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# Market instruments for demand management in the face of scarcity and overuse of water in Gujarat, Western India

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## Abstract

The paper analyses the water scarcity problems in Gujarat in Western India using definitions of water scarcity propounded by Falkenmark, and Raskin and others, and a more universal definition based on supply and demand. While a lion's share of the scarce water goes for irrigating cash crops at the cost of subsistence farming and rural drinking, the pricing of canal water and electricity used for groundwater pumping is highly inefficient and inequitable. To manage demands for water, the paper suggests the use of water market as the institutional arrangement for promoting economically efficient uses, along with rational pricing of canal water and electricity for encouraging conservation. The paper advocates policies that enable: reforms in the governance and management of water for decentralisation and local institutional development; and increased investment in the irrigation and power supply sector for technological innovations and improvements in infrastructure, which are the fountainhead of the demand management strategy. © 2001 Elsevier Science Ltd. All rights reserved.

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## 1. Introduction

Gujarat, located in Western India, is facing growing problems of water scarcity. The state has limited renewable freshwater. The situation is more precarious when the demands for water from different sectors are compared against the available supplies. When priorities clash, water is increasingly diverted for water-intensive cash crops, industry and urban drinking, depriving the rural people of the water needed for growing food grains and meeting drinking-water needs. This is leading to widespread conflicts.

Water use in most parts of the state, nevertheless, does not reflect the natural distribution of the resource and is highly unsustainable by all standards. This is reflected in a variety of resource

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degradation problems. Particularly, irrigation—the largest user of water in the state—is highly inefficient. There is a strong link between water problems, which the state is facing and the way in which water is used for irrigation.

Demand management offers sustainable water management solutions in the face of increasing water scarcity and growing conflicts over water use (Postel, 1996; Frederick, 1993). But, the traditional water management approaches have focussed on augmenting the supplies, with technologies, institutions and policies designed to suit it. On the other hand, the incentive structures in agriculture promote over-exploitation of groundwater, and inefficient and unsustainable water use practices.

The paper analyses the water scarcity in the state using three different definitions. The first one is by Falkenmark, based on the physical availability of water; second one based on the universal criteria of supply and demand of water; and the third by Raskin and others based on percentage use of renewable water. The paper then examines the political economy of water allocation by analysing the equity and efficiency impacts of the current pricing structure for irrigation water and electricity in the farm sector. The paper also analyses the potential impacts of fiscal and market-based instruments in managing the demands for water.

## 2. Water scarcity problems in Gujarat<sup>1</sup>

The water scarcity problems in Gujarat are analysed from the point of view of physical availability of renewable freshwater, available water supplies, and the demand for water from various sectors and the extent of diversion and use of renewable fresh water.

### 2.1. *Physical scarcity of water in Gujarat*

The total renewable freshwater available in Gujarat, including the annual runoff from within Gujarat and that allocated from the neighbouring states, and all the natural recharge to groundwater, is 54,593 MCM. This gives a per capita renewable freshwater availability of 1137 m<sup>3</sup>/annum for the year 2001. Going by Falkenmark's indicator of physical water scarcity, the state is water stressed (as it is below 1700 m<sup>3</sup>/capita), and is likely to face occasional scarcity. But, the availability of water is heavily skewed towards South and Central Gujarat which has 69.5 per cent of the total renewable freshwater. Therefore, it is important to have regional situation, if one needs to assess the magnitude of water scarcity from a supply-based approach. Going by regions, the per capita renewable freshwater availability in North Gujarat is only 427 m<sup>3</sup>. Thus, the region is "absolutely water scarce" (as it is below 500 m<sup>3</sup>/capita) where water becomes a constraint to life. Saurashtra and Kachchh have per capita renewable freshwater availability of 787 and 875 m<sup>3</sup>, respectively. Thus, these regions are "water scarce" (below 1000 m<sup>3</sup>/capita) and water becomes a constraint for economic growth and social advancement.

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<sup>1</sup>The estimates of renewable freshwater availability for the year 2001, the current water use for the year 1997, future water requirements and supplies for the year 2025 are drawn from the first author's own analysis for the White Paper on Water in Gujarat, prepared by IRMA and the UNICEF for the Government of Gujarat, details of which are available in the document (Institute of Rural Management, Anand/UNICEF, 2001).

## 2.2. Demand driven water scarcity

According to the estimates, the total water requirement for agricultural production, domestic and industrial use, and livestock drinking in the year 1997 is 27,622 MCM. Our projections showed that by the year 2025, the total requirement of water for agriculture, industry, livestock and domestic purposes would be 53,050 MCM. We find that even after harnessing all the potentially utilisable surface and ground water resources (100 per cent of the surface water and 90 per cent of the utilisable groundwater) including the water allocated from the neighbouring states of Madhya Pradesh, Maharashtra and Rajasthan, the supplies would be only 41,500 MCM. This leaves a gap of 11,875 MCM of water. While this is the scenario emerging after considering a mammoth project like the Sardar Sarovar Narmada Project, the situation would appear rather bleak, if one does not consider the allocation of 11,000 MCM of water from the Narmada.

Now, the per capita withdrawal of water is found to be totally unrelated to the relative water availability in a particular region. For instance, the maximum withdrawal of water for human uses was found in the case of North Gujarat ( $448 \text{ m}^3$ ) which has the lowest per capita renewable freshwater ( $447 \text{ m}^3$ ). The minimum per capita water withdrawal is in South and Central Gujarat ( $372 \text{ m}^3$ ) where per capita renewable water availability is highest ( $1932 \text{ m}^3$ ). This means that if the current water use patterns continue, most severe scarcity of water is likely to occur in the region where physical availability of water is short.

## 2.3. Scarcity perpetuated by unsustainable water use

A study commissioned by the UN Commission on Sustainable Development (Raskin, Glick, Kirshen, Pontius, & Strezpek, 1997) had defined water scarcity in terms of the total amount of annual withdrawal as a percentage of the annual water resources. According to this criterion, if the annual withdrawal exceeds 40 per cent of the annual water resources, the region can be called water scarce.

Going by this criterion, three regions of the state, namely North Gujarat, Saurashtra and Kachchh are already water scarce and the figures are alarming. In North Gujarat, for instance, the average annual water withdrawal for all uses (estimated to be 6008 MCM) is already close to the annual water resources (6105 MCM), throwing clear signals of unsustainable resource use. As the runoff (which accounts for 33 per cent of the total renewable water) is not fully exploited, the additional water for withdrawal is coming from depletion of the stored groundwater. Alarming drops in groundwater levels manifest this. In Saurashtra, the average annual withdrawal of water is estimated to be 5449.5 MCM against a total renewable freshwater availability of 9287 MCM. In Kachchh, the average annual withdrawal is 691.7 MCM against an average annual freshwater availability of 1275 MCM. The withdrawal is exceeding 40 per cent of the renewable freshwater in all the three regions and therefore going by the criterion of Raskin et al. (1997), these three regions are water scarce.

## 3. Political economy of water allocation in Gujarat

Gujarat is one of the states in India which is undergoing rapid industrialisation, and the annual industrial growth rate (compounded) during the past decade has been 13.83 per cent (Hirway &

Mahadevia, 1999). The industries, which are generally set up in and around urban areas, also bring along large rural populations to these areas, leading to fast growth in urban populations, raising the demand for water rapidly. The decadal growth in urban population in the state was 3 per cent against an average population growth of 1.94 per cent (Hirway & Mahadevia, 1999). Growth in fertiliser industry is dependent on growth in irrigated crops. Growth in other sub-sectors such as sugar and textiles is directly and heavily dependent on growth in cash crops like sugarcane and cotton that provide raw materials to these industries.

In the current political economy of growth based on industrialisation and urbanisation, irrigation of water-intensive cash crops gain priority over subsistence farming and rural domestic uses. For instance, the estimated water use in urban areas of Gujarat (in 1997) was 728 MCM against a requirement of 600 MCM. On the contrary, against a requirement of 753 MCM for domestic uses in rural areas, the estimated use is only 541 MCM. The urban domestic water requirement was estimated using a norm of 100 l per capita per day (lpcd), which included small towns, large towns and big cities. The rural domestic water requirement was estimated using a norm of 70 lpcd. Further, the state required 14,176 MCM of water for growing food grains in 1997. Against this, the use was only 5643 MCM. At the same time, a total of 11,456 MCM of water is used for irrigating cash crops comprising sugarcane, banana, oil seeds and tobacco.

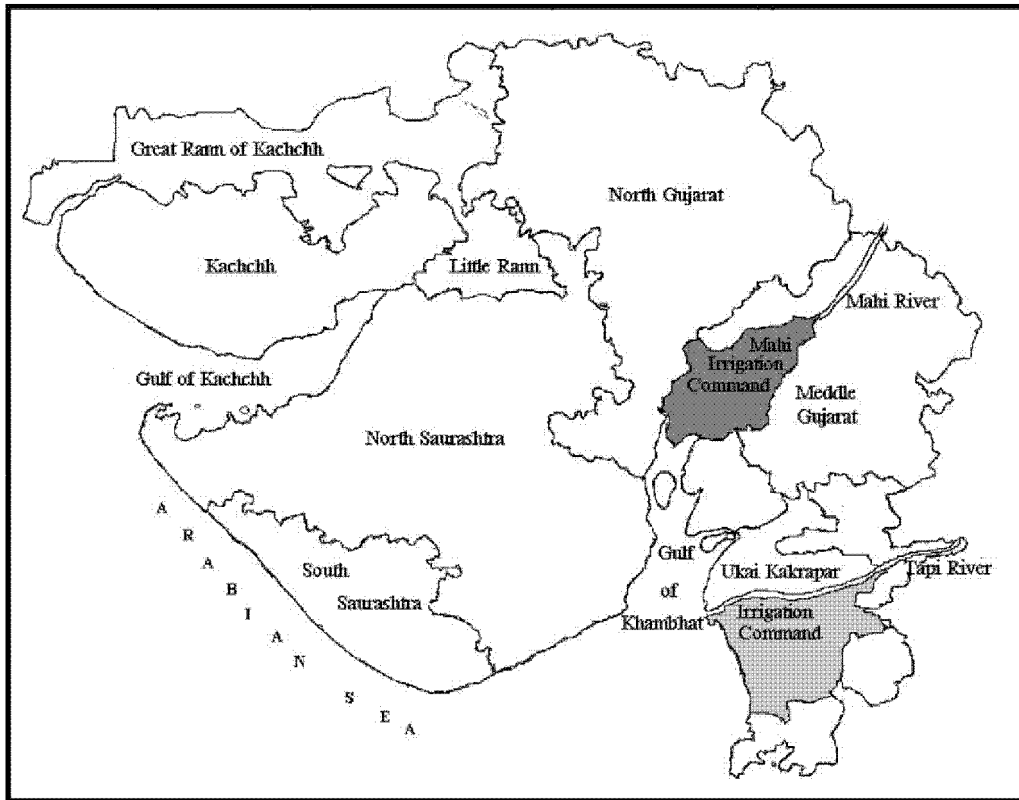
The policies adopted for pricing of irrigation water and electricity used in the farm sector are not driven by the concerns of making maximum benefits of irrigation reach the poor farmers for their subsistence, but for creating facilities for rich farmers to grow crops that support associated industries as reflected in the pricing structure for canal water and electricity used for groundwater pumping. They are analysed in the following sections.

### *3.1. Subsidised pricing of irrigation water*

The annual irrigation subsidies in India are estimated to be around 5400 crore rupees (Wolf & Hubener, 1999). Water rates in canal irrigation are heavily subsidised in Gujarat. The revenue recovery from the farmers is just not sufficient to cover even the cost of operation and maintenance (O & M) of the schemes, let alone the capital investment required for creating the facilities. While part of the reason for the deficit is the low rate of recovery of water charges, which is dealt with in the section that follows, an important reason is the low water rates itself. For instance, in the case of Kakrapar irrigation scheme, which is the largest irrigation scheme in the state (see Map 1), the demand for irrigation water charge during the period 1983–1991 was 34.07 crore rupees, while the amount spent on the O & M of the scheme alone came close to that amount with 33.32 crore rupees (source: Table 4 of Gajja & Prasad, 1998).

The irrigation water charges in the case of canals are based on the area irrigated and the crop types (see Table 1). The highest unit rate (per hectare) is for sugarcane and banana (Rs. 830 each).

For a given crop, the water charge is levied at a flat rate per acre basis irrespective of the volume of water used for irrigating a crop. Again, the implicit unit cost of irrigation water varies widely across crops and is much lower for highly water-intensive crops such as sugarcane and paddy as compared to other less water-intensive crops such as wheat and bajra (see Table 1). Therefore, the farmers do not have any special incentive to optimise watering or adopt water efficient crops and, in turn, adopt water-intensive crops and over-irrigate their fields. As a matter of fact, sugarcane and banana occupy a major share of the largest canal commands in Gujarat, namely, Ukai–



Map 1. Command areas of two major irrigation schemes in Central and South Gujarat.

Table 1  
Irrigation water rates and implicit unit cost by crop in Gujarat

Name of season	Name of crop	Irrigation water rate per hectare of canal water (Rs.) <sup>a</sup>	Implicit unit cost of canal water (Rs./m <sup>3</sup> ) <sup>b</sup>
Kharif	Bajra and jowar	40	0.027 (bajra)
Rabi	Vegetables	100	0.042 (potato)
Kharif	Rice	110	0.021
Kharif	Cotton	110	0.035
Rabi	Wheat	110	0.065
Hot weather	HW bajra, jowar	140	0.047
Two seasonal	Cotton, tobacco	200	0.132
Hot weather	Summer bajra	140	0.047
Perennial crops	Banana	830	0.039
	Sugarcane	830	0.035

<sup>a</sup> Source: Mahi Irrigation Circle, Kheda.

<sup>b</sup> Estimated using the values in column 3 and depth of watering figures estimated for the respective crops.

Kakrapar and Mahi (see Map 1). In 1985–1988, sugarcane accounted for 61.2 per cent of the gross irrigated area in the Kakrapar Irrigation Command. In the same year, paddy accounted for 51.9 per cent of the gross irrigated area in the Mahi Irrigation Command (Patel, 1990). Widespread adoption of these crops in the command areas leads to reduction in the area irrigated. Thus, the revenue that can be generated from the collection of water charges is far less than the amount required to meet the O & M costs of the irrigation systems.

On the other hand, the farmers who buy water from well owners also pay on hourly basis and the unit cost is in the range 0.50–0.80/m<sup>3</sup> of water. In terms of cost per unit area, the well irrigation is many times more costly than canal irrigation (see Fig. 1).

Theoretically, among the nine irrigated crops, paddy, banana, cotton and sugarcane are the most heavily subsidised crops when compared to groundwater irrigation. A rice cultivator, who uses canal water, incurs <4 per cent of what a water buyer or diesel well owner incurs as irrigation cost for growing rice if the depth of watering is considered the same in both cases. At a practical level, however, the subsidy enjoyed by the farmers depends on the area under each crop and intensity of watering, or in other words, the volume of water allocated for different crops. According to our estimates, against the total irrigation water use of 6177 MCM in South and Central Gujarat, sugarcane alone takes 2970 MCM and paddy takes 1644 MCM of water. Thus, the existing pricing structure for canal water leads to poor financial working of the irrigation schemes, promotes inefficient water use and inequitable distribution of the benefits of subsidy.

### 3.2. Subsidised electricity for groundwater pumping

Electricity charges for groundwater extraction are also subsidised. The annual subsidy provided by the government on the electricity supplied by the Gujarat Electricity Board (GEB) to farmers during 1995–1996 was 637.95 crores. Every unit of electricity used for agriculture purpose was subsidised to an extent of 64, 49 and 51.5 per cent, in the years 1992–1993, 1993–1994 and 1994–1995, respectively (GOG, 1996). The charges paid by farmers for electricity are based on the

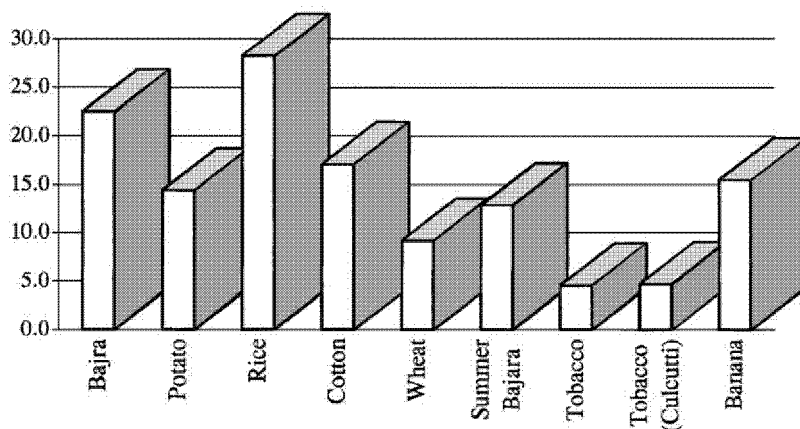


Fig. 1. Ratio of the cost of well irrigation and canal irrigation (Mahi Command, Kheda).



horsepower of the motor used for pumping groundwater and not on the number of units of power used. For instance, a farmer who runs his pump for 1000 h/yr pays just the same charge for the energy consumed as a farmer who uses his pump for 500 h/yr, even if both run pumps of the same horsepower. With the increase in hours of use of the pump, the implicit unit cost of electricity on the electricity used reduces, but for the user, the amount of subsidy increases. Thus, the farmers have no incentive to use electricity or water efficiently.

Fig. 2 shows how the percentage subsidy enjoyed by farmers varies with irrigation performance in different regions. This is based on data of 11 sample well commands in Junagadh and 12 sample well commands in Mehsana. In case of Mehsana, those who run their pump sets up to 2000 h/yr bear only 15 per cent of the cost of producing the electricity required to pump the water. In Junagadh, the amount of subsidy enjoyed by the farmer, who runs his pump set for nearly 400 h/yr is zero. This shows that the flat rate pricing of electricity in Gujarat has anomalies and leads to major regional disparities in the cost of groundwater irrigation and distribution of benefit from subsidies on electricity. Therefore, the electricity subsidy in the farm sector favours those farmers who have plenty of water in their wells, who could run their pump sets for a longer time to irrigate their own land or sell the excess water to the neighbouring farmers.

The result is that well-owning farmers grow water-intensive crops even in areas such as Mehsana, Kachchh and Saurashtra, where groundwater is scarce. In Saurashtra, for instance, according to estimates, 3355 MCM of water is used to irrigate cotton against a total irrigation water use of 5011 MCM in the region. In Mehsana, a total of 695 MCM of water is used to grow water-intensive alfalfa (with an estimated average irrigation water use of 2000 mm) against a total irrigation water use of 5372.5 MCM.

Now, due to the vast differences in groundwater levels that exist across different regions of the state, the electricity required to pump unit volume of water varies widely. This means, a farmer in Mehsana has to use more than  $2\frac{1}{2}$  times the energy a farmer in Saurashtra has to use to pump the same amount of water. Thus, the electricity use does not reflect the amount of water pumped.

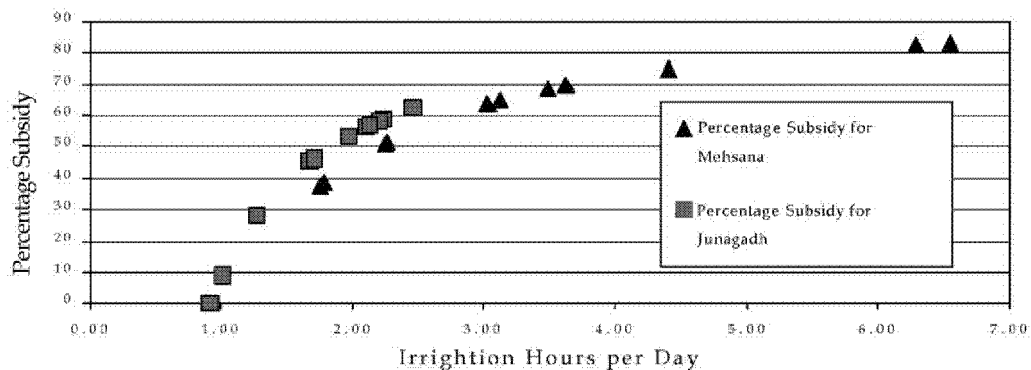


Fig. 2. Subsidy in electricity supply as function of hours pumped.

#### 4. Fiscal instruments for managing demand of water in irrigation

##### 4.1. Volumetric pricing of irrigation water from canals

The fact that water is an economic resource should be reflected in the pricing of water. Volumetric pricing of irrigation water would create incentive among farmers for efficient use of water, unlike in the case of crop-area based pricing where the marginal cost of using water is zero. At the current rates, the price that canal irrigators have to pay for irrigation water is a small percentage of the gross value of output from the crops. In the Kakrapar Irrigation Command, the percentage contribution of irrigation water charge to the gross income from canal irrigated crops varied from 1.96 to 6.15 per cent for land irrigability classes I–IV. In the case of cotton, it varied from 1.1 to 6.91 per cent and in the case of paddy from 1.15 to 5.86 per cent (Gajja & Prasad, 1998). Therefore, prima facia, there is a case for enhancing the water rates. But, the question is as to what level irrigation water rates could be raised so as to improve the financial working of the irrigation schemes without adversely affecting the economic viability of farming.

It costs many times more for well owners in canal commands to irrigate 1 ha of land as compared to canal irrigators (Patel (1990); Gajja & Prasad (1998) and our own estimates shown in Fig. 1). At the same time, they get as much net return as the farmers who depend on canal irrigation (our own estimates) due to the positive differential yield they get when compared to farmers who use canal water. In the case of canals, the poor quality of irrigation leads to poor yields. The differential productivity achieved in well-irrigated fields offsets the increased cost of irrigation that water buyers and diesel well owners have to incur. For instance, the shallow tube well owners in the Kakrapar Command get much higher yield and net returns as compared to their counterparts using canal water (see Table 2).

These observations lead us to the conclusion that the rates for canal water can be increased to substantially higher levels. To begin with, irrigation water can continue to be charged using crop-area as the basis. But, the water charge per unit area of a particular crop can be fixed on the basis of irrigation requirement of crops. For instance, summer paddy, which has a net irrigation requirement of 1200 mm, has to be charged 4–5 times more than mustard that has a net irrigation requirement of only 240–300 mm for every single hectare of irrigation. This can create incentives for farmers to adopt crops that are comparatively more efficient from the point of view of water-use economics. However, such a pricing structure could also result in water wastage. The reason being that the price that a farmer has to pay is only dependent on the type of crop and the area. But, this would be a better alternative than the existing one.

Table 2  
Yield and net income for major irrigated crops in Kakrapar Command, Valsad

Source of water	Sugarcane		Paddy	
	Yield (tonne/ha)	Net return (Rs./ha)	Yield (tonne/ha)	Net return (Rs./ha)
Canal	61.00	3631.00	2.87	2326.00
Tube-well	71.40	5032.00	3.41	3944.00

The next step in the process of reforms in irrigation water pricing should be volumetric pricing of water. Pricing of water should be done in such a way that the volumetric prices reflect the economic value of water.

Pricing of water goes along with improving the quality of irrigation. Today, the quality of irrigation service provided to the farmers is very poor. A main reason for this is the poor physical infrastructure built for water distribution, delivery and drainage. Mostly, canal systems for water distribution are lined only up to the branch canals. The remaining stretches of the canal that run into several hundreds of kilometres are unlined. Therefore, huge amount of water is lost in seepage and breaching of canal embankments. Excessive seepage from the system and the lack of adequate drainage causes water logging and salinity problems in the command area.

The annual budgetary allocations for O & M of the irrigation infrastructure—canal network, head and cross regulators, outlets and drainage—are very small. Furthermore, a major chunk of these funds is being used for meeting the salaries and overheads of the field staff and repairs and upkeep of the buildings and vehicles of the agency. While such establishment charges are increasing over a period of time, there have been no significant increases in the overall provision for O & M. The amount actually available for *repairs and maintenance* of the physical infrastructure therefore remains very low (Patel, 1990; Gajja & Prasad, 1998).

For instance, a study by Gajja and Prasad (1998) showed that in Kakrapar Irrigation Project, the establishment cost ranged from 43.2 to 60 per cent of the O & M costs during the period, from 1983–1984 to 1991–1992, keeping the rest for *maintenance and repairs* (see Table 3). The study also found that a large chunk of the amount spent on repairs and maintenance was for maintenance of office buildings, upkeep of quarters, construction of new buildings and quarters. Thus, nearly 80 per cent of the O & M costs were spent on establishment, leaving only 20 per cent for *maintenance and repairs* (Gajja & Prasad, 1998). Therefore, the actual expenditure on repairs and maintenance of the irrigation systems is approximately Rs. 80/ha, while the Study Group of the Government of Gujarat (1988) suggested Rs. 230/ha as O & M costs per hectare of gross irrigated area. An investment of Rs. 250/ha of the gross irrigated area for *maintenance and repairs* seems to be appropriate for proper upkeep of the irrigation systems, apart from the budget required for meeting salaries and other overheads.

Table 3  
Break up of operation and maintenance cost of Kakrapar Irrigation Project<sup>a</sup>

Particulars	Amount spent in Rs./ha in different years							
	1983–1984	1984–1985	1985–1986	1986–1987	1987–1988	1988–1989	1989–1990	1991–1992
Repairs and maintenance	67	68	68	75	95	86	172	196
Establishment	51	61	78	96	111	188	146	169
Total	118	129	146	171	206	314	318	367
Est. cost as % of total cost	43.2	47.2	53.3	56.1	53.9	59.9	45.9	46.0

<sup>a</sup>Source: Gajja and Prasad (1998).

Rs. 100 = 2.1 US dollars at the current exchange rate.

Inadequate provision of budget for maintenance and repairs results in operational inefficiency affecting the quantity and quality of irrigation service provided adversely. This, in turn, greatly reduces the ability of the agency to recover water charges that are due. Thus, the revenue realised from the sale of water remains below the cost of O & M. In the long run, due to continued neglect, the gap between O & M cost and the revenue widens.

Improved investment in irrigation infrastructure and their O & M is the fountainhead of the larger strategy to increase the water rates and improve the rate of recovery. The budgetary provision for maintenance and repairs of canal systems need to be separated from the provision for meeting the establishment costs. The increased revenue due to the increase in water rates and improvements in rates of revenue recovery from the farmers would greatly enhance the ability of the agency to provide greater budget for the O & M of the irrigation systems. We estimate that the irrigation department (Narmada Water Resources and Water Supply Department) will have to allocate nearly 200 million rupees annually only for the *maintenance and repair* of the irrigation infrastructure. It will also be appropriate to pump in additional funds for rehabilitation of the canals. With such patterns of investment, the total investment required to cover the *maintenance and repairs* and the establishment costs would be nearly Rs. 600/ha, or 480 million rupees for 800,000 ha of irrigated command.

But, technological innovations in the design and construction of irrigation systems would be the corner stone of the entire exercise of bringing in reforms in the pricing policies. Technological innovation includes installation of control structures, flow measuring instruments. Implementation of unit pricing system requires creation of appropriate institutional structures at various levels for proper monitoring of water use and flow measurements. Water users associations could be promoted at the outlets and higher levels for irrigation management. They can perform the following functions: monitoring water delivery at the outlets and higher levels; ensuring allocation of water among farmers and monitor water use by individual farmers below the outlets; recovery of water charges; O & M; and resolving conflicts among farmers and also between farmers and the irrigation bureaucracy. We propose an additional investment of Rs. 150/ha of canal command every year to cover the operating costs.

The volumetric water charge is to be kept at a level so as to cover the full O & M cost, and the additional investments required for technology and local institutional development. If the price of water is kept at Rs. 0.15/m<sup>3</sup>, uniformly across the crops, it will be sufficient to cover the total O & M cost of all irrigation schemes (based on the assumption that on an average a total of 4000 MCM of water is diverted from surface schemes for irrigation). In such a situation, the “price increase” affected the farmers, who grow highly water-intensive crops such as paddy, sugarcane and banana, which will cost much more than for some of the less water-intensive crops. This is in view of the fact that the implicit unit cost of water for these water-intensive crops are much lower than that for low water-intensive crops such as wheat and tobacco (see Table 1). In such a case, the actual price of irrigation water, which a banana or sugarcane grower has to pay, will be nearly Rs. 3600/ha. Similarly, the price of irrigation water, which a farmer who grows paddy in kharif season, will have to pay, will be nearly 7 times the price he/she is currently paying (Rs. 785/ha). Such major hikes in water prices can create incentives among the farmers to use water more efficiently.

Finally, the extent of “saving in water” which can be achieved at the system level through efficient use practices at the farm level by rational water pricing and technology changes depend

on the nature and extent of losses in the irrigation system. The underlying premise is that actual losses occur only when the water is not available for future beneficial uses. Often, the water lost at one part of the system is available for use in another part or in a different system within the same basin. This is mostly the case with the excess runoff from irrigated field, which is available for direct lifting from the drainage systems. In the case of the two irrigation systems, we have dealt with here, the water, which is lost in seepage and percolation, and field evaporation is a significant part of the losses. Excessive seepage and percolation is causing serious water logging and soil salinity problems in the two irrigation commands, as groundwater is under-utilised. The underlying saline groundwater in many areas also acts as the “sink” for the percolating water. Thus, efficient use of canal water would result in actual saving of water. However, the actual extent of saving in water can be analysed only through water balance studies of the entire irrigation system.

#### 4.2. Pricing of electricity for groundwater pumping based on unit power consumption

The introduction of unit pricing system, if implemented properly with adequate institutional arrangements in place to ensure good quality power supply and monitor the use of electricity by the individual farmers, will create disincentives for overuse of energy and water. Thus, farmers will not only use water efficiently, but also invest in improving the efficiency of electric motors and pumps. But given the wide regional variations in the energy requirements for pumping a unit volume of water across regions, a blanket unit rate will not be socially acceptable to the farmers in regions where pumping depths are very large (for instance, alluvial areas of North Gujarat covering Mehsana, Gandhinagar and Ahmedabad). The reason for this is that if the farmers in these regions pay the actual cost of generation of electricity supplied by the GEB, the food crops such as wheat and summer bajra will become economically unviable. Table 4 shows that with unit rate based pricing structure, the net return from wheat will be negative and that from summer bajra and castor will be almost negligible. In such areas, the subsidised unit rates can be implemented if the production of subsistence agriculture is to be sustained in the region.

Today, farmers are not able to take full advantage of the heavy subsidies due to the poor quality and low reliability of power supplies. Due to interruptions in the power supply and the poor quality of power, farmers do not have absolute control over water in their wells. The time of power supply in the farm sector changes once in every fortnight. The farmers water their crops

Table 4  
Estimated net return from well irrigated crops in Mehsana district with unit pricing of electricity

Name of crop	Average water application rate (mm)	Total energy used for 1 hectare irrigation (kW/h)	Total cost of energy (Rs.)	Yield per hectare (kg)	Gross income per hectare (Rs.)	Cost of cultivation excluding energy cost (Rs.)	Net income per hectare (Rs.)
Cotton	891	3440	6880	4230	74890	23,081	45,028
Wheat	902	3434	6865	2362	4998	11,228	–3095
Mustard	508	2220	4440	1312	17,220	9087	3693
Summer bajra	757	3275	6550	2747	16,628	9241	837
Castor	1597	5922	11,855	2115	25,843	12,857	1142

when the power supply is available and often excessively. As a result, crop watering is not timely and optimum.

In spite of the fact that the direct cost of irrigation using diesel pump is much higher as compared to the implicit cost of irrigation using electric motors, the command areas with diesel pumps receive more irrigation and give much higher yield levels as compared to those with electric motors. For instance, in Saurashtra, where the farmers are using dug wells fitted with electric motors and diesel engines for pumping groundwater, the diesel engine owners were found to be obtaining much higher yield as compared to electric well owners (see Table 5).

Similar trends were found in Kheralu taluka of Mehsana district where groundwater is still available at shallow depths and farmers use open wells for irrigation. Out of the five crops, namely, wheat, castor, groundnut, mustard and bajra, for which data on irrigation and yield were analysed, total hours of watering was found to be higher in favour of command areas with diesel pumps for four crops, namely, castor, wheat, mustard and bajra. The yield was found to be higher in favour of commands with diesel pumps for crops, namely, groundnut, castor, wheat and bajra (Kumar & Patel, 1995).

The positive differential yield found in both the cases may be obtained due to a combination of factors including higher rate of application of fertilisers and other inputs rather than timely and adequate watering alone. The reasons being that due to the uncertainty about power supply, the electric well owners may invest less for fertilisers and other farm inputs as a matter of risk coverage. Nevertheless, it is sufficient to offset the increased energy cost and other input costs that the diesel well owners have to incur for energy. Thus control over watering will have greater bearing on the net returns from irrigation than the cost of irrigation. This means that the desired impacts of changes in the pricing structure of electricity on economic efficiency of irrigated crops can be realised only if the quality of power supply is ensured.

Like ensuring good quality power supply, correct monitoring of the use of electricity is also of paramount importance in ensuring the desired impacts of unit pricing. Electricity theft had been very rampant in the tube well-irrigated areas of Gujarat till unit pricing system was abolished in 1987. One way to reduce theft would be to supply electricity in bulk to groundwater users' co-operatives. Such co-operatives could be promoted at the level of a village or a group of 2–3 villages depending on the number of users at the farm level. It will be socially viable to form such co-operatives given the fact that there are only 17,500 tube wells in the entire North Gujarat

Table 5  
Comparison of irrigation water use rates and yields for major crops in Saurashtra<sup>a</sup>

Name of crop	Irrigation water use and yield of major crops with					
	Diesel wells			Electric wells		
	Depth of watering (mm)	No. of waterings	Yield (kg/ha)	Depth of watering (mm)	No. of waterings	Yield (kg/ha)
Cotton	1.33	17.7	2283	1.05	16.4	2175
Onion	1.63	19.3	24,500	1.07	12.7	18,125

<sup>a</sup>Source: Kumar, 1997.

