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Pricing of Irrigation Water in Kerala with Special Reference to Environmental Management

P Indira Devi

Kerala Agricultural University, Thrissur

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P Indira Devi

Kerala Agricultural University, Thrissur

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1. INTRODUCTION

The sustained economic development in India is heavily dependent on the sustainable agricultural production, since agriculture is considered to be the backbone of the nation. Further, water resource availability and the quantum of water available for irrigation determine the sustainable agricultural production in India. It has been estimated that, of the total water use in the country, 80 per cent is being used for irrigation purpose. This highlights the need for an integrated efficient, sustainable and equitable water resource management in the country. Integrated water resource management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quality and quantity determine the nature of its utilization. To this end, water resources have to be protected, taking into account the functioning of adequate ecosystem and the perenniality of the resources, in order to satisfy and reconcile needs for water in human activities (UN, 1996).

The Crisis

The estimates of National Commission on Agriculture and Indian Water Resources Agency projects a widening gap between supply and demand of water in the country. The total utilizable potential in India is estimated at 114 Million-Hectare meters (Planning Commission) while there are projections as low as 86 Million-Hectare meters. The current demand of 75 Million-Hectare meters is expected to rise to 105 Million-Hectare meters in another 25 years.

A wide gap between the potential created and its actual utilization, low productivity in the irrigation commands as compared to the potential and the problems of adverse effects of waterlogging, salinity etc. have made the management of irrigation utmost important (GOI, 1972; Mitra, 1984). This has serious implications on the agricultural production front, as a shift in water availability will result in a shift in the cropping pattern resulting in social, economic, political and cultural divergence. Further, inequitable distribution of water through these projects, evident by the spatial disparity, leads to over use of the resource by a fraction at the expense of other users. The head-tail availability gap is reported to be wider in areas where such projects have been implemented (Prajapathy, 1992). Besides, performance of most of the irrigation projects was very poor with respect to productivity (Joshi and Agnihotri, 1984). The water use efficiency of canal irrigation is only between 38 per cent to 40 per cent and that of ground water 60 per cent. According to Planning Commission of India, a 10 per cent increase in efficiency can save enough water to irrigate 14 Million-Hectare of cultivated land. The challenge of agricultural sector will be to feed the increasing population, while the quality and quantity of water resource is declining.

Pricing of irrigation water

Majority of the population depends on the various major and minor irrigation projects widely distributed in the country and hence the sustained availability of water through this is vital for the society. But 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). Underpricing of canal irrigation is 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 where the economic main stay is agriculture, 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.

Pricing of water service has been a sensitive issue, since long. There is wide variation in water rate structures across the states, depending on the crop, type of irrigation system etc. There are various committees/ groups constituted in India for suggesting ways and means to fix water rates (Appendix-I). The role of water as a basic need, merit good, and a social, economic, financial, and environmental resource makes the selection of an appropriate set of prices exceptionally difficult.

Further, the application of price-based instruments, once an appropriate value system has been agreed, is particularly difficult in the case of water. This is so because the flow of water through a basin is complex, and provides wide scope for externalities, market failure, and high transaction costs.

In this context, the study was undertaken to assess the value of irrigation water as a basis for pricing of irrigation in Kerala for the sustainable and viable performance of the major irrigation projects. Often highlighted as a State of high literacy rate, Kerala is at the same time regarded as a place with very low level of water literacy, may be due to historical reasons. Water in the State is often regarded as a free gift of nature. In view of the emerging problems as explained in the foregoing discussions, it is important that a massive awareness programme on water use is very essential. In the long run it may form the basis for developing a strategy for pricing irrigation water that will reflex the actual value of the resource and highlight the total economic value of the resource. This project aims to generate information on the value of water as an economic good. As such the specific objectives of the study are:

Objectives of the study

- To estimate the value of irrigation water based on water productivity
- To identify the non irrigation uses of irrigation system and estimate the non-use values
- To measure the net benefits of return and estimate the total economic value of irrigation water.

Beneficiaries of the project

In an emerging era of successful decentralized planning process in Kerala, the actuarial pricing of irrigation water will be easier. Estimation of comparison of irrigation efficiency across the crops/ sources will help the farmers to effect the allocation of irrigation water at socially desirable levels in the best way possible according to the comparative advantage. An understanding of the negative impacts of over irrigation will help the farmers in careful irrigation management. A realistic pricing strategy will force the users to adopt an irrigation plan/ cropping pattern ensuring maximum efficiency/ returns. It will encompass the externalities due to irrigation like salination, soil erosion, flooding etc. The results of the study will help the administrators aware of the various effects of irrigation at inter and intra-generational levels and related socio-economic problems. The demand for irrigation water is generally believed to be price inelastic. In that assumption a rise in price of irrigation water (which is on account of internalization of externalities) will generate enough revenue to the supplier to make necessary investments. A pricing strategy which reflects peoples WTP will be acceptable to the people, who relieves the planners of the difficulties related with a price hike. Moreover scientific irrigation planning ensuring maximum returns to rupee invested can be the basis for irrigation management programme and crop planning.

Constraints

There are some drawbacks in the study due to the temporal, and manpower limitations. Absence of detailed farm records with the cultivators, result in memory recalls error. This was avoided to maximum extent by cross-questioning the respondents to ensure the validity of the answers and adopting a multivisit programme. Though maximum care was taken in the measurement of water, the errors associated with it can not be completely ruled out. The irrigation water used by a farmer is not only affected by the personal traits and farm characteristics (like cropping pattern index and farm size etc.), but also by the decision of irrigation authorities regarding release of water. But in this study, the water use was assumed as a function, which can be controlled and managed by the individual farmer. The cost of supply of irrigation water was estimated at the point of release, with out taking into consideration the transit losses and net work expenses. Similarly, the social investments in infrastructure development and other related programmes (Command Area Development Authority) was also not accounted though it can be argued that it is an expenditure, which is part of the irrigation investment.

The secondary data collected from sources like KERI, Irrigation Department and Command Area Development Authority seems to lack accuracy. For instance, the water release data shows that total outflow often exceeds the total inflow and dam capacity, which can't be explained.

2. CONCEPTS AND METHODOLOGY

This session proceeds under following subheads:

1. Sampling design and data source
2. Underlying conceptual issues
3. Analytical tools employed

1. 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.

i) Data sources

(a) Primary data

The important uses to which canal water is used are identified as follows

a) Direct irrigation of paddy lands and garden lands.

b) Irrigation /domestic uses through recharge of wells.

c) Domestic uses (human / livestock.)

As such, the data sources include these specific groups. A detailed list of beneficiaries of canal water (in each user category) were prepared by compiling the information 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 direct irrigation and recharge category and sixty farmers were selected from non irrigation use group. From the list of farmers in the command area of this distributory proportionate number of random sample, were identified. This proportion was the ratio of farmers in that command area to total number of farmers 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. (Direct irrigation, recharge non irrigation uses)	Direct observation, Participatory method
3.	Alternate sources of irrigation drinking water/ alternate cost Willingness To Pay	Contingent Valuation

The measurement of water used was done using a 'V notch' (Plate 1) in the case of irrigation uses. For recharge measurements, the level of water in randomly selected wells at different points of time were made and the volume computed.

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.

(b) Secondary data

The information regarding the irrigation system, its history, water release, cost, revenue etc were collected from various agencies like Kerala State Irrigation Department, Kerala Engineering Research Institute, Command Area Development Authority (CADA), State Department of Agriculture etc.

Economic Concepts Underlying

The proclamation, that water should be treated as an 'economic good' originated in the Dublin Conference. (ICWE, 1992). But the relevant problem now is whether it is to be considered as purely a 'private good' (left to the play of free market forces) or a public good (to be managed through intervention to attain social objective). In the former case, the equity in distribution of the resource will be at stake. But economic tools (subsidies) can be effectively used to correct these problems.

However, there are issues to be addressed while taking pricing decisions, the prerequisite of which is valuation.

Valuation of natural resources poses several methodological and conceptual problems. The methods proposed by different authors are to be primarily modified to suit the peculiarities of resource as well as location factors.

Normally price determination of a good is based on its cost of production and a normal profit. But, pricing decisions on essential services which involve scarce resources are to be taken considering the equity aspects and cost associated with the resource management. Bowers and Young (1999) suggests a "full cost recovery " for urban water supply. "Full costs" are defined to include externalities, sum of operating/ maintenance expenses, administrative costs, replacement cost, depreciation, opportunity cost of capital and externalities (COAG, 1995).

Externalities can be defined as a legitimate action by one economic unit that impact on the welfare of another economic unit that doesn't take place through markets (Bowers, 1997). McTaggart *et al* (1999) define externality as a cost or benefit that arises from an economic transaction that falls on people who do not participate in the transaction. However, lack of any deliberate intention is important (Mishan, 1969). Internalizing the externality ensures "Duty of care" for the environment (Binning and Young, 1998). Water pricing can be an effective tool in

- Internalizing the externalities in water supply system
- Demand management of water
- Ensure efficiency in resource use.

While trying to value irrigation water as a scarce natural resource, the following factors are to be taken in to account.

(a) Cost of supplying the resource.

(b) Incremental benefits derived from the use of the resource (Direct and Indirect)

(c) Scarcity of the resource. (in quantity and quality terms)

(d) Willingness To Pay (WTP) of the users.

a. Cost of irrigation service

Public services are generally considered as free services. This results subsequently in the over use of resources and poor quality of services. Since water resources are believed to the abundant and free gift of nature, irrigation water pricing is abysmally low. The fundamental guiding rule in this regard should be to ascertain at least a break-even condition.

Marginal approach in valuation

Whenever the benefit derived by the use of a resource is greater than the cost of that resource (i.e. the cost to the society, for sacrificing the production of some other commodities i.e., the opportunity cost or scarcity value) the consumption of that resource tend to increase and vice versa. So the value of resource is better expressed by its opportunity cost which can well be taken as the Marginal Value Product (MVP) (Conceptually opportunity cost of irrigation water is the returns foregone from the domestic/industrial sector by not allocating it to those sectors) of the resource in the concerned use. MVP indicate the shadow price (opportunity cost) which the farmers should be willing to pay for an additional unit of water. A price, lower than shadow price, will result in overuse of irrigation water. This concept was employed by Basawaraj (1998) and Suresh (2000), as a tool to fix water rates. The analysis by Suresh (2000) reveals that the existing water charge is almost tallying with the contribution of irrigation towards water yield. It was estimated at Rs. 62.90/ha (Marginal Value Product) But this does not accommodate the cost of providing the service.

Considering welfare, the distribution of water in a canal command is a zero sum game. By carefully measuring all the physical and distributional effects of irrigation water, the social value of a unit of water can be arrived at, which is the shadow price. Knowing shadow prices for water at different locations permit one to compare different water distribution pattern.

MVP function of irrigation shift up with the increased availability of auxiliary inputs and hence due to better access to these inputs, MVP of bigger farms will be higher than small and marginal farms. This warrants discrimination while formulating pricing strategies based on this (Maji, 1985).

On the other hand, estimation of marginal cost is also possible. Marginal cost of supplying water is the cost of delivering last unit of water Thus the short run marginal cost is the variable cost in supply of last unit of water with in the existing capacity of the system and long run marginal cost is the one beyond capacity of the system.

So the short run total cost from which the MC is derived is the sum of variable, and fixed costs. So here the value represents the cost of supplying an additional unit of water at a given time and place.

However, while marginal cost / marginal value concept is employed in making pricing decision, the concept of price elasticity of demand assumes much importance.

To summarize, opportunity cost (equals to the marginal value product) is the minimum value of water. The willingness and ability of the society to pay can be an indicator of people's attitude. However accounting issues in the estimation of TC (Total cost) form a major problem at practical application levels e.g.

- Internalization of externalities (pollution abatement cost)
- Accounting of establishment cost. Whether to take the historical cost or the replacement cost.
- Calculation of depreciation.

b. Incremental income approach

Valuation of irrigation water as a percentage of incremental income from irrigated farm is widely suggested as a basis of pricing strategy. Twenty to twenty five per cent of incremental benefits are suggested as ideal level for fixing the price of water, where it is suggested to revise it every five years or earlier when the product price exhibits a more than 15per cent increase. (Palanisamy *et al*, 1985). The Maharashtra Irrigation commission suggests a cost and benefit based approach. It should cover the cost of providing the service and should include a minimum of 10 per cent of gross income from the farm. Committee appointed by Government of India in 1964 suggests a higher proportion of 25-40 per cent.

c. Resource scarcity

Assured supply of irrigation water is the key to productivity. Most often the time and quantity of water release is not in accordance with crop requirement. Large scale diversions of irrigation water for drinking proposes is noticed in the case of Peechi irrigation project. The mounting alternate cost incurred by the Thrissur municipality and near by panchayats for drinking water supply is an indication of the level of scarcity of the resource. During 2000-01 the amount was Rs.12 lakhs (approximately). For the financial year 2001-02, top priority is given for drinking water projects allocating an amount of Rs.7.15 crores (Total budgetary expenditure is 71.44 crores). The increasing number of tubewells, borewells, and declining water level, increasing investments in water extraction etc also reflect the scarcity of the resource.

Direct incremental income from a farm is influenced by the cropping pattern, cropping intensity and market forces. Apart from this, the quality of microclimate, increased land value and related developments in infrastructure and social facilities are also perceived as the effect of irrigation by the user. Strictly speaking the direct incremental income can be same as MVP.

d. Willingness To Pay (WTP)

The consumers' willingness to pay is the maximum amount that a person will be willing to pay for a service rather than go without it. In irrigation sector this naturally depends on the factors like,

- The present supply system.
- The incremental benefits from the services.
- The alternate cost of enjoying the same service.

The consumer surplus observed is the difference between what he is willing to pay and what he is actually paying. So total WTP is the amount he pays plus the consumer surplus. Willingness to pay reflects the social mindset for payment and hence guides the policy makers in taking decision in water pricing.

The Total Economic Value (TEV) of a natural resource constitute the use and non use values which can further be categorized as Direct use value, Indirect use value, Option value, Bequest value and Existence valueThe Direct use value is measured as the incremental income from farm and indirect and non-use values are represented by the WTP, which is captured by the land values, and incremental income.

Analytical tools employed

1. Cost based valuation

The concepts discussed above are tried to capture by various methodologies as detailed below:

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

A. Fixed cost.

B. Variable cost (Maintenance cost, salaries and wages and other miscellaneous expenses).

Peechi reservoir caters to the needs of Irrigation and drinking water supply to the neighbouring 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.

A. Fixed Cost

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.

The investment in infrastructure on account of irrigation facilities includes indirect investments like better transportation/communication network, extension and development support etc (e.g. Command Area Development Authority). To delineate the cost of irrigation service in the total investment in these activities is a cumbersome process. So these investments are not included in the total investment amount in irrigation water supply.

The fixed cost recovery in any period should include the initial outlay, the interest on fixed capital and an inflation adjustment factor (Murugan and Pushpangadan, 1994).

If the interest is charged only on the outstanding balance and the principal is repaid uniformly, the amount to be recovered in the K^{th} year.

$$l_k = l_0 \left\{ \frac{I}{t} + [1-(k-1)/t]\,(1+r)^{(t-k+1)} \right\}$$

If this is to be distributed equally among the beneficiary farmers in the command area, the amount per hectare of irrigated land is,

$$E_k = \frac{l_k}{n_k}, \text{ and the}$$

$$\text{Inflation adjusted amount, } E_k^{*} = \frac{l_k\,(1+\Delta x_k)}{n_k} \qquad (1)$$

where, l_0 = initial investment

t = expected life

n_k = irrigated area

x_k = price index

The *rate of interest* charged on the fixed capital will be taken as the same as that of the actual interest rate on capital at the time of availing it.

The inflation adjustment factor can be taken as the wholesale consumer price index of industrial workers.

As an alternative to this, the book value of the structure (as estimated by the technical experts.) can also be apportioned per unit area or unit volume of water released {let it be (a)}. However, there are certain points to be considered in accounting the fixed costs.

- The investment cost should cover (apart from the material/ labour costs) the social and environmental costs associated with the irrigation structure and also the opportunity cost of the system. In most of the cases such exercises were not conducted, especially in the case of old projects. The initial investment cost of Peechi irrigation project is estimated as Rs. 235 lakhs, which includes only the direct investments.

- The question as to what proportion of fixed cost is to be accommodated in value estimation is often a matter of concern while formulating pricing strategies in irrigation sector. Tenth finance commission suggests a method to realize at least 1per cent of returns on capital, over and above the operational expenses.

- The allocation of fixed cost component through the life of the project is another issue. Though an equal distribution throughout the expected life span is possible, most often they exceed this target.

- Accounting depreciation as a cost also posed some problem when the usual method based on life expectancy is followed. Most often the book value may reach a negative figure in such cases. The face value of the asset (structure) as estimated by the professionals at the beginning of the year can be taken as the best possible solution in such cases.

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 is collected from the records of the Irrigation department. Dividing with the total volume of water released, cost per unit volume released is estimated i.e. (b). The estimation of Marginal Cost (MC) can also be attempted. So the Total Cost per unit volume of water released = (a) + (b)

Demand function

The cost based approach needs the estimation of demand function. For this the demand function is estimated for the three groups of users, identifying the factors influencing it.

The volumetric measurement of water was done using 'V' notch (Fig.3) specially designed to suit the purpose. The measurement was done as follows:

a) Direct irrigation from canal: The actual water use for irrigation was estimated by measuring water use by standard equipment like 'V' notch readings and actual duration and frequency of irrigation.

b) Recharge of wells: 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.

c) Non irrigation uses: 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 demand function of these group of beneficiaries.

The demand function for irrigation water in the farms in command area (Direct irrigation)

Among the various functions like Cobb Douglas, Linear, Transcedental, Quadratic, Square root etc with and without intercept, the most suited production function according to R2 and Standard Error criteria was:

$W = \alpha + \beta_1 . D + \beta_2 / I + \beta_3 / C$ ……. (1)

where, W is Water use for irrigation during the whole season. (m^3)

D is distance from main canal (m)

(Since the farmers adopt canal to field irrigation directly, the distance from main canal is expected to have an influence on water use.)

I is Income from farm (Rs.)/ hectare.

(Farmer level management decisions are often governed by farm income. Hence this variable is taken.)

C is Diversity Index

(Cropping Pattern Index reflects the crop water requirement, for the whole farm.)

α is intercept

βi is slope coefficient

The function can be estimated in the following form:

$$\boldsymbol{W} = \alpha + \beta_{1} .\boldsymbol{X_1} + \beta_{2} .\boldsymbol{X_2} + \beta_{3}.\boldsymbol{X_3} \quad \ldots\ldots (2)$$

where,

X_1 is D, X_2 is 1/I, X3 is 1/C

The Marginal productivity of each factors was found out by using first derivative of the function.

For the analysis, a Diversity Index has been formulated for each sample farmer. The farms mostly observed in study area were of Homestead farming. The area under each crop has been calculated and weighted average was taken and converted to a scale ranging from 0 to 1. The weight has been formulated as a percentage of total area under that particular crop.

i.e.,

$$W_i = \frac{\text{Total area under crop, i (ha)}}{\text{Gross Cropped area (ha) of sample farmers}} \quad \ldots\ldots\ldots\ldots\ldots (3)$$

where, W_i is the weightage given to crop i under homestead farming

The diversity index of i^{th} farm has been computed as:

$$CPI = \frac{\sum(A_{ij} . W_i)}{\sum A_j} \quad \ldots\ldots\ldots\ldots\ldots (4)$$

where, CPI is Diversity Index,

A_{ij} is Area under crop i under farm j

W_i is weightage for crop i

$\sum A_i$ is the total farm size.

Farms irrigated from recharged wells

The irrigation canal has positive externality through recharging the farm wells through proximity. There are a number of farmers enjoying this facility and this also should be considered while examining the demand for canal water. 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. Thus reducing the sample size to 22.

$$\boldsymbol{W} = \alpha + \beta_1 .\boldsymbol{D} + \beta_2 .\boldsymbol{I} + \beta_3 .\boldsymbol{F} + \beta_4 ..\boldsymbol{C} \quad \ldots\ldots (5)$$

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

i) Human uses:

$Y = f(AB, D, F)$

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

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

D =Distance of user point from house (m)

F = Family size

ii)Non human uses:

$Y = f(AB, D, L)$

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

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

D = Distance of user point from house (m)

L = Number of livestock

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

2. Productivity based valuation

For this purpose, a simple regression equation of the form ***Y= a+bx*** is attempted where,

Y= farm income (Rs./ hectare)

(In the case of direct irrigation and irrigation by recharge. In the case of non irrigation uses it was the additional benefit derived by using the canal water than the alternative strategy.)

x = Quantity of water use in m^3/ ha/ year.

A production function with all variables were not tried due to inherent problems in homestead farming and coconut based multicropping systems.

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, valuation is done by creating a hypothetical or surrogate market like situation and eliciting the consumer's preference for the commodity or service in question. But this method suffers from different kinds of biases, which may many times mislead the results obtained. (Pearce, 1993)

A detailed methodological approach is not resorted in this case. The respondents were asked the question and the revealed preferences are stated.

3. WATER RESOURCE USE IN KERALA

Kerala is one of the smallest states of India with a geographical area of 39,000 sq. km forming 1.18 percent of the country's area. The State supports a population of more than three crores, which is 3.7 percent of national population. The state is located in the South West of the subcontinent, as a narrow strip of land between the Western Ghats and the Arabian sea, lies in the tropics between 8º and 13º Northern latitude. (The map of Kerala is given as Fig.1). Kerala is known for her enchanting greenery, blue and serene backwater, calm ocean, high rainfall in two monsoons, large numbers of rivers and reservoirs and comparatively shallower ground water table.

The water resource position in Kerala

Kerala State is located in a high rainfall region in the country with the benefit of both the monsoons, with a greater contribution from South West Monsoon. Consequently, the habit and style of living as well as the biotic setting of the State are one of high water demanding. Average annual rainfall in Kerala is about 3000 mm, but its variability demands special care for conserving water resources for its optimal utilization over time and space. (Appendix II). It may also be pointed out that Kerala is one of the states with lowest per capita water availability in the country.

Water Availability in the State

Fresh water sources in the State.

The fresh water sources of the State are rivers, fresh water lakes and reservoirs, tanks and ponds, wells, springs, and surangams of North Malabar.

Rivers

Kerala has 44 rivers and all of them have very low discharge in summer. There is a general trend of rivers being more dry in summer than what they used to be decades back.

In summer, salinity enters deep inside the rivers. In some cases as deep as 23KM. Majority of Kerala Water Authority water supply schemes are river based and hence in summer, the water supply is either inadequate or occasionally saline. The rivers in Kerala hardly contain any water during six months in an year, majority of reservoirs do not get filled up even in monsoon and in summer, water level reaches the silted up bottom in many cases.

Fresh water lakes and reservoirs

In Kerala there is 2 freshwater and 19 irrigation or hydel reservoirs.

Tanks and Ponds.

Only around 10% of the tanks are currently being used either for domestic water supply or for Minor Irrigation Schemes.

Wells

Kerala has highest density of family based open dug wells in the world. On an average, there is more than 120 wells/sq. km. In droughty summers, the ground water table declines causing the drying up of about 10% of the house compound wells and thus affecting minimum of 15 lakhs of people with no assured water supply. More than 70% of the State's population get drinking water from their house compound wells and only around 30% population depend on Government sponsored piped water supply schemes. Majority of the bore wells/ tube wells provide less than 5000 litres per hour and are installed in the Government sector. They need high initial investment and high recurring expenses in terms of electrical energy, repair etc. There are occasions where house compound wells got dried up because of pumping from bore wells an there were occasions where tube wells in the coastal belt brought salinity in the coastal aquifers.

Springs

Kerala is endowed with 236Nos. of springs. Majority of the springs have summer discharge ranging from 10 to 100 litres per minute and few have discharge more than 100 litres per minute. Water quality, in general is good.

Surangams.

Surangams are horizontal wells dug through the hills and are in vogue in the semi dry areas of North Malabar to tap freshwater resources for drinking and irrigation. Flow is by gravity and hence do not require any energy to get it. A typical Surangam discharges 10 to 12 litres per minute during summer months and have a great potential to be used for combating drought in North Malabar.

Constraints in water resource utilization.

The singular/unique topographic features of the State introduce several advantages and constraints in the use of the water resources of the State. The undulating topography of varying degrees introduces certain physical and temporal distortions in the distribution and availability of water for productive purposes. The very undulating topography introduces certain restrains in the utilization of surface water in the conventional fashion as in the gravity system. On account of the undulating topography the proportion of irrigable land available per unit of surface area is low and hence the unit cost of distribution is relatively high. On the positive side, the irrigated lands are relatively free from water logging and consequent alkalinity-salinity problems. Again, seepage and percolation in the delivery system is a major loss in the plains. (Nair, 1977). The three-year average of irrigation water release data (1999-2000) shows that per annum, on an average, 79.54 Mm^3 water is released for irrigation purpose. The total water consumption estimated in the study comes to 13.4 Mm^3 for direct irrigation purpose and 39.43 Mm^3 as recharge in wells; the total being 53.01 Mm^3. Rest of the water is supposed to be lost in distribution as percolation, evaporation, seepage and other losses.

The data collected by the Central Ground Water Board (Gopakumar,2000) reveal a progressive fall in ground water level during past 10 years. According to the Board, the ground water level in the State have gone down by 1.5 to 2m from the decade's average level. Owing to small land holdings, high density of population and socio-economic conditions, the State has a very large number of dug wells.

Demand and supply of water

There are vast areas in Kerala, which do not have surface water sources to cater to the need of the people. There exists a very wide gap between the demand and supply of water in all sectors such as irrigation, drinking water supply and industrial water supply.

The demand for water in Kerala is mainly for drinking, agriculture, generation of electricity, aquaculture as well as for prevention of salt-water intrusion. The annual yield of water in Kerala in a normal year is around 7030 crore cubic metres and the ground water resource available is estimated at 7048 MCM. Nearly 40 per cent of the available resources are lost as run off causing heavy floods. Kerala would require around 3000 crore cubic metres of water for agriculture, 750 crore cubic metres for domestic uses and 1220 crore cubic metres for prevention of salt water intrusion. The pattern of demand for water is undergoing gradual but continuous changes towards increasing pressure for drinking and other household and commercial needs relative to the demand for irrigation.

Water requirement

The demand and supply situation in the water use sector in Kerala, looks much worse during the six summer months of December-May when most of the irrigation needs are to be met, salinity intrusion is to be arrested, hydel power generated to their full capacity and drinking water scarcity is most acute.

Of the total annual requirement of 48,600 mm^3 about 70-75 per cent will be needed during these months, while the summer flow will only be about 15 per cent. Thus, while requirements will be of the order of 35,000 Mm^3, the availability will only be about 10,000 $Mm^3$of, which only about 6000 Mm^3 will be utilizable. This is only $1/6^{th}$ of the available water. The only way to meet the demand is by storing the difference of 29,000 Mm^3. The present total storage is only 5500 Mm^3 including hydel reservoirs, i.e., 19 per cent of the needed storage (11.3 per cent of total annual requirement, 8 per cent of surface water yield). In the field of agriculture, out of a total area of about 15.85 lakh hectare of crops, which require irrigation, the irrigation support available is only 3.34 lakh hectare. In the drinking water sector, the average coverage is less than 50%. Out of the total cropped area irrigation facilities are at present available only to 25%.

As against the State's utilizable water resources of 43,000 Million Cubic Metres (Mm^3)[40,000 Mm^3 surface water and 3000 Mm^3 ground water], the future (year 2021) requirements would be of the order of 48,600 Mm^3, with irrigation taking the pride of place at 28,900 Mm^3 (59.5per cent), domestic and industrial uses 7500 Mm^3 (15.4per cent), salinity control 7200 Mm^3 (14.8per cent) and improving karilands (toxicity removal), 5000 Mm^3 (10.3per cent). There is thus a shortage of 5600 mm^3. Even assuming that the entire usable ground water is utilized (about 3000 Mm^3); there will be shortage.

Trade off in water use

In Kerala, the shift in priorities from irrigation to domestic water supply is the natural outcome of water scarcity. By all probabilities, there will further shift of water allocation from irrigation to industry, on economic considerations. This forecasts a dwindling situation of water allocation to agriculture. The challenge of agricultural sector in future may be to meet the food requirements of growing population, while irrigated agriculture will be facing severe problems. The situation is no different in water release schedule from Peechi dam, also showing changes in favour of drinking water supply.

The situation calls for an inquiry into the consequences of gaining proportion of water use trade off in Kerala, since agriculture is the mainstay of the state and diversifying water use at the expense of irrigation use will exacerbate the already stagnant agricultural scenario of the state. It has been proved widely that there exists a positive relationship between the productivity and irrigation and this signifies the relevance of irrigated agriculture in the state.

Irrigation potential of Kerala.

The irrigation potential of Kerala as adopted and estimated in the earlier plans was 15 lakh hectare (net) and 25 lakh hectare (gross) (fig 2,3,4&5). The major contribution anticipated was from the major and medium projects accounting for 6 lakh hectare (net) and 14 lakh hectare (gross). Against this the area actually brought under the major and medium projects till the end of 1996-97 as per command areas estimated by the irrigation department was only 2.16 lakh hectare (net) and 4.35 lakh hectare (gross). During the Eighth plan period, an amount of Rs.375 crores has been approved and Rs.517.50 crores has been budgeted for the major and medium irrigation sector to bring an additional area of 1,48,000 hectare (gross) under irrigation. Even though an amount of Rs.586.93 crores has been expended, the area brought under irrigation was only 26 per cent of the physical target. Escalation in costs consequent to delayed completion of projects resulting in lower physical coverage than originally anticipated has thus assumed a perpetuating phenomenon in the irrigation sector.

The net irrigated area in the State is estimated as 3,80,043 ha (1999-00) which exhibits an annual growth at the rate of 1.02 per cent. Government and Private canals are the major sources exhibiting a fast growth in their area of coverage, while private wells are the main sources of irrigation in the state covering nearly 31.65% of net area. (Table 3.1 and 3.2). Without due consideration to the fact that major share of cropping pattern in the State is perennials and the topography undulating, irrigation investments in the State are mainly aimed at rice. The gross irrigated area in Kerala is 4,70,698 ha. Paddy alone accounts for 44.36 % followed by coconut. (Appendix-III). However, over years, the growth rate in irrigated rice acreage shows the lowest growth rate, among the crops. (Table 3.3). The crop wise irrigated area in the command area of the project is furnished in table 3.4. Of the total area of 15,808 ha, 63% is irrigated. While 75% of area under crops like paddy and banana are irrigated, only 50% of coconut enjoy this facility.

Role of institutions in irrigation sector

Government institutions and supporting services.

The entire canal systems, dams and Kerala Engineering Research Institute(KERI) campus is under the control of the Executive Engineers, Irrigation division, Thrissur. Two assistant Executive Engineers and six Assistant Engineers help the Executive Engineer in the proper working of the distribution system. There are Overseers, canal watchman and lurkers to help the Assistant Engineer for the proper distribution of water. The on farm development works are attended by the engineering wing of

CADA (Command Area Development Authority). The Agricultural Department is doing the Agricultural Extension work in the command area of the project. The Revenue Authorities maintain Land records. Irrigation canal Committees (beneficiary committees) have been constituted for each branch canal. A project Advisory Committee has also been formed which contains members from the Canal Committee to formulate water distribution pattern for each crop.

The project has been in operation for nearly 40 years and the whole system is in a dilapidated condition , the farmers at the tail end reaches of the canals hardly get water to suit their requirements whereas, the ryots at the upper reaches struggle hard to drain water from their lands. A good quantity of irrigation water is being wasted at the upper reaches by seepage. The maintenance grant avilable for the project is not even sufficient to remove the silt deposit in the canals and branches as well as slips and other deposits, as most of the branches are contouring the hills.

Command Area Development Authority

In Kerala, even though Command Area Development programmes were started as early as in 1978, the activities took momentum by 1985 and the Command Area Development Authority was constituted in the State with the promulgation of Command Area Development Act during the beginning of 1985. Ten major irrigation projects in the state viz *Malampuzha, Walayar, Mangalam, Gayathri and Pothundi in Palakkad district, Peechi, Vazhani, Cheerakuzhy & Chalakkudy* in Thrissur district and *Neyyar* at Thiruvananthapuram district were brought under this programme. The ultimate aim of the Command Area Development Programme is to improve the production and productivity of major crops cultivated in the commands of the irrigation projects. Among the various components responsible for the yield increase of any crop, water is the most essential factor. Unless water is provided to crops in adequate quantities, and in appropriate time, the yield cannot be increased. Hence under Command Area Development programme, attention is focussed on creating a proper water distribution system, usage network and management facilities for optimum utilization of available water. For this, provision of all physical activities and other supporting services are envisaged for the exploitation of the full productive potential of the irrigation projects.

The agricultural programme of CAD in the project was started from 1985-86. To maximize the production per unit area and to sustain that in the project area, agricultural development programme was introduced with the following objectives.

- Efficient and profitable production with emphasis on integrated management, conservation of soil, energy and biological resources.
- Greater exploitation of biological and genetic potential of the plant.
- Improving or modifying the cropping system to ensure optimum production levels.
- Improving soil health by adopting scientific management practices.
- To adopt scientific water management practices to increase water use efficiency.
- Improving soil health by adopting scientific management practices.
- To educate farmers about the efficient as well as economic use of irrigation water and scientific crop production.

The most important aspect of the CAD programme is to ensure the active involvement of the beneficiary farmers in CAD activities. With this point in mind, all the beneficiary farmers of the ayacut area were brought under various farmers association. The jurisdiction of these Associations will be the continuous area under one or more neighboring spouts. This ensures timely and equitable distribution of water to each beneficiary member of the association.

Need for pricing of water

Pricing of water service has been a sensitive issue, since long. There are wide variation in water rate structures across the states, depending on the crop, type of irrigation system etc. A multiplicity of principles are suggested for pricing irrigation water, cost of the service, Willingness To Pay, net benefits, crops, source of water supply assurance and a combination of all or a few of these.

Salient Features of the Peechi Major Irrigation Project:

The Peechi irrigation project is one of the major irrigation projects of Kerala. The Project consists of 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. Water was first let out for irrigation in 1953. The Command Area of Peechi major irrigation projects is shown in Figures 6&7.

The Dam situates at the foot of *Vaniampara hills* about 20 KM away from Thrissur town and 8 KM away from the National High way No.47. The dam is at latitude 10° 31' and longitude 76 ° 22'. The dam is located across *Manali river*, one of the major tributaries of Karuvannur River. The *Manali river* which originates from *Vaniampara hills* of the Western Ghats flow for 48km before it joins the *Karumali River* at a point called *Palakkadavu* near *Arattupuzha* in Thrissur district and they together form the *karuvannur river* which drains into the backwaters. 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.

Peechi Dam	
Length of the dam	213 m
Bed level of dam site	39.63 m
Crest level at spillway	76.20
Top of dam	80.46 m
Top width of dam	4.27 m
Full reservoir level	79.25m
Size of spillway gates	10.05 x 3.05m (4Nos.)
Type of spillway	Ogee overflow
Type of dam	Straight gravity - Rubble masonry
Reservoir	
Catchment area	107.09 sq.km
Water spread area	12.95 sq.km
Average annual rainfall (Of the ayacut)	2921mm
Maximum Storage	110.435 M.cum
Maximum flood discharge	368.118 cum/ sec.
Irrigation outlets	
A. Right Bank Sluice:	
Level at inlet	56.38m
Size of outlet	1,219m

B. Left Bank Sluice:
   Level at inlet 67.05m
   Size of outlet 0.914m
C. Trichur water supply piper
   Level at inlet 53.34m
   Size of outlet 0.609m
D. River Sluice Branching off from Right Bank Sluice:
   Level at inlet 54.86m
   Size of outlet 0.837m

Canal System

A. Right Bank Canal

The right bank canal systems with its off take from the reservoir at 56.38M is having 4.90 KM of main canal and 15 branches and distributories to cater to the needs of 4356 ha. The length is 36.85km, with a maximum discharge of 7.079 cum/ sec.

B. Left Bank Canal

The left bank canal systems with its offtake from the reservoir at 67.05M is having 44.90km of main canal and four branches to feed and ayacut of 2828 ha. The length is 24.6 km, with a maximum discharge of 3.540 cum / sec.

Trapezoidal section is adopted for the canal reaches with 1/2 to 1 side slopes.

Water resources:

A. Surface water resources:

Quantity of water received from *Manali river* is sufficient to fill this reservoir to its full capacity during South- western Monsoon period.

Water is supplied to the field through the net work of cnalls RBC, LBC distributories and minors.

It was envisaged to supply to the field for first crop during the period of August to September on demand and continuously for second crop i.e.: Mundakan from September to December in turn system. Water is delivered to the branch canals and then to the fields through field channels and field to field irrigation is practiced in the locality.

The command area (Plate 2) is having moderate slopes in the beginning. The slops flatten towards bottom valley. The Kole lands, a part of the command area, lie 60 cm to 120 cm below Mean Sea Level.

Socio economic profile of the farmers in the command area

Own cultivators account for about 90% of the cultivated area. The holding size varies from 0.1ha to 2 ha. Holdings are split into three or four segments. Tractors and power tillers are used for plowing but still some farmers depend on their own bullocks for farm power. The details of ayacut, holding size and social aspects of cultivators are given in appendix- IV

4. RESULTS AND DISCUSSION

IRRIGATION SCENE IN COMMAND AREA

In a perfectly competitive market situation value of a commodity is usually reflected by its price. When the market imperfection exists as subsidies, taxes, quality differences etc, the price often doesn't accommodate the resource scarcity and naturally the situation tend to be one of overuse and abuse of the resource, and later manifest as unsustainable situations. The existing and proposed water rate structure in Kerala is presented in table 4.1.1. Regional and seasonal water scarcity in major countries of the world is to be viewed in this background. The growing water scarcity is exhibited in most of the societies as increasing cost of new water sources, depletion of ground water levels, pollution of related environment and shift in agrarian systems. If viewed in this background the situation in Kerala highlights an alarming situation of growing water scarcity.

Water use trade off in command area

The water in the peechi reservoir satisfies the needs of the community/farmers. Any change in the capacity of the reservoir will directly affect the water supply. The capacity of the Dam in 1955 was 113.27 Mm^3 which reduced to 87.62 Mm^3 in 1980. The study conducted by KERI in1996 estimated the rate of sedimentation by two methods. (Table 4.1.2). This study also confirms the reducing capacity of the dam. The projected dam capacity in 2002 is 74.01 Mm^3. This was mainly due to the sedimentation effected by the land use in the upstream and deforestation in the area. Further, the poor maintenance of canal system (mostly unlined) facilitated large scale losses at the distribution level.

The water release data from Peechi Irrigation System shows a shift in favour of drinking water. This is evident from the period , duration and quantity of release (Table 4.1.3). The quantity of water released for drinking purpose showed an increase of 83.18 per cent over a period of 17 years while that for irrigation declined by 42.73 per cent.. The release of water through the RBMC/ LBMC mainly starts by September October and ends latest by March (Table 4.1.4). While in RBMC the release continued upto March 15^{th} in LBMC, it was only upto early January (2000), December (2000) and early November (2001). It was reported that the water release during January-February is mainly for recharge of wells. During the severe drought periods of April and May no water is released, and the people are to depend on alternate coping mechanisms. For domestic needs, they depend on perennial wells of nearest availability or depend on drinking water markets. Sixty six percent of sample farmers were to resort to alternate mechanisms, the average cost of which is estimated as Rs.169.44/ family/ season. This included the time/ effort taken for bringing water or the cost incurred on purchase. The effect of shrinking water release to irrigation is manifested in many ways.

- **Declining Command area and changing land use**

The area *reported* as ayacut area of the project remains the same over the years at 18,623 ha, of which15808 ha is cropped area. No systematic reports are available as to the actual extent of coverage of irrigation, over the years. By all means the actual irrigated area might have reduced, owing to reduced water release for irrigation and distribution factors.

Estimating the area utilisation index to assess the target realization, it was seen that only 75 % of area irrigated in the beginning was being irrigated by 2000 which further declined to 63% by 2001 (table 4.1.5). The reduction in area was more drastic in RBC compared to LBC. The area under *kole* lands (Paddy fields) remained the same. (The *kole* lands are submerged fields below mean sea level which are used for paddy cultivation during summer). The data projects a situation of declining levels of irrigated area in the command area of the project, against the targeted area. The declining capacity of reservoir, increasing pressure from domestic sector, and distribution losses are identified as the major reasons for this.

- **Distributional inequality**

Consequent to the decline in release of water, the distributional inequalities result in, head reach farmers enjoying more water. The average use of water for irrigation by the head region farmers is estimated as 14.16 m3/ day/ ha while it is only 4.7 m3/ day/ ha in tail end. In the middle portion it is 6.93 m3/ day/ ha .Suresh (2000) estimated irrigation water use by a head reach farmers as 38 ha cm and 4.2 ha cm by the tail end farmer. Moreover the Standard Deviation of water availability by the middle area farmers were quite high (13.04 ha cm). The data on ground water depth also supports this view. Mean water table declined as one moved from head region to middle and tail reach. However, it was below 1.5 Mt. and did not cause any adverse effects, even in head reach. Table (4.1.6).

The recharge in wells are influenced by canal proximity. Table 4.1.7 depicts the fact that there exist a moderate degree of correlation (correlation coefficient of 0.2512, which is statistically significant at 5 per cent level) between the net recharge of farm wells and distance of farm from main canal. The farms, where the well recharge was less than 10 m^3, are located at a distance 101.2 m away from the main canal. The recharge amount increases with canal proximity and average distance of 31 m, created a recharge in farm wells above 30 m^3. It is clear from the table that the canal irrigation made positive externality in farm wells as there is recharge in summer season. This water was used for irrigating the crops and thus canal system indirectly and strongly affected the farm productivity.

The participatory tools employed in the compilation of farmers opinion and the response of sample respondents also supports this inequality in water distribution. All the sample farmers in the tail, 90% in the mid and 63% in the head region opined that there is disparity in water distribution, which is in favour of head reach farms. While majority in the head portion had no complaints on water availability all in the tail region expressed their difficulties. Seventy five percent of the farmers in the far end attributed this to the excessive use of water by the head reach farmers. Moreover there are alternate irrigation mechanism (tube wells) in the tail end but only rich farmers could afford this.

- **Shift in cropping pattern**

The wide inequality / variability and uncertainty in the distribution of water within the command area is manifested as special and temporal shifts in agricultural system / practices and performance. Cropping pattern adjustments are the major coping strategies to water scarcity in agriculture. Kerala agriculture in general is showing a clear shift in favour of perennial (less water requiring) crops in place of field crops

(Appendix V). While the proportion of food crops declined by 28.1 points, the share of tree crops and plantation crops increased substantially.

The Peechi project had been aimed originally for two crops of paddy. The first crop Virippu starts from May and is harvested in August to September. The second, crop Mundakan starts from September and is harvested in December. The third crop Puncha starts from January and is harvested in April. The first crop is rain fed and hence no water is released from the reservoir.

Over the period, 1995-96 to 2001-02, the paddy acreage has declined drastically from 62.1% to 36.48% of total area (Table 4.1.8). Simultaneously, the coconut and banana acreage has increased. It is to be noticed that the conversion to non-agricultural uses was only marginal and crop adjustments within agricultural area was the major coping strategy.

The kole area in the ayacut was 8816 ha which remained the same over years, as the conversion is technically difficult. The major shift in paddy lands is in non kole area, mainly in the head reach. There is large scale conversion of these paddy fields mainly to banana and vegetables. More than 50% of farmers agreed that they have changed their cropping pattern in accordance with water availability. The cropping pattern in the head, mid and tail region of sample farmers is presented in table 4.1.9.

The proportion of paddy land is lowest in the head reach and highest in the tail, contrary to the case of banana and vegetables. In the head reach all paddy lands except those which are water logged are converted for banana cultivation. A considerable portion of paddy lands (non kole areas) is already converted for banana cultivation. The paddy lands now remaining is unsuitable for conversion due to water logged condition and is not suitable for any other purposes

Estimating the proportionate contribution of banana and vegetables to total farm income, it was seen that in head region it varied between 60-83per cent, in mid 30-65 per cent and in tail 0-10 per cent.

Suresh (2000) reported that the command area of Peechi irrigation system is undergoing a clear shift in favour of garden land crops, especially in tail end where assured water supply was absent. More than 50per cent of sample farmers in the study area have shifted to the cultivation of less water demanding crops, due to water scarcity problems. Gajja 1998 reported a situation of realising lower yields than anticipated in the Ukai-Kakrapur command area in Gujarat, due to cropping pattern shifts without due regard for land sustainability and water availability.

Taking sample farmers of banana and rice along the canal command, Suresh, 2000 also expressed his inability to locate banana growers in the tail region. Banana cultivation is a highly remunerative enterprise, with a significantly high BC Ratio compared to rice (Table 4.1.10). The commercial viability of the crop is also very high. Banana is one of the few crops in Kerala where the acreage has registered an increase. Studying the determinants of paddy area allocation in Peechi command area it was seen that only 45% of additional area brought under wet land was brought under paddy lands and the rest was for banana. Similarly nearer the plot to main canal in head reach the area allocation to paddy is less and banana is preferred (Suresh, 2000). This is reported by Sujithkumar, 1996 as well. The direct benefits enjoyed by the farmers in the head region as higher income, result in higher socioeconomic divergence among the farmers in the canal command. Higher concentration of banana cultivation in the canal command creates several negative externalities as well.

- **Externalities**

 # increasing cost of cultivation

. The conversion of paddy fields for banana cultivation in the head reaches warrants an additional investment of Rs. 10,000 per hectare which is a negative externality. Ridges and furrows are to be taken to facilitate drainage and banana is planted in the ridges. This is due to the water logging in the head region compared to other places. In the mid region this problem is not there.

 # overuse of pesticides

The resource use efficiency study in banana cultivation in the canal command revealed that the expenditure on plant protection chemicals are well above the optimum and it contributed negatively to the yield (Suresh, 2000). Every one unit increase in the cost of plant protection chemicals reduced the yield by Rs. 0.197 as indicated by the MVP: MFC ratio. Over use, unscientific methods of chemical selection and mode of application of systemic pesticides in banana cultivation is already reported in the command area (Bastine, 1983; Devi, 1984 and Sajini 2001). The residual effects of these systemic chemicals on produce, soil, water and biosystems is yet to be studied in detail.

Introduction of Integrated Pest Management (IPM) in banana and paddy is suggested as a measure to regulate the use of pesticides. For this massive awareness programmes are to be planned and implemented

Deforestation

Returns from banana cultivation is significantly influenced by the Stalking (Support provided). Since banana has a weak pseudo stem, stalking with appropriate poles, in time ensures better yield. It was seen that one rupee investment on this item increased the return by Rs.12.61 (Suresh, 2000). The usual stalking materials used by the farmers are Bamboos, *Diospyros sp*., *Hydrocarpos sp. Strychrios mux-vomica*, *Cynometra travaneceria* etc. Due to concentration of banana cultivation, the demand for poles increased drastically. Earlier homesteads were the main source. It was seen that the source of 73.5% of these poles was adjoining Peechi Forest area. Studying the effect of pole harvesting on regeneration of tree species in the forest area, Harinarayanan and Mohan 1999 reported that it affected the vegetative structure of natural forests. Species having less regenerating (coppicing) capacity gradually disappeared, and trees having seed abundance and good germination rate dominated in the lower girth classes. Moreover opening up of mid canopy permitting more sunlight intrusion resulted in the domination of nonarborescent species. This lead to a situation of declining biodiversity in the natural forests which will have its adverse effects in the ecosystem as a whole.

Popularization of alternative method of stalking using ropes, instead of poles can address this problem effectively.

Over use of irrigation water

Agronomic estimates of water requirements of important crops are available. However, the present water distribution system and irrigation management is done with little regard for this. The situations of mounting food grains stocks and policy changes favoring unrestricted food movements across the country pose the question of the relevance of massive investment in irrigation (especially on rice in Kerala). Economic incentives for judicious management is totally absent due to near zero pricing of irrigation water. The flooding system of irrigation is widely adopted in the canal command area often beyond the capacity of the farmer to regulate. This results in over irrigation in head region and absence in tail ends. Estimation of crop wise consumption of irrigation water might have provided a basis for comparison of water consumption with agronomic optimum. But the garden lands of Kerala are characterised by intercropping and majority of them are homesteads. The typical characterstics of homesteads of Kerala are furnished by Nair and Sreedharan (1986); Kumar *et.al* (1994) and Devi (1996). Flooding or basin system of irrigation is practiced in these gardens. In this situation estimating the water use of individual crop is rather quite difficult and is of little practical relevance. Hence it was not attempted. The irrigation requirements of important crops are furnished in table 4.1.11. However, the usual adverse effects such as salination is not reported in Kerala due to geographic factors and gradient.

It is reported that the water use efficiency of irrigated farming in developing countries is only 25- 40per cent. This highlights the potential for water savings from the present system. Appropriate pricing of water can emerge as a tool for regulating irrigation water use.

The water stagnation / excessive use in head region is mainly on account of poor canal maintanance and ineffective management and supervision. Streangthening the activities of water users association and decentralization of duties and powers can be tried in this aspect.

Economic incentive of irrigation project

Irrigation investments were mainly aimed at increasing the productivity of crops in the command area. Hence the efficiency of investment can be assessed with the changes in productivity levels of target crops. The productivity of important crops in the command area of Peechi irrigation project and that of the district (Thrissur) as a whole is presented in appendix VI.

The productivity levels of target crops in the command area compared to that of district average (period: 1985-865 to 1999-2000) is studied in this regard. The analysis to test the significance of the productivity differentials provided the results as given in table 4.1.12 and 4.1.13. It can be seen that Peechi irrigation system could not make significant positive impact in the productivity of any of the crops studied, contrary to what is expected. The most important crops, as per the irrigation requirement criteria, summer paddy and banana experienced significant decline in productivity levels compared to district level averages. It is to be remembered that 75% of rice and banana in the command area are irrigated crops. Similar observations were made by Narayana (1983) also. The report of the steering committee on water resources appointed by Government of Kerala has also raised apprehension over the productivity of irrigated agriculture over unirrigated. The results of earlier studies also supports their observation. (Table 4.1.14 and Table 4.1.15).

However it is to be pointed out that the yield gap between irrigated and unirrigated system narrows down.. Comparing the yield of paddy for three years in the Peechi command area and neighbouring district of Malappuram, (table. 4.1.16) Suresh (2000) has reported that there was 51.7% more yield in irrigated area than that of unirrigated situation. Amongst this diverging views, one can look the situation from a different perspective.

The targeted yield index is a measure to indicate the degree of achievement of the target prescribed by the authorities (Table 4.1.17). Even though the target fixed was 3500 kg/ha for paddy for the last five years, the achievement was only to the level of 76%.

Further, looking the whole situation from a financial point of view, the investments can be justified if the returns are attractive.

Irrigated agriculture is proved to be financially attractive than unirrigated. The productivity, farm income and BC Ratio of irrigated plots were found to be higher than that of the unirrigated plots (Geethakutty and Devi, 1996). However, in all these estimates water is taken as a free good. The expenditure connected with irrigation included the labour, machinery and fuel charges alone. In this background the financial efficiency of irrigation investments will be abysmally low, if estimated at actuarial levels of water rates. Realistic estimates of financial performance, imputing actuarial values of scarce resources may give a different picture.

- **Increasing cost of irrigation**

Rising prices/ cost of good/ service can be considered as an indication of its scarcity, among other reasons. Across the world, countries experience large increases in the cost of irrigation investment per hectare over the past two decades. In India the real cost of new irrigation systems have more than doubled since late 60s and early 70s (Wolff and Hubener, 1999).From independence to 1990, nearly 600 billion (1988-'89 prices) have been spent on major and medium irrigation schemes. But the direct financial recovery from the schemes is less than Rs.3 billion. Gulati *et al* 1994 highlighted the poor financial performance of irrigation projects in India and suggested ways to improve it. Mitra 1996 also made viable suggestions in this sector.

This is also reflected at microlevel, i.e., the farm level costs on irrigation have also risen over time. The overall cost/ acre cm of irrigation water in Chittur taluk of Kerala state was estimated as Rs.12.73 in 1998, and the capital value net of depreciation for irrigation structure, machinery and equipment was Rs.2, 60, 240 (Kalyankrishnan, 1990). There was an increase of expenditure of Rs.47, 419 in irrigated household plots in Thrissur district over unirrigated plots. This off-course includes the increased expenses due to higher levels of input use (Geethakutty and Devi, 1996).

The financial performance of the Peechi irrigation project gives bleak picture,(table 4.1.18) with very low recovery ratio of 11.72 (Total income collected to total expenditure). The per hectare expenditure for providing the irrigation service is Rs.528.93 where as the water charges fixed is only Rs.62 per ha. The actual realized revenue is much lower than this, due to various institutional and management factors.

The working group on major and medium irrigation for the eighth plan (1990-'95) found that at current prices, investment in irrigation had increased from Rs.1530/ ha of irrigated area in first plan to Rs. 34,924/ ha in sixth plan and Rs.36, 800 in seventh plan (Appendix-VII). This rising cost naturally restricts the possibilities of future investments unless it is economically attractive. The State Planning Board as already recommended drastic action to end the bleeding from state's exchequer. The suggestions include sealing down of some of the projects and stopping some others at the stage they are presently in. In this juncture the possibilities of shifting over to small (micro projects) investment alternatives can be thought of. Bahadur and Singh (2001) and Zaman (2000) suggest this based on research studies.

- **Need of the hour**

Though Peechi irrigation project was conceived exclusively to meet the irrigation needs of the farmers in Thrissur, over the years considerable trade off has occurred in favour of non-agricultural uses, and the benefits in agriculture have been unequally distributed, favouring the farmers in the head region, of the command area. This distributional inequality coupled with irrational water use by the most advantaged groups, viz., head region farmers, has lead to unsustainable use of water available from the project over the years. The distributional inequality in the water supply has made distinct impacts on the social, economic, political and cultural front due to changes effected in the cropping pattern in the command area. The shift from traditional crops like paddy to more commercial crop viz., banana has given rise to externalities, which is detrimental to the water resources in the area. The water resource is considered to be a free good by the users and the payment effected for the same is nominal resulting in over use of the same. Further, the cost of supplying irrigation water is not in tandem with the actual value of the resource as explained elsewhere. This situation has made investment on irrigation projects less viable in the state with less or no incentive to start a new feasible project. Changes accorded by the irrigation sector will reflect on the production and productivity of the crops wherein the entire economy may get destabilized.

The study has identified the problems/crisis regarding water use and the efficiency/inefficiency in the existing pricing policy, which has serious implications on the resource use and allocation in the command area. Hence an efficient pricing of irrigation water is necessitated in the area, the relevance of which is discussed. The crisis has resulted in changes in the command area, trade off in water use, distributional inequality, shifts in cropping pattern, increased cost of irrigation, over use of irrigation water and depletion of quality and quantity of water, which is detailed under concerned sections.

VALUATION OF IRRIGATION WATER

The preceding chapter reveals the dismal picture of irrigation sector in Kerala and highlights the need for a proper pricing policy in the sector. The financial viability of the existing projects is not commendable with high costs incurring in the sector, and this affects the viability of the present and future irrigation projects. This can be compensated through an effective pricing mechanism. Further, fixing an appropriate price which includes the real value of water will make users realize the importance of sustainable use of the resource wherein, indiscriminate use of the same can be controlled effectively in future.

Estimation of true value of a scarce resource can form the basis for its actuarial pricing and realistic estimates of its financial worth. The valuation of irrigation water is attempted, based on level of use as well as Marginal Productivity of the resource. Irrigation water released through the canal is used for various purposes. These are categorised under three headings.

A. Direct irrigation

B. Indirect uses (Recharge of wells)

C. Non irrigation uses.

Valuation is attempted separately for each of these groups as detailed in the following section.

A. **Direct irrigation** (Plate 3&4)

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. The average family size was found to be five and the education upto 8th standard. Agriculture was the major activity in the holdings (96.11per cent) and only limited area is allocated for all non-farm uses (3.89per cent), the average land holding size being 1.03 ha. On an average the farmers are getting an income of Rs. 86,049 per annum from farm (which constitute 76.8 per cent of their total income) and Rs. 25,972 per annum as non-farm income. The major share of total farm income was from crops (94.79per cent i.e., Rs. 81, 569) and remaining 5.21 per cent from livestock. On an average, farmer's income accounts to Rs. 1,12,020 per annum (table 4.2.1).

I. Cost based approach

In this method value is estimated as the product of cost of supplying the commodity and the level of use.

i. Cost of supplying irrigation water.

The society incurs a cost for the storage and distribution of water. Considering the scarcity of resources and benefit transfer in favor of only a few it is important that the cost per unit of water supplied be recovered from the users.

A. Fixed cost.

Though the methodological and conceptual issues are detailed in the foregoing session, the fixed cost component is not included in this analysis. Peechi irrigation system was commissioned in the year 1957. Considering the long life period of the project, the rationale of including the fixed cost component in the valuation is doubtful. Hence it was not attempted.

B. Variable cost:

The total variable cost incurred in the project during the last 10-year period from 1990 to 2000 was collected from the concerned office (Table 4.2.2)

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

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

It was estimated that,

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

$$(27.23) \quad (1.44^{*})$$

$R^2 = 0.4273$ $F = 7.72*$ * 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.

ii) Consumption of irrigation water

To delineate the effect of various factors on water used by sample homestead farms, a mixed production function has been employed. The function was selected based on R^2 and Standard Error criteria. The results are presented in table.4.2.3. and 4.2.4.

It has been seen that the independent factors like distance from main canal and income from farm were affecting the total water use of the farm inversely, the respective Marginal Physical Products being negative. Fig.8 shows the relation between the discharge from distributory and distance from main canal. Cropping Pattern Index was affecting the water usage positively. Fig 9 shows the distribution of sample farmers according to Cropping Pattern Index.

It is not possible to dictate the extent of impact of various independent factors from the mixed production function- Income and CPI in inverse terms and Distance from main canal as linear - due to the complexity involved. So the Marginal Physical Products (MPP) of various factors on irrigation water use was calculated separately. The MPP of factor "distance from main canal" was -1.4020. This explains that additional increase in distance over geometric mean level will reduce the water use (water availability) by 1.40 units. Cropping Pattern Index as explained above was having a positive influence on water use, the MPP being 5.31. The higher level of MPP shows the importance of crop diversity in effective water use. The farm income was having a negative marginal productivity, which is primarily due to overuse of irrigation water, especially in the head reaches. Note that the percentage of sample size in more from head region.

Marginal Cost per unit of water (m^3) released per year was estimated as Rs. 0.1434. The average level of water use in sample farms is being estimated as 18.9 m^3 per day per farm (ha). Rs. 2.71 (product of average water use and Marginal Cost per unit of water released) is thus the average cost incurred by the Irrigation department on sample farm per day, using irrigation water for farm use. The total number of days irrigated in an year is found to be 71 days and hence the annual cost is Rs.192.41/ farm.

II. Productivity based approach

The value of water when estimated based on its productivity is also attempted. Due to reasons detailed in the methodology the whole farm income was taken as a proxy, and the estimation is done for the three regions.

An additional unit of (1m3) water applied at the head region results in a decline in farm output (income) worth Rs.2256 in the head portion, indicating that the farmers are operating in the irrational (third zone) region of production.

By virtue of their overuse, the tail end farmers are denied of an average income of Rs.52550/ ha (which is the difference between average farm income in the head and tail region). This amount can be considered as the value of water, in head region. Middle reach farmers reap an attractive income from each additional unit of water over the mean level, (Rs.38040) per year/ ha. Earlier studies on effect of irrigation on productivity and net farm income has established that irrigated farm generate 4.2 times more income compared to unirrigated. Applying this proportion in this case, the value can be fixed at Rs.9013 per ha per year. Following the same concepts the value per additional unit of water applied at the tail end is Rs.836.09 per ha/ year.

Suresh(2000) has analyzed the resource productivity in paddy cultivation in Peechi canal command. Total return from paddy crop was regressed with independent variables such as area under the crop, value of seeds, human and machine labour charges, expenditure on manures and fertilizers, plant protection expenses, amount of water applied ,dummy for water stress days and supplementary irrigation It was seen that irrigation had positive significant impact only in tail reaches. The MVP of water per hactare was estimated as Rs.62.90.

B. *Indirect uses (irrigation / domestic) through recharge of 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 4.2.5). In this case also 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 raised form crops (95.07 per cent i.e., Rs. 65,010) 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

a. Consumption of water for irrigation

The total quantity of water recharged in the farm wells after the water release through the main canal was estimated, and the factors affecting the same was worked out using linear production function analysis. The results are shown in table 4.2.6. It is seen that the distance of farm from the irrigation canal has inverse relationship (fig.10) with the net recharge of the wells, the slope coefficient being -0.3980. 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 model is well fit; the adjusted R^2 being 0.84.

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)). This specifies that the farmers irrigating from recharged wells are enjoying a positive externality equal to Rs. 225.67 per year, whose reward is not being paid.

II. Productivity based approach

The irrigation from recharged wells realised an average increase in farm income to the extent of Rs.31.54 for every additional unit of water applied. For this the average farm level investment was estimated as Rs.12.90 per m^3 of water. The value of water used for irrigation through recharge is thus Rs.18.64 for every unit of water. ($1m^3$). However, it was seen that the nearer the farm to main canal, the water use was above optimum and hence, it resulted in a fall in total farm income (negative additional income). Hence for the nearer farm the difference in farm income between the two groups can be taken as the value when it is taken as a basis for pricing decision(Rs.45921/ha). For the distant farms it is Rs.2961 per additional unit of water applied.

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). (Plate 5). 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 on the canal for all water requirements. (own wells were not there and the recharge was poor). Table 4.2.7. However, the farmers towards the mid portion were reluctant to use the canal water for human use, for fear of 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. However, it may be remembered that this is the educational level of the respondents and not of all the family members 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. 31682 per annum as non-farm income (32.79 per cent). The major share of total farm income was raised from crops (19.32 per cent i.e., Rs. 12548.26) and remaining 80.67 per cent from livestock (Rs. 52387.45). On an average, farmer's income accounts to Rs. 96618.16 per annum. (Table 4.2.8)

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 4.2.9.a&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. Higher additional benefit of using the canal will definitely lead to more quantity of water enjoyed on account of higher time taken for the activity. The facility for using the own sources (wells) may be rather nil or low on account of poor recharge. Similarly the distance (from the user point to the residence) and quantity of water are found to be positively correlated.

The people residing up to a distance of two hundred and fifty metres were found to depend on the canal. 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. In faraway wells the recharge is rather nil or insignificant and they have to fully depend on the canal.

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. Considering these two situations we may infer that human factors and non-human factors play an equally important role in deciding the use of water. Multiplying the consumption level with MC, the value of water used for non human purpose is estimated at

Rs. 215.88/ year/ family and for human use it is Rs292.71/family/ year.

II. Productivity based approach

The water used for non-irrigation purpose is not completely consumed up in the process. But, quality losses occur. Water use for non-human uses, when regressed with the additional benefit of depending on canal water, projected non-significant results. This may be attributed to the large volume of water involved. In this case the benefit over alternate strategy is taken as the value of irrigation water. Thus it is estimated as Rs. 3024/year. It was reported by the sample respondents in the mid reach that they do not depend on the canal water for human uses as the head reach residents have already polluted it. When the additional benefit derived by the use of canal water over alternative methods was regressed to estimate the MVP, the values were insignificant. However, the value of water for this purpose may be considered as equal to the foregone benefit of mid and tail end farmers. (Rs.21.95 /day in mid and Rs.42.47/day in tail). Hence, the average value is estimated at Rs. 32.21/day i.e., Rs.4058.46/year.

Productivity based valuation for the farmers in Head, Mid and Tail region is given in table 4.2.10.

Willingness to pay

Valuation of irrigation water can form the basis for making pricing decisions.The issue is more pertinent in this case.

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 4.2.11 and 4.2.12).

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). In the direct irrigation group, it was 80%. The domestic use was given more priority than irrigation, hence this result. 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.

More than seventy percent were ready to effect payment 25% higher than existing rates of Rs.62/ ha if the supply is satisfactory. Only a meager (8.6%) expressed to effect payment in the existing condition. All of them, obviously, residing in the head portion of the canal system.

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. The value of irrigation water in Kerala assessed through the aforesaid approaches is summarized and presented in table 4.2.13.

Within the canal command value of water varies based on its availability/scarcity. The WTP increases as the resource become scarce. When value is to be taken as the basis for pricing decision , the base level should invariably be fixed so as to cover the O&M cost(social cost). A differential pricing strategy for mid and tail and user groups based on volumetric measurement will be ideal way wherein the measurement and collection of payments can be entrusted with water users associations. This also ensures adequate funds for maintenance of canal system.

Table 3.2. Growth rates of Net area irrigated in Kerala (Source wise) during 1990-91 to 1999-2000

Sl.No	***Source***	***Compound Growth Rate (%)***
	Area Irrigated by -	
1	(i) Government Canals	-0.0178
2	(ii) Private Canals	-0.0032
3	(iii) Tanks	0.0013
4	(iv) Wells	0.0681
5	(v) Other sources	0.0108
6	*Total*	0.0152
8	*Gross irrigated area*	0.0193
9	*Net area irrigated to net area zone*	0.0147
10	*Gross irrigated area to total cropped area*	0.0219
11	*Irrigated area under paddy tot total irrigated area*	-0.0097

Table 3.3 Growth rate in Gross Area Irrigated (Crop wise) in Kerala during 1990-91 to 1999-2000

Sl. No.	***Crop***	***Compound Growth Rate (%)***
1	Paddy	-0.0286
2	Tubers	0.0140
3	Vegetables	***0.3575***
4	Coconut	0.0024
5	Arecanut	0.0523
6	Nutmeg/ Clove	0.1224
7	Other Spices & Condiments	0.0625
8	Banana	0.0998
9	Betel vine	0.0339
10	Sugarcane	0.2039
11	Others	0.0539

Table: 3.4Proportion of crop wise irrigated area in the command area of Peechi irrigation project.(2001).

Crop	*Total area in hectares*	*Irrigated area in hectares*	*Percentage of irrigated area to total area*
Paddy	6,950	5095	75
Coconut	6,793	3475	50
Banana	1005	754	75
Arecanut	500	350	70
Vegetables	560	336	60
Total	15808	10010	63.32

Source: CADA, Thrissur.

Table 4.1.1. Prevailing and proposed water rates structure in Kerala (Rs./ha/year)

Sl. no	Crops	Existing rates	Proposed rates
1	Single crop	62	250
2	Double crop	99	400
3	Three crop	99	550
4	Other lands	62	550

Table 4.1.2 Estimated capacity of Peechi Dam (Mm^3)

Year	*Design capacity*	*Present capacity*	*Space of study*	*Capacity loss (inflow out flow method)*	
				Total	Annual
1957	110.43	-	-	-	-
1982	110.43	87.62	25	22.81	.062
1995	1100.43	79.611	35	30.819	0.797

Source: Kerala Engineering Research Institute, Peechi, Kerala.

Table 4.1.3 Water release data from Peechi irrigation project from 1983 to 2002 (Mm^3)

Year	*Quantity released for drinking*	*Quantity released for irrigation*	*Total quantity released*	*Total inflow*
1983	10.95	126.358	143.731	155.794
1984	10.98	129.37	146.773	153.13
1985	10.95	135.727	153.1	156.0481
1986	10.95	70.665	88.038	97.67
1987	10.95	70.763	88.136	181.671
1988	10.98	158.525	175.928	142.746
1989	10.95	142.108	159.481	146.643
1990	13.146	114.291	133.86	194.8455
1991	15.33	170.818	192.571	197.226
1992	15.372	140.454	162.249	130.489
1993	15.33	129.314	151.067	191.643
1994	15.33	173.795	195.548	210.175
1995	15.33	126.105	147.858	130.489
1996	19.113	102.02	127.556	68.249
1997	20.075	165.332	191.83	116.5083
1998	20.075	122.817	149.315	NA
1999	20.075	75.9708	96.046	NA
2000	20.13	111.863	105.013	NA
2001	20.075	55.139	52.585	NA
2002	20.075	71.61	58.649	NA

Source: Kerala Engineering Research Institute, Peechi, Kerala.

Table 4.1.4 Period and duration of Water release from Peechi irrigation project - 2000-01 and 2001-02.

RBMC/ LBMC	***SL. No.***	***Opened on***	***Closed on***	***Number of days***	***Quantity of water released in Mm^3***
RBMC	1	21.09.1999	29.09.1999	8	4.683
	2	05.10.1999	07.12.1999	63	36.28
	3	10.12.1999	15.03.2000	95	44.325
	4	28.10.2000	29.12.2000	62	30.226
	5	20.01.2001	03.02.2001	14	6.153
	6	08.11.2001	14.03.2002	126	49.132
LBMC	1	30.09.1999	05.01.2000	97	26.58
	2	26.10.2000	29.12.2000	64	18.76
	3	06.11.2001	10.11.2001	4	0.815
	4	20.11.2001.	04.02.2002	75	21.663

Source: Kerala State Irrigation Department, Government of Kerala.

Table 4.1.5

Area utilization index of the irrigation system

Canal system	***Targeted (ha)***	***Actual (ha)***	***Area Utilization Index***
RBMC	6764	3240	0.48
LBMC	2823	2019	0.72
KOLE	7664	7664	1.00
TOTAL	17256	12923	0.749

Source: Suresh, 2000..

Table. 4.1.6 Sustainability of the system based on depth of ground water table

Parameter/ Reach	***Head (m)***	***Middle (m)***	***Tail (m)***
Mean depth	2.57	2.86	7.56
Standard deviation	0.36	2.11	0.94

Source: Ground water Department, Thrissur.

Table 4.1.7 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 4.1.9 Cropping pattern in Sample farms (Irrigation), Peechi Command Area

Crop	*Mean Area under cultivation (ha)*	*Percentage to total farm area*		
		Head	*Mid*	*Tail*
Paddy	0.23	10.00	24	27
Arecanut	0.09	8.71	7.18	8.21
Coconut	0.39	36	32.14	49.24
Pepper	0.03	3.02	2.91	3.87
Banana	0.14	27	18.14	1.05
Nutmeg	0.01	0.54	0.51	0.62
Ginger	0.01	1.42	1.00	1.3
Vegetables	0.04	9.41	8.12	2.71
Tapioca	0.03	2.54	3.14	2.06
Coleus	0.00	0.28	0.14	0.36
Rubber	0.03	1.08	2.72	3.58
Total	*0.99*	*100.00*	*100.00*	*100.00*

Table 4.1.10 Relative economics of and Paddy and Banana

Crop	***B:C ratio***	***Net Income***	***Area***	***Author***	***Year***
Paddy	1.08	Rs.1833.03	Kuttanad (Alleppey)	Shanat. K. Mathew	2001
	1.34	Rs.28999.00	Peechi	Suresh. A	2000
Banana (Nendran)	1.17	Rs.34247.66	Thrissur	Nambiar Sajini Balakrishnan	2000
	1.71	Rs.77112.00	Peechi	Suresh	2000

Table 4.1.11. Irrigation requirement per crop cycle/ hectare

Crop	*Irrigation requirement in m^3.*
Rice	
II crop	2361
III crop	7484
Coconut	555
Arecanut	714
Banana	690

Source: CADA, Thrissur.

Table 4.1.12 Significance of Yield variation in command area of Peechi irrigation project and Thrissur District

Particulars	*Paddy (kg/ha)*			*Coconut (Nuts/ ha)*	*Banana (kg/ha)*	*Tapioca (kg/ha)*
	Autumn	*Winter*	*Summer*			
Mean of Difference* in productivity	498.93	461.33	87.47	3315.07	-891.33	8763.80
Standard Deviation in Difference in productivity	623.39	818.61	1135.02	2538.22	4888.15	8837.74
t- value	0.8003	0.5636	0.0771	1.3061	-0.1824	0.9916

- Productivity of Command Area minus Productivity in Thrissur District

Table 4.1.13 Results of Production Function Analysis to determine significance of productivity difference in important crops between Command area and Thrissur District

Function used:

P = A + b1.D + b2.T + b3.D.T

where, P is productivity of crop

D is dummy for region (0- Thrissur, 1- Command Area)

T for time variable (years)

Crop	*Unit*	*Intercept*	*D*	*T*	*D.T*	*R2*	*F Value*
Paddy- Autumn	kg/ ha	2301.11*	-128.9	-4.2464	78.4786*	0.4690	9.9357
Paddy- Winter	kg/ ha	2427.42*	-99.89	12.8643	70.15	0.3026	5.1939
Paddy- Summer	kg/ ha	2915.76*	-665.39	-9.2536	94.1071	0.1359	1.8635
Coconut	Nuts/ha	6494.51*	860.81	19.38	306.78*	0.5952	15.2133
Banana	kg/ ha	12053.37*	-6818.93*	177.87	740.95*	0.5475	12.6937
Tapioca	kg/ ha	12535.43*	-2097.77	754.39*	1357.69*	0.7798	35.2458

Table 4.1.14 Effect of irrigation on the yield of paddy in [kg/ha.] in Kerala

Sl.no.	*Year*	*Average yield in irrigated area*	*Average yield in unirrigated area*	*Difference*
1	1967	3512	2724	188
2	1977-78			
	Virippu H	2178	1589	591
	O	1302	1369	67
	Mundakan H	2324	1988	336
	O	2115	2188	75
	Puncha H	1974	1277	697
	O	2780	3379	599
3	1983-84	1797	1521	276
4	1985-86	1792	1567	225

Source: Report of the Steering Committee on water resources, State Planning Board, Thiruvananthapuram, 1998.

Table 4.1.15 Effect of irrigation on the productivity of garden land crops in Kerala

No.	***Crop***	***Before irrigation investment***	***After irrigation investment***	***Difference****	***Irrigated plots***	***Unirrigated plots***	***Difference*****
1	Coconut (nuts/palm /year)	63	48	15	64	40	14
2	Arecanut (nuts/palm / year)	178	188	10	44.20 (kg/palm/ year)	3.25 (kg/palm/ year)	40.95 (kg/palm/ year)
3	Banana (kg/ha)	7.30	10.60	3.30	***Nendran*** -11.40 ***Other varieties*** -11.5	***Nendran*** -8.90 ***Other varieties*** -9.25	***Nendran*** -2.50 ***Other varieties*** -2.25
4	Pepper (kg/ha)	2.97	3.40	0.43	3.40	2.97	0.43

***** *Source: George C.A (1996).*
****** *Source: Geethakutty and Devi (1996).*

Table 4.1.16 Rainfed yield index for paddy in the command area

Year	***Yield in command area***	***Yield in Malappuram district***	***Rainfed Yield Index***
1995-96	2870	1720	1.668
1996-97	2506	1719	1.457
1997-98	2380	1670	1.425
Average	2585.33	1703	1.517

Source: Economic Review, Planning Board, Kerala, 1997.

Table 4.1.17 Targeted yield index for paddy in the command area

Year	*Actual yield*	*Targeted yield*	*TYI*
1995-96	2870	3500	0.82
1996-97	2506	3500	0.71
1997-98	2380	3500	0.68
1998-99	2815	3500	0.80
1999-2000	2892	3500	0.83
Average	2693	3500	0.76

Source: CADA, Thrissur.

Table 4.1.18 Financial self sufficiency of the irrigation project

Year	*Works (Rs.)*	*Maintenance expenditure (Rs.)*	*Total expenditure*
1997	10.09	30.03	40.12
1998	9.67	31.06	40.73
1999	8.31	29.18	37.49
Average	9.36	30.09	39.44

Department of Irrigation, Divisional Office, Thrissur.

Mean expenditure on works and maintenance=Rs.39.44 lakhs.

Average salary/ year = Rs.28.90 lakhs.

Total expenditure = Rs.68.34 lakhs.

Per hectare expenditure = Rs. 529

Revenue collectable through water charge = Rs.8.01 lakh.

$$\text{Financial self sufficiency} = \frac{\text{Revenue collectable}}{\text{Total expenditure.}}$$

$$= \frac{8.01}{68.34}$$

$$= 0.1172.$$

Table 4.2.2 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 4.2.1Personal characteristics of sample farmers (Irrigation) of Peechi Irrigation Command Area, Thrissur

Personal Characteristics	*Unit*	*Mean Value*
1. Family size	(Numbers)	5
2. Years of schooling	(Years)	8
3. Age	(Years)	48
4. Land Holding size		
4a. Agricultural use	(ha)	0.99 (96.11)
4b. Non Agricultural uses	(ha)	0.04 (38.89)
Total	(ha)	1.03 (100)
5. Farm Income		
5a. From Crops	(Rs. per year)	81,569 (94.79)
5b. Livestock	(Rs. per year)	4480 (5.21)
Total Farm income	(Rs. per year)	86,049 (100) (76.81**)
6. Non-Farm Income	(Rs. per year)	25972 (23.18)
Total Income of farmer	(Rs. per year)	112,021 (100)

* Figures in parenthesis show percentage to total

** Percentage to total income of farmer

Table 4.2.3 Factors influencing irrigation water use in homestead farms of Peechi Command Area (Mixed production function)

Variable	*Coefficient*	*Standard error*	*t value*
X_1*(Distance)*	-1.4020*	0.3374	-4.1552
X_2 *(1/Income)*	97802.99*	26866.78	3.6403
X_3 *(1/CPI)*	-0.1214*	0.0325	-3.7414
Intercept	29.8566*	3.9939	7.4756
Regression Statistics			
Multiple R	*0.6590*		
R Square	*0.4343*		
Adjusted R Square	*0.3896*		
Standard Error	*10.640*		
Observations	*42*		
F value	*9.72**		

- *Statistically significant (at 1 per cent level)*

Table 4.2.4 Marginal Physical Product of factors contributing canal water use

Independent variables	*Marginal Physical Product*
1. Distance of farm from main canal (m)	-1.4020
2. Income from farm (Rs.)	- 0.0004
3. Cropping pattern Index	5.3140

Table 4.2.5 Socio economic characteristics of sample farmers (Recharge) of Peechi Irrigation Command Area

Personal Characteristics	*Unit*	*Mean Value**
1. Family size	(Numbers)	5
2. Years of schooling	(Years)	9
3. Age	(Years)	47
4. Land Holding size		
4a. Agricultural use	(ha)	0.74 (97.37)
4b. Non Agricultural uses	(ha)	0.02 (2.63)
Total	(ha)	0.76 (100.00)
5. Farm Income		
5a. From Crops	(Rs. per year)	65,010 (95.07)
5b. Livestock	(Rs. per year)	3,370 (4.93)
Total Farm income	(Rs. per year)	68,380 (100) (56.65**)
6. Non-Farm Income	(Rs. per year)	52,310 (43.34)
Total Income of farmer	(Rs. per year)	120,690

* Figures in parenthesis show percentage to total

** Percentage to total income of farmer

Table 4.2.6 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)

ble 4.2.7 Factors Affecting Total Volume of water used (cum/family/day) (Production Function: Inverse Model) (non irrigation uses)

Dependent variable: Water use (cum/family/day)

Independent variable	*Coefficient*	*Standard Error*	*t-value*	*Geometric Mean*⊕	*Marginal Physical Product*
Number of Family members	0.0075*	0.0036	2.0625	4.1878	1802.44
Distance (m)[φ]	0.0062*	0.0023	2.7416	27.7075	34.22
Additional Benefit (Rs.)[Λ]	-0.0003	0.0011	-0.2488	6.9886	-23.16
Intercept	-0.0009	0.0009	-0.9950	--	--
Regression Statistics					
Multiple R	0.5732				
R Square	0.3286				
Adjusted R Square	0.2694				
Standard Error	0.0016				
Observations	38				
F Value	5.5471*				

* Statistically significant at 5 per cent level
φ Distance means distance of user point from house
Λ Additional benefit = [Alternate cost (i.e., Cost of using well water) - Cost of using canal water]
⊕ Geometric mean of dependent variable is 2051.48 cum/family/ day

Model

$$1/WU = \alpha + \beta_1/N + \beta_2/D + \beta_3/AB$$

Where,
WU is water use (cum/ family/ day)
N is family size
AB is additional benefit
D is distance of user point from house (m)

Marginal Physical Product, $M.P.P = \beta_i . \{ \bar{Y}^2 / \bar{X}^2 \}$

Where, βi is regression coefficient
$\bar{Y}$ is Geometric mean of Dependent variable
$\bar{X}$ is Geometric mean of Independent variables

Table 4.2.8 Socio economic profile of sample farmers (Non-irrigation Purpose) of Peechi Irrigation Command Area, Thrissur

Personal Characteristics	*Unit*	*Mean Value*
1. Family size	(Numbers)	4
2. Years of schooling	(Years)	6
3. Age	(Years)	51
4. Land Holding size		
4a. Agricultural use	(ha)	0.04
4b. Non Agricultural uses	(ha)	0.03
Total	(ha)	0.07
5. Farm Income		
5a. From Crops	(Rs. per year)	12548.26 (19.32)
5b. Livestock	(Rs. per year)	52387.45 (80.67)
Total Farm income	(Rs. per year)	64935.71 (100) (67.21*)
6. Non-Farm Income	(Rs. per year)	31682.45 (32.79)
Total Income of farmer	(Rs. per year)	96618.16 (100)

Figures in parentheses shows percentage to total
* percentage to total income of farmer

Table 4.2.11 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

Table 4.2.12. Willingness to pay - Category wise

Category	*Willing to pay*		*Not willing to pay*	
	Number	*Percentage*	*Number*	*Percentage*
Irrigation	40	80	10	20
Recharge	36	72	14	28
Non irrigation	58	97	2	3
Total	**134**	**83.8**	**26**	**16.2**

Table. 4.2.13. Value of irrigation water for different users

Sl.no.	Category	Average use.M^3/ha/year M^3/family/year	Value of irrigation water		
			Cost Based Rs./ha/year;Rs./well/family/year	Productivity based Rs./ha/year	WTP Rs/ha/year
1	Direct irrigation	18.9	192.41	836-52550	153
2	Recharge of wells	12.5	225.67	2961-45921	
3	Non irrigation uses • Non human uses • Human uses	1542 2090.81	215.88 292.71	3024 4058	

Table 4.2.10. Productivity based valuation

Marginal Value Product of water

	Direct irrigation			**Irrigation from recharge**		
	Head	*Mid*	*Tail*	*Near to the canal*	*Away from canal*	*Average distance from canal*
MVP Rs./ m^3 of water	-2256	38040	3528	-1271	2961	31.54

Table. .4.1.8 Cropping pattern changes in the command area of Peechi irrigation project.

Crop	*1995-96*		*2002*		*Total area in hectares*	*Irrigated area in hectares*	*Percentage of irrigated area to total area*
	Area in hectares	*Percentage*	*Area in hectares*	*Percentage*			
Coconut	2961	15.9	6,950	37.32	6,950	5095	75
Paddy	11546	62.1	6,793	36.48	6,793	3475	50
Banana	205	1.1	1005	5.40	1005	754	75
Arecanut	224	1.2	500	2.69	500	350	70
Others including vegetables	875	4.7	560	3	560	336	60
Total cropped area	15,811	85	15,808	84.49	15,808	10010	63.32
Non agricultural use	2812	15.0	2815	15.11	2815		
Total ayacut	18623	100	18623	100	18623		

Source: CADA, Thrissur.

Table: 4.2.9 a Results of analysis on demand function- non human uses

Sl.no.	**Form**	α	β_1	β_2	β_3	R^2	**F**
I	Reciprocal $Y = \alpha + \beta_1 Ab + \beta_2 Di + \beta_3 Nu$						
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 $\log \ln Y = \ln\alpha + \beta_1 \ln Ab + \beta_2 \ln Di + \beta_3 \ln Nu$						
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: 4.2.9 b Results of analysis on demand function- non irrigation uses- human uses

Sl.no.	Form	α	β_1	β_2	β_3	R^2	F
I	Reciprocal $Y = \alpha + \beta_1 Ab + \beta_2 Di + \beta_3 Nu$						
a)		0	0.0032 (0.07)			0.943	271.52
b)		0		0.138 (0.008)		0.843	111.73
c)		0			0.0094 (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 $\ln Y = \ln\alpha + \beta_1 \ln Ab + \beta_2 \ln Di + \beta_3 \ln Nu$						
a)		0	0.00082 (0.071)			0.893	614.97
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