

REPORT NO. 22171-IN

**INDIA
POWER SUPPLY TO AGRICULTURE**

VOLUME 3 ANDHRA PRADESH CASE STUDY

JUNE 15, 2001

Energy Sector Unit
South Asia Regional Office



Document of the World Bank

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CHAPTER 1

OVERVIEW AND CHARACTERISTICS OF SAMPLE FARMERS

A. Introduction

1.1 The supply of electric power to agricultural consumers is often thought to be the source of the crisis in the power sector in India. Farmers are estimated to pay tariffs (agricultural tariffs) that represent a fraction of the increasing cost of power supply, and some states, such as Tamil Nadu and Punjab, supply power to agricultural consumers free of charge. In Haryana farmers pay just 12 per cent of the cost of supply yet they use nearly half of the electricity produced. In Andhra Pradesh, farmers pay about 4.5 per cent (FY2000) of the cost of supply and use 40 per cent amount of the electricity produced in the state. Obviously the decision to increase tariffs is among the measures that generate the strongest political opposition.

1.2 The agricultural sector is key to the economic development of the state of Andhra Pradesh. In FY1999, agriculture contributed 28 per cent of the State Gross Domestic Product (GSDP), and employed about 70 per cent of the workforce in the State. Continued agricultural growth, therefore, is viewed to be critical not only to sustaining economic growth in the State, but also to reducing rural poverty as it drives rural employment and income growth. In FY1994 it was estimated that half the total poor population of AP, about 7.7 million people, lived in rural areas. AP, like Haryana, is one of the major surplus producers of rice, accounting for about 13 per cent of India's total production in FY1999 (CMIE 1999b).

1.3 The agricultural sector in Andhra Pradesh has grown significantly in the past two decades, in part due to increased access to irrigation. The gross irrigated area (GIA) in FY1999 accounted for about 45 per cent of total cultivated area, or 6.1 million ha, up from 30 per cent (4.7 million ha) of GIA in FY1982. The more widespread use of irrigation also contributed to yield growth, reduced production variability and diversification to higher value crops (oilseeds, cotton, fruits and vegetables). In FY1999, about 95 per cent of rice and sugarcane area was irrigated, 75 per cent of wheat, 34 per cent of maize, 20 per cent of groundnut and 17 per cent of cotton.

1.4 The power sector, therefore, exerts a critical influence on the performance of the agricultural sector as it influences farmer access to, and use of, power for a variety of agricultural operations but most importantly for pumping groundwater for irrigation purposes. A large share of the increase in irrigated area in the State came from the expanded use of groundwater. Net irrigated area using groundwater pumped from wells increased 140 per cent to 1.9 million ha between FY1982 and FY1999. During the same period, the share of farms with wells in net irrigated area doubled from 21 per cent to 42 per cent. By the most recent estimates (FY1995), AP has a high density of pumps, with a ratio of 125 electric pumps per 1000 ha of gross irrigated areas. As much of the groundwater is pumped using electric pumps sets, the supply of power, therefore, is key to the production performance of a major sector of the farm population. The diesel pumps in the state of Andhra Pradesh were estimated around 165,000 in 1993 (Directorate of economic and Statistics, GOAP) whereas the electric pumpsets are estimated to reach about 2 million in the year 2000.

1.5 This study has been done in collaboration with the government of Andhra Pradesh to facilitate the decision making process on agricultural tariffs and, more generally, to help formulate recommendations on power policy reforms as well as irrigation and agricultural measures which could complement power sector reforms to improve rural development opportunities. In this chapter the methodology used in the study is discussed along with a description of the characteristics of farmers that

were surveyed, such as land ownership, cultivation practices and pump ownership. A separate report describes in detail the methodology and sampling.

1.6 In Andhra Pradesh, the study used data collected from an Attitude survey and six Recall surveys undertaken during the year 1999/2000. In Haryana which also collected data from farmer surveys, a separate metering study of both electricity consumption and supply was conducted in parallel. This was not possible in AP because of delays in pump selection due to a change in the sample, delays and difficulties in meter installation and incomplete meter readings. In addition, the recall surveys were also not as complete as the ones conducted in Haryana because of the difficulties in reaching farmers because of the flooding that affected many regions in the summer of 2000. and hostilities faced by the survey teams in some of the villages, which are known to be affected by serious order problems. These problems led to shortcomings in the completeness and reliability of the recall survey data. This, coupled with the lack of information from a metering study, meant there were inadequate data for building an accurate econometric model, as was done for Haryana. As a result it was not possible to produce policy simulations for Andhra Pradesh. However, a metering program is underway in AP and is expected to generate results in the next fiscal year and data collected through the survey will be further reviewed. Therefore, there may be a possibility to conduct policy simulations in AP when these data become available in 2002.

1.7 In the following chapter, the relationship between irrigation choices and farm incomes is discussed. It describes the regressive nature of the current flat rate tariff and shows the costs associated with different irrigation choices. It also shows that farmers who use electric pumps have the highest incomes.

1.8 The conclusions and broad recommendations discussed in Chapter Three are similar to those presented in the report on Haryana. Despite the absence of an econometric model for AP it is reasonable to suggest that the recommendations posited for Haryana can also be made for AP since the state faces the same problems in power sector and there are enough similarities in the make up of its farm population and cropping patterns.

B. Methodology

1.9 **Farmer Household Survey.** The study collected data from farmer household recall surveys undertaken during the year 1999/2000, covering the 1999 Summer season, 1999 Kharif season and 2000 Rabi season.¹ Two recall surveys were conducted in each season, one in the beginning and the other at the end of the season. The survey included 1,819 farmers using combined technologies for irrigation (groundwater using electric pumpsets or diesel pumpsets, canal and other surface water irrigation, water purchasing) and 301 farmers cultivating under rainfed conditions, in six regions (Table 2.1). The sampling methodology and procedures, included in the Methodological Framework and Sampling Report, were discussed and agreed with the government of AP. The regions were selected to ensure farming conditions, such as cropping patterns, types of irrigation used, rainfall and water quality, were more or less similar within a region.

1.10 Farmers were classified into several categories according to irrigation choices and the amount of land they owned and/or cultivated. A small number of pump owning farmers (electric and diesel) also use canal irrigation as an additional source of water. There were no farmers who owned both electric and diesel pumpsets in the sample. Since the primary focus of this study is on the impact of power supply on agriculture, a larger sample was selected for electric pump owners.

¹ Summer season-April to June; Kharif season – June to November; Rabi season – November to April .

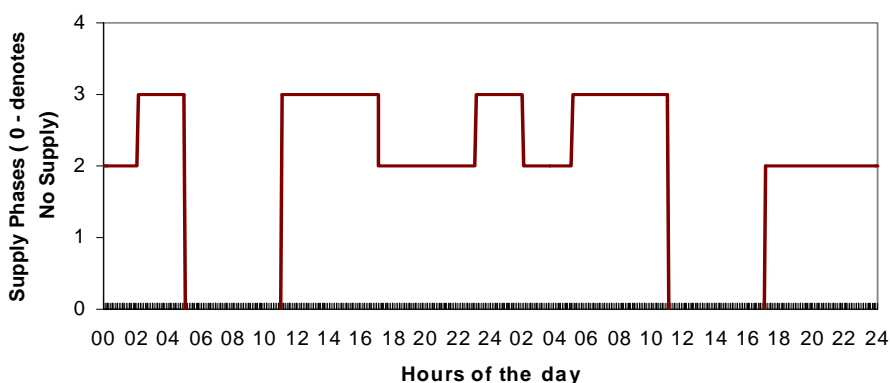
Table 1.1 - Distribution of sample farmers by source of water

	Electric pump owners			Non-electric diesel pump owners			Non-Pump Owners			Total Sample
	Electric pumps only	Electric pumps & canal only	Total	Diesel pumps only	Diesel pumps & canal	Total	Canal user only	Water purchasers	Rainfed	
I	116	16	132	43	4	47	67	37	46	329
II	207	5	212	74		74	104	76	70	536
III	135		135	43		43	67	16	44	305
IV	122		122	31		31	59	22	42	276
V	134		134	27		27	52	17	41	271
VI	172	9	181	41	2	43	85	36	58	403
TOTAL	886	30	916	259	6	265	434	204	301	2120

Source: Farmers recall survey

1.11 Electricity supply conditions in AP. Power supply to agriculture is allocated through rostering. This involves supplying power during pre-announced and restricted hours. Adherence to the rostering schedule by the utility is critical for farmers to ensure that adequate water is available, particularly during critical periods in the crop growth cycle. Any delays could adversely affect crop performance and the ability to achieve the optimum yields. Rostered generally involves: (i) dividing farmers into groups and (ii) supplying power (outside of peak load periods) to a particular group only for a fixed number of hours at a pre-announced “scheduled” time during the day or night. Access to power by farmers is regulated by providing the “three phase” supply for operating the electric pumps only during the pre-scheduled hours. At other times, only “two phase” supply is provided or power is cut off completely². This arrangement reduces the power demand to one half or one third of the total coincident maximum demand of the whole sector. The utilities use an ingenious technical mechanism to implement this arrangement, which is probably unique to India (see Box 1.1). In AP, farmers are divided into two groups, rotating every two days, following a schedule of 9 hours of three-phase supply (6 & 3 hours), 9 hours of two-phase supply and 6 hours of no power (Figure 1.1).

Figure 1.1 - Power supply Rostering in Andhra Pradesh



² The two phase mode is supplied so that only the single phase domestic/commercial requirements are met. However, this approach also restricts the access by the three phase industrial consumers in the same area, if they are provided with power supply from the same rural feeder.

Box 1.1 - Power Supply Rostering Arrangement for Agricultural Consumers

The agricultural pumping load is mostly supplied through three phase system and the consumers use three phase induction motors of varying horse power to suit their irrigation requirements. This unique technical arrangement used to restrict power supply hours to the agricultural consumers employs switching of specially designed load make/ break switches, which with the help of a single lever operation, snaps the power supply to one phase from the source side and connects to one of the remaining two phases. (Generally a three phase power supply system would have in each line power with same magnitude as the other line but with different directional orientation (technically with phase angle separation of 120 degrees from each other). These phases are traditionally known as R, Y & B designated with the name of three different colors. Although the current European practice is to designate these as L1, L2 and L3. After this arrangement comes in operation the feeder has all the three lines charged, but two of them are running in same phase and in parallel. This arrangement hinders the farmers from running three phase motors, but allows other single phase supply users like domestic and shops etc. to use the electricity for their consumption. This arrangement puts tremendous stress on the phase which supplies power to two lines and also could be a contributor for high equipment failure rate in the distribution system. Notably, some of the farmers have developed a way out to pump water, when it is needed most by them, by converting this two phase system to three phase system by using phase split capacitors.

C. Characteristics of Farmers

Land Ownership and leasing

1.12 Farmers were classified into four categories according to the amount of land they owned. These categories, and the percentage of sample farmers in each category, are as follows:

- (i) marginal if they own less than 1 ha –39 per cent;
- (ii) small if they own greater than 1 but less than 2 ha – 29 per cent;
- (iii) medium if they own greater than 2 but less than 5 ha—26 per cent;
- (iv) large if they own greater than 5 ha –5 percent.

1.13 Farmers were also classified by operational holdings, that is the sum of land owned and leased. This changed only slightly the distribution in the sample: marginal – 38 per cent, small –30 per cent, medium –27 per cent, large –5 per cent. This compares with the population distribution of farmers by operational holding in AP (FY1996), which is marginal—59 per cent, small—21 per cent, medium—13 per cent, and large—6 per cent.

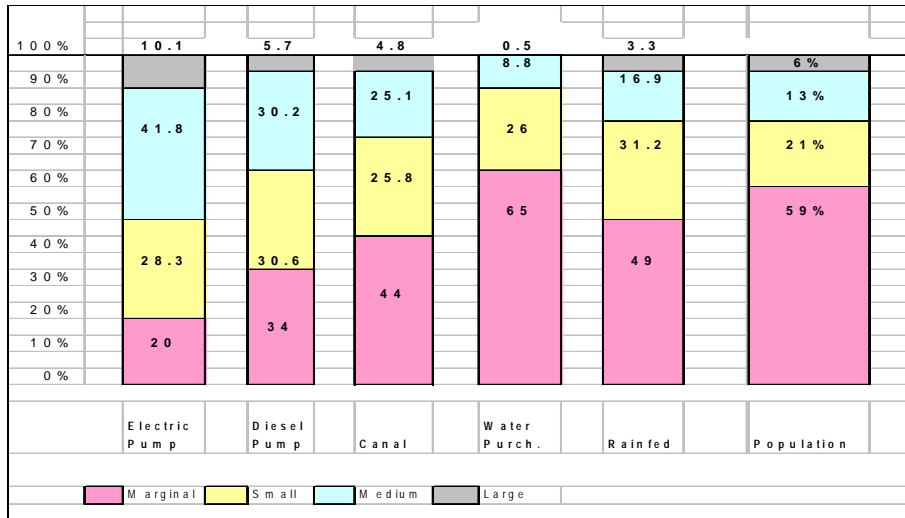
1.14 The land market in AP is not very active as compared to Haryana where the distribution in the sample for operational holding changes significantly when compared to that based on land ownership. In Haryana, for example, marginal farmers who owned electric pumps were able on average to increase their holding from one to five hectares through leasing. Electric and diesel pump users in AP, on average, own more land than other technology categories. (Table 1.2) However, a comparison of farmers’ operational holdings in the sample, with that of the total population reveals that although 50 per cent of the sample of marginal and small farmers own an electric tubewell, they represent a smaller portion compared to the entire population of farmers in the state (small and marginal represent almost 80 per cent of the population). Sample farmers using other technologies have a smaller land size, more in line with the overall population proportion.

Table 1.2. - Average land owned by type of technology (hectares)

Farm Size	Electric pump owners			Non-electric diesel pump owners			Non Pump Users			Total
	Electric pumps only	Electric & canal only	Total	Diesel pump only	Diesel and canal	Total	Canal user only	Water purchasers	Rainfed	
Marginal	0.7	0.7	0.7	0.6	0.8	0.6	0.6	0.5	0.6	0.6
Small	1.5	1.4	1.4	1.3	1.4	1.3	1.4	1.3	1.3	1.4
Medium	2.8	3.2	2.8	3	3.7	3	3	2.7	2.8	2.9
Large	7.1	7.7	7.2	7		7	7.4	6.1	8.2	7.3
	2.1	3.3	2.2	1.9	2.8	1.9	1.7	0.9	1.4	1.8

Source: Farmers Recall survey

Fig. 1.2 - AP Distribution of Farmers by Technology and Operational Holding*



* Defined as land owned minus land rented out plus land rented in

1.15 As noted, the farm sector in AP is dominated by marginal and small farmers who make up 2/3 of the farmers sampled and 80 per cent in the state population. This compares to Haryana where half the farmers are marginal and small. Reflecting this, the average farm holding in AP at 1.8 hectares is one hectare less than the average land owned in Haryana. However, as in Haryana, pump ownership is not confined to larger sized farms, as shown in Figure 1.2. Among the farmers sampled, marginal farmers account for 20 percent of those who used electric pumps. However, marginal farmers constitute 44 per cent of sample farmers who use canal water and 65 per cent of the sample farmers who are water purchasers.

1.16 The survey also found that across technologies, there are insignificant differences in the average land owned by small (1.3-1.4 ha) and marginal farmers (0.6-0.7 ha). However, there is greater variation in farm size owned by medium and large farmers. In Haryana, though the landholdings are slightly larger, the pattern of ownership is the same: electric pump users own more land than farmers in other categories.

1.17 The relatively small size of the average land owned in the State overall (1.8 ha) and across technologies (1.4 ha to 2.2 ha) is also consistent with the findings of other studies. They also reinforce concerns about the increasing marginalization/fragmentation of land in AP. This has several implications, not only in terms of decreasing economic viability of extremely small farms, but also in terms of limiting incentives for on-farm productivity enhancing investments (e.g. pumps and tubewells). Access to lease markets could partly compensate for declining farm sizes, but as discussed below, extensive restrictions on leasing limit this option.

1.18 Unlike in Haryana where there is an active land leasing market, although it is permitted in AP, there is very limited leasing happening on the ground. Only about 0.1 per cent of farmers using electric pumps, diesel pumps, canal irrigation and water purchasers participate in the lease market (see Annex 1, Table 2.3). As the legal framework for formal leasing in the state is highly restrictive, not only in terms

of area but also duration (only renewable 5 years terms are permitted), it creates disincentives for official leasing. This is confirmed by the results of the study, which show that the average net area leased in is 0.1 ha. Limited access to land leasing has important implications. Due to the short-term nature of arrangements, it discourages productivity enhancing investments (including fixed investments such as wells and pumps). It could also impose constraints to accessing credit, by the inability to show recognized rights to land.³

D. Gross cultivated area and cropping intensity

1.19 On average, electric pump users in the sample cultivated a larger area per year (3.7 ha) relative to other technologies. The average area cultivated annually by diesel pump and canal users was 3.3 ha. Rainfed farmers cultivated 2.2 ha on average, while water purchasers cultivated 1.8 ha.

1.20 Small and marginal farmers with access to electric pumps are able to irrigate and cultivate a larger area than farmers using other technologies, although the differences are not as great as in Haryana where electric pumps owners can lease land in. Although there is insignificant difference in the size of land owned by small and marginal farmers across technology categories, small and marginal farmers using electric pumps cultivate a larger area per year—2.1 ha and 3.2 ha respectively—compared to 1.3 ha and 2.3 ha for diesel pump users, and 1.6 ha and 2.7 ha for canal users (Table 1.3).

Table 1.3 - Average gross area cultivated annually (ha)

Farm Size	Electric pumps only	Diesel pump only	Canal user only	Water purchasers	Rainfed
Marginal	2.1	1.3	1.6	1.2	1.7
Small	3.2	2.3	2.7	2.4	2.1
Medium	4.5	5.3	4.8	3.3	2.8
Large	7.9	9.2	12.5	12.1	5.5

Note: gross cultivated area for rainfed farmers

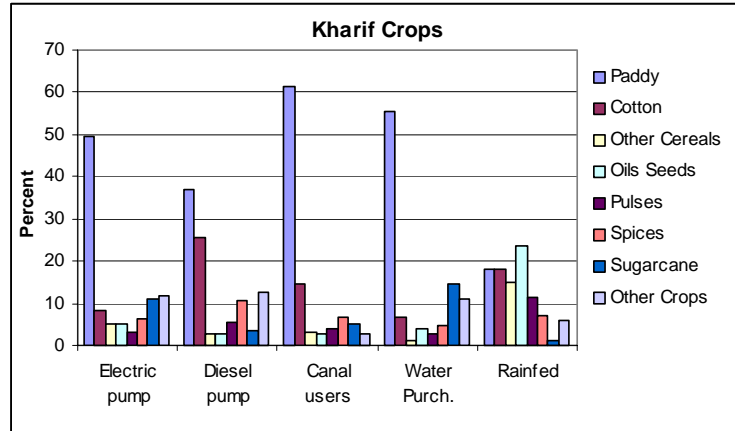
Source: AP Recall Survey

Marginal and small farmers who own electric pumps have the highest cropping intensity, ie. cultivating the same land over different growing seasons. They use all their land (0.7 ha and 1.4 ha, respectively) for cropping during each of the three cropping seasons which gives them annual gross cultivated areas of 2.1 ha and 3.2 ha, respectively. Farmers who use other irrigation technologies do not use their land as intensively. However, supplementary irrigation permits farmers to cultivate a proportion of their land in Kharif, when rainfall is more plentiful, and in the Rabi and summer seasons when rainfall is scarce. This increased cropping intensity is demonstrated by the significantly larger amounts of land under cultivation across all technologies compared to solely rainfed farmers.

³ See World Bank, Andhra Pradesh Rural Poverty Report, May 17th, 2000 (mimeo) for more detailed discussion.

1.21 **Cropping Patterns.** Rice, a highly water intensive crop, dominates the cropping pattern in AP. Cotton is the second largest crop cultivated. Among the sample farmers, during the Kharif season, when rainfall is plentiful, rice was the largest single crop for all farmers, with the exception, as expected, of rainfed farms who put just 18 per cent of their land down to paddy and planted 23 per cent of cropped area with oilseeds, a less water intensive crop. Access to irrigation and the cost of that form of irrigation clearly affects cropping decisions. For canal users who use the cheapest source of water, rice accounted for 61 per cent of cropped area; for water purchasers it was 55 per cent. For electricity pump users, 50 per cent of cropped area went to rice and for diesel pump users, 37 per cent (see Fig.1.3).

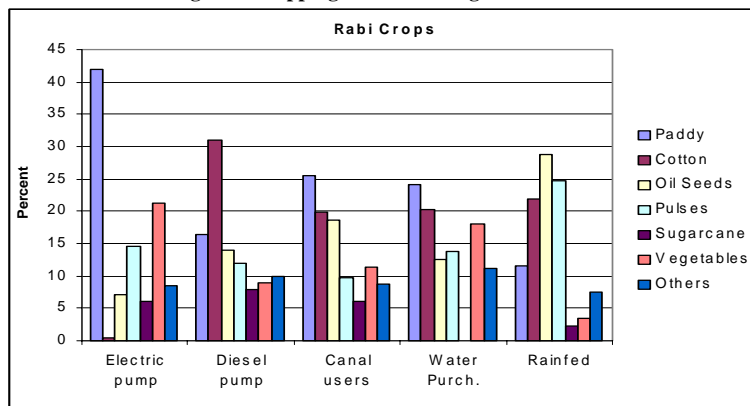
Fig 1.3 - Cropping Pattern during Kharif Season



Source: AP Farmer recall survey.

1.22 Rice is similarly favored during the Rabi season, especially among electric pump users. It accounted for 42 per cent of cropped area (Figure 1.4). Greater control over water availability when using electric pumps may partly explain this preference. Notably, there is a significant shift to less water intensive and higher value crops like oilseeds, cotton, vegetables in the non-electric pump using categories. Among diesel pump users, there is a decline in area devoted to rice (from 37 per cent to 16 per cent of the area) in the Rabi season, with a shift to other major crops such as cotton (31 per cent), oilseeds (14 per cent), pulses (12 per cent), and vegetables (9 per cent). Among canal users, there is also a sharp decline in area devoted to rice: 26 per cent compared to 61 per cent in the Kharif season. Instead, cotton (20 per cent) oilseeds (19 per cent), vegetables (11 per cent), and pulses (10 per cent) take up most of the area. This is probably partly due to the increasing scarcity of water during the Rabi season for diesel pump owners and canal users and water purchasers. However, other factors may also be driving the shift, such as improved access to markets for these higher margin crops and attractive prices. In the summer, due to limited water supply, few crops are grown. They consist mainly of oilseeds and sugarcane, the later confined to areas with assured irrigation.

Fig 1.4 - Cropping Pattern during Rabi Season



Source: AP Farmer recall survey.

1.23 **Crop Yields.** There is very little variation in yields across technologies for rice (Table 1.4). There is greater variation in yields among other crops, although no clear pattern or trend is identifiable. For oilseeds and cotton, those using diesel pumps post the highest yields, followed by electric pump users and canal users. Fruit and vegetable yields are highest among electric pump users. Given that yields are determined by many other factors (e.g. agro-climatic conditions, soil quality, output prices, socio-economic characteristics of farmers, etc), linkages between source of water and productivity cannot be clearly established without more rigorous analysis.

Table 1.4 - Yields of selected major crops in study area, quintal/ha

Crop	Electric pump	Diesel pump	Canal users	Water Purchasers	Rainfed	TOTAL
Paddy	25.0	27.8	25.8	26.3	26.8	25.6
Pulses	85.7	54.6	29.2	37.7	77.6	76.7
Other Cereals	77.6	47.9	43.3	21.9	47.7	84.1
Oil Seeds	57.0	63.8	24.4	55.3	28.3	64.1
Cotton	3.9	4.0	3.6	4.0	3.9	3.9
Flowers	3.9					3.9
Fruits	17075.6	12491.8	17.3	199.0		15976.9
Vegetable	768.6	502.2	341.0	281.8	266.1	767.4
Spices	212.1	230.2	234.0	82.5	165.3	253.0
Sugarcane	484.1	291.3	463.1	437.9	404.1	468.4
Tobacco	15.6	14.4	12.4	14.0	15.2	15.1
Coconut	6929.0	7968.6	10097.8	6188.1		7237.1

Note: quintal =100 kg
Source; AP Recall Survey

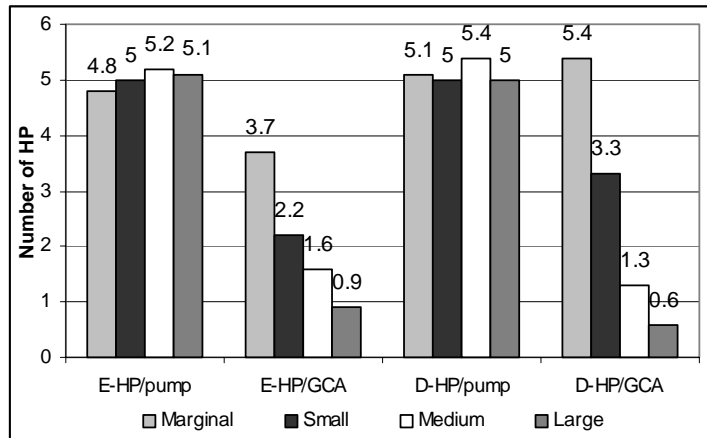
E. Characteristics of Pump Ownership

1.24 In the study, the number of pumps exceed the number of farmers who own pumps in the sample: the 916 electric pump owners have 946 pumps, while the 265 diesel pump owners have 293 pumps. This is due to multiple-pump ownership and/or joint ownership. Well depth is an important factor in the choice between using electric or diesel pump. Electric pumps are more predominant in areas where the groundwater depth is higher. Diesel pumps are more efficient and cost effective to use in areas where the water table is not so deep.

1.25 The majority of farmers who own electric pumps, regardless of size category, generally own just one electric pump. This does not differ much by farm size category (See Annex 1 Table 1.5). Multiple electric pump ownership was limited, unlike in Haryana where nearly half electric pump owners have more than one pump. A few farmers in all farm size categories own more than one pump. The study found that around between 4 per cent and five per cent of marginal, medium and large farmers own more than one pump, but just one per cent of small farmers own an additional pump. About one per cent of farmers own less than one pump—this is made feasible through joint ownership. Only six farmers, out of the more than 1,800 farmers surveyed in the study report joint ownership of electric pumps. Among farmers who own diesel pumps, they all own only one pump.

1.26 **Distribution of pump horsepower (HP) reported by farmers.** On average, there is little variation in electric pump capacity across farm size. Among electric pump owning farmers, the HP of pumps of marginal and small farmers on average are 4.8 and 5.0 HP respectively, in contrast to 5.2 to 5.1 HP for medium and large farmers (Figure 1.5). The absolute size of pumps, however, vary significantly across regions. The average size of pumps in Region I and II, where the groundwater depth is higher than other regions, is around 6 HP, while the average size of pumps in the rest of the state is around 4.3 to 4.8. A similar trend is found among diesel pump users. The average size of pumps among small and marginal farmers are 5.0 and 5.1 HP respectively, while those of medium and large farmers are 5.4 and 5.0 HP respectively.

Fig1.5 - Distribution of horsepower of pumps by farm size (hp) and gross cultivated area (hp/ha)



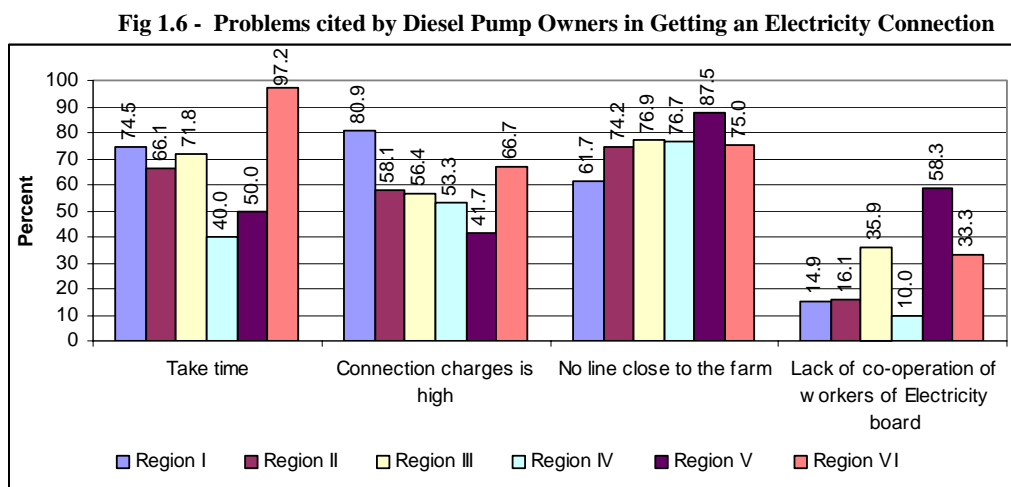
Note: E- electric pump, D- diesel pump, GCA-gross cropped area
Source: APfarmer recall survey.

1.27 Although small and marginal farmers generally operate pumps with lower HP in absolute terms, there appears to be an inverse relationship between farm size and the horsepower per hectare of gross cultivated area. Marginal farmers using electric pumps invest in more than three times greater HP (3.7 HP) than large farmers (0.9 HP). Small farmers also had comparatively more powerful pumps per cultivated hectare at 2.2 HP. A similar trend is observed among diesel pump owners. The average HP per cultivated area among marginal farmers is 5.4 HP per ha compared to 0.6 HP per ha for large farmers.

1.28 There are several possible reasons for this investment behavior. First, small and marginal farmers who tend to be more risk averse, may be investing in higher HP to cope with the limited availability and reliability of power supply. This permits them to pump larger volumes of water in a shorter period of time. Second, the minimum size of pumps available (i.e. 3 HP for electric pumps), and the indivisibilities in pump sizes available places a lower bound on the choice of pump size for small farmers, relative to their farm size. Third, larger HP may be necessary in regions where groundwater depth is higher. Fourth, there is limited prevalence of joint ownership in AP (as compared to Haryana, and fifth, there is a limited capacity for smaller farmers to lease land.

1.29 **Pump Choice Between Diesel vs Electric Pumps.** Diesel pump owning farmers were asked why they invest in diesel pumps. Three quarters cited the unavailability of an electricity connection. This was cited by more farmers in regions III, V and VI. Other factors cited by farmers as influencing their choice of the diesel pumps are the ease of bringing the engine to the field (18 per cent overall but nearly 30 per cent in Region II), reliability (14 per cent) and availability of diesel fuel (14 per cent). Nearly 45 per cent of farmers in region II cited the availability of diesel as a key reason for investing in diesel pumps. In Haryana the responses to the same question were slightly different though the biggest reason by far was also the availability of an electricity connection (40 per cent). Farmers in Haryana were less concerned with the ease of bring a pump to the field (5 per cent) and more interested in the reliability of supply (about 20 per cent).

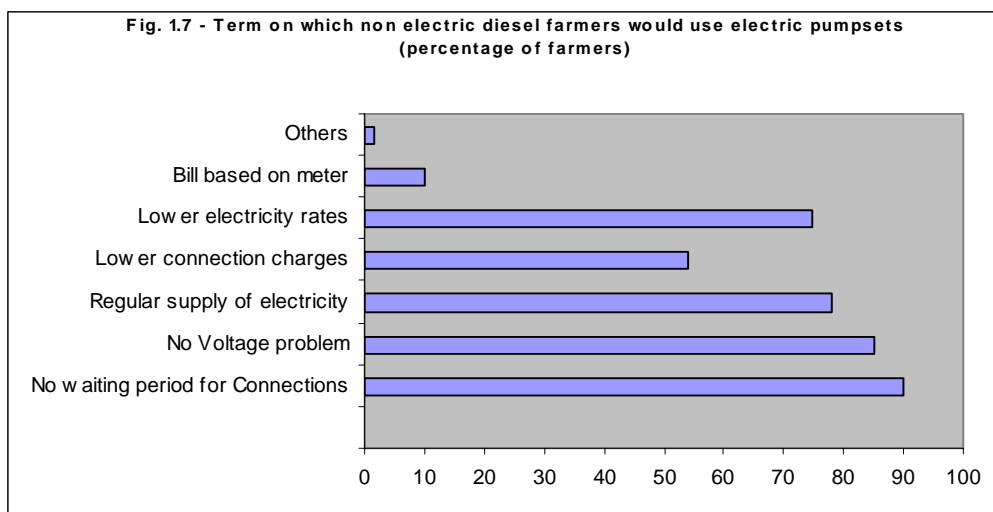
1.30 When the same farmers were asked what are the problems in getting a connection, three quarters again cited the lack of lines close to the farm, followed by the length of wait to be connected (69 per cent) and high connection charges (61 per cent⁴) as the main stumbling blocks. Only about a quarter of diesel owners cited lack of cooperation of Utility employees as a problem. According to AP, since 1996 until recently, there has been no regular allotment for new connections of pumpsets. This could explain some of the farmers' responses (see Fig. 1.6)



Source: AP Recall Survey.

1.31 Diesel farmers recognized several disadvantages of using diesel pumps over electric pumps. About 88 per cent of the diesel owners cited high operating cost; about 67 per cent cited increased difficulty in starting the engine and about 64 per cent cited its lower effectiveness when the groundwater is deeper as disadvantages of using diesel. When diesel pump owners were asked what would encourage them to shift to electric pumps, more than 90 per cent said they would do it if there was no waiting time for a connection and an elimination of voltage fluctuations. The regular supply of electricity was the third most frequently cited factor (78 per cent) closely followed by lower electricity tariffs (75 per cent) and lower connection charges (54 per cent) as reported in Fig 1.7 below. In Haryana, farmers had very similar responses to the same question. About 90 per cent cited waiting period for connections and voltage problems as their main concerns about electricity. They were more worried about connection charges (about 80 per cent) than lower tariffs (60 per cent).

⁴ In cases where connection to a pumpset is further than a distance three poles from the grid, farmers have to pay a one time charge of Rs. 30,000.



1.33 **Water Markets.** Buying and selling water is very limited in the study area. Only 199 farmers (11 per cent) reported buying water compared to 22 per cent in Haryana. Water buying appears to be more wide spread in Region 1 and 2. As expected, a large share of marginal (7 per cent) and small farmers (3 per cent) are water purchasers compared to medium and large farmers, very few of whom reported buying water. Of the total 199 water purchasers, 185 farmers rely exclusively on water purchasing as the source of their water requirements. However, there are 10 canal users and 4 electric pump users who also reported purchasing water. Only 32, or 1.8 per cent, of pump owners reported selling water and these are all electric pump owners. Farmers may be downplaying the sale of water, possibly for social reasons, as water is considered a natural resource available to all, because there is a clear disparity between the number of water purchasers and water sellers. Albeit limited in scope, water selling is occurring in all farm size categories, with a larger share of small and marginal farmers involved in water sales (Table 1.5).

Table 1.5 - Percentage of Farmers, who reported purchasing water

Farm Size	Percentage of Farmers, who reported purchasing water by Region						
	I	II	III	IV	V	VI	Overall
Marginal	9.9	10.1	3.1	4.3	5.7	6.6	7.1
Small	3.2	4.5	1.5	3	1.7	2.3	2.9
Medium	1.8	1.3		0.4	0.9		0.8
Large		0.4				0.3	0.2
Overall	14.8	16.3	4.6	7.7	8.3	9.2	10.9
Farm Size	Percentage of Pump Owners who reported Selling water in at least one season by Region						
	I	II	III	IV	V	VI	Overall
Marginal	1.1	0.2	2.7	1.7			0.8
Small		0.4	1.1	2.1		0.3	0.6
Medium		0.9					0.2
Large		0.4					0.1
Overall	1.1	1.9	3.8	3.8		0.3	1.8

Source: AP farmer recall survey

1.34 Average water charges vary significantly across regions and seasons. In both the Kharif and Rabi seasons, water charges per acre range from about Rs. 350 to Rs. 850 per acre and from Rs. 20 to Rs. 60 per hour (Table 1.6). Note however that the lack of volumetric measures does not allow more rigorous comparisons. In Haryana, water purchase rates are more modest in the range of Rs. 18 to Rs. 27 per hour.

Table 1.6 - Average Water Purchase Rate by Region

Farm Size	Region						Overall
	I	II	III	IV	V	VI	
Kharif Season							
Rate of WP/Hour	20	35	35	54	48	44	36
Rate of WP/Acre	351	425	646	775	761	577	515
Rabi Season							
Rate of WP/Hour	23	31	.	58	58	44	34
Rate of WP/Acre	345	476	465	853	700	581	554
Summer Season							
Rate of WP/Acre	325	270	363		500		329

Source: AP farmer recall survey

CHAPTER 2

COSTS AND RETURNS ACROSS DIFFERENT TECHNOLOGICAL OPTIONS

A. Introduction

2.1 This section presents the results of the analyzes made on the main indicators of farmers' activity, such as gross income, production costs and, in particular, irrigation cost components. Gross and net farm incomes are observed to vary according to the irrigation methods used by farmers. In general, electric pump owners in the sample had both the highest gross and the highest net annual incomes. Electric pump users have gross incomes three times that of farmers who rely on water purchases or are solely rain fed. Input costs for pump users are also significantly higher, as one would expect. Analysis of the production cost components indicates the relative importance of rewinding expenses and pump maintenance costs and shows how the quality of the electricity supply adversely affects farmers' bottom lines. Despite higher production costs, the net farm incomes for farmers who use pumps, and in particular electric pumps, are still higher than those of farmers who do not. The analysis of the flat rate tariff structure, as a component of production costs, shows it to be regressive with marginal and small farmers paying more per hectare of land under cultivation for their power than medium and large farmers.

B. GROSS FARM INCOME ACROSS FARM SIZES

2.2 Irrigation choices across the sample of farmers affect the gross value of production or gross farm income, defined as the sum of the price times the volume of all crops produced during the survey year (see Table 2.1)⁵. Electric pump owners in the sample have the highest average annual gross incomes (Rs.111,889), followed by diesel pump users at (Rs.91,167). Water purchasers and rainfed farmers have the lowest average gross income. Canal⁶ users fall in the middle at Rs.53,766). In Haryana, the breakdown is similar with electric pump owners reporting the highest average gross incomes. However, In AP have the lowest gross incomes, whereas in Haryana canal users have higher gross incomes than water purchasers and rain fed farmers. On average, the gross income of electric pump owners was almost three times that of their counterparts in the rainfed and water purchasers category⁷.

Table 2.1 - Average Annual Gross Income by Farm Size (Rs.)

Farm size owned	Average Annual Farm Gross Income by Farm size					
	Electric	Diesel	Canal	Water Purchaser	Rainfed	Total
Marginal	39,420	34,109	17,308	25,070	19,701	27,663
Small	78,630	66,514	43,176	49,189	40,304	63,736
Medium	153,776	153,072	97,237	58,895	55,928	132,769
Large	285,504	197,895	198,652		158,668	247,710
Overall	111,889	91,167	53,766	34,420	38,116	80,807

Source: Farmers' recall data

Gross income is defined as the sum of the price times the production volume of all crops produced

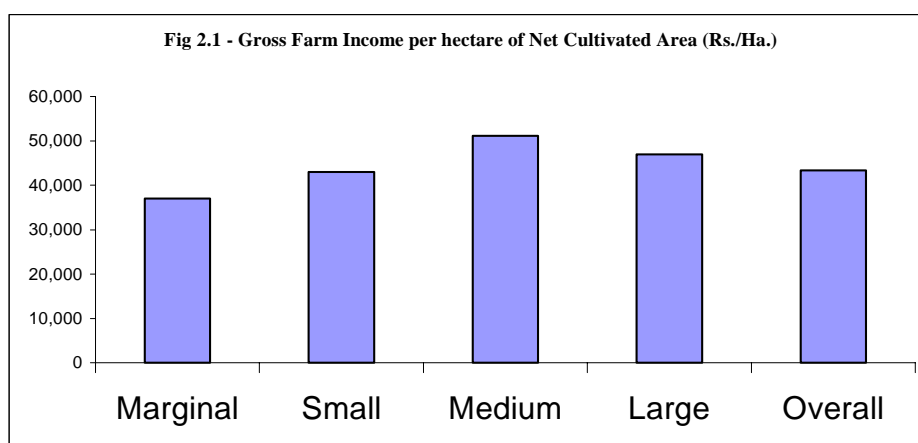
⁵ The gross farm income does not include proceeds from the sale of crop by-products, non-crop activities (e.g. livestock) and sale of water. Total crop production was taken into account here irrespective of whether it was used for self-consumption, as seed for next year or as marketable surplus. Crop production was valued at the price as reported by farmer for the marketed portion.

⁶ Canal users in Andhra Pradesh also include farmers who use minor and major irrigation sources, mostly canals and tanks surface irrigation like ponds etc.

⁷ Tables in the Annex 1 give region wise distribution.

2.3 The average gross income of marginal farmers who own electric pumps is more than double that of farmers who use canal water or are rain fed. Small farmers with electric pumps also have almost the same advantage over canal and rainfed farmers. Medium sized farmers who use pumps, whether electric or diesel have the same gross incomes. But large farmers who use electric pumps have gross incomes 44 per cent higher than large size farms with diesel pumps or that use canal water for irrigation.

2.4 When gross returns for alternative sources of water, normalized on a per hectare of net cultivated land, are analyzed, farmers with access to irrigation show the highest incomes due to several reasons. First, it is likely to increase the yields of many crops (particularly those that are water intensive), keeping everything else constant. Secondly, it helps to reduce some of the risks associated with variations in rainfall. Thirdly, it enables the land to be cultivated more intensively through multiple cropping. However, it should also be recognized that there are a large number of variables that could influence income levels such as agro-climatic conditions affecting yields, farmer specific socio-economic characteristics, availability and quality of infrastructure and services, including electricity, etc Fig 2.1 presents the average annual gross farm income per hectare of net cultivated area for alternative sources of water⁸. On average, diesel pump owners had the highest gross returns per unit of net cultivated area, followed by electric pump owners and water purchasers.



C. PRODUCTION COSTS

2.5 This subsection examines the structure of production costs across different alternative sources of water. Total farm production costs were aggregated into three major categories: hired labor, materials and irrigation costs. To compare across different types of technologies, these costs are presented as a percentage of gross income (Table 2.2).

2.6 Irrigation costs for pump users dwarf those for canal users and water purchasers. Irrigation costs are the largest component of costs for pump owners, accounting for about 36 per cent of gross income of electric pump owners and 48 per cent of gross income of diesel pump owners.⁹ In Haryana, irrigation

⁸ Net cultivated area is the maximum area cultivated by a farmer in any season. Normalization by net cultivated area as opposed to gross cultivated area helps to capture the returns associated with multiple cropping.

⁹ Since the sample of electric pump owners who use canal and/or diesel pumps conjunctively is rather small, production could not be separately estimated for these categories. Similarly for diesel pump owners who use canal conjunctively. Tables on production costs of pure electric pump owners and pure diesel pump owners are presented in Annex 1. For pure users of electric pumps, irrigation costs were found to be around 37% of gross income. For pure diesel pumps owners irrigation costs were found to be 49% of gross income.

costs are also the largest component of costs for pump owners, however, the proportions are significantly lower. For pure electric and diesel pump owners, they average about 18 per cent of production costs.

2.7 Irrigation costs for non-pump categories are much lower accounting for less than 11 per cent of gross income for water purchasers and just 4 per cent for canal users. The same is true in Haryana, where irrigation costs for water purchasers are about 9 per cent, and less than one per cent for canal users. For these non-pump categories, the cost of other materials (such as fertilizers, pesticides, farm cultivation services like tractors and animal draft, non-irrigation diesel, etc) is the most important component of cost. Compared to Haryana, however, material costs as a percentage of gross income are nearly four times more for farmers in AP. In general, for all categories, the costs of materials like fertilizers, pesticides, tractor and bullock services is higher in AP which is less agriculturally advanced than Haryana. For rain fed farmers in AP, they account for 43 per cent of production costs compared to 15 per cent in Haryana. The high ratio of material costs as a percentage of gross income for canal users may be because of the overall lower gross incomes, as compared to Haryana. In AP, canal users include farmers who use minor and major irrigation sources, mostly canals and tanks that are poorly maintained. On average, hired labor costs account for less than 8 per cent of gross income for all categories, except for diesel pump owners where these costs are somewhat higher at 13 per cent. Annex 1 provides the regional results across different irrigation technologies for both total production costs and the irrigation cost components.

Table 2.2 - Production Cost as Percent of Gross Income

Region/ farm size category	Hired Labor	Materials	Irrigation Cost		Total
			Variable Costs	Annualized Fixed Cost of Pump and Well	
1. Electric pump owners					
Marginal	1.8	27.7	17	47.1	64.1
Small	1.9	25.6	8.6	26.1	34.7
Medium	2.8	23.3	5.9	16.9	22.8
Large	4.1	20.7	5.3	12.6	17.9
Overall	2.4	24.9	9.4	26.9	36.3
2. Diesel pump owners					
Marginal	9.3	32.4	13	65.1	78.1
Small	22.1	34.8	11.3	35.5	46.8
Medium	8.4	27.9	7.7	16.5	24.1
Large	17.6	28.7	7.6	10.4	18.1
Overall	13.2	31.4	10.5	37.7	48.2
3. Canal users					
Marginal	11.4	66.6	4.1	n.a. ¹	4.1
Small	6.7	65.0	4	n.a. ¹	4
Medium	4.5	62.4	5.2	n.a. ¹	5.2
Large	2.6	45.9	3.8	n.a. ¹	3.8
Overall	8.1	64.0	4.3	n.a. ¹	4.3
4. Water Purchasers					
Marginal	6.8	47.6	11.1	0	11.1
Small	6.1	47.2	12.4	0	12.4
Medium	3.1	29.9	7.4	0	7.4
Large					
Overall	6.3	46.2	11.2	0	11.2
5. Rainfed					
Marginal	5.5	40.1	0	0	0
Small	6.9	43	0	0	0
Medium	5.4	49.5	0	0	0
Large	8.7	46	0	0	0
Overall	6	43	0	0	0
State Wide					
Marginal	6.5	43	9.5	21.6	31.1
Small	6.2	37.2	7.4	17.3	24.7
Medium	4.1	33.3	5.5	11.9	17.5
Large	5.9	28.5	4.9	8.9	13.8
Overall	5.7	37.7	7.5	16.9	24.4

Notes: * Imputed at village level wages for male and female labor. Material costs include fertilizers, pesticides, etc. In general canal users do not pay for the fixed costs of canal construction and maintenance. However in some minor irrigation schemes, canal users are now paying about 15% of rehabilitation costs. Data on these costs was not collected during the survey.

D. DECOMPOSITION OF IRRIGATION COSTS

2.8 Total irrigation costs can be decomposed into two broad categories: fixed and variable costs. The fixed cost component refers to the annualized amortized value of the initial investment in well, pumps and related equipment (such as sheds, collection tank if any etc.). For the non pump owning sample categories this component is almost zero. Variable costs refer to the yearly expenses on electricity tariffs, motor rewinding after a burnout, pump maintenance, diesel used for pumping, water purchases (if any) and canal fees.

2.9 For the pump-owning categories, the irrigation costs are particularly high because of the large annualized fixed costs of investing in a well and a pump. The burden of these fixed costs is particularly high for marginal farmers who cultivate very small plots of land. For marginal electric pump owners in particular, these costs account for about 47 per cent of gross income while for marginal diesel pump owners these costs account for about 65 per cent of gross income (check the data based on computation of fixed cost annuity) . In contrast to this, for large electric and diesel pump owners these costs account for less than 13 per cent of gross income. The non-pump categories do not bear these fixed costs and thus their irrigation cost share is much lower. The irrigation cost share for pure canal users, at about 4 per cent, is significantly lower than all other sources of irrigation. This points to the large disparity between the cost of irrigation using canal as opposed to private owned pumps.

2.10 **Electricity tariff rates in AP** Farmers in AP are charged for their electricity consumption on the basis of a flat rate per month. The flat rate varies according to the installed HP as shown in Table 2.3.

Table 2.3 - Electricity tariff rates for agricultural sector in AP

HP of pump	Tariff rate/BHP/year	
	DPAP districts ¹	Non - DPAP districts
0-3	Rs 100	Rs 150
>3 - 5 HP	Rs 200	Rs 250
>5 - 10 HP	Rs 300	Rs 350
> 10 HP	Rs 400	Rs 450

Notes: ¹DPAP are drought prone districts. There are 14 such districts in AP: Prakasham, Medak, Anantapur, Adilabad, Khamam, Cudappa, Mehboobnagar, Chittoor, Rangareddy, Nalgonda, Nellore, Karimnagar, Kurnool, Srikakulam

During the survey, a number of difficulties were encountered to arrive at a precise calculation of the tariff paid by farmers. Problems in recording payments based on different period of recalls, which compounded with the lack of metering make any rigorous estimate difficult. Thus the amount reported by the farmer in any season may not be a true indicator of the total amount due to him. The procedure for imputing the cost of tariff is explained in Box 2.1. While it is difficult to say very much about the exact magnitude of the discrepancy between the actual amount paid by farmers and the tariff cost imputation here, it is clear that the latter defines the upper bound on the actual cost borne by farmers. The results on tariff costs in this section need to be interpreted keeping this in mind.

Box 2.1 - Tariff Cost Computation

The tariff cost for electric pump owners in this study was computed in the following way. The district wise official tariff rate per HP was multiplied by the electric HP reported by the farmer. This tariff cost imputation may differ from the actual amount paid by farmer because of several reasons:

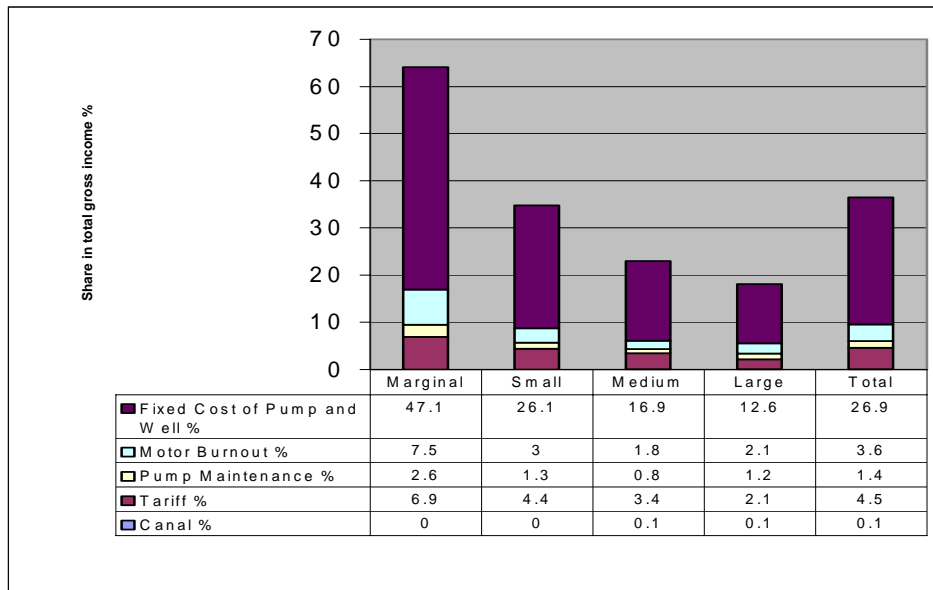
- The HP reported by farmer in the survey might be different from the HP in utility records on the basis of which the tariff cost is actually assessed.
- There might be some illegal connections for which the farmer bears very little cost (in form of bribes) or no cost at all.
- Very often farmers do not pay the full amount due in any payment cycle. Payment arrears often accumulate over time. Although default of payments often result in disconnecting the supply, the exact policy here is not clear and probably depends a lot on the discretion of the field staff. There have been instances where politicians have forgiven part or whole of past arrears.

2.11 On average, electricity tariffs account for 4.5 per cent of gross income of electric pump owners. Because of the regressive nature of the flat rate tariff, the share of tariff costs as a percentage of gross farm income is highest for marginal farmers (7 per cent) and lowest for large farmers (2 per cent). Figures 2.2 and 2.3 show a detailed breakdown of irrigation costs for electric and diesel pump owners

respectively.¹⁰ Electricity tariff costs have therefore a much lower incidence on gross income than in Haryana¹¹, where for marginal tariffs is over 13% and for large is over 6 percent. For diesel pumps owners, the incidence of the the fuel cost for diesel is progressive rather than regressive. The cost share of fuel for diesel pump owners is higher than electricity tariffs, but varies only between 5 per cent to 6 per cent across the different farm size categories. The conclusions are the same for pump owners in Haryana.

2.12 For electric pump owners, the cost of repairing burnt motors at 3.6 per cent of gross income is only slightly less, in percentage terms, than the share of electricity tariffs in total costs. However, the cost of rewinding electric pumps affects smaller farmers more than larger farmers. For marginal farmers, the cost share of repairing burnt motors is 7.5 per cent of gross income, which is higher than their tariff cost share. In effect, marginal farmers are paying more to a mechanic than they are to the utility. Hence, although farmers are paying quite low tariffs, their effective costs are considerably higher due to these additional indirect costs. In Haryana, burnout cost incidence was higher by a third, and tariff cost incidence was double.

Figure 2.2 - Electric Pump Owners: Breakup of Irrigation Cost as a Percent of Gross Farm Income



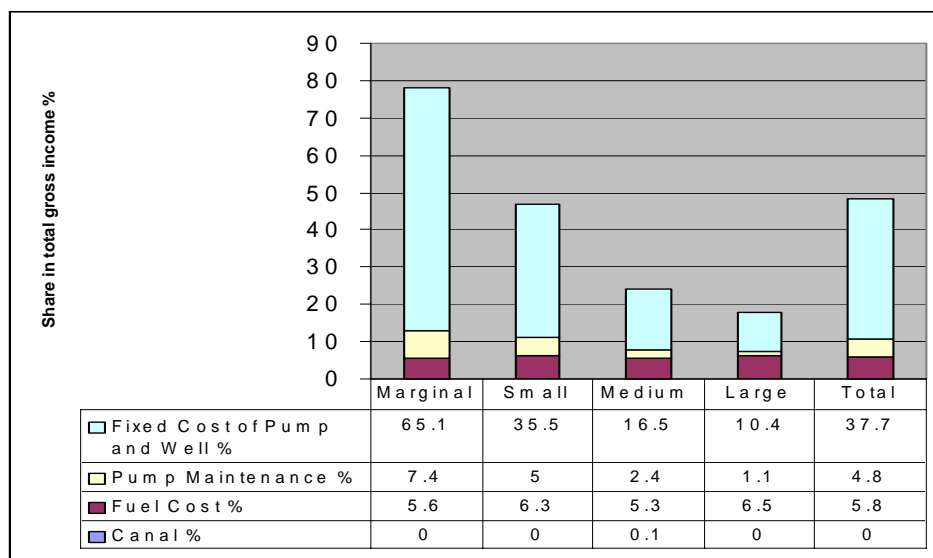
Source: Recall survey

Notes: The electric pump repair and expenditure includes travel costs for repair and other costs. Rewinding cost and tariff cost is listed separately but included in the total variable irrigation costs. Some farmers have zero fixed costs, as pumps are fully depreciated (assuming 20 yrs lifespan).

¹⁰ These figures show the breakdown of irrigation costs for all electric pump owners and all diesel pump owners. Annex 1, table A show the breakdown for the category of pure electric and pure diesel pump owners, respectively. The tariff cost share for pure electric pump owners was found to be the same as that for the category of all electric pump owners (around 4.5%).

¹¹ For Haryana, the comparison is made with electricity pump owners only.

Figure 2.3: Diesel Pump Owners: Breakup of Irrigation Cost as a Percent of Gross Farm Income



Source: Recall survey

Notes: The diesel pump maintenance expenditure includes belting cost, oil and greasing cost and bearing replacement cost. Fuel cost includes the expenditure on diesel for running the pump

E. COMPARISON OF VARIABLE IRRIGATION COST PER HECTARE OF PADDY CULTIVATION AND PER QUINTAL OF PADDY PRODUCTION

2.13 To get further insights into the comparative cost of irrigation across technology groups, it is helpful to analyze the per hectare irrigation costs of cultivation of an important water intensive crop, namely paddy grown in Kharif season in AP¹². Rice, (used interchangeably, one of the words rice or paddy should be used) as noted in Chapter I, dominates cropping patterns in the sample. All farmers who use irrigation technology plant more rice than any other crop. In the survey year, canal users, who have the lowest irrigation costs, allocated 61 per cent of their land to rice. Electric pump owners devoted half their acreage to paddy and diesel pump owners 37 per cent. The average cost of irrigating a unit hectare of paddy is found to be Rs. 2,543 (Table 2.4).

Table 2.4 - Variable irrigation costs per hectare of Kharif paddy cultivation (Rs/Ha)

Farm Size	Electric pump only	Electric pump & canal only	Total Electric pump owners	Diesel pump only	Diesel pump & canal only	Total Diesel pump owners	Canal users	Water purchasers	Total
Marginal	3011	788	2947	1588		1588	492	1318	1524
Small	1410	1236	1406	1109		1109	492	984	1132
Medium	1445	722	1395	927	864	924	492	1026	1112
Large	1389	348	1295	559		559	492		882
Overall	1919	818	1873	1250	864	1246	492	1234	1299

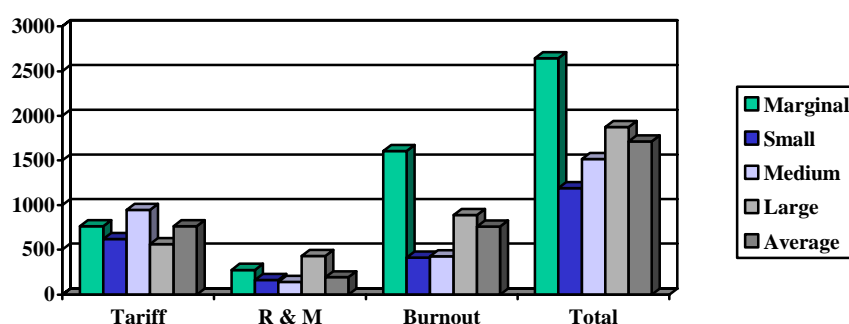
Source: Recall survey

Notes: Table pertains to those farmers who cultivate only paddy in kharif season. For pump owning categories, the above irrigation costs do not include the annualized fixed investment costs of well and pump.

¹² The per hectare cost of rice is based on the subset of sample farmers who only grew rice in Kharif. Similarly the per hectare cost of wheat is based on the subset of sample farmers who only grew wheat in Rabi. This was done because in the data files, the costs of irrigation are available on a per pump or per farmer basis. The costs of irrigation are calculated as = seasonal electricity tariff + canal costs (if used canal) + diesel costs (if used diesel pump)+ cost of pump repair and maintenance + 1/3annualized investment cost of pump and well. The tariff cost for electricity was calculated on the basis of the official rate. The canal cost is based on what farmers reported in the survey.

2.14 This cost varies considerably across the different technology groups. The cost of rice irrigation per hectare for pure canal users at Rs. 492/ha, is just 12 per cent of the irrigation cost borne by pure electric pump owners on average. The cost of irrigating a unit hectare of rice is highest for exclusive users of electric pumps (Rs. 4,102/Ha.), followed by pure water purchasers (Rs. 1,907/Ha.) and then exclusive users of diesel pumps (Rs.1,352/Ha). Canal users who do not own pumps have the lowest costs (Rs. 492/Ha.). Among the pump owning categories, access to canal reduces the cost of paddy irrigation substantially. Thus, for instance, the cost of irrigation for electric pump owners who use surface water conjunctively is about 30 per cent of that borne by electric pump owners who do not have access to any surface water source. (Fig 2.4)

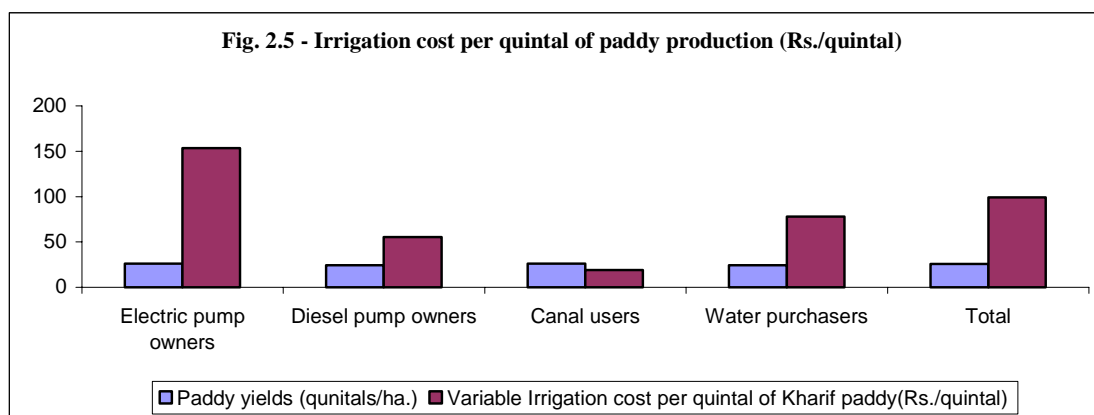
Fig. 2.4 - Pure Electric Pump Owners Variable Irrigation Costs for Kharif paddy (Rs./Ha.)



On a per hectare basis, the variable irrigation costs for electric pump owners was much higher for marginal farmers due to the regressive nature of the flat rate tariff structure and the cost of poor quality power (motor burnouts) Motor burnouts for marginal farmers cost, on per hectare basis, twice the electricity tariff cost.

2.15 Although there does not appear to be any systematic relation between paddy irrigation cost per hectare and farm size within each technology group, in most cases the costs are highest for marginal farmers (and in some cases medium farmers) and lowest for large farmers. This may probably be due to more intensive use of inputs (including water) by marginal farmers.

2.16 It is often argued that the quality of irrigation service in terms of reliability and adequacy of supply differs significantly across irrigation sources. Thus although a unit of water received from canals is the least expensive, its quality in terms of the control that farmers have on its timing and volume is also generally the lowest. But given that yields for Kharif paddy do not differ significantly across irrigation sources, it is not surprising that variable irrigation costs per quintal of paddy production mimics the pattern observed for irrigation costs per hectare of cultivation (see Fig 2.5). Thus Per quintal of paddy production, variable irrigation costs are highest for electric pump owners (Rs.153/quintal), followed by that for water purchasers (Rs.78/quintal) and then diesel pump owners (Rs.55/quintal). The costs are lowest for canal users (Rs.19/quintal).



F. COSTS OF POOR QUALITY OF SUPPLY IN OPERATION OF ELECTRIC PUMPS

2.17 This section analyzes some of the direct costs resulting from the poor quality of supply in the specific form of motor rewinding costs and days lost due to transformer burnouts. There are several causes of motor burnouts, and thus the need for motor rewindings. These include the quality of electricity supply, age and type of the pump (branded versus local), and care and maintenance practices. On average motor burnouts cost 3.6 per cent of gross income for electric pump owners. It is especially critical for marginal farmers for whom it amounts to as much as 7.5 per cent of gross farm income. Hence, although farmers are paying low tariffs, their effective costs are considerably higher due to these additional indirect costs.

2.18 Almost half the pumps operated during the Rabi season and almost all of those operated during the Kharif and summer season were rewound at least once during the season (Table 2.5). The highest frequency of pump rewindings occurred during the Kharif season and summer season (actually system demand is highest during Rabi in Andhra). One possible reason for this high incidence of failure is the adverse conditions of weather, which significantly affect the performance of motors. In summer, the ambient temperatures are very high and in Kharif, the motors are exposed to rains/ moisture and the poor quality of the motors are not able to withstand long hours of working. In the summer season all the pumps needed to be rewound at least once, while in kharif season around 97 per cent had to be rewound at least once. The situation was most severe in Regions VI with more than one third of the pumps having to be rewound twice during the summer season and around one-fifth of the pumps having to be rewound twice in Kharif season¹³. In Haryana, motor burnout frequencies were significantly lower, but rewinding costs are twice those faced by farmers in AP.

¹³ The data did not permit measuring how many times a single pump had to be rewound during the year. Since not all the pumps are used in every season, the sample of pumps differs somewhat across seasons. Because of this difference in sample and the fact that not all the pumps can be matched across seasons, it was not possible to calculate the number of times a single pump had to be rewound during the year.

**Table 2.5 - Frequency Distribution of Number of Rewindings per Pump
(% of Sample Farmers)**

	No Rewinding		Two / year	Three / year	Four / year
Kharif	3.2	79.7	14.4	2.4	0.3
Summer	0.0	85.7	13	1.3	0.0
Rabi	54.3	27.8	15.5	1.6	0.8

2.19 Sample farmers reported paying around Rs. 1,300 to Rs. 1400 to get the motor rewind each time it burned out (Figure 2.6). The price paid for rewinding varies a lot across across regions and across seasons. Across seasons, the price paid for rewinding is highest during Kharif and Rabi season when the largest number of rewindings occur. Across regions, on average the highest price for rewinding was observed in regions I and II. The average cost of motor burnouts of the sample farmers is estimated to be Rs.237/HP/year, which is 115 per cent of the average cost paid by farmers for purchase of electricity (Rs.206/HP/year). The poor quality of power supply, thus, imposes a significant financial burden on the farmers in Andhra Pradesh, resulting in effective cost of power supply to be more than twice of their electricity bill.

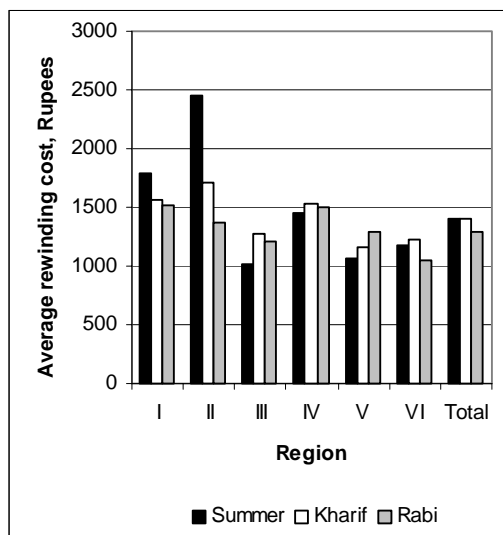


Fig 2.6 - Average price paid for each rewinding (Rs. per rewinding)

Source: Village questionnaire

2.20 Voltage fluctuations are one of the main causes for motor burnouts. Between 83 per cent and 96 per cent of all farmers experienced voltage fluctuations during the three growing seasons. This varied slightly across regions and seasons, however, there was a consistently large portion of the farm population affected by the poor quality of power supply (see Table 2.6). The situation on voltage fluctuations experienced by the farmers in Haryana is similar, where farmers across regions and seasons face high incidence of voltage fluctuations.

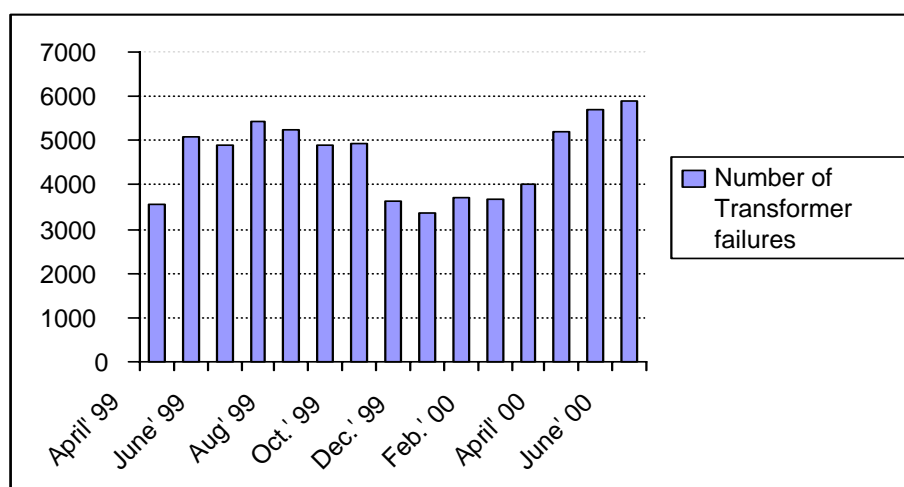
Table 2.6 - Voltage fluctuations Experienced by Farmers (percentage distribution)

	Regions					State Average
	1	2	3	4	5	
Summer season						
% of farmers experienced voltage fluctuations	97.78	95.24	96.15	100	97.22	94.12
Kharif season						
% of farmers experienced voltage fluctuations	80.3	92.92	90.37	99.18	88.06	88.4
Rabi season						
% of farmers experienced voltage fluctuations	78.79	85.38	85.93	94.26	82.84	75.69

G. TRANSFORMER BURN OUTS

2.21 The high frequency of transformer burnouts has been cited by farmers as one of the main reasons for interruptions in power supply. There are many reasons for failure of transformers like overloading, non existent protection, no maintenance, lightening strokes, unbalanced load during single or two phasing arrangements, presence of harmonics etc. In AP distribution transformer failure rate in FY2000 was about 29 per cent¹⁴. Thus, on average each transformer has a life of about 3.6 years. Figure 2.7 provides for the period April 1999 through June 2000, the month-wise failure of distribution transformers in AP out of about 187,00 total installed as on March, 2000. The transformer failure rate is higher in the rural areas and the frequency of burn outs is greater during the months of April to August, which is the Summer and early Kharif time, when the soaring ambient temperatures and the high humidity during the Kharif, with windy conditions highly stress the performance of poorly maintained transformers. The transformer failures are reported to be highest in region V, where about 82 per cent experienced the transformer failure problem, while it is the lowest in region 4, where only 42 per cent faced the transformer failures.

Fig 2.7 - Transformer Burnout in Andhra Pradesh (Month wise details for April 1999 to June 2000)



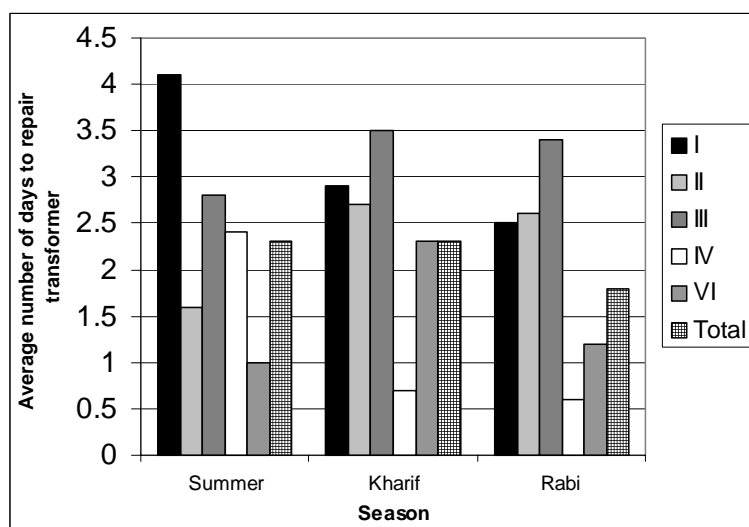
Source: APTRANSCO data

¹⁴ In western utilities, transformer failure rate is below 2%.

In the village questionnaire canvassed at the end of the survey, a group of farmers from each village was asked about the number of transformer burnouts that occurred over the different seasons in the survey period and the average time it took to repair the transformer. (Annex 1, Table 3.8-9 shows regional and per season frequency distribution of transformer burnouts) On average across regions, around two-third of the villages reported at least one transformer burnout during the year and around 30 per cent reported two or more burnouts during the year. The situation was observed to be worst in region V where more than 90 per cent of villages reported at least one burnout. Over loading of transformer by way of increased number of pumpset per transformer and use of higher HP of pumpset than that sanctioned was reported to be the prime reason. In Kharif, short circuit was also reported to cause transformer burnouts in a few villages. Across seasons, the situation was observed to be worst in summer and Kharif, when more than one-third of the villages reported at least one burnout as opposed to summer when only around a quarter of the villages reported at least one burnout.

2.22 Average Number of Days Taken to Repair Transformers. Transformer burnouts adversely affect farmers, because they cut the power and thus water supply to all electric pump users connected to the transformer. The speed at which the transformers are repaired is, therefore critical, because it determines the speed at which water supply is resumed and hence the potential yield losses and income reductions farmers bear due to the unavailability of water to meet crop needs. On average, it takes about 2.3 days to repair burnt out transformers during the Kharif and summer season and 1.8 days during the Rabi Season (Figure 2.8). In the case of Haryana, the time taken to repair burnout transform was much higher (on average 6.4 days during the Rabi season and 10.1 days in the Kharif season)

Figure 2.8 - Average Number of Days taken to Repair Transformers by Region



H. NET FARM INCOME ACROSS FARM SIZES

2.23 Electric pump owners report the highest net farm incomes as well as the highest gross farm incomes. Net farm income is defined as gross farm income minus annualized fixed costs and all variable costs (except the imputed cost of family labor and land cultivated). This definition of net farm income measures the net returns to family labor and cultivated land. Costs of other owned inputs such as machinery, bullocks, seeds etc. is imputed at the prevailing market rate and deducted from the gross income under this definition. Thus, this is an economic definition of net income which takes into account

the opportunity costs of all inputs except family labor and cultivated land. Another useful income measure is the net cash flow measure which is defined as: (price*marketed production)-(paid out cost of all inputs).¹⁵ In this section, tables on net farm income alone are discussed(detailed tables are given in Annex 1).

2.24 The average net farm income of farmers in the sample is Rs. 58,900 with pump owners earning significantly more than non-pump owners. Electric pump owners report the highest average income (Rs. 88,320), followed by diesel pump owners (Rs. 63,670). As expected, the net income of rainfed and water purchasers is found to be the lowest. The net income of the electric pump owners is found to be 1.35 times that of the non-electric diesel pump owners, 2.8 times that of non-pump canal users, three times that of the rainfed farmers and four times that of the water purchasers. (Table 2.7)

Table 2.7 - Annual net farm income per farm (Rs.)

Farm size owned	Electric	Diesel	Canal	Water Purchaser	Rainfed	Total
Marginal	22,880	17,800	8,040	15,490	14,820	16,080
Small	57,610	44,270	22,860	32,770	29,540	44,490
Medium	123,950	115,100	61,290	38,390	38,400	102,030
Large	232,200	138,040	117,460		129,710	190,600
Overall	86,320	63,670	31,150	22,090	28,130	58,900

Source: Farmers' recall data

2.25 Net farm income, like gross income, is highly dependent on the area cultivated, hence the above values are normalized to a per hectare basis in Table 2.8. This table compares the net returns to a unit of cultivated area across technology groups. On average, net farm income per net cultivated area is highest among electric pump owners at Rs. 35,220 per ha, followed closely by diesel pump owners (Rs. 35,060) and water purchasers (Rs.26,460). Although pure canal users have higher net farm incomes than water purchasers and rainfed farmers (Table 2.7), on a per hectare basis they have much lower net incomes in large part because they are only able to cultivate their land when rainfall is available. The results suggest that rainfed farmers cultivate their land with relatively greater intensity than canal users, given that they report higher gross incomes per net cultivated area but canal users have higher net annual incomes.

Table 2.8 - Net Farm Income per Net Cultivated Area (Rs./Hectare)

Farm size owned	Average Annual Farm Gross Income by Farm size					
	Electric	Diesel	Canal	Water Purchaser	Rainfed	Total
Marginal	20,340	30,250	14,270	26,560	18,440	20,750
Small	33,890	32,660	16,240	24,710	22,660	28,640
Medium	44,720	43,650	22,300	32,250	23,290	38,440
Large	43,780	26,800	17,790		19,210	34,780
Overall	35,220	35,060	16,990	26,460	20,670	28,910

Source: Farmers' recall data

I. Costs and returns excluding drought affected areas

2.26 In AP in any given year it is common that regions are affected by drought. A drought-affected district is defined as a district that received less than 70 per cent of its average. During the survey year, the government of AP declared 688 mandals out of a total of 925 mandals in 18 districts as drought hit. Some of the farmers in these regions took part in this study. With the data available at this stage, it is not possible to assess the exact magnitude of the production loss suffered by these farmers due to this

¹⁵ Under this definition annualized value of fixed costs of pump and well are not accounted for. Similarly the opportunity costs of all owned inputs is not accounted for.

drought. It is likely, therefore, that the tables on costs and returns presented in the previous sections, may not be representative of an average year. The key point, however, is that the trends identified using the total sample of farmers, including those in drought affected areas, remain the same: on average, electric pump owners have higher gross and net incomes. When the drought affected areas are excluded, these incomes increase even more than the incomes across other technologies (see Annex 2. Drought conditions in AP during survey year).

2.27 In this section, some of the important costs and returns tables are presented just for the non-drought areas and compared with the tables presented in earlier sections which covered the entire state. annual rainfall during the survey year. The following five districts were designated drought-hit and were excluded in the computation of the tables below: Nellore, Cuddapah, Mahabubnagar, Medak and Nalgonda.

2.28 When the drought-hit areas are excluded from the computations, the average gross income of electric pump owners increases more than other technology groups. Table 2.9 presents the gross income, net income and irrigation costs in the non-drought areas.¹⁶ The percentage change in net farm income after excluding drought affected areas is shown in Fig. 2.9. On average across technology groups, gross and net incomes are about 8 per cent higher when drought areas are excluded. Electric pump owners show a much steeper increase (around 14 per cent) than other irrigation technology groups. Within the category of electric pump owners, the net incomes of marginal farmers shows the highest increase (around 20 per cent) when drought affected areas are excluded. However, marginal farmers who own diesel pumps report a 13 per cent drop in net farm incomes.

Table 2.9 - Costs and Income in Non-Drought Areas

(Figures in parenthesis give percentage difference between excluding and including drought areas)

	Electric		Canal	Water Purchaser	Rainfed	Total
Gross income(Rs.)	127,630 (14.1)	94,590 (3.8)	57,020 (6.1)	36,790 (6.9)	38,740 (1.6)	87,020 (7.7)
Net income (Rs.)	100,730 (14.3)	66,210 (3.8)	33,560 (7.2)	24,250 (8.9)	28,490 (1.2)	64,350 (8.5)
Irrigation costs as % of gross income (excluding drought areas)	32.1	44.6	4.2	9.5	0	21.4
Irrigation costs as % of gross income (not excluding drought areas)	36.3	48.2	4.3	11.2	0	24.4

Source: Recall data

2.29 Irrigation costs account for about 21 per cent of gross income in non-drought areas as opposed to 24 per cent in the state as a whole. For electric pump owners, irrigation costs constitute about 32 per cent of gross income in non-drought areas and 36 per cent in the entire state (see Annex 1, table A.2.26) Table 2.10 shows a further breakup of irrigation costs in non-drought areas for electric and diesel pump owners, by farm size categories. For marginal and small electric pump owners irrigation costs account for about 60 per cent and 32 per cent of gross income, respectively, in non-drought areas (as compared to 64 per cent and 35 per cent) in the state as a whole. The share of electricity tariffs in gross income shows hardly any difference whether drought affected areas are included or excluded. For diesel pump owners there is virtually no difference between the irrigation costs in non-drought areas and the state as a whole.

¹⁶ Detailed tables on costs and income after excluding the drought affected areas are given in Annex 1.

Fig 2.9 - Percentage change in net farm income after excluding drought affected areas

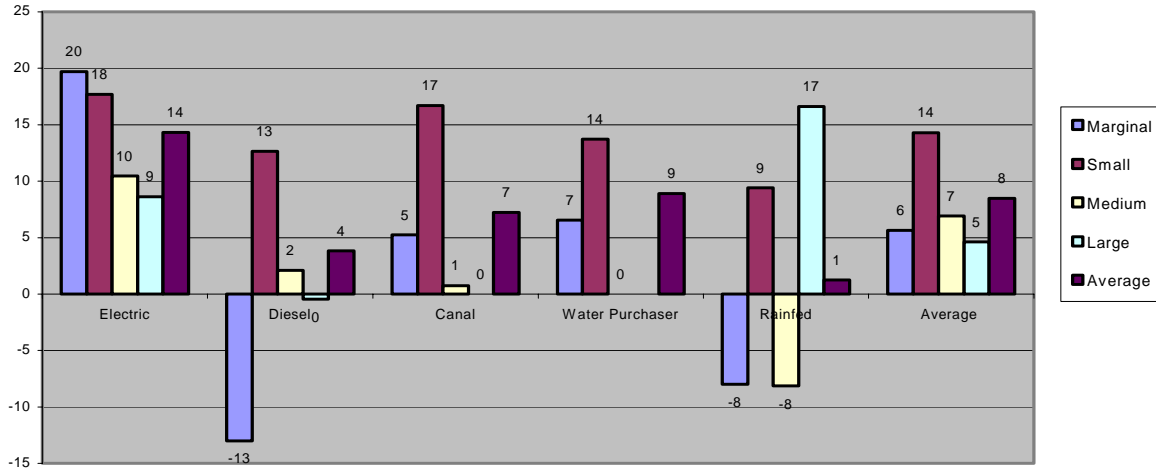


Table 2.10 - Break up of irrigation cost as percentage of gross income in non-drought areas

Region/ farm size category	Canal	Tariff	Pump Maintenance	Motor Burnout	Variable Costs	Fixed Cost	Total Cost
1. Electric pump users							
Marginal		0.1	6.4	1.8	6.5	14.6	45.4
Small		0.1	4.2	1.2	2.7	8.1	23.9
Medium		0.1	3.3	0.7	1.4	5.3	13.1
Large		0.2	2.1	1.6	2.7	6.3	10.5
Overall		0.1	4.2	1.2	3.1	8.4	23.7
2. Diesel pump users							
	Canal	Diesel Cost	Pump Maintenance	Motor Burnout	Variable Costs	Fixed Cost	Total Cost
Marginal		0	5.9	7.6	0	13.5	61.1
Small		0	6.3	5.2	0	11.6	29.2
Medium		0.1	5.2	2.3	0	7.4	15.5
Large		0	6.7	0.8	0	7.5	9.8
Overall		0	5.8	4.8	0	10.6	34

3. CONCLUSIONS AND RECOMMENDATIONS

3.1 Andhra Pradesh faces the same problems in the power sector as Haryana. Furthermore, while it is true that Haryana is a smaller state and that farming is relatively more advanced than in AP, there are fundamental similarities in the make up of its farm populations, pump ownership and cropping patterns, gross and net income and composition of irrigation costs that it is reasonable to suggest that most of the recommendations for Haryana can also be applied to AP.

3.2 Metering. The difficulties of metering a state as large as AP where the number of agricultural consumers is almost 2 millions, are enormous. However, the lack of metering provides an incentive to utilities to camouflage non-technical losses (i.e. theft) under the estimated electricity consumption by agriculture consumers. The recent Tariff Order of the APERC mandates universal metering to be completed by March 2003 and also provide any new connection with metering only.

3.3 Tariff Structure. As in Haryana, the present tariff based on a flat rate structure in AP is regressive, penalizing marginal and small farmers who are using less electricity for a given connected capacity. It also discourages farmers from conserving groundwater resources, as the marginal cost of pumping is zero. In AP, where some regions are drought prone and where water is a scarce resource, over-pumping in the long run will adversely affect agriculture.

3.3 The introduction of universal metering would allow utilities to charge agricultural consumers on the basis of the energy consumed and, therefore, remove the inequity associated with the present tariff regime.

3.4 Metering and the conversion to an energy charge in place of the present flat rate, would also allow the Electricity Regulatory Commission to devise methodologies and test different mechanisms for targeting subsidies more efficiently and effectively to the more vulnerable farmers, particularly the marginal farmers who constitute about 20% of the farmers using electricity for irrigation. For example, it could be possible to define "lifeline rates". A meter based tariff regime would also allow the elimination of misreporting/under-reporting of installed horsepower capacity by farmers.

3.5 Raising Electricity Tariff. The current tariff level for agriculture consumers in AP as in Haryana is inadequate to cover the cost of supply. Efforts to rectify this have already caused political upheaval in AP. Nevertheless, because the tariffs that farmers pay represents only about 4.5 per cent of the average cost of power supply, it results in a significant burden on the finances of the utilities. The total estimated subsidy for supply of power to agriculture consumers is estimated to be Rs.2850 crores¹⁷ (FY2000),

3.6 Farmers in AP, similar to the ones in Haryana, are paying a higher price for electricity than stated by the utility, because the poor quality of electricity supply increases their costs mainly due to. One way by which it increases cost is through frequent pump motor burnouts. Another is through power interruptions due to transformer burn outs and the time required to repair them and other unscheduled power cuts, which impose an additional cost to farmers in terms of the potential loss in crop yields. While farmers in Andhra Pradesh face more frequent motor burnouts and transformer failures, the days taken to repair a burnt transformer is significantly lower in Andhra.

3.7 Adopting measures to improve electricity supply conditions would increase the acceptability of power tariff increases. These could involve a number of technical measures for improving the

¹⁷ A part of this subsidy is made good by cross-subsidy from industrial and commercial consumers. In FY2001 as per APERC's order Rs.703 crores of subsidy was allocated to agriculture sector.

distribution infrastructure to target reduction in transformer failure rates and improve voltages. AP is already moving in this direction. The four distribution companies are formulating plans for the rehabilitation of the distribution system to improve the reliability and quality of power supply. Stricter monitoring of the scheduled supply hours in Andhra Pradesh shall help increase the reliability of power availability and equity across regions.

3.8 Improving technical and operational efficiency are critical to lower the cost of supply. The earlier privatization of the distribution companies would speed up the process of improving conditions of power supply and also introduce a different and equally important managerial culture and commercial orientation.

3.9 **Canal Water Pricing.** The Government of Andhra Pradesh has made considerable progress in raising water charges to recover a large share of O&M costs of the surface irrigation system, beginning in 1997. The challenge for the future is to strengthen the efforts to raise the water charge collection efficiency and to undertake the regular periodic adjustments of water rates by the Water Charges Review Committee of the Irrigation Department to ensure that the water charges cover the full O&M requirements of the irrigation system. The present subsidized pricing of canal water puts electric pump owners at a disadvantage and does not encourage water conservation. These actions are critical to (i) enable appropriate execution of O&M activities and thus ensure the longer term sustainability of surface irrigation systems; and (ii) eliminate the fiscal burden and contribute to the improved fiscal health in the State. It would also foster more efficient use of water in areas dependent on surface irrigation.

A. Complementary Measures to Improve Returns to Agricultural Production Activities

3.10 In the short- to medium term, the state should invest in improving rural infrastructure such as all-weather rural roads, village markets, and telecommunications. These investments would significantly reduce the cost of marketing of both agricultural inputs (fertilizer, seeds, etc) and agricultural products. Poor infrastructure increases marketing costs due to associated higher physical losses (spoilage, spillage, wastage, etc) and bottlenecks (loading and transport) created in the system due to the inadequate capacity in meeting demand for marketing services. Such investments would in turn benefit both producers and consumers by reducing marketing margins, and translating to higher farm and lower consumer prices (Figure 3.1).

Figure 3.1 - Impact of Rural Roads Improvement in Andhra Pradesh

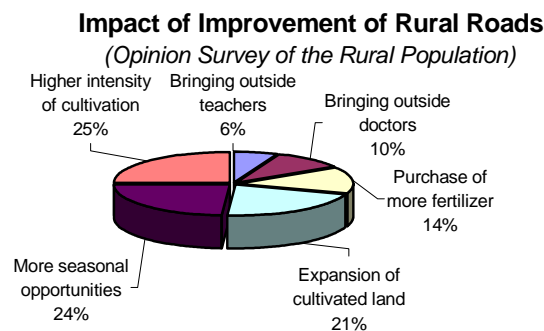
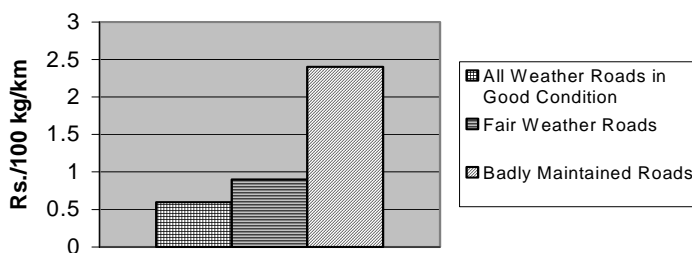


Fig 3.2 - Average Freight Charges



Source: Rural Transport Surveys (1997) – Andhra Pradesh Economic Restructuring Project

3.11 The state should increase efforts in the short to medium term to improve the delivery of public and private agricultural support services, particularly agricultural extension programs to increase the productivity of irrigated agriculture and to enhance farmer capabilities to diversify production to higher value crops. For example, diversification to higher value crops and the adoption of improved agricultural technologies that would facilitate increased on-farm efficiency and productivity would enhance farm incomes and thus enable farmers absorb increasing electricity tariffs. Measures should include dissemination of improved technologies (such as higher yielding seeds, farm equipment, more efficient pumps), transferring knowledge to foster diversification to higher value crops and providing training on on-farm management practices, such as improved on-farm nutrient and water management, integrated pest management, and post-harvest practices. Government efforts could involve both improving public extension services as well as promoting the enabling environment for private delivery (including subcontracting to the private sector some activities).

3.12 Over the medium-term, the Government of India should lift various regulations related to marketing as this would improve marketing efficiency and would be critical to the longer term sustainability of power sector reform. These would include lifting controls on marketing activities, such as storage, movement, credit, export and import controls and the small-scale reservation of selected industries. At the state level, this would include phasing out the levy on rice mill output, currently at 50 per cent and permanently removing restrictions of rice exports to other states. Elimination of these controls will reduce transaction costs of marketing and hence allow better prices for farmers and consumers. They will also encourage greater private sector investments in marketing infrastructure (e.g. storage) that will reduce marketing losses. Improved electricity supply in rural areas would also facilitate growth of such industries. Progress in the reform of these restrictions, however, has been slow. The ongoing WTO negotiations on agriculture are likely to necessitate some reform of domestic regulatory policies, thereby hastening the process. Collaborative efforts across states to move the reform process forward would be critical. The State should not resort to offering higher commodity support prices to compensate farmers for the increase in power tariffs to agriculture for three key reasons.

3.13 The increasing fragmentation of land in AP also merits a review and re-evaluation of the current State land policy particularly the restrictions on land leasing. This could serve as a first step to developing a new land policy that better meets the needs for the rural sector in the 21st century. As noted earlier, the increasing fragmentation of land sizes, with limited access to leasing, reduce the incentives for adopting modern productivity enhancing methods for farming that could help improve both farm incomes and competitiveness.

B. Integrated Demand Side Management Programs

3.14 There are several measures that would help improve the use of groundwater resources. Metering, as noted above, whether for surface irrigation or water extracted by electric pumps, would permit improved pricing of the water to better reflect its scarcity value. A further advancement of graduated tariff rates (higher per unit rates at higher consumption levels), could help deal with the "rebound effect", that is farmers will irrigate more area with improved electricity supply leading to groundwater resource degradation.

3.15 Regulating access to water through registration of wells and regulation of well depth, spacing and pump capacity could also help limit over use of water. These regulations, however, would be administratively difficult to enforce in India due to large number of small farmers. Equity is also an important concern, as registration would favor current pump owners vs new ones.

3.16 Organization of regional/local groundwater user groups could provide a mechanism for workable collective self-enforcement. The organization of community-based groundwater conservation districts is being piloted in Rajasthan and would provide useful lessons in the future. These could be complemented by information and education campaigns to generate greater awareness on the importance of sustainable groundwater use. Pilot projects in Haryana have already demonstrated the benefits of Integrated Agricultural DSM (see Haryana Report, Chapter 5). Similar programs could be initiated in Andhra Pradesh (see Box 3.1).

Box 3.1 -Agricultural DSM Experience in Andhra Pradesh

In early 1990s, Andhra Pradesh recognized the potential benefits of introducing end use efficiency for agricultural. The requirement of a steady quality power supply as prerequisite was also appreciated. The state pioneered the concept of integrated energy efficiency in India by introducing High Voltage Distribution System (HVDS) to improve the quality of power supply to agricultural consumers along with replacement of existing inefficient pumps with higher efficiency and lower capacity pumps to reduce energy consumption for the same water delivery. Under this plan, existing three phase Low Voltage Distribution System (LVDS) was to be converted as single phase HVDS as close to consumer as possible. Small capacity single phase transformers (10 or 15 KVA) were to be installed to supply a group of few consumers and the existing three phase pumpsets were to be replaced with energy efficient single phase models.

A technology demonstration involving 7,200 pumpsets was undertaken in Warangal district with the support from the Japanese OECF (now JBIC). The response from consumers to this forced conversion program was mixed and only about 2,010 pumpsets were replaced by efficient single phase models. A similar demonstration was attempted with the support from UK DfID in Nalgonda district involving 3,200 pumpsets connected to one 33/11 kV substation. Losses were brought down to about 2-2.5% in the LT section. However, only about 850 consumers participated in the demonstration project. The less than adequate response from farmers is attributable to a combination of factors including the resistance to change by unauthorised consumers, use of higher than required or declared horse power etc. Other issues faced during the implementation of these programs included farmers' apprehension of the single phase system, some problems with contractor for the repair and maintenance of the new pumpsets, APTRANSCO/DISCOM's inability to roster and manage agricultural consumption in these areas, interference from local mechanics whose livelihood was affected by the contractor implemented pumpset program etc.

Learning from this experience, Andhra Pradesh is now adapting a modified approach in the AP Integrated Agricultural Energy Efficiency Pilot project funded through a US\$ 4.6 million grant by the Government of Norway under its Activities Implemented Jointly (AIJ) Program. This pilot covers approximately 5,800 pumpsets connected to two 33/11 kV substations in Chittoor and Karim Nagar districts. Under this pilot project, HVDS will be developed in a three phase configuration, to eliminate one of the main concerns of farmers for participating in the program.

An outreach program explaining the benefits of the new distribution system and a voluntary efficient pumpset scheme will be offered to farmers in close coordination with local groups/banks involved in outreach activities for other agricultural and rural development initiatives. On an average, it is expected that the end-use efficiency will go up from about 25% to about 50%. This pilot is in early stages of implementation and is expected to be completed by December 2002.