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TANK IRRIGATION IN SOUTH INDIA: WHAT NEXT?

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1 INTRODUCTION

Tanks are a common feature of the south Indian cultural landscape, irrigating about one third of the total rice area in the states of Andhra Pradesh, Karnataka and Tamil Nadu. The concentration of tanks is high in these states because of topographical features such as undulating terrain, hardrock geology, red soils (alfisols), and the bi-modal rainfall distribution. (In Tamil Nadu, there are about 39,000 tanks accounting for about 32% of the irrigated area.) This paper examines reasons for the poor performance of tank irrigation in recent years, and reports on a simulation study developed in Tamil Nadu to examine potential modernisation strategies. This paper examines the results of financial criteria used to evaluate these strategies, but also summarises findings when production and equity criteria were applied.

Tanks are classified as system and non-system tanks, based on the source of water supply. Tanks depending purely on rainfall are called non-system tanks, while those depending on perennial surface water sources such as reservoirs, rivers, etc, in addition to rainfall, are called system tanks. Typically, more than 90% of the tanks are non-system tanks; these tanks are the focus of this paper. Though a majority of the tanks are small, with a command area of not exceeding 50 hectares, some tanks are very large, irrigating more than 2000 hectares. Tanks are also classified on the basis of the size of the command area; minor tanks are those with a command area of less than 80 hectares, and major tanks serve more than 80 hectares. Minor tanks account for more than 70% of the total tanks. The area irrigated is based on the assumption that 1 million m^3 irrigates 85 hectares of rice. Normally one rice crop is grown between September and December, and, depending upon the water storage, a second non-rice crop may be possible. Besides the irrigation tanks, there are about 5,300 percolation ponds (tanks) in the State which are used only for recharging the wells in and around 1 kilometre radius.

The average rainfall of the State is about 950 mm per year and it is mainly the rains during the Northeast monsoon (October-December) which fills the tanks. Variation in the rainfall in the Northeast monsoon period heavily influences the tank filling and the tank irrigation. On average, over a 10 year period, the tanks overflow in 1 year and get adequate (70% to 100%) supply in 2 years; in 2 years there is complete failure, and in the remaining 5 years the tanks are partially filled (Palanisami & Flinn, 1988).

2 CURRENT STATUS

Since India's independence, the development of tank irrigation has stagnated. Several factors have contributed to this. Firstly, the developments of major and medium surface irrigation projects, and of groundwater, have received priority. Exploitation of favourable sites for surface projects has helped surface irrigation development expand on a large scale, and groundwater development has been favoured by the introduction of diesel and electric pumpset technology and availability of institutional finance. Tank irrigation has been somewhat neglected both by the government and the local community. For example, from 1960 to 1983 alone, the exploitation of the groundwater has been so fast that it rose from 30% to 42% of irrigation nationally, and the proportion of the tank irrigation declined from 19% to 12% nationally, and from 38% to 31% in Tamil Nadu.

In addition, other factors, such as heavy siltation of the tank and feeder channels, encroachment on the tank foreshore area, deforestation in the catchment area, poor functioning of the tank (upper) sluices, defective tank structures (lower sluices and canals), and weak farmers' organisation, have contributed to the decline in tank performance. Tank siltation has reduced the water storage capacity by about 15% on average, and in some of the tanks heavy siltation has almost eliminated the storage capacity (Palanisami & Easter, 1983). In conjunction with this siltation, farmers during the last 2 decades have slowly encroached on the tank storage area. It was observed that 10% to 25% of the water-spread area of the tank has been encroached by the villagers for unauthorised cultivation. In total both siltation and encroachment has reduced the tank storage capacity by about 30%. The other important factor which affects the water storage and irrigated acreage is the rainfall. As the command area under each tank is based on the capacity of the tank multiplied by the number of fillings, variation in rainfall pattern influences the quantity stored and area irrigated. It was observed that the variability in rainfall pattern has increased by about 8% over the last 10 years. Thus the performance of the tank irrigation has declined over years, and tank irrigation, formerly a source of stability, has become a source of instability.

However, recently it has become apparent that major irrigation projects are not yielding the expected benefits because of the inordinate delays in completing projects, as well as cost escalation. In addition, under-utilisation of the created potential, coupled with water-logging in several locations, made it clear that future investment should be made carefully. In the case of groundwater, poor availability of power, increasing power costs, and over-exploitation leading to declining watertables in several locations, have constrained development. In view of these problems, the government now feels that tanks could be made a viable source to meet the future demand for irrigated acreage, and tank modernisation is the only possible way to achieve this demand in both the short and long-term, in the areas we discuss.

3 TANK MODERNISATION

The Tamil Nadu government, realising the seriousness of the tank management problems, has already started work to rehabilitate the tanks through several initiatives. The Agricultural Engineering Department of the State government has started lining the canals of small tanks. Further, the assistance of the European Economic Community (EEC) has been utilised to modernise about 150 non-system tanks. Following evaluations, the EEC is proposing to modernise more tanks in the second phase of their assistance. The World Bank is also considering major investment in tank modernisation.

The various modernisation strategies being adopted by different departments and agencies fall into 2 groups:

(a) **improving the tank structures**

this includes strengthening the tank bunds, and restructuring the existing sluices and surplus weirs. Since the functional specifications of the existing control structures have been lost due to tank siltation and poor management, restructuring the sluice gates and surplus weirs will help correct this problem;

(b) **on-farm water management**

since water losses in the unlined canals and field channels range from 20 to 30%, lining has been done in several tanks, which reduced the water losses by about 20%. Further, lining the field channels and reorganising the water distribution around blocks is also done for efficient water distribution.

4 WHAT IS NEXT?

The above modernisation strategies in restoration and improved efficiency are not making the expected impacts on overall tank performance. The strategies of structural improvements are inadequate as they confine the nature and scope of the tank modernisation to existing conditions. It is important to consider all the following strategies for tank modernisation. Depending upon the scope and nature of the government intervention needed for tank modernisation, the strategies are grouped as 'above' and 'below' outlet strategies.

5 ISSUES ABOVE THE OUTLET

(a) Desilting the Tanks

Siltation over years has reduced tank storage capacity by about 15%. In the earlier days farmers used to desilt the tanks using their bullock carts and manual labour with the aim of maintaining the tank storage, as well as obtaining manure for their lands. Today it is becoming increasingly difficult to desilt by themselves due to the lack of bullock carts and the reduced spirit of kudimaramathu (community repair work). The government cannot perform the desilting, since it is too expensive to desilt the entire tank capacity, and also it is difficult to dispose of silt outside the tanks. Further, the tanks surplus in only 1 out of the 10 years, or are 70% to 100% full in 2 out of the 10 years, and the desilting will not have much impact in the remaining drier years. Hence, what is needed is for the farmers in each tank to organise and start the desilting in a phased manner, so that the disposal of the silt is easier.

(b) Desilting the Supply (Feeder) Channel

In many tanks the supply channels feeding the tanks are heavily silted, and in several cases they are missing due to the combined effect of both siltation and encroachment. Restoration of the supply channels with original capacities will help capture the run-off water to the tanks. The estimated run-off from catchments is 10% to 15% depending upon the soil type; for alfisols (red soils) run-off is deemed to occur when the rainfall exceeds 17 mm/day (Agricultural Engineering Department, 1987).

(c) Curtailing Encroachment

The use of illegal 'pattas' (rights from the government) to encroach the tank foreshore should be discouraged via the intervention of the Revenue

Department. The removal of the encroachment will further help increase the tank water storage by proper filling.

(d) Afforestation Programmes

Tank siltation is one of the major causes for the reduction in the tank storage capacity. This is further aggravated by deforestation in the tank catchment area, both by the encroachers and tank irrigators for firewood, and causing extensive soil erosion during heavy rains. Hence, the afforestation programme has to be strengthened in the tank catchment area. The social forestry programme now introduced in other areas has to be introduced in the tanks also. As per the social forestry programme, the Forestry Department is planting trees in the tank catchment and foreshore areas. In some cases the water spread area of the tanks are also used for planting the trees and after 10 years, the trees will be auctioned off. About 50% of the revenue from the auctioned trees will be given to the local Panchayat (village level administrative body) which will be spent on tank and village improvement works.

(e) Tank Water Management

The simple procedure of closing the sluices during the rainy days, when there is no apparent demand for water has been shown to increase storage, which in turn increases the irrigated area by more than 20%, with a 17% lower risk of crop failure. According to the ICRISAT study (Venkatram, 1980), supervisors, at the rate of 1 person for every 100 tanks, could be used to enforce minimal water regulation rules and provide technical guidance. Such a guideline still has to be tested in Tamil Nadu.

6 ISSUES BELOW THE OUTLET

(a) Redefining the Water Requirements/Command Area

The command area of the tanks has been fixed in relation to the rainfall pattern, number of tank fillings and the capacity of the tanks. After the introduction of high yielding varieties of rice, the water requirement of the rice crop has steadily increased. Hence, to satisfy the same command area, water supplies have to be increased from the given level, or for the given water supply. The size of the command area has to be respecified.

(b) Conjunctive Use of Tank and Well Water

Due to inadequate tank water supplies from the tank for the rice crop, particularly at the end of the crop period, there is a growing need for supplemental irrigation from wells. Currently, about 15% only of the tank farmers own wells, and there is a powerful monopoly market for groundwater. It was estimated that about 38% of the crop income of the non-well owners is paid as water charges to the monopoly well owners (Palanisami, 1987). Hence, provision of additional groundwater wells in the command area either by private, community or government investment will help increase crop income via conjunctive use and discourage the monopoly pricing of well water. The hydraulic interaction between tank storage and well water recharge will further encourage the investment in groundwater development, depending on the suitability of geology and tank bund construction.

(c) Farmer Involvement in Tank Modernisation

In view of the huge investment proposed in tank modernisation, it is important that farmers should be encouraged to participate both in the pre- and post-modernisation activities. Participation by the farmers, as well as incentives to farmers' associations, will help define appropriate proposals and their implementation. The incentives may be in the form of additional funds from the government to meet emergency repairs, or additional authority to raise fish in the tank and market them without outside intervention.

(d) Crop Management

Changes in crops during years of low rainfall are another possibility for increasing income from tank irrigation. Tank irrigation choices, based on tank storage adequacy, can be grouped as 'a good year' (surplus), 'a satisfactory year' (normal), 'a deficit year' (below normal), and 'a very bad year' (failure). For example, in a 10 year period, the surplus year occurs once, a normal year occurs twice, a deficit year occurs five times, and for 2 years there is failure. Hence, particularly during deficit years, (i.e. on average, every alternate year) non-rice crops can be grown to minimise the risk due to inadequate tank irrigation.

(e) Tank Administration

Under the present 2-tier system, ownership and maintenance of most of the tanks lies with the state Public Works Department (PWD), and the irrigation fee collection lies with the Revenue Department. There is practically no coordination between the 2 departments. The funds allotted by the Revenue Department to tank repairs and maintenance are highly inadequate. It costs about Rs 40 hectares[1] for the operation and maintenance of the tanks, and the fund allotted for this purpose is only about Rs 15 hectares.

7 EVALUATION OF IMPROVEMENT STRATEGIES

A simulation study was performed to evaluate the tank modernisation options (Palanisami & Flinn, 1988). The model constructed permits the simulation of decision-making at several levels, such as water release from the tank, water allocation to rice crops in different sectors of the command area, crop yield reduction due to water stress at different stages of growth, and at different positions in the irrigation system. The Srivilliputhur Big Tank in Ramanathapuram district was selected as a representative tank to test the model. The catchment area of this tank is over 1,500 hectares, storage capacity is 14,160 hectares cm, with a water spread of 53 hectares. The irrigated rice area is 402 hectares.

Several modernisation options were simulated in the model, such as sluice modification, canal lining, provision of additional wells for supplementing the tank water, sluice management (closing the sluices for 2 days when the daily rainfall exceeds 60 mm), and rotation management (closing the alternative sluices for 1 week). These are listed in Table 2.

Alternative management and improvement in irrigation structure leads to farmer gains. Thus strategies can be evaluated both by production criteria and for their contribution to improved equity. However, it is also necessary to evaluate whether these investments are beneficial from the point of view of society. In principle, strategies should be cost effective to justify their adoption.

The direct benefits of tank improvement are increased rice production. But production increase is not always constant year-to-year due to seasonal failures of the tank system. Alternatively, there will be minimal benefits from system improvement in water surplus years, as in these years water is not a constraint even with the existing situation. The 10 years of data available on levels of tank replenishment, and associated benefits from tank improvement are given in Table 1 below, and arranged in the order

[1] In 1990 US$ 1 = 17.28 rupees.

they occur. Over this 10 year period, full benefits of modernisation were expected to be realised in the 5 years when the tank storage reached 50 to 70% of storage capacity. Partial benefits, assumed to be half the benefits, were assumed to be realised in the 2 years the tank was 70% to 100% filled. In turn, no benefits are realised in the year the tank overflows (because tank supply was not a constraint), or in the 2 drought years when no rice was planted.

TABLE 1: PATTERN OF OCCURANCE OF TANK IMPROVEMENT BENEFITS IN A 10 YEAR CYCLE, RAMANATHAPURAM, TAMIL NADU, INDIA

Year	Tank storage level (%)	Groundwater supplementation[1] (%)	Benefits of tank modernisation
1	50-70	30-40	Full
2	50-70	30-40	Full
3	<50	No cultivation	No
4	>100	0	No
5	70-100	5-10	Half
6	50-70	30-40	Full
7	<50	No cultivation	No
8	70-100	5-10	Half
9	50-70	30-40	Full
10	50-70	30-40	Full

1 Based on survey data on groundwater supplies for 4 years (1981-84).

(Source: Palanisami, K and Flinn, J C, 1988.)

The sequence of water supply events was used to calculate the expected values of benefits of the eight improvement strategies defined in Table 2. These, in turn were used to calculate the benefit cost Ratios (B/C), and the Internal Rates of Return (IRR) for the various improvements in tank management (Table 2).

TABLE 2: BENEFIT-COST RATIOS & INTERNAL RATES OF RETURN FOR DIFFERENT TANK IMPROVEMENT STRATEGIES, TAMIL NADU, INDIA

Strategies	Life period (years)[1]	B/C ratio[2]	IRR
Sluice modification	6 11	0.5 0.6	0 0
Sluice management	10 15	10.0 10.6	2204 2204
Canal lining	6 11	1.8 2.9	54 63
Additional wells	8 16	1.7 2.1	35 38
Rotation management	10 15	10.8 10.9	1974 1974
Canal lining + additional wells	8 16	1.5 1.9	30 33
Sluice management + additional wells + canal lining	18 16	1.7 2.1	37 39
Rotation management + additional wells + canal lining	8 16	1.4 1.8	27 31

1 Upper figure represents life period without maintenance, the lower figure represents lif period with maintenance

2 Discount rate = 12.5%

(Source: Palanisami, K and Flinn, J C, 1988)

Two periods for investments were assumed; one with no maintenance and another with proper maintenance of structures. Thus, in Table 2, each strategy is shown with two life periods. For example, sluices and canal linings have a life period of about 6 years without proper maintenance. After that time sluices silt up and the cement slabs used as canal lining break, and sometimes are lost. With proper maintenance the useful period before major reconstruction is up to 11 years. The life period of wells is assumed to be 8 years initially, and up to 16 years with further deepening. The management strategies of sluice management and sluice rotation have no time limit; for the purpose of the analysis, 10 to 15 year benefit periods were assumed. However, when management is combined with the physical investments, the benefits of improved management are assumed to be of the same duration as the life periods of the other investments for purposes of this analysis.

The results of the financial evaluation indicated that both sluice and rotation management has the highest returns, followed by the canal lining and provision of additional wells. This is because the management strategies have low cost components compared to their benefits. Further, combinations of strategies have lower benefit-cost ratios compared to strategies considered individually. This is because the maximum possible modernisation benefit expected can be reached with one or two of the strategies, and each additional strategy generates comparatively fewer benefits. Since the cost of each strategy is almost fixed compared to their benefits, the benefit-cost ratio is lower for the combination of the strategies. This is a very interesting conclusion since most of the modernisation strategy considered by the EEC, or any other funding agency may be to go for 'total package' rather than 'selective items'. Given the vast numbers of tanks, limited budget and other constraints, it is important to select the most appropriate strategies for modernising tanks. However, the success and scope in implementing the strategies depend heavily upon how the farmers are involved in various stages of the tank modernisation. The management strategies also depend heavily on competence and commitment to the operation of these strategies. Physical improvements alone, or in combination with management improvements, also generated substantial IRRs, although the B/C ratios, at less than 2.0, were modest.

The simulation model also looked at modernisation strategies in terms of production and equity criteria. Aggregate rice production was used as a measure of production performance. However, it was also recognised that access to food and increased income for poorer households is an important development issue, so the equity impact of modernisation strategies was as important. An equity ratio was developed which compared per hectare net returns of head-end farms, to per hectare net returns of tail-end farms. While management strategies gave the best returns under financial criteria, this was not the case with production and equity criteria. The most substantial reduction in production losses occurred when management and physical investment strategies were used in combination. These were not the strategies with the best equity ratios, but nevertheless had the second best (and very reasonable) 'equity' scores, and are likely to be preferred by all sets of farmers because of their contributions to farm income. The strategy with the most favourable equity ratio is canal lining and well development. However, this equity is achieved by reduced head-end net returns, as opposed to higher tail-end yield gains and so higher net returns, and so does not give the best results in productivity. As discussed earlier, well provision needs to be spread across all groups, and provide water at reasonable prices for well development strategies to contribute to equity in a broader sense.

8 CONCLUSIONS

The study demonstrated interesting results in the behaviour of financial criteria when applied to modernisation strategies. It also showed the differential effect that selection criteria can have on selection of modernisation strategies for tanks. The existence of trade-offs between financial and equity criteria are useful in defining the system performance in a consistent way to permit comparisons between different improvement strategies. The existence of trade-offs between financial and equity gains also highlights the importance of the political process in determining actual choices, and the importance of incorporating farmers in the identification of improvement strategies which best meet their needs, and is operationally realistic within the social system in which they live (Palanisami and Flinn, 1988). This study has illustrated the advantages in all areas of mixed strategies providing management skills are available, but also help target physical improvements if these wider improvements are unfeasible.

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