ISSUES RELATED TO INTERVENTIONS IN FARMER-MANAGED IRRIGATION: REHABILITATION OF A TANK IRRIGATION SYSTEM

R. Sakthivadivel* and C.R. Shanmugham**

BACKGROUND

The four southern states of India -- Andhra Pradesh, Karnataka, Kerala, and Tamil Nadu -- have more than 125,000 tanks. These serve the irrigation, domestic, and livestock water requirements of a large percentage of the rural population, and recharge the groundwater reservoirs. The tanks in these states account for 60 percent of the tank irrigated area in India. About 30 percent of the irrigated area in the four states is served by tanks, most of which are farmer-managed. Some of these tanks are constructed in series so that the surplus flow from one tank falls into the next tank downstream, an efficient method of water harvesting and conservation. But the utilization of tank water has not been as efficient as its acquisition. The tanks are shallow, and a substantial part of the stored water is lost by evaporation, seepage through unlined channels, leakage through defective control structures, and wastage through improper water distribution and management, resulting in inefficient irrigation.

Improving tank irrigation systems through rehabilitation, better management, and the conjunctive use of ground and surface water is necessary to utilize the already developed irrigation potential for higher cropping intensity and greater agricultural productivity or to extend the irrigation facilities to new areas or both. It is in this context that a study funded by the Ford Foundation, New Delhi office, was undertaken by the Center for Water Resources, Anna University, in a selected farmer-managed tank irrigation system at Padianallur Village in Tamil Nadu.

The study objectives were:

1. to examine the present status of the tank system and to design measures to remedy deficiencies;

2. to have necessary physical improvements carried out by collaborating organizations and farmer beneficiaries, and to suggest measures for improving water distribution and management; and

3. to monitor postrehabilitation irrigation practices adopted by farmers, and to evaluate the effectiveness of the various measures.

In order to undertake rehabilitation measures and interventions, an interdisciplinary approach was established with the state government departments of Public Works

*Director and **Special Officer, Center for Water Resources, Anna University, Madras, India.

(Irrigation, PWD), Agricultural Engineering (AED), Agriculture (AD), Forest (FD), and Revenue (RD), as well as farmer beneficiaries responsible for the upkeep and improvement of tank structures, on-farm development, crop production, watershed improvement, water "cess" and land revenue, and water management.

Padianallur tank in Chengalpattu District was chosen for this study due to its proximity to the university, accessibility, representativeness of the tanks encountered in Tamil Nadu, and location in a district where 75 percent of the net irrigated area is covered by tanks. This is a nonsystem tank receiving water from its own catchment area without any extraneous source of supply.

PREREHABILITATION STUDIES

In order to gain an insight into the status of selected tank irrigation systems, a bench mark study was undertaken to collect data about: 1) the watershed, including the feeder channels, tank bed, and storage capacity of the tank and the verification of its adequacy to meet the needs of the command area, and water yield and anticipated flood discharge; 2) tank structures, comprising the tank bund, surplussing arrangements, sluices and their capacity to discharge the required quantity of water, and irrigation and drainage channels; 3) supplemental sources of irrigation available from wells and other water sources; 4) command area, including size of land holdings, land development done, soil type and depth, and other physical features of command area; 5) quality of irrigation and drainage water; 6) water distribution and control; 7) cropping pattern and agricultural practices; and 8) socio-economic conditions of the landowners of the command area and their aspirations and attitudes that affect the system.

The following additional surveys, observations, measurements, and studies were made: 1) engineering and topographic surveys of the catchment area, tank waterspread, command area, and preparation of maps; 2) measurements of water storage in the tank using depth gauges and of water flowing through each sluice using V-notches and Parshall flumes installed in the main channels; 3) water table measurements in selected open wells in the head, middle, and tail reaches of the command area; 4) drum culture studies to measure evapotranspiration and deep percolation losses; 5) measurements of transit water losses through main channels; 6) analysis of the soils in the command area for their suitability for irrigation and nutrient status; 7) testing the water quality; and 8) measurement and collection of hydrometeorological data.

Preliminary analysis of the data collected permitted the following proposals to be framed: 1) treatment of the watershed, improvements to watercourses, and strengthening of tank bunds to prescribed standards; 2) improvements and repairs to the surplus escape; 3) construction of additional sluices and improvements to the existing leaky sluices; 4) realignment and sectioning of main channels and provision of distributaries and field channels; 5) provision of additional control structures; 6) land levelling and shaping; 7) provision of drainage facilities; 8) development of an irrigation schedule and operational policies for water distribution; 9) improvements to cropping patterns and agricultural practices; and 10) organization of farmers' committees and supporting services for regulation of water.

THE REHABILITATION PROJECT

Padianallur tank has a free catchment of 375 hectares (ha) and an intercepted catchment of 310 ha. While the entire runoff from the free catchment flows to the tank, only part of the intercepted catchment, limited to 2.38 cubic meters per second (m^3/sec), is allowed to flow into the tank through an inverted sypnon; the excess runoff flows out into a feeder channel leading from Sholavaram Lake to Red Hills Lake below it, and supplies drinking water to Madras. This syphon was found choked with rock, debris, and silt and was therefore not functioning as a water carrier to the tank.

The present waterspread area of the tank is 97.3 ha with a storage capacity of 721 thousand m^3 as against the designed waterspread of 97.7 ha with a storage capacity of 817 thousand m^3. The loss in storage capacity over the years due to siltation is 11.8 percent. Besides, thick vegetative growth of weeds like nut grass (Cyperus spp.) occupies a considerable storage space and depletes the tank water by evapotranspiration. An extent of 37 ha of private agricultural lands bordering the tank on the foreshore, which is under cultivation, contributes to soil erosion and silt accumulation in the tank bed. The salient features of Padianallur tank are shown in Table 1.

Table 1. Salient features of Padianallur tank.

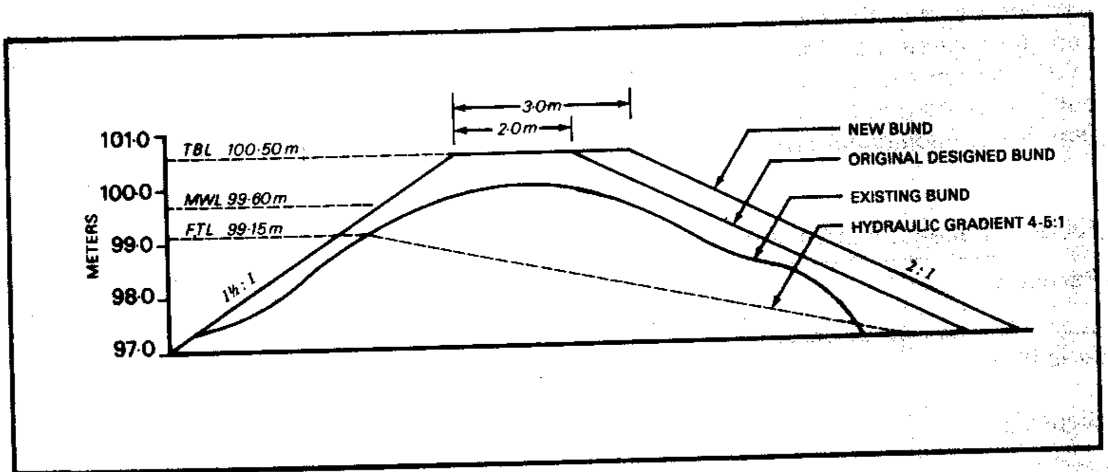
Particulars	Watershed area		Waterspread area	Command area
	Intercepted	Free		
Area (ha)	310	375	97	260[a]
Slope (%)	3.0	1.5	0.5	0.05
Soil classification[b]	RL	RL	SL	SLFS
Erosion	Mod	Slight-mod	-	-
Fertility	-		-	Low[c]
Vegetation (%)				
Agricultural crops	15	90	30	90[d]
Weeds	-	-	40[e]	-
Tree plantation	20[f]	-	-	-
Ragi & vegetables	-	-	-	10
Barren	65	10	30	-

[a]Gross (240 ha net); [b]RL - red loam, SL - sandy loam, SLFS - sandy loam & loamy fine sand; [c]poor in available N & P_2O_4, well-supplied with K, free of salinity & alkalinity; [d]mainly rice; [e]nut grass; [f]eucalyptus.

The storage capacity of the tank was originally designed for two fillings per year, with a total storage of 1.634 million m^3 to supply water for a single crop of 260 ha at the rate of 158.5 ha per million m^3 of water stored. The quantity of water received, the extent of cultivation, and the crops raised from 1982-86 are presented in Table 2.

The tank bund is a 1,845 meters long earthen embankment, trapezoidal in shape. A cross section of the tank bund along with its original formation level is furnished in Figure 1. The top level and side slopes have been obliterated over the years due to rains and erosion, encroachment by adjacent land owners, and willful cutting by the farmers. The bund needs to be strengthened and brought up to the design standard. By widening the tank bund, it can be used as a cart track which will improve the communication system between different villages situated near the north and east sides of the tank.

Figure 1. Typical cross-section of Padianallur tank bund.



A 38-meter long broad-crested masonry weir at the southern end of the tank and an earthen by-wash at the northern end of the tank bund dispose of an estimated flood discharge of 21.75 m^3/sec from the free catchment, and 2.38 m^3/sec from intercepted catchment received through the syphon, with a maximum discharge head of 0.45 meters over the crest of the weir. The surplus weir needs repair to its body wall, revetment, and apron.

There are four irrigation sluices. Sluice 4, a rectangular notch 0.5 meters wide with a sliding shutter, is located in the body wall of the surplus weir, while the other three, having plug and rod type controls, are located at different points along the tank bund. The location of each sluice in the tank bund, its sill levels, size of sluice openings, and area commanded are furnished in Table 3. About 6 ha of land north of sluice 1 is at a higher elevation and needs a very high heading up to draw water from the channel served by sluice 1. The owners of these lands cut open the tank bund and take water through the

Table 2. Particulars of water received in Padianallur tank and crops grown in the tank command area from 1981-86.

Year	1981-82			1982-83			1983-84			1984-85			1985-86	
Crop season*	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd	1st	2nd
Max storage (million m³)	0.50	0.22	-	0.51	-	-	0.71	0.68	-	0.73	0.66	-	0.73	0.70
Date measured	Nov 81	Feb 82	-	Nov 82	-	-	Oct 83	Feb 83	-	Nov 84	Feb 84	-	Nov 85	Feb 85
Crops raised (ha)														
Rice, direct sown	159.59	-	-	160.77	-	-	156.24	-	-	164.32	-	-	117.43	-
Rice, transplanted	76.60	43.97	10.78	78.94	48.09	9.31	83.47	152.93	16.58	70.82	82.50	12.44	85.24	132.73
Rice, total	236.19	43.97	10.78	239.71	48.09	9.31	239.71	152.93	16.58	235.14	82.50	12.44	202.67	132.73
Green gram	-	68.13	-	-	72.48	-	-	-	-	-	16.34	-	-	-
Groundnut	-	14.35	1.59	-	14.19	2.22	-	2.03	-	-	17.34	0.51	-	7.15
Ragi	-	0.42	22.45	-	0.42	23.82	-	0.17	3.36	-	2.50	12.29	-	0.29
Chilli	-	0.13	0.92	-	0.13	-	-	0.19	-	-	0.57	-	-	-
Cumbu (Bajra)	-	2.88	4.16	-	-	4.16	-	-	-	-	-	1.31	-	-
Gingelly (Sesamum)	-	-	1.95	-	-	2.50	-	-	-	-	-	-	-	-
Tapioca	-	0.75	1.71	-	0.62	1.36	-	-	-	-	-	-	-	-
Vegetables (Brinjal)	-	-	-	-	-	0.65	-	-	-	-	-	-	-	-
Sugarcane	-	-	-	-	-	-	-	-	-	-	4.35	1.50	-	4.21
Total (non-rice crops)	-	86.66	32.78	-	87.84	34.71	-	2.39	3.36	-	41.10	15.61	-	11.65
Total (all crops)	236.19	130.63	43.56	239.71	135.93	44.02	239.71	155.32	19.94	235.14	123.60	28.05	202.67	144.38

Year	1981-82	1982-83	1983-84	1984-85	1985-86
Rainfall received (mm)					
Southwest monsoon (Jun-Sep)	487.80	373.90	800.60	490.20	352.20
Northeast monsoon (Oct-Dec)	542.00	426.40	809.60	702.00	933.20
Dry weather & summer (Jan-May)	-	2.00	377.20	115.20	289.60
Total annual rainfall**	1029.80	802.30	1987.40	1307.40	1575.00

*1st crop - direct sown, Sep to Jan, and transplanted, Oct to Jan; 2nd crop - transplanted, Feb to May; 3rd crop -transplanted, June to Aug.
**Average annual rainfall - 1340.18 mm.

earthen cuts. This is an annual feature resulting in breaches to the tank bund during the subsequent floods. Sluices 3 and 4 are leaky. The leakage from sluice 3 was as much as 18 percent of its designed discharge. These sluices have to be repaired and made water-tight to facilitate conservation, and improve control of water regulation.

Table 3. Location of sluices (with circular tops and rectangular bottoms at sill level), specifications (in meters) of tank structures, and command area (in hectares) at Padianallur tank.

Sluice	Location	Sill level		Size of opening		Area
		Top	Bottom	Top	Bottom	
New	LS 358	98.74	98.14	0.100 dia	0.10 x 0.125	6
1	LS 680	97.84	97.24	0.146 dia	0.30 x 0.175	82
2	LS 1166	97.63	96.93	0.150 dia	0.15 x 0.175	137
3	LS 1443	97.70	97.08	0.200 dia	0.30 x 0.175	33
4	LS 1771	98.29	98.14	0.40 x 0.86	0.10 x 0.15	8

Note: LS = longitudinal section; length of tank bund, 1845 meters; top width, 2 meters (proposed increase to 3 meters); side slopes: front = 1.5:1, rear 2.0:1; Full Tank Level (FTL) = 99.15, Maximum Water Level (MWL) = 99.6 Tank Bund Level (TBL) = 100.5.

Main irrigation channels are aligned mostly in cutting to minimize seepage losses. As their bed levels are lower than the adjoining field levels, water is diverted from these channels to the field by heading it up with temporary earthen blocks. As the water level in the tank goes down toward the end of the irrigation season, the farmers remove the silt and deepen the channels to make full use of tank storage.

The command area is gently sloping eastward (0.05 percent); the soils are sandy loam and loamy fine sand, low in organic matter, nitrogen, and potash and well supplied with phosphorus. Both soil and water from the tank and the wells are suitable for irrigation and do not pose any problem of salinity. The extent of land holdings in the command area varies from 0.1- 5.1 ha. The command area totals 260 ha in the 3 revenue villages of Padianallur (157 ha), Theerthakarayampattu (28 ha), and Palavoyal (75 ha). But, in many years, the farmers cultivated only 163-239 ha (63-92%) for want of an adequate supply of water to the tank. The distribution of wells under each sluice command and the area irrigated by them are furnished in Table 4.

The water table in the command area during the post-monsoon period is 0.35, 0.54, 1.40 meters below ground level in the head, middle, and tail end reaches, respectively. There are 30 open wells and 20 tube wells in the area, of which 22 and 16, respectively, are presently in use. Irrigation from wells is resorted to when the tank is dry. Most of these wells have electric or diesel powered pumps and the area under their command is 94.50 ha (36%). After meeting their needs, the farmers sell water to neighboring landowners at a cost of Indian Rupees (Rs) 7.00 (US$0.70) per hour of pumping. It takes about 15-20 hours of pumping to irrigate 1.0 ha of land to a depth of 5 centimeters (cm).

Table 4. Wells under each sluice and area irrigated (in hectares), using electric motors (EM) or oil engines (OE) for pumping, during 2nd crop season, 1985-86.

Sluice	Open wells in use		Tube wells in use		Open wells not in use	Irrigated extent		Total irrigated extent
	EM	OE	EM	OE		well owner's land	others	
1	4	-	4	9	-	24.16	8.76	32.92
2	11	-	7	1	5	35.90	9.08	44.98
3	3	1	6	1	1	12.41	4.06	16.47
4	-	-	-	-	1	-	-	-
Total	18	1	17	11	7	72.47	21.90	94.37

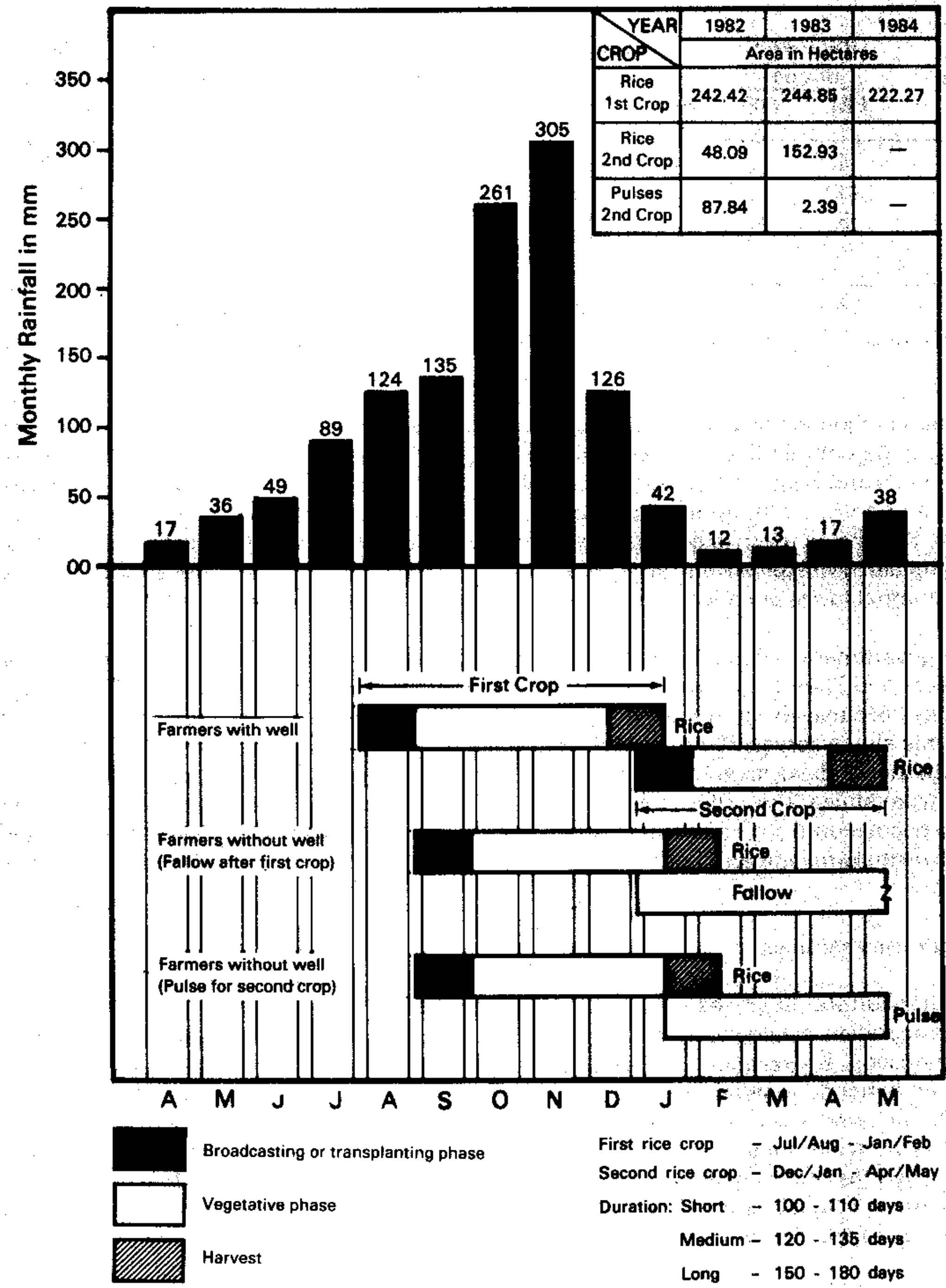
Water is regulated by a water guide (*Neerkatti*) employed by the farmers who pay him 25 kilograms (kg) of paddy per hectare of land irrigated by tank water per year. The water guide opens and closes the sluices and regulates the water to the land holdings on the basis of demand and mutual agreement among the land owners under the command of each sluice. So long as there is adequate water available in the tank to meet the total demand, no complaint is received but often the tail enders and farmers who are away from the main channel fail to get adequate supply when the level of tank water recedes.

The government has authorized a turn system by which the farmers in the villages of Palavoyal and Theerthakarayampattu draw the entire water supply from sluice 2 on alternate days exclusively to irrigate their 100 ha at the tail end of the system. On the other days, this sluice serves 35 ha in Padianallur village. Apparently, there is a need to examine whether Palavoyal and Theerthakarayampattu villages deserve a greater share of water from sluice 2 in order to receive an equitable distribution. But then, there will be strong opposition from Padianallur village for providing any additional water to Palavoyal and Theerthakarayampattu, as these villagers are latecomers in using the Padianallur tank system.

Agricultural Practices

The agricultural practices near the Padianallur tank closely follow the rainfall pattern. Land preparation commences in July or August after the first few showers of the southwest monsoon. Broadcasting of rice seed begins by about the middle of August and continues for a month or more. Usually, heavy rains are expected by the last week of September. Tank water is replenished during October, but the farmers do not use the tank water as rainfall is normally adequate from October to mid-December. The crop is irrigated with tank water only after the rain stops or when the interval between the rains is long. Generally, two or three irrigations are given to a depth of 8-10 cm each before the crop matures. Figure 2 gives the rainfall and the crop pattern prevailing in this command area.

Figure 2. Rainfall and crop pattern at Padianallur tank, 1982-84.



CROP \ YEAR	1982	1983	1984
	Area in Hectares		
Rice 1st Crop	242.42	244.85	222.27
Rice 2nd Crop	48.09	152.93	—
Pulses 2nd Crop	87.84	2.39	—

About 70 percent of the farmers raise a broadcast rice crop during the first season (August-January). The crop yield is about 1.7 metric tons per hectare (t/ha). The broadcast crop usually suffers due to vagaries of the monsoon and excess of weed growth. To avoid this, about 30 percent of the farmers raise transplanted rice using their well water for irrigating nurseries. The yield of transplanted rice is about 2.8 t/ha which is nearly 65 percent higher than the broadcast crop due to better weed control and fertilization. However, the net income to the farmers for the transplanted rice is Rs 550/ha (US$55/ha) and that for the broadcast crop is about Rs 500/ha (US$50/ha). About 60 percent of the farmers sow improved varieties like Ponni and IR 20, and others raise traditional varieties like Vadan Samba and Buyyagunda.

When the water level in the tank is high at the end of the first crop, about 20 percent of the farmers raise rice as a second crop and another 20 percent raise green gram. Only 3 percent of the farmers cultivate groundnut in the elevated fields which are well-drained. A few farmers cultivate gingelly (an oilseed crop) during April and May. When the water level in the tank is low, as it was in 1981-82, farmers switch to green gram for a second crop. When the early southwest monsoon rains are subnormal, *ragi* (millet) is raised in nurseries under irrigation from wells in July and August, transplanted after 25 days, and harvested two months later. The yield is about 2 t/ha.

Socio-Economic Survey

The baseline survey data on the socio-economic conditions of the farmers in the tank command were analyzed by classifying the farmers according to land holdings: small (less than 1 ha), medium (1-2 ha), and large (more than 2 ha), and subdividing them into head, middle, and tail end farmers. The data revealed that small-scale farmers constituted 80 percent of the total, while the medium- and large-scale farmers constituted 14 and 6 percent, respectively. About 10 percent of the farmers possessed supplemental sources of irrigation like wells (open and tube) and had field channels on their land. Ninety percent of the small farmers lacked field channels for irrigation. Although only 62 percent of the medium-scale farmers had field channels, all the large-scale farmers had them. In all, about 65 percent of the area lacked field channels. Therefore they have been following field-to-field irrigation.

Generally, water to a depth of 8-10 cm is applied to the rice crop in each irrigation by the three groups of farmers. Sometimes, the depth increases to 12 cm in head and middle reaches. Whenever there are heavy rains and the depth of water exceeds 12 cm, the farmers cut open their field bunds to permit surface drainage of the excess water. The lands are also drained just before applying pesticides and again about 10-12 days prior to harvest. Table 5 shows a breakdown by type of farmer and the irrigation schedule they followed.

About 85, 57, and 67 percent of the small-, medium- and large-scale farmers, respectively, expressed their dissatisfaction about the poor timing and inadequacy of water supply. All three groups of farmers in the tail end expressed their dissatisfaction over the water distribution. They all required augmentation of water supply by carrying out necessary improvements to the tank and distribution network.

Table 5. Breakdown of landholdings in different reaches and the farmers' irrigation schedule (total area in ha, irrigation intervals in days).

Location and farmer type	Number of holdings	Total area	Irrigation intervals	Number of irrigations
Head Reach				
Small	43	21.56	5	13
Medium	18	26.43	6	12
Large	3	12.34	7	10
Total	64	60.33		35
Middle Reach				
Small	65	30.21	6	12
Medium	19	27.26	6	11
Large	3	12.33	6	11
Total	87	69.80		34
Tail Reach				
Small	141	39.93	6	12
Medium	8	10.86	7	10
Large	5	56.59	6	12
Total	154	107.38		34

Note: Observed data for second rice crop during 1985-86. Rice planted is IR 50 (105 days to maturity). Nursery, 25 days. Last irrigation 10-15 days prior to harvest.

PROJECT IMPLEMENTATION

Based on the surveys, observations, and measurements made during the pre-rehabilitation studies, the deficiencies of the system were identified and measures to correct them were designed. The proposed rehabilitation measures were discussed with the farmer beneficiaries and their views were collected regarding the physical improvements envisaged for the irrigation system. The proposals were then modified to meet their requirements. New members who showed interest in the proper operation of the irrigation system were added to the farmers' committee responsible for managing the tank.

The design and specifications of the proposed rehabilitation, as modified by the suggestions of the farmers, were forwarded to the collaborating organizations for implementation. Their work was coordinated and monitored by Anna University. The improvements could be executed only during the off season when agricultural operations were not in progress. The working days were few in number and there were many interruptions to field operations due to rain, scarcity of labor required for heavy earth work, and field staff of implementing departments being diverted to other work which slowed down completion of the envisaged improvements.

The PWD undertook improvements to earthen embankments, stone pitching, surplus weirs, sluices, and main irrigation channels. The Agricultural Engineering Department (AED) undertook the on-farm development (OFD) works. And the Forest Department (FD) carried out the tree planting on the tank bed. The Survey and Land Records Department identified government field boundaries in a small part of the command area and helped to fix demarcation stones to prevent encroachment by adjacent farmers. The farmers undertook emergency works, such as breach closing of the tank bund during floods and silt clearance of supply channels to augment water supply in the tank.

Completed Improvements

The following improvements to the physical facilities had been carried out as of 1986. Tree planting of about 12,000 *eucalyptus spp.* was done on 4 ha of private land on the foreshore during 1983 and with about 22,000 *acacia spp.* on 11.5 ha of government-owned tank bed during 1985. These tree plantations were meant to minimize silt accretion into the tank waterspread to some extent. The main feeder channel from the syphon to the entrance of the tank was excavated by the farmers as community work. Although not to the designed standard, it was enough to carry the inflow during low rainfall. The farmers requested desilting and deepening of the tank bed so that, even if it increased the dead storage, they could pump out that water for the last two to three wettings of the second crop because water shortage at that time (April) was critical. However, the PWD was not able to do this work due to the problem of where to dispose of the excavated earth. As a compromise, arrangements were made to permit the farmers to excavate the tank silt within a demarcated area in the tank bed and apply it to their fields. The earthen embankment of the tank bund with laterite stone pitching on the front slope had been strengthened at vulnerable places according to prescribed standards.

Clearing the choked-up syphon. The PWD cleared the vent way of the syphon conveying runoff from the intercepted catchment.

Surplussing arrangements. The broad-crested masonry surplus weir which was leaky in many places was grouted with cement and strengthened with concrete. Computations of the anticipated 50 year flood flow showed that the spillway capacity of the existing surplus weir was adequate. However, in order to prevent breaching of the tank bund at the northern end, where the fetch of the water spread is large, a masonry paved by-wash (overflow gate) was constructed in place of the existing earthen one.

Sluices. New sliding shutter and plugs and rods were provided for all four existing sluices. These sluices were also repaired and the leaks stopped. A new sluice was constructed north of sluice 1 to provide water for the elevated fields which had difficulty receiving water from the sluice 1.

Irrigation and drainage channels. The main earthen channels conveying irrigation water from the sluices to the fields in the tank command were all restructured to design specifications and deepened to the downstream sill level of the sluices. The meanders and sharp ends were eased to smooth curves or straightened where feasible. The side banks that had eroded and caved in were brought in line with designed side slopes after the removal of weeds and other vegetation. Stone pitching on the side slopes of the main channel was done for a length of 18 meters downstream of the sluices in order to stabilize the channel bank and permit precise flow measurements. Portable "V" notches and Parshall flumes were installed at these locations and the daily outflow of water from each sluice was computed.

On-farm development works (OFD). The AED has carried out OFD works in the command areas of sluices 1, 3, and 4. The 33 ha command area of sluice 3 was divided into three convenient blocks -- A, B, and C -- of about 11 ha each. Two bed regulators were constructed at selected points across the main channel to head up the required depth of water and to divert the designed flow to the lined laterals to irrigate one field at a time in each block. The carrying capacity of each lateral was 0.03 m^3/s (1.06 cusec). It takes 3 hours to apply 5 cm depth of water to 0.40 ha (1.0 acre). Irrigation was proposed only during the daytime hours from 0600 to 1800 each day and therefore each lateral can irrigate 1.60 ha (4.0 acres) in a 12 hour day. Thus it takes 6-7 days to complete one irrigation in each 11 ha block. Because the bed regulators permit simultaneous irrigation of one field at a time in each of the three blocks, all the blocks have the benefit of equitable water distribution, and the second irrigation can be taken up immediately following the first rotation in a predetermined order.

Physical facilities such as distribution boxes with mild steel (MS) plate sliding shutters, field channels, pipe inlets, and drainage outlets have been provided in many of the fields. The actual operation of distributing the water to fields within each 11 ha block is vested with the farmers' committee and the landowners for implementation.

OFD works were also executed in the command areas of sluices 1 and 4. After observing the actual working of the water distribution and application using these physical facilities, similar work was proposed in the command area of sluice 2. In this command water distribution is complicated by the larger area irrigated and by the need to supply two groups of villages with widely different areas to irrigate -- Padianallur (35 ha) and Palavoyal and Theerthakarayampattu (100 ha) -- on alternative days for 12-hour periods.

As the terrain of the command area is almost flat (0.05%), the quantity of water in the lateral flow (subsurface runoff) or return flow is minimal. Hence, the irrigation system was designed to meet the water requirements of the entire command for growing rice at its peak requirement, which is during the land preparation and puddling stages.

Proposed Improvements

The following activities were originally proposed but have yet to be undertaken and completed:

1. Tree planting in possible vacant lands in the catchment area which will further prevent sedimentation of the tank.

2. Closing the breach in the right bank of the Sholavaram lower supply channel which will further augment the water supply to the tank.

3. Completing the strengthening of the tank bund, providing gravel casing on the top and sides, and extending the tank bund on the north beyond LS 00 to meet the high ground, which will facilitate greater storage.

4. Constructing a causeway providing access to the tank bund from Padianallur village during the rainy season.

5. Providing a toe-drain to collect seepage water and divert it into the main channel to prevent flooding of fields.

6. Permitting the farmers and others to remove the silt from the tank bed within a demarcated zone to increase storage.

7. Providing a shutter for the newly constructed sluice as well as locking arrangements for the sluice shutters recently replaced.

8. Providing shutters for the bed regulator constructed in the first sluice head-reach.

9. Fixing survey stones and demarcating government land boundaries to identify encroachments.

10. Interchanging the sluice openings between sluices 2 and 3 to improve equity.

11. Desilting the supply channel to the tank and the drainage channel from Sholavaram, which also augments irrigation supply to the tank command.

12. Providing shutters to all distribution boxes and lining laterals as found necessary.

13. Reconstructing damaged lined laterals and distribution boxes in the OFD works.

14. Completing the excavation of field channels.

15. Evicting encroachers from government land and preventing further encroachment which aggravates sedimentation.

16. Counselling farmers more intensely about improved cropping patterns and agricultural practices.

17. Educating farmers on the benefits of improved water management practices.

This work had not been completed when this was written. Reasons include the lack of sanctions from the authorities concerned, lack of funds, lack of adequate labor, and the failure to realize the importance of the work. With the necessary conviction and commitment of the authorities and farmer beneficiaries, these works can be completed thereby providing the full benefits of the interventions to the farmers they were designed to help.

ASSESSMENT OF INTERVENTIONS

As this is a pilot project study, a critical assessment was made of the constraints encountered and of the benefits arising from the interventions. Although such an assessment of a local study is perhaps limited in its application to other farmer-managed irrigation systems, it provides valuable information on common problems which one might encounter in other tanks. Some of the benefits have been cost effective, while others resulted from motivating farmers to act in ways that promote the common welfare.

Tree Planting in the Foreshore Private Lands and the Tank Bed Area

When the plan was drawn up suggesting the planting of trees in the catchment area and the foreshore lands as a measure of soil conservation, it was given first to a large-scale farmer to plant a substantial portion of his lands to eucalyptus hybrids. The FD was to follow by planting the tank bed land with *acacia spp.*, which would minimize silt accretion into the tank.

Clearing of Silt and Debris by the PWD from the Choked-up Syphon

Though of low cost, this work helped augment water supply to the tank, increased its storage, and resulted in greater cropping intensity in its command area. It also motivated the farmers to clear silt from the supply channel between the syphon and the tank as community work.

Strengthening the Tank Bund

Flooding of fields in the head reach due to seepage through the bund has been minimized by strengthening and widening the bund. The threat to the bund by breaching has also been minimized. The widened tank bund now serves as a cart track to transport seeds, manure, other inputs from the village to the fields, and produce from the fields to the market. Communications have improved considerably.

Restructuring the Main Irrigation Channels and Providing Lined Laterals

The seepage loss during conveyance from the sluice to the fields was reduced due to weed removal from the main channels. Easing meanders and sharp bends and straightening the channel course have helped to convey the water to the lower fields with less travel time. Provision of uniform bed grade has helped provide non-erosive velocity to the water.

Similarly, providing lined laterals has helped to minimize operational losses and to convey irrigation water rapidly, a need of the tail end farmers. This in turn has helped to reduce the time lag in transplanting operations and to minimize moisture stress of crops. Providing lined laterals in a planned layout has prevented the farmers from excavating earthen channels every year and introduced discipline in the conveyance of water. It has also constrained the farmers who used to take water by cutting the embankment of the main channel and placing earthen blocks across it. Some farmers who had fields adjoining the main channel or the lateral have become tail enders in the newly laid out OFD works and therefore wait longer for the water to reach their fields. These farmers, as well as the water tenders of absentee landlords, seldom await their turn to receive water through the newly-constructed laterals and, instead, cut the banks at places adjoining their fields to expedite irrigation.

On-Farm Development Works

Previously, 65 percent of the landholders in the tank command lacked channels to convey water to their fields and practiced field-to-field irrigation. The OFD works have provided adequate irrigation channels at a density of 39 meters/ha for lined laterals and 175 meters/ha for earthen field channels. Considering that there are 336 fields in a 260 ha command area, this density is considered necessary for the water to reach every one of them. The layout of the water courses was decided upon in consultation with farmer beneficiaries who agreed to maintain them in good condition.

Repairs to the Leaky Surplus Weir and Sluices and Replacement of Worn-out Shutters

About 18 percent of the designed discharge was wasted through leaky sluices and leakage from the surplus weir. Repairs have eliminated these leaks thus preserving water in the tank. This additional water has helped farmers to increase cropping intensity in the area.

Day-time Irrigation

Hitherto, once the sluice was opened at the beginning of the irrigation season, it was closed only when the heavy monsoon rains inundated the fields and drainage became difficult. Water would otherwise flow continuously in the main channel and the farmers who needed it diverted it to irrigate their fields; at other times the water was wasted. A system of 12-hour irrigation from 0600 to 1800 was introduced with the consent of the farmer beneficiaries. This has also helped to conserve water for the second crop season and thus helped to increase the cropping intensity in the tank command. Table 2 gives the area irrigated during the different years, and shows a substantial increase both in the total area cropped and the farmers' preference for the price-supported cereal crops and cash crops.

Another progressive step by farmers was the switch from the traditional long-duration rice varieties, which covered about 20 percent of the area during 1981-82. High-yielding, medium- to short-duration varieties like IR 20, Ponni, IR 50, and IET were adopted, which require the right quantity of water at the right time for a good crop yield. This switch was mainly due to the greater reliability of water ensured by the interventions.

Increase in the Number of Wells

The farmers were quick to realize the value of wells as a supplemental source of irrigation and the benefit of conjunctive use of tank and well water. Farmers owning wells could raise nurseries with well water and transplant the seedlings in time for the first crop to take full advantage of the monsoon rains. Similarly, wells could contribute at the critical stage of the second crop (Feb-May) to prevent moisture stress to the crop and thereby increase yield. As a result, farmers have sunk new wells in the 260 ha tank command area, and increased the number of operational wells from 38 to 47 in 5 years. Crop yields from the fields having supplemental sources of irrigation from wells have been generally higher.

Drum Culture Studies

Drum culture studies made in the field during the first (Sep-Jan) and second (Feb-May) crop seasons show that, when properly managed, rice can be grown with 95 cm of consumptive water use, providing a good yield during the first season. However, many farmers use 105-110 cm of water. This wasteful practice was highlighted in the field demonstration conducted at this tank command under the operational research project in collaboration with Tamil Nadu Agricultural University, Coimbatore. It showed that with 10-15 percent reduction in irrigation water, a higher crop yield of 12-14 percent could be obtained. The same farmers who over-irrigate their fields with tank water during the first crop season, use it economically during the second crop season when the water level in the tank recedes. The switch amounts to a 25 percent reduction in consumptive water use and illustrates the farmers' awareness that reduced water use need not be detrimental to the crop. This water conservation concept needs to be emphasized and encouraged to further increase cropping intensity in this area.

Investment Cost and Benefit

It is perhaps premature to make a systematic cost benefit analysis before the improvements contemplated in the entire tank irrigation system have been completed. However, it is worth studying the investments made in the rehabilitation project so far and their apparent benefits.

So far, Rs 709,201 (US$70,920) have been spent on this rehabilitation project by various organizations. This works out to Rs 2,955/ha (US$296/ha) of land benefitted. The main benefit to farmers that could be attributed to the improvements is a better water supply, resulting in increased crop yields and increased cropping intensity (from 120% to 140% under rice, Table 6).

Importance of Farmers' Cooperation

While all the farmers in the tank command expressed eagerness to acquire and store water in the tank, they did not show the same concern for its economic and equitable distribution. The farmers who used to divert water by blocking the main channel found it cumbersome and time-consuming to operate the bed regulator to head up the water and draw it through a lined lateral, a masonry distribution box, and an earthen field channel.

Table 6. Rice yields (in kg/ha) and profits (in Rupees/ha) related to improved water supply in areas of the tank command.

	Rice yield		
	In unimproved areas	**In improved areas**	**Profits**
Crop I	2200	2800	1040 (US$104)*
Crop II	3700	4500	1400 (US$140)**

*At Rs 130/bag of 75 kg; **at Rs 135/bag of 75 kg.

The main channels are on government land, while the lined laterals, distribution boxes, and field channels are constructed on private land. These common facilities, which pass through individual properties, create conflicts even though all the farmers concerned expressed their whole-hearted cooperation and willingness to have them located on their land for the benefit of all. Disagreement between two farmers over the excavation and maintenance of a field channel affects many others downstream who have to depend on this channel for irrigation. Although these difficulties could be resolved at the farmers' committee level or even among the farmers involved, often it ends up in damage to the field channel and denial of water to the farmers. Patient and persistent education of the farmers at the village level to adapt themselves to the changed pattern of water conveyance and application appears to be the only solution.

Frequent meetings, short training programs, pamphlets illustrating the irrigation system and its operation, visits to an efficient irrigation system, and films and videos about irrigation can make important contributions to farmer education. Simultaneously, punitive measures against water users who ignore the agreed code of conduct have to be taken if equitable distribution and economic use of water and proper maintenance of physical facilities are to be ensured. Unless these follow-up measures are taken during project implementation, the success of the project will be in doubt. People generally respond favorably when they benefit. As the rehabilitation project bestows a benefit on the community, that community would want to use the benefit to the best advantage. As rehabilitation projects are more advantageous than new projects in terms of investments and returns, they should be pursued with enthusiasm and dedication so that the projects which once provided an assured water supply could be improved to bestow increased benefits to the people of the area.

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