Is Irrigation Water Only Used for Irrigation? An Enquiry into the Alternate Uses and Its Value

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Abstract: *Irrigation sector investments in Kerala have been mounting since independence. But the financial performances of these investments were far from satisfactory level. In an era of growing divergence in water supply and demand, the emergence of water markets is imminent. This calls for a realistic pricing strategy for water use, whether in agriculture or other sectors. The canal water though targeted at the agriculture sector, often is put to non- irrigation uses. This paper discusses a method to quantify the non irrigation uses of canal water and assess the value of the same, based on a study at Peechi irrigation command area in Thrissur District of Kerala, India . The people's Willingness To Pay for the same is also assessed. The study was funded under e world Bank Funded India: Environmental Economics Capacity Building Project implemented by Indira Gandhi Institute of development Research,Mumbai..*

Development of Irrigation Infrastructure has been a priority area in Kerala, as evidenced by rising public investment in this sphere. Total investment on irrigation structure was Rs 11.79 crores during the first plan period, which rose to Rs 1050.96 crores during the ninth plan period. Most often, one third of these investments were for the minor/major irrigation projects. On the other side, the financial recovery of these investments was found to largely questionable. Gulati et al 1994 and Mitra 1996 has highlighted the poor financial performance of irrigation projects in India. Simultaneously, the productivity of irrigated agriculture was also not significantly higher than that of the counter part situations, often. This can be attributed to unscientific water use pattern among the users, and unequal distribution in the canal commands

If the irrigation investments are to be made socially just, financial performance of the same needs to be assured. In an era of growing water scarcity, the water becomes an economic good. Still the existing water rates in different States of India are too low to cover even the operation and maintenance costs of such projects (GOI, 1972; Patel and Himmat 1990; Gulathi, 1992). Under pricing of canal irrigation is reported as one of the major causes of its low productivity and this leads to over-irrigation, wastage and misutilization leading to low productivity (NCAER, 1959; GOI, 1972; Asopa, 1977; Patel and Himmat 1990).

Even though the overall receipts from water charges increased during the last decade, the modest increase in receipts from irrigation schemes was not sufficient to keep with increased operational and maintenance costs Gulathi (1994). At the same period, price of agricultural commodities roughly doubled, but water charges remained the same. In Kerala the water cess collected was much below (11.72 per cent) than the cost of irrigation (Suresh, 2000).This necessitates the restructuring of the existing policy in the irrigation sector for improving the efficient production, management and utilization of canal irrigation

The people in the canal commands depend on the system for varied uses, both agriculture and domestic. An understanding of the non irrigation uses of canal water and the value of the same can help a lot in framing a suitable pricing policy. This paper is an attempt on that line.

The paper forms a part of a major study conducted with support from the world bank aided India: Environmental Economics Capacity Building Programme implemented by Indira Gandhi Institute of Development Research,Mumbai.

Study site

The Peechi irrigation project is one of the major irrigation projects of Kerala, India. The Project consists of

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masonry Dam and a storage reservoir at Peechi and a system of irrigation canals which criss cross the Thrissur taluk. The project was started in 1947 and completed in 1959. It has a canal system consisting of two main canals, on either banks and its branches and distributories to irrigate an area of 18,623 Ha.

This dam is the source of drinking water to the Thrissur Municipality and adjoining Panchayats.

Sampling Design and Data Base

Multistage stratified random sampling technique (stratification based on length of canal) was adopted for sample selection. The Right Bank Canal (RBC) and Left Bank Canal (LBC) were divided in to approximately three equal parts based on the total canal length to demarcate the head, mid and tail portions. From each portion one distributory was randomly selected.

A detailed list of beneficiaries of canal water who donot depend on canal water for irrigation directly was prepared.

This included

1. farms which depended on the canal for recharging the wells, in the command area(irrigation and domestic uses from the well)

2. people who depended on canal directly for domestic uses and not for irrigation.

a)human uses washing,bathing b) non-human uses

The information was compiled from various sources (Department of Agriculture, Command Area Development Authority, local Non Governmental Organisations, Neighborhood Groups etc.) A random sample of fifty farmers were selected from recharge category and sixty from non irrigation use group. From the list of farmers in the command area of each distributory, proportionate number of random samples, were identified. This proportion was the ratio of residents in that command area to total number of residents in the command area of the project.

Data were collected through personnel interview method using structured questionnaire, direct observation, participatory method and Contingent Valuation Method. A multivisit programme schedule was resorted for collection of data. The following chart shows the data collected by each method.

SL. No.	Type of data collected	Method of data collection
1.	Cropping pattern, Farm income Socio economic parameters	Questionnaire/ Direct observation
2.	Water use measurements. (recharge, non irrigation uses)	Direct observation, Participatory method
3.	Alternate sources of irrigation drinking water/ alternate cost Willingness To Pay	Contingent Valuation

The volume of water by recharge was measured by monitoring the level of water in the wells in the sample farms at different points of time and computing the same. Similarly the costs and income estimation were made based on the prices prevailing at the time of survey, i.e. 2000-01 and 2001-02.

Analytical tools employed

The value of water was computed by adopting two approaches as detailed below.

1. Cost based valuation

The cost of providing the service is considered as the basic factor reflecting its value. The various costs considered are

A. Fixed Cost

Peechi reservoir caters to the needs of Irrigation and drinking water supply to the neighboring corporation of Thrissur. Of the total volume release of 117.55mill.m^3 /year 89.82 mill.m^3 is given to Kerala Water Authority and the rest is for irrigation supply.

The fixed cost component includes the investment on plant and machinery, the distribution system and related initial expenses. The Dam was commissioned in the Year 1957 and the total initial investment cost is reported as Rs. 235 lakhs. However, considering the long life span of the Peechi irrigation system this component was not included in this study.

B. Variable costs

The total variable cost incurred in the project during the last 10-year period from 1990 to 2000 was collected from the concerned office

The Marginal Cost (MC) was estimated from the function, $C = \alpha.Q^{\beta}$, by taking the first derivative.

$$MC = \beta * \bar{C} / \bar{Q}$$

where, C is the Total variable cost incurred in the project per year (Rs.)

Q is the quantity of water used per year (m^3)

Demand function

The cost based approach necessitates the estimation of demand function, for estimating the value. For this measuring scales was fixed in chosen wells and readings at definite intervals were recorded. The volume of recharge was computed from the readings and diameter of the well, which is considered as the consumption in the farm/household.

For non irrigation users the exact duration of activity (washing/bathing), frequency (hours/day, days/week, week/month, month/year), distance from dam, measurement of canal at the point of use were the important data, gathered for estimating the consumption data.

The demand function:

Farms depending on recharged wells

The factors determining the recharge of the farm wells were determined. The best-fitted model selected according to R^2 and Standard Error criteria was linear function. This was estimated after excluding the extreme values to get a better fit.

$$W = \alpha + \beta_1 .D + \beta_{2}.I + \beta_{3}.F + \beta_4..C$$

where, W is Net water recharge in wells (m^3)/ well/ season of irrigation (November to May)

D is distance from main canal (m)

I is Initial level of water (before opening the canal- m^3).

C is cost on irrigation structures (Rs.)

(The recharge facility can be effectively used if only irrigation investment for drawing water from the well is there. So this variable is included.)

F is farm size (ha) (small farms generally have a single well where as larger ones have more. This influence the recharge levels and hence farm size is taken as a variable.)

α is intercept

βi is slope coefficient

[This function was selected after running several production functions like, linear, Cobb-Douglas, Transcendental, Square root and Quadratic -with and without intercept term.]

For non irrigation purposes

Human uses:(bathing,washing)

Y=$+$1Ab+$2Di+$3Nu

Where Y = Quantity of water enjoyed (used) for the purpose (m^3/ year)

B = Benefit (Rs./ family/ year)(cost of using alternate methods-cost of using canal water).

D =Distance of user point from house (m)

$_{Nu}$ = Family size(no.)

ii)Non human uses

Y=$+$1Ab+$2Di+$3Nu

Where Y = Quantity of water enjoyed (used) for the purpose. (m^3/ year)

B = benefit (cost of using well water-cost of using canal water) (Rs./ family/ year)

D = Distance of user point from house (m)

Nu = Number of livestock

On estimation of Demand function for each group, the value is estimated by multiplying unit cost with mean consumption.

Willingness to Pay

The concept of WTP is extensively used in the measurement of intangible benefits (Ghatak and Singh, 1994). The WTP expressed by the group reflects the additional benefits they derive by way of canal water, by way of increased land value, incremental farm income and better socio-economic facilities. So WTP can be taken as the upper limit of the value attached to irrigation water, over and above the cost of supplying it.

Contingent valuation is a direct method of valuing a service or commodity as good or bad for which a proper market does not exist. In that case, creating a hypothetical or surrogate market like situation and eliciting the consumer's preference for the commodity or service in question does valuation. The respondents were asked the question and the revealed preferences are stated.

Results

The farms depending on recharged wells

The Sample profile

Data pertaining to the personal characteristics such as family size, years of schooling, age, and land holding size, farm income and non farm income were collected from the sample farmers (Table.1). Most of the land was utilized for agricultural purpose (97.37 per cent) and only limited area is allocated for non-farm uses (2.63per cent), the average land holding size being 0.76 ha. On an average the farmers are getting an income of Rs. 68,380 per annum from farm (which constitute 56.66 per cent of their total income) and Rs. 52,310 per annum as non-farm income. The major share of total farm income was from crops (95.07 per cent) and remaining 4.93 per cent from livestock. On an average, farmer's income accounts to Rs. 1,20,690 per annum.

I. Cost based approach

The total variable cost incurred during the period from was compiled from the records of irrigation department.(Table.2)

It was estimated that,

$$\ln C = -60.04 + 3.9936.\ln Q$$

$$(27.23) \qquad (1.44^*)$$

$R^2 = 0.4273$

$F = 7.72^*$

* Statistically significant at 1% level

where, C is the Total variable cost incurred in the project per year (Rs.)

Q is the quantity of water used per year (m^3)

As such the Marginal Cost per water m^3 released is estimated as ***Rs. 0.14***. It is to be pointed out that this is the cost at the point of release and doesn't include the various social costs associated with the command area development programme.

a. Consumption of water for irrigation

The extent of indirect dependence on canal water by the sample population and the benefit derived out of the same is estimated and is presented in Table.3. the quantity and value of the same increases as one resides away from the main canal. It is seen that the distance of farm from the irrigation canal has inverse relationship with the net recharge of the wells, the slope coefficient being -0.3980. (Table 4) The unit increase in distance from main canal reduces the net recharge by 0.3980 m^3. The initial level of water table, which is determined by many factors like, proximity to wet land, position of well etc., has positive relationship with net recharge. Also the farm size (ha) positively influences the net water recharge. The level of water consumption through recharged wells was estimated and the result is presented in table 5

The recharge of the wells due to the proximity of canal is a positive externality and on an average the water table rise is calculated as 12.50 m^3 per well. The MC of m^3 water released was Rs. 0.1434, and the total positive externalities associated with the water recharge can be quantified as Rs. 225.67 per well per year (Product of Marginal cost of water release and quantity of water recharge per year (12.5x126 days of water release). This specifies that the farmers irrigating from recharged wells are enjoying a positive externality equal to Rs. 225.67 per year.

C. Non irrigation uses

The sample profile

The people living on either side of the canal depended on the canal for various non-irrigation uses (bathing, cleaning kitchen / household utensils, vehicles and livestock etc). The people who resided up to 200 m were found to use the canal for these purposes. The sample respondents in this case was confined to the head and mid portion, with a higher proportion in the head region.

Naturally the proportion of sample population who depended on the canal both for human and non-human uses decreases with distance from the release point as well as from the main canal. The farther the house, the fewer number of people enjoyed the canal water. On the contrary, the proportion of sample respondents who owned well was in the reverse order of the distance of their residence from canal. This is primarily due to the recharge facility due to canal as most of the parts of the canal are unlined. The recharge beyond 200m was found to be rather poor, which was also influenced by the gradient. This was further, evidenced by the average volume of water enjoyed by the respondents. The volume per time of use (day) was highest for the respondents who resided farther away, as they have to fully depend the canal for all water requirements. (own wells were not there and the recharge was poor). However, the farmers towards the mid portion of the canal system were reluctant to use the canal water for human use, for fear of poor quality. So it can be concluded that the dependence on canal water for non irrigation uses is skewed in favour of head region residents, that too within a distance of 200 Mts. on either side of the canal.

Data pertaining to the personal characteristics such as family size, years of schooling, age, and land holding size, farm income and non farm income were collected from the sample farmers.

The average age of sample population using the canal for non-irrigation uses was found to be 51 years (in the range of 25 years to 80 years). Avoiding two extreme values the range was 35 to 65 and the average was 67 years. This points out to the situation were the younger generation keeping away from agricultural or household related activities as well as becoming more urbanized.

Similarly educational status of the sample respondents reveals that most of them had university education (30.65per cent). 30.65per cent studied up to Xth standard and 27.42per cent studied up to primary level (IVth standard). Only one of the respondent was a graduate. The area allocated for agriculture and non-agricultural uses are almost equal (0.04 and 0.03 ha respectively), the average land holding size being 0.07 ha. On an average the farmers are getting an income of Rs. 64,936 per annum from farm (which constitute 67.21 per cent of their total income) and Rs. 31,682 per annum as non-farm income (32.79 per cent). The major share of total farm income was from livestock (80.67 per cent) and remaining from crops. On an average, farmer's income accounts to Rs. 96618.16 per annum. (Table 1)

I. Cost based approach

a. Consumption of water

For estimating this function, various functional forms were tried with the theory of "Confluence analysis" and among the outputs the log reciprocal and first differential estimate provided reasonable estimates and hence they were accepted. Accordingly, the results are furnished in table 6a&b.

The output suggests that all variables are having considerable influence over the quantity of water enjoyed by the users. While each variable was treated independently the "t" value was found to be significant in the case of distance and number of livestock. But while considering the overall fit the livestock number had a negative coefficient, but statistically insignificant. A reasonable high R^2 validate the hypothesis that these variables are interrelated.. Similarly the distance (from the user point to the residence) and quantity of water are positively correlated.

The quantity of water used for non human activities was found to be significantly influenced by the distance of house from the canal. The farther the house to the canal greater the quantity of water enjoyed as they are depending the canal fully for all water needs. Obviously people who stay near to the canal is enjoying a higher recharge and hence part of their requirement are met from own well.

The human uses primarily include bathing and washing of clothes, utensils, and vehicles. It is also seen from the estimates that as in the previous case the identified variables are significantly influencing the water use. The R^2 is found to be statistically significant and F ratios are reasonably high except for the pooled equation. Multiplying the consumption level with MC, the value of water used for non human purpose is estimated at Rs. 5715.5/ year/ family and for human use it is Rs294.18/family/ year.

3. Willingness to pay

Social and political dimensions of pricing decisions will be taken care of if willingness to pay of the beneficiaries are explored. Hence an attempt was made in these lines though a detailed framework was not adopted for the same.

Of the total respondents (in all the group) 16.2% was not willing to pay for water as it was beyond their thinking, "*to pay for water*"- water is to be a free gift of nature, as air. (Table 6).

Majority of the respondents (84%), however, was ready to pay, though the extent of payment and conditions varied. While 97% of respondents in the non irrigation group expressed their willingness to pay, it was only 72% in the indirect use group (recharge). Though the respondents agreed to the fact that the recharge facility was due to canal network, the argument was that they are not directly using the canal water. However, 72% were willing to effect the payment.

Among the group who were willing to pay, 91.39% of respondents expressed their willingness to pay for water if the supply is adequate and timely. This points out to the changing mindset of beneficiaries from considering water as a free gift. As one moved farther away from the origin of the canal system, people were ready to pay higher, even up to Rs.153/ ha, under satisfactory conditions of supply.

In a study confirming to paddy growers of Peechi irrigation command area in (Suresh, 2000), 18% of farmers declined to pay for water. The average willingness to pay of head, middle and tail reach farmers were Rs.107, Rs.127 and Rs.162 respectively. He established significant positive correlation of offered water charges with canal distance and negative relation with water available in the field.

The willingness to pay for a natural resource, which is treated as a public good primarily emerges only on account of the scarcity of the resource or restricted access. The user's willingness to pay in this case varies between the existing level of Rs.62/ ha to Rs.153/ ha, under ideal conditions of supply.

This points out to the need for creating water literacy -on its availability (present/ future), use and conservation. In a State like Kerala where literacy level is quite high, this task is easy. On the other side, the water use pattern of the people of Kerala is that of an abundant free gift of nature.

Table 1: Total variable cost incurred in Peechi irrigation project

SL No.	Year	Cost in Rs.
1	1991	1356136
2	1992	12434491
3	1993	32520515
4	1994	14981341
5	1995	8249881
6	1996	3248727
7	1997	3498905
8	1998	3414522
9	1999	4567871
10	2000	5490049

Source: Kerala State Irrigation Department

Table 2: Socio economic characteristics of sample farmers of Peechi Irrigation Command Area

Personal Characteristics	Unit	Mean Value* (recharged wells)	Mean Value (non-irrigation uses)
1. Family size	(Numbers)	5	4
2. Years of schooling	(Years)	9	6
3. Age	(Years)	47	51
4. Land Holding size			
4a. Agricultural use	(ha)	0.74 (97.37)	0.04
4b. Non Agricultural uses	(ha)	0.02 (2.63)	0.03
Total	(ha)	0.76 (100.00)	0.07
5. Farm Income			
5a. From Crops	(Rs. per year)	65,010 (95.07)	12548.26 (19.32)
5b. Livestock	(Rs. per year)	3,370 (4.93)	52387.45 (80.67)
Total Farm income	(Rs. per year)	68,380 (100) (56.65**)	64935.71 (100) (67.21*)
6. Non-Farm Income	(Rs. per year)	52,310 (43.34)	31682.45 (32.79)
Total Income of farmer	(Rs. per year)	120,690	96618.16 (100)

* Figures in parenthesis show percentage to total; ** Percentage to total income of farmer

Table 3: Non-irrigation use of canal water and benefit derived

Sl. No.	Distance of residents from canal	Volume of water enjoyed in cum/ day/ family		benefit (Rs. per use)	
		Human uses	Non-Human uses	Human uses	Non-Human uses
1.	Less than 50 m	3547.06	1463.10	9.47	3.24
2.	50-100m	9654.46	1868.83	7.68	4.18
3.	101-200m	5342.67	2336.61	11.91	6.00
4.	More than 200m	19116.00	2823.77	12.55	7.41

Table 4: Relationship between net recharge in wells and distance from Main canal

Net Recharge due to canal proximity (m^3)	Frequency	Percentage to sample farmers	Distance from canal (m)
Less than 10	13	26	101.2
10 to 20	22	44	76.9
20 to 30	11	22	81.2
More than 30	4	8	31
Total	50	100	

Correlation coefficient: 0.2512 (Statistically significant at 5 per cent level)

Table 5: Demand function for water in the farms with recharged wells(Linear production function)

Variable	Marginal Productivity Coefficient	Standard Error	t Value
Distance from main canal (m)	-0.3980*	0.05437	-7.3199
Initial level of water (Before opening the canal) (m3)	0.8391*	0.2176	3.8564
Farm size (ha)	2.2836**	0.9440	2.4192
cost on irrigation structures (Rs.)	0.00002	0.00005	0.4358
Intercept	19.7433*	1.7007	11.6091

Regression Statistics

Multiple R	0.9176
R Square	0.8420
Adjusted R Square	0.8048
Standard Error	3.7744
Observations	22
F value	22.6508*

*, ** Statistically significant at 1 and 5 per cent levels respectively.

Table 6a: Results of analysis on demand function –non human uses

Si.no.	Form	$	$1	$2	$3	R^2	F
1	Reciprocal Y=$+$1Ab+$2Di+$3Nu						
a)		0	0.0014 (0.000017)			0.942	614.92
b)		0		0.3427 (0.0061)		0.824	518.33
c)		0			0.572 (0.37)	0.724	619.92
d)		0	67.18 (0.007)	15.63 (0.37)	-2.84 (1.34)	0.983	913.42
II	First Difference Log In Y= In $+$1InAb+ $2In Di+$3In Nu						
a)		0	0.003 (0.00031)			0.631	73.14
b)		0		2.97 (0.032)		0.731	24.18
c)		0			1.93 (0.004)	0.634	32.18
d)		0	0.0082 (0.0064)	3.18 (0.37)	-1.64 (0.58)	0.584	46.84

Table 6b: Results of analysis on demand function- non irrigation uses – human uses

Si.no.	Form	$	$1	$2	$3	R^2	F
1	Reciprocal Y=$+$1Ab+$2Di+$3Nu						
a)		0	0.0032 (0.07)			0.943	271.52
b)		0		0.138 (0.008)		0.843	111.73
c)		0			0.0094572 (0.00003)	0.989	913.98
d)		0	71.28 (0.003)	18.72 (0.14)	-91.45 (1.92)	0.634	4.96
II	First Difference Log In Y= In $+$1InAb+ $2In Di+$3In Nu						
a)		0	0.00082 (0.071)			0.893	7614.97
b)		0		3.33 (0.74)		0.784	413.92
c)		0			1.99 (0.58)	0.793	418.94
d)		0	0.137 (1.94)	0.242 (1.33)	-0.137 (0.0003)	0.641	39.95

Table 7: Willingness to pay of sample farmers

SL No.	Category	Percentage
1.	Not willing to pay	16.2
2.	Willing to pay	83.8
2.a	Willing to pay in the present condition	8.61
2.b	Willing to pay in a better condition	91.39
2.b.1	Up to 25% higher than existing rates	71.06
2.b.2	Up to 50% higher than existing rates	18.42
2.b.3	Up to 100% higher than existing rates	7.89
2.b.4	Up to 150% higher than existing rates	2.63

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