EQUITY, COMPARATIVE FEASIBILITY AND ECONOMIC VIABILITY OF GROUNDWATER INVESTMENT IN SAURASHTRA REGION

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Abstract

The paper tries to analyze two districts of Saurashtra from the point of equity and economic feasibility of groundwater abstraction and use. Using various simulation and economic analyses tools, the paper concludes that there is equity of access and consequently access of irrigation. For different pricing and discount rates, the BC ratio and IRR are positive. Thus groundwater withdrawal for irrigation seems feasible. However, if the electricity subsidy to the agriculture is removed, the investments are not feasible.

1. INTRODUCTION

Groundwater is gaining importance as a source to meet the needs of India's ever-increasing population, for drinking as well as industry and irrigation (Shaheen and Shiyani, 2005). India is the biggest groundwater user in the world, followed by USA and China (Shah et al., 2003). In South Asia, in addition to India, Pakistan, Bangladesh and Nepal are the major groundwater users. However, our estimate is that between them, these four countries pump about 210-250 km^3 of groundwater every year. In doing so, they use about 21-23 million pumps, of which, about 13-14 million are electric and around 8-9 million are powered by diesel engines (NSSO 1999, for India). If we assume that an average electric tube well (with a pumping efficiency of 25 %) lifts water to an average head of 30m, the total energy used in these countries for lifting 210 km^3 of groundwater is about 68.6 billion kWh equivalent per year. The demand for fresh water in the country has been rising over the years due to increased demand for food production and growing urbanization and industrialization. Currently, total water use (including groundwater) is 634 BCM, of which 83% is for irrigation. The demand for water is projected to grow to 813 BCM by 2010, 1093 BCM by 2025 and 1447 BCM by 2050, against utilizable quantum of 1123 BCM. Clearly, in 35-40 years, groundwater in particular will come under even greater pressure in the intervening years (GoI, 2007).

According to a World Bank estimate, groundwater irrigation contributes to about 10% of India's GDP (World Bank, 1998 and GoI, 1998). This is possible because groundwater irrigation uses about 15-20% of the total electricity consumed in the country. Groundwater with subsidized power to the farm sector plays an important role in sustaining the agrarian economy of north Gujarat. Groundwater contributes more than 90% of the total irrigated area in the region, which has experienced high rates of over-exploitation. The water table is falling at the rate of 5-8 m annually [Moench and Kumar 1997], coupled with high well failure. The depletion of the water table is chased by boring at deeper depths with huge investments, which can be afforded by large and financially sound farmers (Shaheen and Shiyani, 2005).

Most of the problems in the use and management of groundwater resources lack well defined property rights and appropriate institutions for regulating the use of water (Marothia, 1997). The ownership of groundwater is tied with the ownership of land in India, and the land owners have the right to extract groundwater beyond any time as long as it is available (Singh, 1991). Groundwater mostly lies in the open access regime throughout the country (Singh, 1995), as also in Gujarat.

2. STATEMENT OF THE PROBLEM

Groundwater plays a critical role in the agricultural economy of Gujarat. Over-exploitation and mismanagement of the resource have led to depletion and degradation of groundwater aquifers. Due to hard rock formation, the possibility of holding large quantity of water is low in many districts of Saurashtra. Thus, they are severely affected by groundwater over-exploitation and falling water table levels. Electricity is supplied to farm sector on flat tariff rate with high subsidy. Many researchers argue that the farmers of Saurashtra would benefit from pro rata pricing, given the fact that the amount of energy they use annually would be very small (Kumar and Singh, 2001).

In Saurashtra region, irrigation facilities have been growing rapidly and the sources of irrigation are both surface water and groundwater. Between 1999 to 1997, irrigation potential increased by 37.6 and 21.0% in Amreli and Bhavnagar districts respectively (Sharma, 2002). The tremendous growth of groundwater development for irrigation in this area, which faces frequent draughts, has added to the problem of lowering water levels. Withdrawal of ground water beyond recharge capacity caused the water table to decline beyond the recommended limits (Sikarwar, et. al., 2005).

This study not only focuses on equity issues but also examines comparative feasibility and economic viability of groundwater investment in Saurashtra region. The specific objectives of study are:

2.1 Objectives

(i) To study the equity issues among the selected respondents of Saurashtra region.

(ii) To examine comparative feasibility and economic viability of groundwater investment in Saurashtra region.

3. SAMPLING DESIGN AND DATA BASE

The study was conducted in the Saurashtra region of Gujarat state. Two districts viz., Amreli and Bhavnagar, which have severe groundwater problems were selected purposively. Two talukas from each district were selected adopting the same criteria. Again, two villages from each taluka were selected randomly. Ten farmers with metered (pro-rata tariff rate system) and equal number of farmers with flat rate were selected at random from each selected village. Thus, total of 160 farmers were interviewed to collect information. The study pertains to the agricultural year 2006.

4. ANALYTICAL FRAMEWORK

4.1 Equity

The equity of access to resource (groundwater) among the farmers was analyzed by comparing the number of wells and percentage share in well(s), gross irrigated area (GIA), income realized per ha of GIA, water used per hectare of GIA, net returns per-unit of water use, physical and economic access, and various inequality measures like Gini Concentration Ratio (GCR), Weighted Gini coefficient, Theil entropy index, Theil Bermoulli index and Exponential index. These measures are defined as follows:

Gini Concentration Ratio (GCR) was calculated to measure the inequality in the income among different farm classes using the following formula:

$$GCR = 1 - \sum_{i=1}^{n} P_i (Q_i + Q_{i-1})$$

Where,

P_i = Proportion of number of farmers.

Q_i = Cumulative proportion of income.

Q_{i-1} = Preceding cumulative proportion of income.

The weighted Gini coefficient is given as:

$$\text{Weighted Gini} = \sum_{i=1}^{j} W_i (y_i / \mu)$$

and

$$\text{Wi} = p_i \left[\sum_{i=1}^{j} \left(2p_j - p_i - 1 \right) \right]$$

Where, W_i = A weight associated with the proportion of the population in the ith group,

p_i = The proportion of the population in the ith income group,

y_i = The average income in ith group,

μ = The overall mean income.

The Gini coefficient is derived from the Lorenz curve and is defined as the area between the Lorenz curve and the diagonal line (line of perfect equality) divided by the area of the whole triangle formed by line of perfect inequality. The Gini coefficient therefore, has a value between 0 and 1; where a value of 0 means that all individuals in the population have the same earnings (Perfect equality). The value is consistent with the Lorenz curve lying along the 45^0 line. A Gini coefficient with a value of one means that one individual holds all the income and the Lorenz curve lies along the horizontal axis (Perfect inequality).

4.2 Bottom sensitive measures of inequality

Three other statistical measures used to measure income inequality viz., the Exponential index, the Theil-Entropy index and the Theil-Bernoulli index are given below. These measures assume slightly different income distributions in an effort to control peculiarities in the data, and are bottom sensitive, i.e. sign will change if transfers occur at the bottom of the income distribution.

Theil Entropy index: When the parameter 'C' of the generalized entropy index is equal to 1 or 0, we have the Theil index. For the natural logarithm of incomes, it is expressed as;

$$\text{TE} = \left[\frac{1}{N} \right] \sum_{i=1}^{N} \frac{y_i}{\mu} \ln \left[\frac{y_i}{\mu} \right]$$

Theil-Bernoulli index

$$\text{TB} = -\sum_{i=1}^{j} p_i \ln \left(y_i / \mu \right)$$

Exponential index

$$\text{EXP} = \sum_{i=1}^{j} p_i \exp \left(-y_i / \mu \right)$$

Where, ln = Natural logarithm

p_i = The proportion of the population in the ith income group

y_i = The average income in ith group in Rs

μ = The overall mean income in Rs

5. ECONOMIC FEASIBILITY IN WELL INVESTMENT

In order to evaluate the economic feasibility of investment on bore well/groundwater irrigation, the project evaluation measures such as Net Present Worth (NPW), Benefit Cost Ratio (BCR), Internal Rate of Return (IRR) and Pay Back Period were employed.

The mathematical forms are given below:

$$\text{NPW} = \sum_{t=1}^{n} \frac{(B_t - C_t)}{(1+r)^t}$$

The formula for benefit cost ratio is:

$$\text{BC ratio} = \sum_{t=1}^{n} \frac{B_t}{(1+r)^t} \div \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

The pay back period is the length of time taken to liquidate the investment on well from the commencement of the project. The pay back period was calculated as:

$$P = I \div E,$$

Where, P = Length of time in years, I = Investment in Rs.

E = Expected annual return in Rs.

The internal rate of return is the rate of return ' r ' at which

$$\sum_{t=1}^{n} \frac{B_t}{(1+r)^t} = \sum_{t=1}^{n} \frac{C_t}{(1+r)^t}$$

Where,

Bt = Benefits in each year in Rs.

Ct = Costs in each year in Rs.

t = Number of years (1, 2, 3, ……… n)

r = Discount rate in percentage

The IRR was arrived through interpolation by using different discount rates, to confirm that NPW is equated with zero. At the outset, the project costs and benefits were discounted at an arbitrary discount rate (designated as the lower discount rate - LDR) so as to get a positive net worth. Similarly, a higher discount rate (HDR) was chosen so as to get a negative present worth. Using these, the IRR was computed through interpolation as follows;

IRR = LDR + (HDR-LDR) {(NPW at LDR)   (Absolute difference between NPW at LDR and NPW at HDR)}

The IRR also facilitates ranking of different investments in order of their maximum earning capacity. The IRR should be greater than the opportunity cost of capital for economic feasibility and financial soundness.

6. INCOME INEQUALITY FROM GROUNDWATER IRRIGATION

The extent of inequality in gross income per hectare realized from the groundwater irrigation was assessed which can be taken as a proxy to examine the extent of inequality in access to groundwater irrigation. Various measures of income inequality were estimated which are presented in Table 1 and depicted in Lorenz curve (Figure 1).

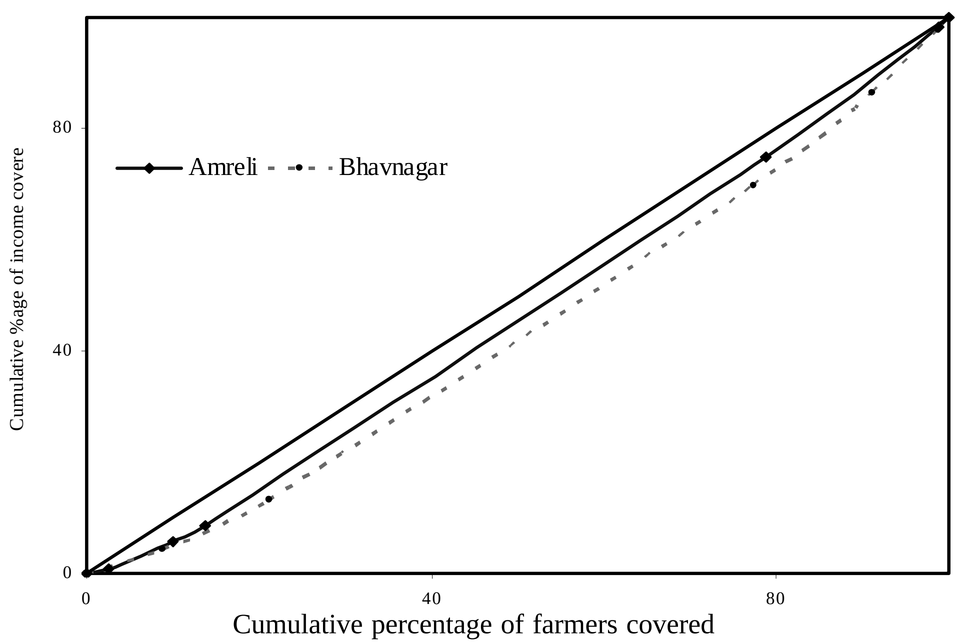
The Lorenz curve shows how the farm income from the groundwater irrigation is distributed among the sample farmers of both the districts. The inequality of income distribution is indicated by the degree to which Lorenz curve departs from the diagonal line: the farther the curve is from diagonal line, the more unequal is distributed farm income and vice versa. It is observed from the figure that the income inequality is less among the sample farmers of Amreli than the farmers of Bhavnagar district as in later case, Lorenz curve lies farther from the diagonal line.

Seven measures of income inequality were tried to measure the degree of inequality in the income realized from groundwater irrigation among the sampled farmers, which are presented in Table 1. In terms of Gini Concentration Ratio (GCR), the degree of inequality was 0.074 for Amreli and 0.129 for Bhavnagar districts, i.e. the degree of inequality is almost double. The pooled analysis of both the areas further aggravated the inequality measure (0.109). The GCR value clearly supports the Lorenz curve graph. Similar trend was also observed in Weighted Gini Coefficient and Coefficient of Variation measures. In case of Theil Entropy Index, Amreli district showed 0.010, whereas in Bhavnagar district, it was 0.217. In terms of Theil Bernoulli Index, Exponential Index and Standard deviation of logarithmic incomes, the degree of inequality was found higher in Bhavnagar district as compared to Amreli district.

Table 1: Measures of income inequality in study area

Sr. No.	Inequity Measures	Amreli	Bhavnagar	Overall
1.	Gini Concentration Ratio (GCR)	0.074	0.129	0.109
2.	Weighted Gini Coefficient	0.074	0.129	2.437
3.	Theil Entropy Index	0.010	0.217	0.144
4.	Theil Bernoulli Index	0.013	0.035	0.056
5.	Exponential Index	0.374	0.380	0.754
6.	Standard Deviation of Logarithmic Incomes	0.228	0.283	0.258
7.	Coefficient of Variation	0.180	0.261	0.223

Figure 1: Lorenz curve- distribution of income among sampled farmers



From all these measures as well as Lorenz curve, it can be concluded that the income realized from the farmers using groundwater irrigation in Amreli was more evenly distributed than that of Bhavnagar district. This was due to more skewed distribution of groundwater irrigation among the different classes of farmers in Bhavnagar district. The economic access to groundwater was higher for Amreli district than that of Bhavnagar district farmers. The physical access and economic access to groundwater with holding size in Amreli and Bhavnagar districts are presented in Figure 2 and Figure 3, respectively. Moreover, the proportion of the marginal and small farmers having access to groundwater irrigation in Bhavnagar district was also relatively less as compared to Amreli district.

7. ECONOMIC FEASIBILITY IN GROUNDWATER INVESTMENT

The economic feasibility of investment on well irrigation was evaluated by using standard discounted cash flow techniques. The measures used were benefit cost ratio (BCR), net present value (NPV), internal rate of return (IRR) and the payback period (PBP). The economic feasibility test was worked out at different discount rates because of changing banking policies and other market conditions. The sensitivity analysis was also done by taking into account three cost concepts; viz., paid out crop cost, C_1 crop cost and C_2 crop cost for cultivation of crops.

Sensitivity analysis for investment in wells at 6% discount cash flow is presented in Table 2. The IRR for the investment on well per farm was 8.13% for Amreli and 7.58% for Bhavnagar with the present tariff (Rs. 665/HP/year upto 7.5 HP motor and Rs. 807.5/HP/year above 7.5 HP) and paid out cost. However, the high IRR in Amreli reduced to 1.12 and 0.61% at C_1 and C_2 cost levels, respectively. The discounted BC ratio at 6% discount rate was 1.71 and 1.58 for Amreli and Bhavnagar districts, respectively, indicating that for every one rupee of present value of cost, the investment yielded Rs. 1.71 and Rs. 1.58 of the present value of return in the respective district over the economic life span of wells. The NPV, an indicator of the magnitude of total present value of stream of returns left with the investor at the end of economic life span of the well was Rs. 3,91,507 for Amreli and Rs. 2,65,703 for Bhavnagar districts. This implies a return in excess of the capital invested plus the specified rate of interest (6 %) of capital. The NPV was fairly high for Amreli district compared to that of Bhavnagar district. The payback period to recapture the investment was 1.44 and 1.64 years for Amreli and Bhavnagar districts, respectively. It can be concluded from the table that the returns to investment are highly feasible.

Figure 2: Physical and economic access to groundwater with holding size in Amreli district

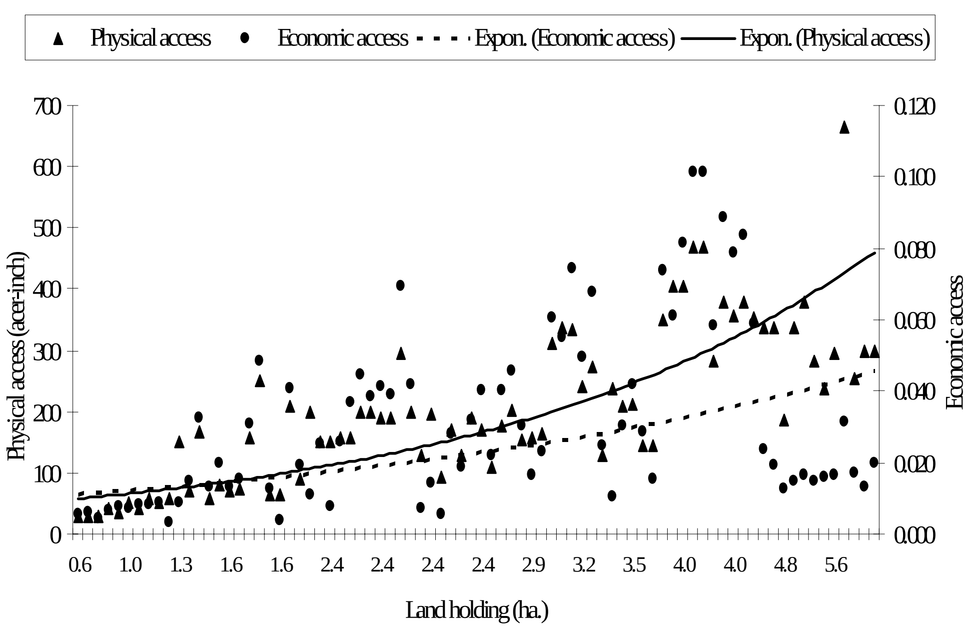
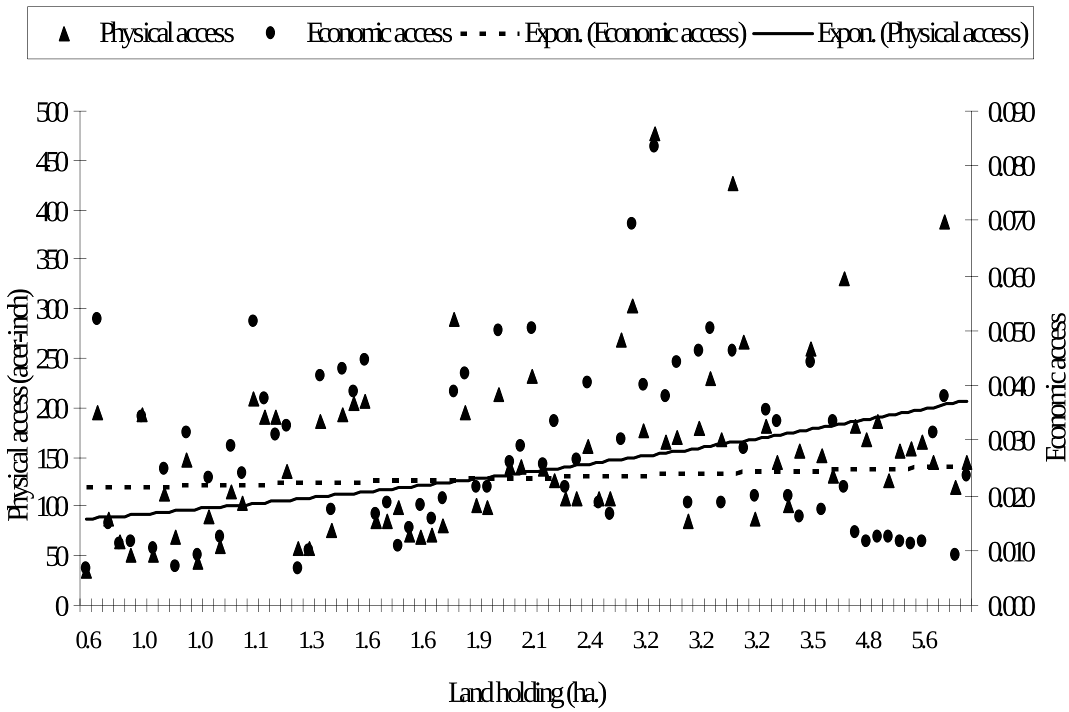


Figure 3: Physical and economic access to groundwater with holding size in Bhavnagar district



The results pertaining to BCR, IRR, NPW and PBP are in conformity with the results obtained by Neelakantaiah (1991), Kolavalli and Atheeq (1993), Nagaraj and Chandrakanth (1995), Shaheen (2004) and Talathi et al., (2005).

The project appraisal criteria were also estimated at higher discounted cash flow interest rates (8, 10 and 12 %). The results of which are presented in Table 2. At higher discount rates of interest, the feasibility measures decrease. It means that the returns on investment fall. If we look at BCR ratios at discount rates of 6%, 8, 10 and 12% for Amreli (at first combination - present tariff plus paid out crop cost), they come to 1.71, 1.69, 1.68 and 1.67, respectively, whereas in Bhavnagar, they come to 1.58, 1.56, 1.55 and 1.54. Similarly, all other measures come down at higher discount rates for all the combinations in both the districts. From these, it can be concluded that the investment in well irrigation is feasible at all the combinations in both the districts, even at a high discount rate of 12%. Furthermore, it was revealed by the sensitivity analysis that lower interest rates encourage the development of groundwater projects that generate high costs early in the project and benefits well into the future. The lower interest rate reduces the importance of early costs and values more gains that occur in future. The sensitivity results arrived at different interest rates are supported by the study of Fox and Hederfindahl (1964) on American Water Projects. They found that only 20% of projects were viable at an 8% discount rate, while 91% projects were viable at 4% discount rate.

Sensitivity analysis was also done at various pro-rata tariff rates. The energy consumed per farm was worked out by considering the pump HP and number of hours in a year, for which the pump was operated. The complete procedure for calculation of energy consumption is given in methodology chapter. The sensitivity analysis was done at three different pro-rata tariff levels viz., present rate of tariff with subsidy (Re. 0.50/kWh), an immediate next stage of tariff (Rs. 1.0/kWh) and the government purchase price of electricity (Rs. 2.50/ kWh). The discounted cash flow analysis was done at 6, 8, 10 and 12% interest rate.

The investment appraisal measures estimated when electricity is priced at Re. 0.50 per kWh with 6% discount rate are given in Table 3. It is observed from the table that BCR is 1.70 with an IRR of 71.75% for Amreli district at paid out cost level. Similarly, for Bhavnagar, BCR of 1.58 and IRR of 7.92% were estimated. The returns were worthwhile even on C_1 and C_2 costs for both the districts.

Table 2: Sensitivity analysis for investment in wells at different discount rate

Sl. No.	Combination	Amreli				Bhavnagar			
		BCR	NPV	IRR	PBP	BCR	NPV	IRR	PBP
	At 6% discount rate								
1	Present tariff + Paid out crop cost	1.71	391507	8.13	1.44	1.58	265703	7.58	1.64
2	Present tariff + C_1 crop cost	1.24	185573	1.12	3.05	1.11	74327	0.46	5.87
3	Present tariff + C_2 crop cost	1.15	122098	0.61	4.63	1.03	18498	0.11	23.57
	At 8% discount rate								
1	Present tariff + Paid out crop cost	1.69	368009	7.98	1.54	1.56	249383	7.42	1.75
2	Present tariff + C_1 crop cost	1.24	172321	1.08	3.28	1.11	67530	0.43	6.46
3	Present tariff + C_2 crop cost	1.14	112006	0.58	5.05	1.02	14478	0.09	30.11
	At 10% discount rate								
1	Present tariff + Paid out crop cost	1.68	346651	7.83	1.63	1.55	234550	7.27	1.86
2	Present tariff + C_1 crop cost	1.23	160277	1.05	3.53	1.10	61352	0.41	7.11
3	Present tariff + C_2 crop cost	1.14	102832	0.55	5.50	1.02	10825	0.07	40.27
	At 12% discount rate								
1	Present tariff + Paid out crop cost	1.67	327190	7.69	1.73	1.54	221034	7.12	1.97
2	Present tariff + C_1 crop cost	1.22	149303	1.01	3.79	1.10	55723	0.38	7.82
3	Present tariff + C_2 crop cost	1.13	94474	0.53	5.98	1.01	7497	0.05	58.15

Note: Present Tariff at the rate of Rs. 665 per HP/year upto 7.5 HP motor and Rs. 807.5 per HP/year above 7.5 HP

The project appraisal criteria were also estimated at higher discounted cash flow interest rates (8, 10 and 12 %), the results of which are presented in Tables 2. It was observed that at higher discount rates of interest, the feasibility measures decrease. It means that the returns to investment fall. If we look BCR ratios at discount rates of 8, 10 and 12%, for Amreli at first combination (Power cost (Rs. 0.5/kWh) plus paid out crop cost), they come to 1.69, 1.68 and 1.67, whereas for Bhavnagar they comes to 1.57, 1.56 and 1.55. Similarly, the values of all other measures declined at higher discount rates for all the combinations in both the districts.

The investment appraisal measures were estimated when electricity is priced at Rs. 1/kWh with discounted cash flow interest rates of 6, 8, 10 and 12%, the results of which are presented in Tables 4. The BCR ratios at different discount rates for Amreli district were found relatively higher as compared to Bhavnagar district. The value of BCR less than one at higher discount rate with cost C_2 implies that the project is not viable at that combination. This suggests that no further investment should be encouraged beyond that combination.

The investment appraisal measures estimated when electricity is priced at Rs. 2.5/kWh with discounted cash flow interest rates (6, 8, 10 and 12 %) are presented in Tables 5. The BCR ratios at different discount rates for both the districts were relatively low compared to that of lower tariff rates. It can be concluded that investment is viable at paid out cost and C_1 cost level in Amreli district, whereas in Bhavnagar district, the measures were found favourable only at paid out cost level. Thus, looking at overall picture of both the districts, the investment is economically viable at paid out cost at all levels of discounted measures.

Table 3: Sensitivity analysis for investment in wells at different discount rate for power cost at the rate of Rs. 0.5/kWh

Sl. No.	Combination	Amreli				Bhavnagar			
		BCR	NPV	IRR	PBP	BCR	NPV	IRR	PBP
	At 6% discount rate								
1.	Power cost (Rs. 0.5/kWh) + Paid out crop cost	1.70	390785	71.75	1.45	1.58	267256	7.92	1.63
2.	Power cost (Rs. 0.5/kWh) + C_1 crop cost	1.24	184851	1.12	3.06	1.12	75881	0.47	5.74
3.	Power cost (Rs. 0.5/kWh) + C_2 crop cost	1.15	121377	0.61	4.66	1.03	20051	0.12	21.74
	At 8% discount rate								
1.	Power cost (Rs. 0.5/kWh) + Paid out crop cost	1.69	367323	70.40	1.54	1.57	250859	7.75	1.74
2.	Power cost (Rs. 0.5/kWh) + C_1 crop cost	1.24	171636	1.08	3.29	1.11	69006	0.44	6.32
3.	Power cost (Rs. 0.5/kWh) + C_2 crop cost	1.14	111320	0.58	5.08	1.02	15954	0.09	27.32
	At 10% discount rate								
1.	Power cost (Rs. 0.5/kWh) + Paid out crop cost	1.68	345998	69.10	1.63	1.56	235956	7.60	1.85
2.	Power cost (Rs. 0.5/kWh) + C_1 crop cost	1.23	159624	1.04	3.54	1.11	62758	0.42	6.95
3.	Power cost (Rs. 0.5/kWh) + C_2 crop cost	1.14	102179	0.55	5.53	1.02	12231	0.07	35.64
	At 12% discount rate								
1	Power cost (Rs. 0.5/kWh) + Paid out crop cost	1.67	326567	67.85	1.73	1.55	222375	7.44	1.96
2	Power cost (Rs. 0.5/kWh) + C_1 crop cost	1.22	148680	1.00	3.80	1.10	57064	0.39	7.64
3	Power cost (Rs. 0.5/kWh) + C_2 crop cost	1.13	93850	0.52	6.02	1.01	8838	0.06	49.32

Table 4: Sensitivity analysis for investment in wells at different discount rate for power cost at the rate of Rs. 1.0/kWh

Sl. No.	Combination	Amreli				Bhavnagar			
		BCR	NPV	IRR	PBP	BCR	NPV	IRR	PBP
	At 6% discount rate								
1	Power cost (Rs. 1.0/kWh) + Paid out crop cost	1.59	349484	8.49	1.62	1.49	240088	4.26	1.82
2	Power cost (Rs. 1.0/kWh) + C_1 crop cost	1.18	143549	0.76	3.94	1.07	48712	0.29	8.95
3	Power cost (Rs. 1.0/kWh) + C_2 crop cost	1.09	80075	0.37	7.06	0.99	-7118	-	-
	At 8% discount rate								
1	Power cost (Rs. 1.0/kWh) + Paid out crop cost	1.57	328077	8.31	1.72	1.48	225042	4.16	1.94
2	Power cost (Rs. 1.0/kWh) + C_1 crop cost	1.17	132389	0.73	4.27	1.07	43189	0.26	10.09
3	Power cost (Rs. 1.0/kWh) + C_2 crop cost	1.09	72074	0.35	7.84	0.99	-9862	-	-
	At 10% discount rate								
1	Power cost (Rs. 1.0/kWh) + Paid out crop cost	1.56	308620	8.14	1.83	1.47	211367	4.06	2.06
2	Power cost (Rs. 1.0/kWh) + C_1 crop cost	1.17	122246	0.69	4.62	1.06	38170	0.24	11.42
3	Power cost (Rs. 1.0/kWh) + C_2 crop cost	1.08	64801	0.32	8.72	0.98	-12357	-	-
	At 12% discount rate								
1	Power cost (Rs. 1.0/kWh) + Paid out crop cost	1.55	290890	7.98	1.94	1.46	198907	3.97	2.19
2	Power cost (Rs. 1.0/kWh) + C_1 crop cost	1.16	113003	0.66	5.00	1.06	33596	0.22	12.98
3	Power cost (Rs. 1.0/kWh) + C_2 crop cost	1.08	58174	0.30	9.71	0.98	-14630	-	-

Table 5: Sensitivity analysis for investment in wells at different discount rate for power cost at the rate of Rs. 2.5/kWh

Sl. No.	Combination	Amreli				Bhavnagar			
		BCR	NPV	IRR	PBP	BCR	NPV	IRR	PBP
		At 6% discount rate							
1	Power cost (Rs. 2.5/kWh) + Paid out crop cost	1.31	225579	1.63	2.51	1.28	158581	1.35	2.75
2	Power cost (Rs. 2.5/kWh) + C_1 crop cost	1.02	19645	0.09	28.77	0.96	-32794	-	-
3	Power cost (Rs. 2.5/kWh) + C_2 crop cost	0.96	-43829	-	-	0.89	-88624	-	-
		At 8% discount rate							
1	Power cost (Rs. 2.5/kWh) + Paid out crop cost	1.31	210337	1.58	2.69	1.27	147592	1.31	2.95
2	Power cost (Rs. 2.5/kWh) + C_1 crop cost	1.02	14650	0.07	38.57	0.95	-34261	-	-
3	Power cost (Rs. 2.5/kWh) + C_2 crop cost	0.95	-45666	-	-	0.89	-87313	-	-
		At 10% discount rate							
1	Power cost (Rs. 2.5/kWh) + Paid out crop cost	1.30	196484	1.53	2.88	1.26	137603	1.26	3.17
2	Power cost (Rs. 2.5/kWh) + C_1 crop cost	1.01	10111	0.05	55.89	0.95	-35595	-	-
3	Power cost (Rs. 2.5/kWh) + C_2 crop cost	0.95	-47335	-	-	0.88	-86121	-	-
		At 12% discount rate							
1	Power cost (Rs. 2.5/kWh) + Paid out crop cost	1.29	183861	1.49	3.07	1.26	128501	1.22	3.39
2	Power cost (Rs. 2.5/kWh) + C_1 crop cost	1.01	5974	0.03	94.59	0.94	-36810	-	-
3	Power cost (Rs. 2.5/kWh) + C_2 crop cost	0.94	-48855	-	-	0.88	-85036	-	-

Hence, it is concluded that, without heavily subsidized electricity to farm sector it is not possible to sustain the economy. In other words, with raised power tariff, some crops (high water intensive) would become unviable. (Kumar, 2005) studied that with pro rata pricing (which induced marginal cost of electricity and water) farmers could not only make irrigation more efficient, but also adopt crops that are highly water efficient, with the result that the economic viability will not get altered. If social and environmental aspects of project analysis are also taken into consideration, then it forms a strong basis for non investment in groundwater irrigation where the aquifers are depleting. For the improvement of power sector, seven more Ultra Mega Power Projects by the GoI are under process and at least two have been awarded in July, 2007. Accelerated Power Development and Reforms Project (APDRP) are being restructured to cover all district headquarters and towns with a population of more than 50,000. The budgetary support for APDRP has been increased from Rs. 650 crores to Rs.800 crores. Allocation of this budgetary support to different states if done evenly, it would help the farmer community.

8. MAJOR FINDINGS

The findings from the paper are mention below:

- Lorenz curve and from other inequality measures revealed that the income realized from groundwater irrigation was more evenly distributed among the farmers of Amreli district than that of Bhavnagar district.
- The sensitivity analysis was done by taking into account three cost concepts; viz., paid out crop cost, C_1 crop cost and C_2 crop cost for cultivation of crops at 6%, 8%, 10% and 12% discount cash flow. The results showed that the investment is feasible for both the districts in all the combinations.
- The sensitivity analysis was also done at three different pro-rata tariff levels (Rs. 0.50, Rs. 1.0 and Rs. 2.50/kWh) with all above indicated rates of discount. It was observed that the investment is viable at paid out cost and C_1 cost level in Amreli district, whereas in Bhavnagar district, the measures were found favourable only at paid out cost level. In other words it can be said that with raised power tariff, some crops would become unviable.
- The development of groundwater markets particularly in Bhavnagar district will stimulate aquifer depletion and create a monopoly of water lords.

9. SUGGESTIONS AND POLICY IMPLICATIONS

Given that under pro rata pricing of electricity, groundwater irrigation become unfeasible, there is a need to conserve groundwater. Various measures can be taken to manage groundwater such as:

1. There should be well defined property rights setting absolute limits to collective and individual withdrawals of water.
2. There should be water zoning within the state and the cropping pattern should be guided and regulated in accordance with such zoning.
3. The government should fix the maximum time limit for providing power subsidy for the long term sustainability of groundwater.
4. There is a need for establishing training and awareness program to the farmers regarding groundwater scarcity and power tariff.

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