is in spite of the much higher operating costs for diesel pumps.

The analysis in this section leads one to conclude that the productivity gains achieved by diesel pumps in terms of their better reliability and quality are more than compensated by their higher operating costs in the current situation. Thus although diesel pump owners have higher gross returns per unit of land, their higher operating costs lead them to get lower net farm incomes on average than electric pump owners. The current flat tariff structure for electricity leads electric pump owners to pump more intensively in order to irrigate a larger area with more water intensive crops relative to their diesel counterparts, thus reaping higher net incomes. All this suggests that if a shift is made to metered tariffs for electricity use with no change in quality of electricity supply, then the gross income of electric pump owners would fall, as gross cultivated area falls and the incentive to grow water intensive crops falls. Whether electric pump owners would then prefer to shift over time to diesel pumps would depend on how the relative prices of electricity and diesel compare with the reliability and quality of their supply.

These conclusions, however, need to be interpreted with caution because as pointed put above, there are a number of differences between diesel and electric pump owners. Thus the difference between net incomes of pure electric and diesel pump owners cannot be attributed to any specific cause, such as difference in the reliability of their energy source or difference in their cost structures, without controlling for the effect of these other contributory factors. Through the use of an econometric model it is possible to control for the other contributory factors and isolate the effect of a single factor or set of factors. In the next sub-section, an econometric model is developed to estimate the net income gain for electric pump owners if the reliability and quality of electricity supply is improved so as to make electric pumps comparable to diesel pumps.

J. Econometric model to estimate comparisons between Electric and Diesel pumps

Let Z be the vector of explanatory variables that affect the decision on whether a farmers owns an electric or diesel pump. Let Y_{1i} be the net income of the i^{th} farmer if he owns an electric pump and Y_{2i} be his net income if he does not own an electric pump, but owns a diesel pump. Let X_i be the vector of common explanatory variables such as land owned, availability of canal etc. that affect net incomes of both types of pump owners. Further, let E_i be the vector of characteristics of electric power supply that affects net incomes of electric pump owners only. The first two equations given below give the net income of electric and diesel pump owners respectively and the third equation is the selection equation which determines whether a farmer is an electric or diesel pump owner. Together these three equations constitute a switching regression model (Maddala, 1983).

(1) $Y_{1i} = X_i\beta_1 + E_i\alpha_1 + u_{1i}$ Net income function for electric pump owners
(2) $Y_{2i} = X_i\beta_2 + u_{2i}$ Net income function for diesel pump owners
(3) $I_i^* = Z_i\gamma + \varepsilon_i$ Selection equation for electric pump ownership

The observed Y_i is defined as

$Y_i = Y_{1i}$ iff $I_i = 1$
$Y_i = Y_{2i}$ iff $I_i = 0$

where

$I_i = 1$ iff $I_i^* > 0$
$I_i = 0$ iff $I_i^* < 0$

Under the normality assumption, the expected net income gain to a random electric pump owner i if he were to own a diesel pump is given as

(4) $E(Y_{2i} | I_i=1) - E(Y_{1i} | I_i=1) = X_i(\beta_2-\beta_1) - E_i\alpha_1 + (\sigma_{1\varepsilon} - \sigma_{2\varepsilon})\,\phi(Z_i\gamma)/\Phi(Z_i\gamma)$

The above equation breaks up the expected net income gain into 3 parts. The first term on the right hand side captures the net income gain due to the differing effect of various socio-economic and regional characteristics that affect incomes of both electric and diesel pump owners. The second term captures the effect of electric power supply characteristics that affect net incomes of electric pump owners only. The third term captures the correction for selection effect, which arises because it is expected that a farmer's selection of electric versus diesel pumps is based in part on his comparative advantage in using either technologies. In this third term, $\sigma_{1\varepsilon}$ and $\sigma_{2\varepsilon}$ are the covariances of the error term in first and second net income equation, respectively, with the error term in the selection equation. $\phi(.)$ and $\Phi(.)$ are, respectively, the density function and the distribution function of the standard normal.

Tables 11 and 12 give the results of estimation of equations (1) to (3). From these equations, equation (4) above can be estimated. The main motivation behind estimating equation (4) is to get an estimate of the second term on the right hand side which captures the pure effect of poor electric supply conditions on net incomes of electric pump owners relative to diesel pump owners, after controlling for all other differences between these two types of farmers.

Table 11 - Determinants of Farm Income –Electric Vs Diesel Pump Owners
(OLS estimates corrected for selection, using Heckman two step procedure)

Variable	Electric	Diesel
I. Power supply factors		
Days Lost due to Transformer Burnout -Kharif(Days/Season)	-0.17	
	(-0.16)	
Days Lost due to Transformer Burnout *Land owned (Days/Year)	-0.62***	
	(-4.02)	
Unscheduled Powercuts (hrs/day: Rabi-Kharif average)	12.16	
	(0.98)	
Unscheduled Powercuts (hrs/day: Average annual)* Land owned	-5.41**	
	(-3.03)	
Power availability (hrs/day: Rabi Kharif mean)	2.07	
	(0.41)	
Motor burnouts (Average annual)	-1.10	
	(-0.18)	
II. Farm and Region specific factors		
Diesel (Dummy =1 if farmer owns a supplemental diesel pump)	11.21	
	(0.55)	
Total Pump Horsepower	1.02	-0.23
	(0.81)	(-0.05)
Canal (Dummy = 1 if farmer uses canal irrigation)	2.73	52.74*
	(0.12)	(1.73)
Diesel Price (Rs.)	-11.18	-7.65
	(-1.05)	(-0.31)
Credit Constraint (dummy = 1 if farmer is constrained)	16.01	-36.72
	(1.18)	(-1.45)
Groundwater Depth (Feet)	-0.06	0.28
	(-0.21)	(0.36)
Rainfall (mm: Annual Averagel)	-0.08**	0.05
	(-2.12)	(0.75)
Land owned (Hectares)	29.03**	15.58**
	(5.53)	(2.94)
Education of Household Head (Dummy =1 if educated)	-10.48	-43.09
	(-0.73)	(-1.47)
Value of assets owned (in Rs. 1,000)	0.17**	-0.03
	(3.45)	(-0.21)
Paddy price(rs./quintal)	0.01	0.02
	(0.13)	(0.20)
Wheat seed price	10.45	11.76*
	(1.35)	(1.89)
Wage rate (Rs./hour)	-1.15	1.41
	(-0.70)	(0.49)
Fertilizer price	-0.39	0.37
	(-0.51)	(0.42)
Constant	109.10	-96.50
	(0.75)	(-0.38)
Inverse Mills Ratio	39.45	-70.89
	(1.41)	(-1.62)
Number of Observations	346	102

Notes: Figure in parenthesis gives t statistics
* denotes significance at 10% level
** denotes significance at 5% level

Table 12 - Choice Regression: Determinants of Choice of a Diesel Pump (Sample of pump owners)
(Probit Estimates)

Dependent Variable = 1 if farmer has a diesel pump, zero otherwise

Variable Description	Parameter Estimate	T-statistic
I. Power supply factors		
Connection constraint (Percentage of sample farmers in a district who reported being unable to get a connection)	4.E-03	0.22
Day lost in Transformer Burnout	0.11*	1.84
Power availability (hrs/day: Rabi Kharif mean)	-7.07**	-5.64
Power availability (hrs/day: Rabi Kharif mean)* Land owned	0.29**	5.72
Unscheduled powercuts (hrs/day: Rabi-Kharif mean	22.82**	5.41
Unscheduled powercuts (hrs/day: Rabi-Kharif mean))* Land owned	-0.89**	-5.64
Power availability during period of peak demand in Summer (dummy =1 if available)	7.71**	4.60
II. Farm and region specific factors		
Electric Tariff bill rate(Rs./HP/month)- 1978 Rates	1.91*	1.66
Land owned (hectares)	-0.94**	-4.24
Value of Owned Assets (Rs)	-0.01**	-3.66
Non-farm Income (Rs/year)	0.01	0.73
Education of Household Head (dummy =1 if educated)	0.98**	2.58
Household Size	0.14**	2.78
Credit Constraint (Dummy = 1, if farmer is constrained)	0.75**	2.10
Rainfall (mm: Annual Normal)	4.E-03	1.37
Coefficient of Variation of Rainfall	0.06	0.47
Canal availability (dummy=1, if farmer has access to canal water)	-0.24	-0.69
Groundwater Depth (feet: average annual)	-0.01*	-1.68
Percentage of Fresh Groundwater in Aquifer	-0.02	-0.98
Water price (Rs/ha/irrigation)	0.02**	2.44
Price of Well (in Rs. 1,000)	0.06**	2.78
Price of Diesel Pump (in Rs. 1,000)	-0.07	-1.48
Price of Electric Pump (in Rs. 1,000)	-0.10**	-4.11
Paddy price (Rs/quintal)	-2.E-03	-1.57
Wage rate (Rs/day)	3.E-03	0.10
Ferilizer price	-0.01	-1.17
Diesel price (Rs/liter)	-0.14	-0.35
Constant	-16.40	-0.83
Number of Observations 486		

Notes: * denotes significance at 10% level