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Rehabilitation of Irrigation Tanks in Eastern Zone of Karnataka - An Economic Analysis

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INTRODUCTION

Canals and tanks are main sources of surface irrigation. Wells and borewells are the sources of groundwater irrigation. Irrigation tanks are small reservoirs impounding run-off water. They are concentrated in peninsular India. Tanks are common property resources supporting the village economy. With the breakdown of the institutions governing the tank management, a vast majority of the tanks have been silted up thereby reducing their live storage capacity. Besides, encroachment of tank beds continued unabated. All these have affected the degree of groundwater recharge in irrigation wells. Hence in recent years, there has been a growing realisation for rehabilitation and restoration of the irrigation tanks. The Government of Karnataka initiated a programme of desiltation of irrigation tanks on pilot basis parallel to the efforts of voluntary organisations in tank rehabilitation in 1990-91 in Kolar, Bangalore rural and Tumkur districts. This study is a modest attempt to assess and appreciate the economics of tank rehabilitation efforts at different levels of governance with the following objectives: exploring the causes for the decline of tank irrigation at the farm level; estimation of costs and benefits of tank rehabilitation; and examination of the economics of silt application and financial feasibility of investment in tank rehabilitation.

Karnataka State has ten agro-climatic zones. There are two transitional zones (north-eastern and north), five dry zones (central, northern, north-eastern, eastern and southern), one hilly and one coastal zone. This study pertains to the eastern dry zone comprising Kolar, Bangalore rural, and parts of Tumkur district. The climate is tropical and semi-arid, characterised by hot summer months with scanty rainfall of 731 mm (with a range of 679 mm to 899 mm). The maximum temperature goes upto 39° C during summer months and the minimum being 10° C during winter. The geographical area of the zone is 17.97 lakh hectares and the net cultivated area is 8.48 lakh hectares. About 28 per cent of the total cultivated area is irrigated. Alfisols (red sandy) are the predominant soils. Ragi, maize, small millets, pulses, groundnut, maize, horticultural crops (vegetables, flowers and perennial fruits) and mulberry are the crops cultivated. The horticultural crops and mulberry are mainly supported by groundwater irrigation. The area has no perennial rivers or major irrigation projects. Irrigation tanks are the only source of surface water. There are 7,862 tanks irrigating a gross area of 1,12,035 hectares. About, 23 per cent of the tank capacity is silted up, reducing the live storage capacity and the area irrigated substantially (Government of Karnataka, 1991).

There is considerable variation of area under tank irrigation over the years depending upon the volume of tank fill. The probability of total or partial tank fill with rain water is

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low and varies across locations and years. With 80 per cent of the cultivated area being rainfed, the farmers gamble on rainwater. In addition, in the absence of rivers, as the rainfall is the only source of groundwater through recharge, the farmers also gamble on groundwater. Thus the overall scarcity of water for irrigation has resulted in (a) devoting around 30 per cent of the area irrigated on groundwater farms to mulberry, a low water using crop, (b) construction of earthen overground water storage structures by more than 75 per cent of the groundwater farmers, (c) appreciable demand for drip irrigation systems by groundwater farms for crops like mulberry, grapes, sapota, coconut and pomegranate, (d) high borewell failure probability of 40 per cent, (e) increase in depth of borewells extending upto 450 feet and even beyond in the recent years (Nagaraj and Chandrakanth, 1995).

Status of Tank Irrigation in Peninsular India

Highlighting India's water-governing institutions and the history of their decay, Chandrakanth and Romm (1990) opined that irrigation tanks exerted positive externalities by recharging the groundwater resource and also by providing tank silt. The policy derived from the historical understanding of the relations between tank institutions and aquifer conditions indicates revitalisation of tank systems for surface irrigation, groundwater management and silt fertilisation. Tank investment becomes more attractive when groundwater and soil fertility effects are considered, which is the corrective policy instrument proposed to alleviate the problem.

Uma Shankari (1991) assessed tank irrigation in Chittoor district of Andhra Pradesh. Non-participation of farmers in cleaning the channels, encroachment of tank bed, inadequate repairs, weed infestation and siltation were responsible for disintegration of the conventional tank management. It was suggested that the tank management should be transferred to the farmers in the tank command to formulate rules and regulations and the Government should adopt a need based approach to promote them.

Reddy *et al.*'s (1993) study which examined the deterioration of tank irrigation in Andhra Pradesh indicated that financial stringency with the Public Works Department contributed to the decline in tank irrigation. Tanks are to be restored and maintained in the interest of the economies and ecosystems of these regions. The suggestions included, *inter alia*, regular maintenance and repair of tanks and raising the bunds and waste weirs to recover tank capacities foregone due to siltation.

Having surveyed 32 tanks in Andhra Pradesh and Maharashtra, von Oppen and Subba Rao (1980) indicated that in areas of dense population, tank irrigation has been declining due to deforestation, soil erosion, siltation, tank bed cultivation and lack of administrative structure to provide timely repair and maintenance. High water use efficiency and command area utilisation were associated with some tanks whose internal rate of return worked out to be high (23 per cent). Upon simulation, they found that a 20 per cent increase in the area could be irrigated by improved water control and by closing sluices on rainy days.

Traditional Institutions

Hoysala kings built more than half the tanks and most of the *kolas* (small tanks) between the eleventh and thirteenth centuries. Most of the *kattes* (small tanks) were built by the

Mysore rulers in the seventeenth century (Kuppuswamy, 1980-81). The presence of 40,000 tanks in around 26,000 villages shows the ingenuity of the past rulers and their prominence to recharging groundwater in the hard rocks aquifers. The institutions of tank construction were religious in nature. The construction of irrigation tanks was considered sacred conferring religious merit. Further, the construction and maintenance of tanks were vital for the prosperity of society, and considered to be one of the seven meritorious acts a person could perform in his lifetime (Chandrakanth and Romm, 1990). Inscriptions of old tanks and the remains of irrigation tanks and channels further provide evidence of these institutions (Ganapesvaram Inscription of Ganapathi, 1896). Tank maintenance such as desilting and repairing was performed through gifts of land. Individuals donated bullock carts exclusively for maintenance of the tank. Temples provided funds for such operations and leased lands to the farmers to encourage the construction of tanks for land reclamation. The farmers who did not maintain tanks would lose their right to two-thirds of the land leased to them in favour of farmers who maintained tanks at their own expense. A portion of crop production was also earmarked for tank maintenance. A committee for 'supervision of tanks', consisting of six members of the village assembly, was established in some villages to invest endowments received from religious people for periodical removal of silt and for repairs.

Reasons for Decline of Tank Irrigation

Harris (1982), describing the relegation of tank irrigation, noted: "The tank is of slight importance in village agriculture [in India] today, however. The fact that five of the richest farmers in the [Randam] village own lands which are mainly well-irrigated and are remote from the tank, compared with only two from the group of 'magnates' whose lands lie near the main sluice, shows how groundwater irrigation has now reduced the importance of control of tank water."

As the Government passed the Tank Panchayath Regulation (1911), the 'sentiment of belongingness' of the tank moved further away from the farmers. The tendency of 'leaving it to the government' prevailed in most parts of the Deccan Plateau. During 1956, the Public Works Department (PWD) created a Minor Irrigation Department vested with the task of tank maintenance. Even with the new dent, tank maintenance did not receive adequate budgetary allocation. Besides, the officials had no commitment to manage tanks as their future in the profession did not depend on how well they serve (Chandrakanth and Romm, 1990). The PWD is interested in allocations towards new constructions (dams, public buildings, and highways) rather than old works.

The reasons for the decline in the tank irrigation system in Karnataka (Table 1) are classified as socio-economic, institutional/historical and physical.

METHODOLOGY

For the purpose of empirical work, an irrigation tank desilted by the Department of Minor Irrigation (Muttur) and another tank desilted by a voluntary organisation (Kasraghatta) have been chosen. Muttur tank has a waterspread area of 153 acres and a tank command area of 71 acres. The original live capacity is 28 million cubic feet. The length of the tank bund is 900 metres with 5 feeder channels, and a waste weir. The tank is seventh in the series and 500 years old. Kasraghatta tank has a waterspread area of 5 acres and a command area of

40 acres, with two feeder channels. This tank is the second in the series and 600 years old (according to Tank Register). According to official records, the silt accumulation in Muttur tank is higher (by 25 per cent) than in other tanks. In this tank, waterspread area is larger (153 acres) than the command area (61 acres) of the tank, supporting irrigated agriculture in seven villages through groundwater recharge.

TABLE 1. REASONS FOR DECLINE IN TANK IRRIGATION SYSTEM IN KARNATAKA

Socio-economic (1)	Institutional/Historical (2)	Physical (3)
1. Magnitude of off-farm income	1. Degree of community homogeneity involved in tank management	1. Age of the tank
2. Accessibility to groundwater use	2. Adminstrative structure to provide timely maintenance	2. Inorganic fertiliser use on the farm
3. Own labour and own bullock labour	3. Encroachment of tank bed	3. Type of vegetative cover in the catchment and in the encroached land
4. Crop pattern under the tank command and the catchment	4. Sense of belongingness of the community to tank management	4. Degree of vegetative cover in the tank catchment
5. Amount of investment by the Minor Irrigation Department for tank repairs	5. Extent of community participation	5. Type of the soil in the tank command and in the tank catchment
	6. Relegation of silt fertilisation	6. Degree to which the catchment is prone to erosion in terms of topography, ploughing along the slope
		7. Size of the irrigation tanks
		8. Frequency of tank fill-up
		9. Variation in area under irrigation in tank command over years
		10. Siltation of irrigation tanks
		11. Deforestation in tank catchment

In order to analyse the factors responsible for tank degradation, a sample of 60 households in the village was drawn and then classified into two groups: Silt applying farm group (SAF) and Silt not applying farm group (SNAF). From within each group a sample of 30 farmers was randomly selected in order to assess their degree of participation in tank management and the reasons for not applying silt and their dependency on tank for diversified needs. Another random sample of 30 farmers was drawn from Kasraghatta tank to reflect the scenario in voluntary desiltation. The particulars of quantity of silt removed, cost involved and the associated benefits in desiltation were collected from the records of the village accountant and assistant engineer (Minor Irrigation) and Tank Management Committee (TMC) of the respective villages.

ANALYSIS

The performance of the study tanks at the micro level was considered by examining the data on area irrigated by wells, encroachment of channels, tank bed, rainfall received and the number of rainy days in a year drawn from the records of village accountant, which were tabulated and analysed. The cost involved in tank rehabilitation was obtained from the records maintained by the voluntary organisation, the village accountant and assistant engineer (ZP). Total investment on tank rehabilitation minus the returns realised from the sale of silt is taken as the actual investment on desiltation. Considering the enormous degree of encroachment of tank catchments, tank feeder channels and the waterspread areas and considering the uniformity in the rainfall and the number of rainy days over the last 14 years, the volume of rainwater flow to the tank in general has reduced. Since the volume of rainwater has reduced, the tank siltation rate also gets reduced due to encroachments. Hence, the life of desiltation effort is assumed as 20 years even though the period of twenty years appears as a long duration for the tank to accumulate the magnitude of silt necessary enough to undertake yet another desiltation endeavour. The investment on tank rehabilitation was amortised to obtain the annual share of the fixed cost by using the formula:

$$\text{Annual amortised cost per year} = \text{Investment} \left[(1+i)^t \times i \right] / \left[(1+i)^t - 1 \right]$$

where t = total life of the rehabilitation exercise, i = interest rate at 10 per cent and investment = investment on tank rehabilitation in the base year.

The assessment of the benefits of tank rehabilitation was done by considering the area irrigated by the tank before and after rehabilitation. This data were drawn from the registers maintained by the village accountant. The yield differentials and the cost of cultivation of the crops grown before and after rehabilitation were obtained from the farmers.

Economics of Silt Application

Partial budgeting has been used to assess the augmented yield and the savings in the cost of fertiliser on account of silt application by the farmers to their crops considering the cropping pattern of SAF and SNAF groups. The economic feasibility of investment in tank rehabilitation is appraised by using discounted cash flow measures of net present worth, benefit-cost (B-C) ratio and the internal rate of return. The following assumptions have been made in using discounted cash flow measures: (1) The benefits of tank rehabilitation are considered for 20 years at constant price. (2) The recharge in the wells located only in the proximity of Muttur tank has been considered even though the recharge extends over seven villages. (3) The recharge in the wells remains the sâme in the period of tank rehabilitation of 20 years. (4) The yield or income from pisciculture will fluctuate with the probability of tank fill-up. The probability of tank fill-up is provided below based on the farmers' perceptions:

Percentage of tank fill-up	< 25	25	50	75	100
Frequency in 10 years	1	2	4	2	1

(5) The crop pattern, technology and economics of crops will remain constant throughout the life of tank rehabilitation.

Micro-Level Indicators of Decline of Tank Irrigation System

Irrigation tanks which were irrigating about 52 per cent of the total area irrigated in 1901, now irrigated 12 per cent of the area irrigated (Table 2). The temporal distribution of irrigation wells in the proximity of Muttur tank (Table 3) shows that there were 30 dugwells

TABLE 2. AREA IRRIGATED BY DIFFERENT SOURCES IN KARNATAKA

(000 ha)

Year (1)	Tanks (2)	Canals (3)	Wells (4)	Other sources (5)	Net area irrigated (6)
1901	261	56	60	127	504
	(52)	(11)	(12)	(25)	(100)
1949-50	289	151	129	78	647
	(45)	(23)	(20)	(12)	(100)
1950-51	290	146	123	55	614
	(47)	(24)	(20)	(9)	(100)
1970-71	365	450	460	92	1,367
	(27)	(33)	(34)	(60)	(100)
1980-81	304	547	364	146	1,361
	(22)	(40)	(27)	(11)	(100)
1986-87	258	800	522	235	1,815
	(14)	(44)	(29)	(13)	(100)
1990-91	240	862	713	298	2,113
	(11)	(41)	(34)	(14)	(100)
1992-93	260	910	720	308	2,188
	(12)	(42)	(32)	(14)	(100)
CGR (per cent)	-1.3	4.2	5.6	6.2	3.9

Source: Directorate of Economics and Statistics, Government of Karnataka, Bangalore.
Note : Compound growth rate for the period 1981-1993.
Figures in parentheses are percentages to the total.

TABLE 3. TEMPORAL DISTRIBUTION OF IRRIGATION WELLS AT MUTTUR TANK

Year (1)	Dugwell (2)	Dug-cum-borewell (3)	Borewell (4)	Total (5)
1981	30	-	-	30
1982	39	-	-	39
1983	84	-	-	84
1984	112	-	1	113
1985	118	-	2	120
1986	97	10	4	111
1987	91	18	5	114
1988	83	23	7	113
1989	79	37	9	125
1990	71	43	11	125
1991	63	56	11	130
1992	60	61	12	133
1993	71	64	13	148
1994	70	65	15	150
CGR(per cent)	2.6	25	27	4

Note: Figures are cumulative and imply that most dugwells have been converted to dug-cum-borewells by 1994.

in 1981. There was a spurt in dugwells upto 1985. In 1986, their number reduced to 97 and 10 dugwells were bored inside. Hence, the discharge and recharge of groundwater from the dugwells was sustainable till 1985-86. Ever since 1984, the borewell construction was on the rise in the tank proximity. The number of dug-cum-borewells (DCBW) increased from 10 in 1986 to 65 in 1994. The compound growth rate (CGR) of dugwells was 2.6 per cent, that of DCBW was 25 per cent and that of borewells was 27 per cent, and considering all wells it was 4 per cent.

Farmers of both the tanks indicated that cultivation of tank catchment due to Government's populistic policies such as land to the landless and to weaker sections coupled with poor soil conservation practices leads to a decline in the size of catchment. These are responsible for reduced tank inflows, resulting in siltation of the tanks. In Muttur prior to 1970, well irrigation was modest as tank irrigation dominated. This tank system sustained due to protective forest cover of the catchment in the upstream. By 1985, the forest cover gradually receded due to encroachments where wells were dug for the purpose of extending irrigation in the catchment. The excavated earth from these dugwells entered the tank and reduced the tank capacities. By 1995 around 93 per cent of the dugwells were bored inside. This further enhanced the importance of well irrigation and reduced that of tank irrigation. The tree cover virtually vanished in the catchment. The siltation in the tank increased and the meagre voluntary desiltation efforts by 20 per cent of the farmers also did not help in sustaining tank irrigation.

At present, tank irrigation serves only 10 per cent (65/639 acres) of the net cultivable area while well irrigation serves 20 per cent of the cultivable area. Accordingly, in the seventies the livestock profiles were higher due to the grazing lands and forested lands in the catchment of the tank. By the mid-eighties most of the forested and grazing lands in the tank catchment were cultivated and this pattern increased since then contributing to siltation. The policy of distributing the revenue and forested lands to the landless and the encroachments have exacerbated the siltation of tanks.

COST-BENEFIT OF TANK REHABILITATION

(A) *Particulars of Work under Tank Rehabilitation*

The details of work undertaken in rehabilitation programme at Muttur tank are provided in Table 4. This work was supervised and funded by the Government of Karnataka with the help of Minor Irrigation Department. In Muttur tank 1,10,164 cubic metres of silt has been excavated and transported. Around 28 per cent of the top soil was applied to the cultivated area by the farmers. Farmers were able to make good their eroded top soil by applying tank silt and thus restore the fertility of the catchment lands. According to the farmers, silt application improved water holding capacity of the soils. The crops thrived well even if there was a delay in irrigation. The total volume of silt removed from Kasraghatta tank was 13,186 cubic metres in 155 days spread over three years (Table 5). In Kasraghatta tank, most of the desiltation work was by human labour component which is laborious and time consuming when compared with mechanical labour component employed in Muttur tank. In Kasraghatta also around 28 per cent of silt was used as manure. Totally five silt traps were constructed. Around 8,000 tree saplings were planted with the co-operation of Karnataka Forest Department in the catchment area. On account of tank rehabilitation, employment generated was 2,587 man-days and 1,811 woman-days in all the three phases which were implemented in the summer season of the corresponding year(s). Thus the programme ensured efficient utilisation of local manpower, resources and provided rural employment.

TABLE 4. DETAILS OF TANK REHABILITATION WORKS AND SILT USED IN MUTTUR IN 1993

Activities (1)	First phase (2)	Second phase (3)	Total (4)
Number of days worked	92	27	119
Number of trippers used	3	3	6
Total number of tripper loads transported	15,423	2,937	18,360
Volume of silt removed from tank(M^3)	92,539	17,625	110,164
Volume of silt used as manure (M^3)	21,789	8,652	30,441
	(23)	(49)	(28)
Volume of silt for barren government lands(M^3)	2,180	1,012	3,192
	(2)	(5)	(3)
Structural strengthening of bund (M^3)	27,419	317	27,736
	(29)	(2)	(25)
Road expansion(M^3)	31,719	5,811	37,530
	(34)	(33)	(34)
Filling pits and wells(M^3)	9,433	1,833	11,266
	(10)	(10)	(10)
Agricultural area applied with silt (ha)	120	-	120

Source: Village Accountant, Mullur Hobli, Shidlaghatta Taluk, Kolar District, Karnataka.
Note: Rehabilitation was undertaken in two phases in two years.
Figures in parentheses indicate percentages to the total.

TABLE 5. PARTICULARS OF TANK REHABILITATION WORK AND SILT USE AT KASRAGHATTA

Activities (1)	1990-91 (2)	1993 (3)	1994 (4)	Total (5)
Number of days worked	51	40	32	123
Number of tractor days	96	74	56	226
Number of cart days	12	0	0	12
Total tractor loads of silt removed	1,683	1,994	1,118	4,795
Volume of silt removed from tank(M^3)	4,628 (100)	5,484(100)	3,074(100)	13,186
Volume of silt used as manure(M^3)	2,952(63.70)	212(3.33)	573(18.18)	3,737(28.30)
Area applied with silt (ha)	47.23	3.04	9.72	59.99
Silt used for Bund strengthening(M^3)	-	323(5.80)	695(22.60)	1,018(7.70)
Silt used for filling pits(M^3)	1,065(23.10)	1,146(20.89)	308(10.50)	2,519(19.10)
Silt used for road expansion	611(13.20)	3,803(69.90)	1,498(48.70)	5,912(44.90)
Number of silt trap constructed	-	2	3	5
Number of tree sapling planted	3,500	2,900	1,600	8,000
Number of labour days worked				
Men	905	1,071	611	2,587
Women	605	798	408	1,811

The desiltation work at Muttur was beset with limitations such as non-involvement of the village community who are the real beneficiaries of the programme. In addition, a large column of silt was dumped on either side of the tank (foreshore) and only a small proportion of silt was used by the farmers as manure. The deposited silt on either side of the tank foreshore will most likely re-enter the tank during rainy season, thus defeating the very purpose of desiltation. For effective tank rehabilitation, other aspects like compacting, rolling and turfing on either sides of the tank bund, construction of check dams for prevention of silt inflow, catchment treatment, social forestry, development of wastelands and soil conservation, are also necessary. The programme at Kasraghatta, however, covered all aspects of tank rehabilitation, since it is a smaller tank as compared to Muttur tank.

(B) *Investment Analysis of Tank Rehabilitation*

The total cost of rehabilitation of Muttur tank was Rs.37.6 lakhs and was borne by the Government of Karnataka. The Bharat Earth Movers Limited, a public sector undertaking of Government of India did the desiltation work with the help of earth moving machineries. The human labour component in desiltation was obviously minimal.

The total outlay for tank rehabilitation in Kasraghatta was Rs.1.97 lakhs. The total cost of desiltation was around Rs. 1.76 lakhs. Over 57 per cent of the cost of desiltation was towards hiring tractors and 40 per cent of expenditure was towards human labour charges and around 2 per cent was for material inputs used for the project work. An amount of Rs. 20,421 was spent on the construction of silt traps. About 1.5 per cent of this expenditure was contributed by farmers in the form of '*shramadan*' which refers to the voluntary contribution of farm labour in the rehabilitation programme. This is a crucial institutional aspect of tank rehabilitation programme. The catchment was treated with 8,000 saplings of different tree species supplied by the Karnataka Forest Department. The human labour was provided by the farmers and other charges for this purpose were also borne by them.

Increased Storage of Water

The desiltation facilitated storage of surface water by increasing impounding capacity. In Muttur, around three feet of silt was removed from 33 acres of waterspread area. In Kasraghatta, on an average, two feet was removed from an area of five acres of waterspread area. Tanks of both the villages had reasonable amount of water during monsoon after rehabilitation. Before the desiltation activity in Muttur tank, paddy was grown on 38 acres and a total of 570 quintals of paddy was produced. After the tank desiltation, the production of paddy almost doubled to 1,050 quintals from 42 acres. The total area sown was 56 acres before desiltation and 65 acres after desiltation. The incremental income due to desiltation was Rs. 2.77 lakhs (Table 6). In Kasraghatta, desiltation provided for storage of a larger

TABLE 6. COSTS AND RETURNS OF CROPS FOR TANK COMMAND AREA (MUTTUR)

Particulars	Before desiltation (1993)			After desiltation(1994)			Incremental income
	Paddy	Semi-dry crop	Total	Paddy	Semi-dry crop	Total	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Area(acre)	38	18	56	42	23	65	
Yield(qtl)	570	180*	750	1,050	414*	1,464	
Rate (Rs./qtl)	425	600*	-	425	600*	-	
Gross income(Rs.)	2,42,200	1,08,000	3,50,200	4,46,200	2,48,400	6,94,600	3,44,400
Expenditure(Rs.)	1,33,000	72,000	2,05,000	1,68,000	1,03,500	2,71,500	66,500
						Net income	2,77,900

* Due to aggregation problem the monetary value of the output is considered.

volume of water in the tank. Paddy crop was grown after rehabilitation. Before rehabilitation, paddy crop could not be grown because of the low volume of water impounded in the tank. The incremental return from desiltation was Rs. 77,125 by way of raising paddy and using the tank water (Table 7).

TABLE 7. PARTICULARS OF BENEFITS AND COSTS OF TANK REHABILITATION

	Particulars (1)	Muttur (2)	Kasraghatta (3)
1.	Total investment on tank rehabilitation	37,55,859	1,96,806
2.	Income from sale of silt	1,31,430	16,700
3.	Actual investment	36,24,429	1,80,106
4.	Investment per acre of command	59,416	12,300
5.	Life of rehabilitation (years)	20	20
6.	Amortised cost (AC) per year	3,75,584	19,679
7.	Annual O & M expenditure @ Rs. 40/acre	2,600	1,600
8.	AC per acre of water spread of tank	2,276	3,935
9.	AC per acre of desilted area	11,381	3,935
10.	AC per acre of command area	5,961	492
11.	AC per well of tank proximity	4,173	3,935
12.	Incremental net return from crops of tank command area	2,77,900	77,125
13.	Income from fisheries after deducting fish seed cost	28,000	2,750
14.	Income from sale of grass on bund	-	175
15.	Incremental return from well irrigated land due to enhanced groundwater during 1994	2,37,100	-
16.	Total costs (6+7)	3,78,184	21,273
17.	Total benefits	5,43,000	80,050
18.	Net income/tank	1,64,816	58,771

Recharge of Groundwater

Owing to desiltation of tank bed, there has been an improvement in the recharge capacities of groundwater. The recharge by way of improvement in groundwater yield in wells at Muttur is given in Table 8. After desiltation efforts, 12 dugwells had an average yield of 808 gallons per hour, 32 dug-cum-borewells had an yield of 1,493 gallons per hour and 7 borewells had an yield of 1,350 gallons per hour during the *kharif* and *rabi* seasons. On an average, for each well, the additional net area irrigated was to the extent of 1.33 acres of mulberry crop. The estimated incremental return from 90 wells was Rs. 2,37,100 from Muttur tank.

TABLE 8. RECHARGE OF GROUNDWATER IN WELLS AT MUTTUR

Type of well (1)	Numbers (2)	Average area irrigated (acre) (3)	Average yield before rehabilitation (GPH) (4)	Average yield after desiltation (GPH) (5)	Average distance (feet) (6)
Dug wells	12	0.79	500	808	558
DCBWs	32	2.62	1,000	1,493	932
Bore wells	7	2.71	1,000	1,350	885

Note: GPH = Gallons per hour; DCBWs: Dug-cum-borewells.

Farmers indicated that even during rainy days, there was no improvement in the groundwater level in open wells and borewells before rehabilitation. After rehabilitation, whenever there was water in the rehabilitated tank, groundwater was recharged in open wells and borewells.

Economics of Silt Application

Partial budgeting analysis was used to evaluate the profitability of silt application (Table 9). In maize, an amount of about Rs. 740 per acre was saved by silt application. Similarly, in ragi about Rs.100 per acre can be saved by silt application. In grapes, by silt application, an additional net return of Rs. 6,250 per acre can be obtained. Thus reasonable net returns through silt application were realised due to silt use. Silt application saved the cost of inorganic fertilisers and promoted organic agriculture which is a crucial aspect in the context of ill-effects of inorganic agriculture. About 20 per cent of the farmers in that area have been applying the silt regularly and voluntarily every year and thus have reduced the use of chemical fertilisers. This has contributed towards sustainability of silt fertilisation.

TABLE 9. PARTIAL BUDGETING ANALYSIS CONSIDERING CROPS GROWN AFTER DESILTATION (MUTTUR)

(Rs.)

Crop (1)	A: Cost (2)	(3)	B: Returns (4)
Maize			
Increased cost		Decreased cost	
Silt 15 TL	1,200	FYM 10 cart loads	1,500
Land levelling	100	DAP 50 kgs	540
Decreased return		Increased return	
Decreased yield	Nil	Increased yield	Nil
Total	1,300	Total	2,040
Net savings from silt application = B - A = 2,040-1,300= 740			
Ragi			
Increased cost		Decreased cost	
Silt 10 TL	800	Urea 100 kg	360
Land levelling	-	DAP 50 kg	540
Decreased return		Increased return	
Decreased yield	Nil	Increased yield	Nil
Total	800	Total	900
Net savings from silt application = B - A = 900-800 = 100			
Grapes			
Increased cost		Decreased cost	
Silt 50 TL	2,816	FYM 10.5 TL	4,200
FYM 7 TL	4,000	Oilcake 220 kg	616
Decreased return		Increased return	
Decreased yield	Nil	Increased yield	
Total	6,816	1.5 tons @ Rs. 5,500	8,250
		Total	13,066
Net returns from silt application = B - A = 13,066 - 6,816 = 6,250			

TL = Tractor load. FYM = Farmyard manure.

Appraisal of Investment in Tank Desiltation

The internal rate of return (IRR) was 14 per cent for an investment of Rs.37 lakhs in the rehabilitation of Muttur tank (Table 10). The IRR was 29 per cent in Kasraghatta tank for an investment of Rs.1.96 lakhs considering rehabilitation life of 20 years. Thus investment on tank desiltation is economically viable. The IRR for Muttur was lower than that of Kasraghatta tank, because of the huge expenditure involved in rehabilitation of the huge waterspread area which demanded large scale desiltation efforts.

The discounted B-C ratio at 10 per cent was 1.13 and 1.7 for Muttur and Kasraghatta tanks respectively. The sensitivity analysis also proves that the longer the time distribution of benefits, the better would be the performance in terms of IRR, B-C ratio and net present worth. All these indicate that desiltation is an economically worthwhile proposition and brings equity and efficiency in the conjunctive use of surface and groundwater resources in a rain starved region fret with agro-climatic uncertainties as in the Eastern dry zone.

TABLE 10. DISCOUNTED CASH FLOW MEASURES

Discounted cash flow measures of costs and returns (1)	Muttur (2)	Kasraghatta (3)
Internal rate of return	13.80	29.18
Net present value (Rs. lakh)	8.19	2.19
Benefit cost ratio	1.13	1.70

Note: A time period of 20 years is considered. A discount rate of 14 per cent is used.

Considering the cost of desiltation per cubic metre of silt, there are sharp differences in the per unit cost of desiltation. Since the Governmental efforts to desilt employed earth moving equipments, the cost of desiltation was twice that of the labour dominated desiltation effort by voluntary organisation. In Muttur, the cost incurred by voluntary efforts of farmers to apply silt was Rs. 29.50 per cubic metre; the expenditure on desiltation using earth moving equipments was Rs. 43 per cubic metre. In Kasraghatta, the cost incurred by the voluntary efforts of farmers to apply silt was Rs. 20 per cubic metre, while that by the voluntary organisation was Rs. 15 per cubic metre. In Kasraghatta, the difference of Rs. 5 per cubic metre in the desiltation by voluntary organisation and by the voluntary efforts of the farmers is because the opportunity cost of labour provided by the farmers' *shramadan* was Rs. 18 per man-day while that of the market wage was Rs. 25 per man-day. A cursory examination of the different costs per cubic metre of desiltation indicates that if desiltation work is valued at market rates, there seems to be no difference between desiltation by Governmental or voluntary organisation initiatives or by the farmers themselves (Table 11).

The (amortised) annual cost of desiltation per acre of command area works to Rs. 5,961 in Muttur tank and Rs. 472 in Kasraghatta tank. The direct annual benefit per acre is Rs. 3,914 and Rs. 1,928 for Muttur and Kasraghatta tanks respectively. With the consideration of indirect benefits, the returns per acre would be around Rs. 7,647 in the case of Muttur and Rs 2,000 in the case of Kasraghatta. This is a pointer to the fact that tank desiltation is economical considering both direct and/or indirect benefits.

TABLE 11. COST OF DESILTATION BY DIFFERENT INSTITUTIONS

Village (1)	Institutions (2)	Year (3)	Quantity desil-ted(M^3) (4)	Rs. per M^3 (nominal prices) (5)
Tattamachanahally	Government	1993	33,000	32.51
Maragondanahally	NGO	1990-91	8,945	14.51
Kasraghatta	NGO	1991-94	13,186	14.92
Kasraghatta	Farmers	1993-94	60*	20.00
Muttur	Government	1995	1,10,164	34.08
Muttur	Farmers	1995	795**	29.50

* For a sample of 7 farmers at 1995 prices.
** For a sample of 30 farmers at 1995 prices.
Note: The cost of desiltation per M^3 is comparable after removing inflation.

POLICY IMPLICATIONS

If social benefits and equity are a prime consideration, encroachments of tank catchments, feeder channels and water spread area should be checked and punitive fines need to be imposed on the farmers who have made large scale encroachments affecting the volume of water flow to the tanks.

The evaluation of investment in desiltation indicated that desiltation is economically viable. Desiltation improved the groundwater recharge and also provided silt as manure. Hence, desiltation should be accorded top priority because (a) the perceived benefits of groundwater recharge due to desiltation efforts are higher. (b) By silt application an increase of around 24 per cent of the net returns in grape, 17 per cent savings in the cost of cultivation of ragi, and 20 per cent savings in the cost of cultivation in maize crop were observed. (c) Even though the cost of desiltation is comparable in the governmental efforts, efforts of NGO and that of farmers, it is desirable to use earth moving equipments to desilt the irrigation tanks. This facilitates expedition of desiltation of work, the task is done more efficiently and the common leakages in the implementation of the civil works of desiltation are kept to a minimum. However, the local labour which is replaced due to the use of earth moving equipments during desilting period, will certainly get opportunities to work in groundwater farms for a much longer term almost every year whose wells get recharged due to desiltation.

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