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Sustainable Management of Tank Irrigation Systems in South India

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Abstract

Irrigation tanks in India are the classic examples of common property resources which are mostly distributed in southern states. Most of the tanks have, over time, degraded into open access resources due to weak property relations. Encroachment, privatization and government appropriation of the tanks have been the main outcomes of the failure of local authority system to enforce the institutional arrangements under common property resources management regime. About 2 per cent of the tanks in the less tank intensive region and 67 per cent in the tank intensive region have become defunct. Wells that are supposed to be a security against late season tank water scarcity, have, of late become a major threat to the very survival of the tanks. Also taxes from the multiple uses of the tanks if collected by a single agency are sufficient to meet the operation and maintenance expenditure of the tanks both in the short run and in the long run. The modernization options derived from the simulation model indicate that software strategies such as sluice management will have higher pay-off than the hardware strategies such as canal lining and additional wells.

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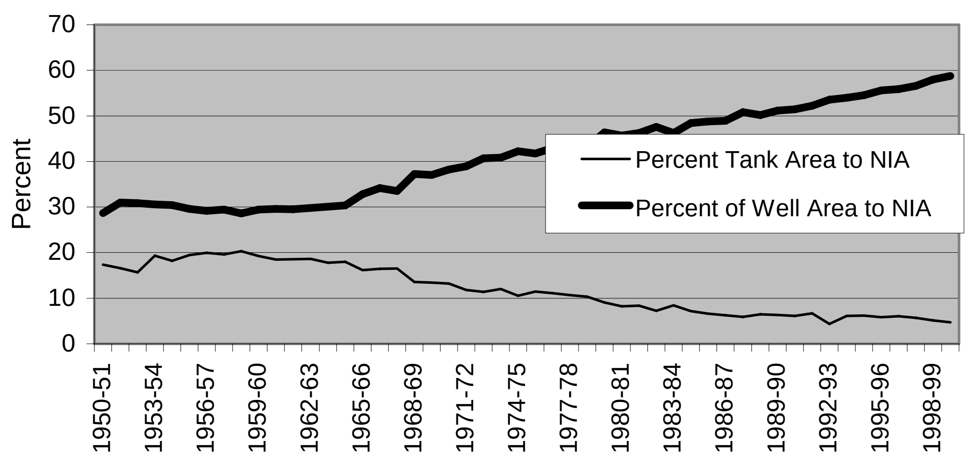
1. Tank Irrigation Systems in India

Tank irrigation contributes significantly to agricultural production in parts of South and Southeast Asia. Especially in South India and Sri Lanka, tank irrigation has a long history and many currently used tanks were constructed in the past centuries. The tanks have existed in India from time immemorial, and have been an important source of irrigation especially in southern India. They account for more than one-third of the total irrigated area in Andhra Pradesh, Karnataka and Tamil Nadu states. The tank irrigation system has a special significance to the marginal and small scale farmers. They make a very large number, and essentially depend on tank irrigation, as these systems are less capital-intensive and have wider geographical distribution than large projects (Palanisami 2000).

An irrigation tank is a small reservoir constructed across the slope of a valley to catch and store water during rainy season and use it for irrigation during dry season. Tank irrigation systems also act as an alternative to pump projects, where energy availability, energy cost or ground-water supplies are constraints for pumping. The distribution of tanks was quite dense in some areas. However, over the years the performance of the tanks has been in decline.

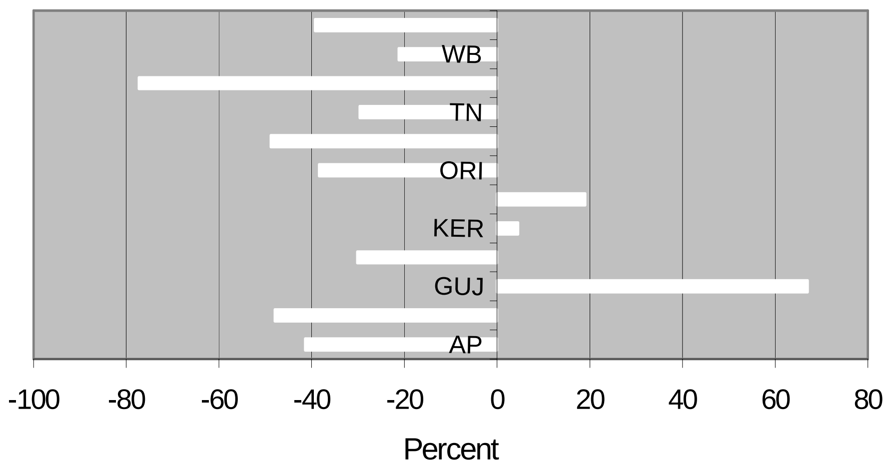
The share of tank irrigated area in India has declined from 16.51 percent in 1952-53 to 5.18 percent in 1999-2000, whereas the share of groundwater irrigation has increased from 30.17 percent to 55.36 percent during this period. The share of the tank irrigated area to net irrigated area (NIA) had been declining continuously over the years (Fig. 1). Among the three major sources of irrigation, tank is the only source, where the irrigated area has been declining continuously since early seventies and many argue that the area under tank irrigation started declining only after the introduction of the green revolution. Further, among the states in India, the area under tank irrigation has declined more drastically in those states where tank irrigated area accounts for relatively a larger share in the net irrigated area and it has increased marginally in certain states where it accounts for very low share in the net irrigated area (Fig. 2).

Fig 1. Share of Tank and Well Irrigated Area to Net Irrigated Area(NIA), India



Data from the Agricultural Census of India for five time points namely 1970-71, 1976-77, 1980-81, 1985-86 and 1990-9 indicated that the resource poor farmers (owning less than 2 hectares) still account for major share of tank-irrigated area in India. Marginal (less than 1 ha) and small farmers (1-2 ha) together accounted for about 40 percent of tank-irrigated area in 1970-71, which further increased to nearly 55 percent in 1990-91 thus accounting for nearly two third of tank irrigated area. On the other hand, the share of tank irrigated area used by large farmers declined from 13.59 percent to 6.02 percent during this period. Since the farmers belonging to marginal and small size group are mostly poor, they couldn't afford for cost-intensive irrigation sources like groundwater as in the case of medium and large farmers and tank irrigation continues to play a crucial role among small and marginal farmers even today. This is also true across different states where tank irrigation has considerable presence even today (Narayanamoorthy 2004).

Fig 2. Statewise Percentage Change in Tank Irrigated Area: 1962-63 to 1999-2000



2. Tank Systems of Tamil Nadu, South India

Southern parts of India are noted for the intensity of tanks. Unlike the northern region, the rivers in the south are mostly seasonal and the plains are not much extensive. Further, the geology is not favourable for groundwater storage. The local topographic variations have been effectively exploited to impound rainfall in tanks which are used to raise irrigated rice crop and simultaneously serve as means of improving groundwater recharge in their command areas. There are about 127,000 tanks in the southern region consisting of Andhra Pradesh, Tamil Nadu and Karnataka states (Agarwal and Narain 1997).

This tradition of tanks as the largest source of irrigation continued until mid 1960s. The decline of tank irrigation was due to the constitution of policy which had its origins in the very early phase of British rule in India. An impression was created that the smaller irrigation works were uneconomical and unnecessary burden on revenue officials because of changes in the tenurial system towards Raiyatwari or Zamindari.

Among the southern state, Tamil Nadu state alone has about 39.200 tanks with varying sizes and types. The tanks are classified into system tanks (which receive supplemental water from major streams or reservoirs in addition to the yield of their own catchment area) and non-system / rainfed tanks which depend on the rainfall in their own catchment area and are not connected to major streams / reservoirs. The tanks are also classified into Panchayat Union, Public Works Department (PWD) and *Ex-zamin* tanks based upon the management authority. Panchayat Union tanks have a command area less than 40 ha, and under the control of village communities (Panchayat union). Those tanks having a command area more than 40 ha as well as all the system tanks are maintained by PWD. *Ex-zamin* tanks were constructed by z*amindars* (landlords) during the British administration. After abolishment of *zamindari* system by the State government in 1957, they were transferred to Panchayat Union and PWD based upon the sizes of command areas. Out of the total of 39,200 tanks in the State, 53 per cent are PU tanks, 22 per cent are PWD tanks and 25 per cent are ex-*zamin* tanks (Table 1). There are about 9,800 *ex-zamin tanks*, of which more than 60 per cent are concentrated in the undivided Ramanathapuram district (Palanisami et al. 1997).

3. Management of Tanks

In ancient days, tanks were considered to be the property of rulers. The farmers paid a portion of the produce to the ruler. Farmers also were in charge of the maintenance of the tanks, and supply channels. Zamindars ensured the proper maintenance of the tanks, and channels, since they reaped the benefits of farming in large areas. However, when the British introduced the Raiyatwari system in 1886, tanks with an ayacut of 40 ha and above were brought under the control of PWD and smaller tanks were under the administrative control of local bodies, or vested with the villagers themselves. Since the local bodies did not have qualified engineers. and the duties of the ayacutdars were not clearly mentioned, the system of the farmers themselves taking up maintenance work known as *kudimaramath* works slowly declined. Tanks were silted up, and supply and distribution channels choked. The deterioration of the tank irrigation system has been a subject of considerable discussion, at least since the middle of the 19th century. The Report of the Public Works Commission of 1852 stated that there was not much of voluntary community labour involved in tank maintenance, and it reported that in all districts labour was more or less forced to work. In fact an act was passed, namely the Madras Compulsory Labour Act of 1858 (or what is known as the *Kudimaramath* Act), with a view to legalising compulsory labour for certain aspects of maintenance, and also to penalize the non-performance of *kudimaramath* labour. The entire administration of the act of levying and collection of fines was left with the irrigation panchayats. The Famine Commission of 1878 brought to light quite forcefully the deteriorating conditions of tanks and advocated a systematic policy of maintenance. One of the most important recommendations of the commission was the creation of tank restoration parties.

However, at present the responsibilities are shared between different institutions which also vary among the different states (Table 2)**.** In all the states, the local village is responsible for water distribution and management of the tanks with a command area of below 40 ha. In spite of these institutions on tank management, the performance of the tanks has been reduced over the years.

4. Performance of Tanks over the Years

In a 10-year period, the tank usually gets normal supply for three years and gets deficit supply for five years, and the water supply fail completely for two years (Table 3). Given the rainfall uncertainties, the tank performance is seen as declining over the years. There are above-outlet problems such as poorly maintained structures (bunds, surplus weirs). Catchment is mismanaged and forest land adjacent to the catchment is already converted for human settlement by the Government. There is severe encroachment in the tank foreshores. Siltation of the tankbed has reduced the water storage capacity, ranging from 20 to 30 per cent. In the case of below-outlet problems, channels are not maintained and broken, resulting in heavy water losses. Well irrigation has dominated the tank irrigation in several cases where the increase in the number of wells in the tank command had been signaling the inactiveness of the tank systems for providing reliable water supply. In fact it had been found that a large number of tanks have become defunct in less tank intensive districts (i.e. 76 per cent of Panchayat Union tanks and 64 per cent of Public Works Department tanks have become defunct) compared to tank intensive regions, where the percentage of defunct tanks is less[1] (Palanisami 2000).

The credit facilities through loans provided under agricultural cooperative credit societies and banks further facilitated the intensification of the well investment. Hence, tanks were no longer an asset that needed to be maintained, but at the same time, the prolonged deterioration has resulted in the acquisition of the tankbed by the influencing villagers for their private cultivation. The village level irrigation institutions like *kudimaramath* had also slowly became inactive and their roles insignificant. Government allotment of funds has also been insufficient for the operation and maintenance (O & M) of the tanks (Palanisami and Easter 2000).

Compared to all India level, in Tamil Nadu state, the share of tank irrigated area to net irrigated area by marginal farmers has decreased from 39.53 per cent in 1970-71 to 35.17 per cent in 1990-91, area by small farmers had decreased from 32.02 to 0.23 per cent, medium farmers (2-4 ha) has decreased from 30.03 per cent to 21.47 per cent and large farmers (more than 4 ha) has decreased from 28.46 per cent to 19.40 per cent during the above periods respectively, indicating the poor performance of the tank irrigation systems in the state (Table 4).

The neglect of tanks has meant that most farmers receive inadequate quantities of water from tanks. To offset the decline in tank water supplies, farmers have resorted to supplemental well irrigation to avoid crop losses (Palanisami and Easter 1987, 1991). Since only about 15 per cent of the farmers in the tank command area own wells, and there is a growing demand for well water, the well owners in most cases act like local monopolists and are able to charge high prices for well water. However, profit-making through privately owned water source (i.e. wells) within the hydrological boundary of the common property resource (tanks) poses serious threat to the very survival of the tanks, because of the declining interest among well-owners in proper upkeep of tank structures. The level of well interference on tank performance is also different between PU and PWD tanks.

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[1] Less tank intensive regions refer to the regions where tank irrigation is not the major source of irrigation compared to tank intensive regions, where the tanks are the major source of irrigation.

The analysis of the well distribution in the tanks has shown that the well density (number of wells per ha of command area) was higher in PU tanks (0.42) than in PWD tanks (0.35), but the difference is not significant (Table 5). The reason for higher number of wells in PU tanks is that the duration of water supply is comparatively lesser in PU tanks (2-3 months) than in PWD tanks (3-5 months) (Palanisami et al. 1995).

4.1 Factors Affecting Tank Performance

Even though several factors have influenced the tank performance, the level of their influences has varied across locations. The major factors influencing the tank performance are given in Table 6**.** The well density had negative influence on the tank performance. It was observed that the higher the well density, the less the tank performance. Tanks without the well supplementation in the tank season had performed well and this clearly indicated the availability of adequate tank water supplies.

Concerning the O & M expenditure on tanks at state-level, the results of the study had indicated that though outlay per hectare of command area at current prices increased from Rs.26 to Rs. 161 per ha, the outlay at constant (1980-81) prices has increased only marginally from Rs. 33 to Rs.43 per ha. However, the level of O & M amount spent on the sample tanks revealed that the average amount spent was high for PU tanks (Rs. 154 per ha) compared to PWD tanks (Rs. 74 per ha). Since the O&M amount was spent, mainly in accordance with the urgency of the tank repair and the local political pressure, the level of tank performance and the amount of O&M spent could not be directly related (Palanisami et al. 1995).

In view of the inadequate financial support from the state for tank maintenance, farmers mobilize financial resources for tank maintenance from tank usufructs. The major sources of income are : a) sale of fishes raised in tank water, b) sale of trees grown on the tank bunds and the water spread area, c) sale of silt, and d) collection of fees / rents from duck-growers and cattle growers for allowing the ducks and cattle in the tank command area after harvesting of rice crop, etc. Classification of parameters influencing tank performance under different levels of tank performance revealed that there is a negative relationship between resource mobilized and the tank performance. The resource mobilized per ha of command area was found to be higher in tanks with poor performance. The average resource mobilization was Rs. 28 per ha in PU tanks and Rs. 68.80 per ha in PWD tanks with performance less than 25 per cent. The resource mobilization was about Rs. 8.25 to Rs. 9.50 per ha in tanks (both PU and PWD) with performance between 50-100 per cent. The reason for this might be that farmers used to mobilize the resources (mostly labour) expecting that the tanks will be filling in the coming seasons, but, due to erratic rainfall pattern, the tanks will not be filling up, resulting in poor tank performance. After 1990s, the picture is changing where farmers not mobilizing the resources for supply channel maintenance as they feel the tanks are not getting the fillings and it is a waste of their labour, as the weeds and other bushes will be coming up again in the season even after cleaning the supply channels. The long run impact of this short-run decision is that some bushes will be too big to clean by using the routine labour mobilization by the farmers. This trend is unwarranted as this tendency will spoil the morale of the tank farmers in mobilizing the resources for future tank maintenance.

Further, the percentage of PU tanks having water users' organisation was lower when compared to the PWD tanks. As much as 31 per cent of the PWD tanks had informal Water Users' Organization (WUO), whereas only 14 per cent of the PU tanks had informal WUO. The functions of these organizations include the appointment of 'neerkattis' (common waterman), organizing and coordinating tank maintenance works (mainly cleaning supply channels and main canals), resource mobilization for tank maintenance, lobbying with government departments for better maintenance of tank structures, etc. The farmers' participation in tank maintenance was also comparatively higher in PU tanks (0.54 man days per year per ha of command area) than in PWD tanks (0.30 man days per year per ha of command area). It is observed that the performance of tanks and farmers' participation were directly related. In the case of encroachment in the catchment, supply channel and water spread area, it was higher (16.23 per cent) in PU tanks as compared to only 10.23 per cent in PWD tanks. The results had indicated that the level of encroachment directly influenced the performance of tanks. Because of lesser catchment, foreshore and water spread area in the case of PU tanks the encroachment is relatively high. Further, since the PU tanks are smaller in size with less number of farmers, the aggression of the encroachment is also comparatively higher.

4.2. Resource Mobilization and Use

The major source of tank operation and maintenance expenses (O & M) is from funds allotted by the Government. However, in real terms it has been almost constant over the years. There are also funds mobilized from forestry, fishery resources besides farmers own contribution. More commonly, the resources mobilized in recent years can be grouped under forestry and fishery resources. The individual contributions are restricted to periods when water scarcity is acute. Farmers' contribution to water users' association (subscription fees), direct labour contribution for tank maintenance works, getting commission from the social forestry contractors, and other minor sources such as grazing lease, duck and goat rearing in the command areas (after harvest), sale of trees in tank bunds and village common lands are considered important in quantifying the resource mobilization by the farmers and authorities.

The social forestry project was launched in 1981 with Swedish International Development Authority's (SIDA) assistance in Tamil Nadu. The project contemplated a massive afforestation programme to ensure sustained supply of fuel wood, bamboo, small timber, fodder, grass, fruit, oil seeds and other minor forest produce to rural population to satisfy the local needs. More than 80 per cent of the social forestry has been established in tank foreshores and bunds and became integral part of tank systems in recent years. Consequently a new set of rules and regulations were framed by the government for selection, planting, maintenance, harvest and sharing of income thereof.

Fishery is an important water based resource of the tank system. The rights of the people to the tanks are usually customary usufruct rights if the tank is on public land. Rights of the tank are vested in the panchayat or municipality. But if the tanks are on private land the state or the people have no rights. If the lakes and tanks are natural, then the people have the customary rights and the state has the absolute rights.

Historically, the rights to benefits were vested with the respective local village panchayats as regards the fishery and forestry in the tank systems. There were no organized set up to culture fish or plant trees and enjoy the benefits. But the village panchayats enjoyed the benefits of whatever was available. Only after launching of social forestry project in 1981 and establishment of Fish Farmers Development Agency (FFDA) in 1982 there has been an organized way of promotion, maintenance and harvesting and sharing the benefits of fishery in the tank system.

The revenue mobilized per ha of command area was less in the case of PU tanks (Rs. 9.00 per year) than PWD tanks (Rs. 14.00 per year) . This might probably be due to the higher expenditure on operation and maintenance by the PU, which in turn reduces the necessity for resource mobilization by the farmers. The extent of revenue mobilization was found to be positively correlated with the presence of water users' organization and the correlation coefficient was significant at one per cent level in PU tanks and at 5 per cent level in PWD tanks. This clearly indicates that the presence of water users’ associations will help to capture the resources in a better way through collective efforts and decision making.

4.3. Multi-uses from Tanks

Even though tank were originally serving irrigation and other village needs such as domestic, livestock, besides fish production, due to change in the village profile over the years, tanks are mostly saving the irrigation needs only. However, judging the tank performance using the irrigation component may be inadequate, as it will not reflect the true performance of the tank benefiting the village in several ways. Hence, multi-uses of the tank should be considered in arriving at the tank performance. If such uses are in reasonable proportion, then rethinking tank management in terms of multi-use performance may be warranted. Also using the multiple benefits approach will indicate the magnitude of the receipts from all the uses which can be effectively used for tank maintenance.

In absolute terms, as given in Table 7, social forestry raises the most revenue (averaging Rs. 170 per ha), followed by irrigation (Rs. 88 per ha) and fisheries (Rs. 15 per ha). However, Table 8, which presents revenue realized as a percentage of revenue mobilized from each use, give a different picture. Social forestry collects the highest revenue (100 per cent) as a proportion of total value of output, but irrigation pays a relatively small proportion of the value of output (3.2 per cent) in various fees. Social forestry appears to perform well in absolute, as well as relative, revenue realisation at the tank level. The State Revenue Department, Social Forestry Department, Mines Department, Panchayats, and informal organizations in the village community are all involved in collecting revenue from the tank users. The agency-wise income realised is presented in Table 9. Among the various agencies, Panchayat Unions receive the maximum realised revenue (64.96 per cent), followed by the Social Forestry Department (24.84 per cent), village community (5.18 per cent), and the Revenue Department (4.67 per cent). But if the panchayats generate so much income from the tank uses, why are they not investing more in attending to the maintenance of the tanks? The panchayats feel that it was the responsibility of the state government to pay for the maintenance, and therefore did not put their own resources into tank maintenance. It is not clear what effect the Panchayati Raj Amendment has had on this situation, but it is essential to explore what will happen if the responsibility for tank maintenance as well as the entire revenue collection authority is given to a single institution such as local panchayats or water users association.

It is important to note from the tables that the total revenue realized in terms of taxes, fee etc., ranges from Rs. 337.12 per ha in PU tanks to Rs. 270.29 per ha in PWD tanks, with an average realization at the tanks as Rs. 275.40 per ha (Palanisami et al. 1997). This is higher than the government allotment of Rs. 140 per ha for tank O & M. Hence, instead of receiving heavy small allotments from the government, in fact tanks themselves can generate more resources for maintenance. Present practices do not seem to be even exploiting the full potential of tapping all the uses of tanks for revenue to support them and hence tanks suffer from lack of maintenance funds which is one of the major reasons for poor condition of the tanks. However, further analysis is needed to determine whether the revenue generation will be uniform across tanks, and how different combinations of uses may be competitive and or complimentary in nature.

5. Tank Modernization

Given the poor state of the tanks, efforts have been initiated at various levels to improve the tanks under minor irrigation category. Those which benefit an ayacut (command area) below 2,000 ha are considered as the minor irrigation schemes. In the State, 67 per cent of net irrigation area comes under minor irrigation schemes. The major components of minor irrigation schemes relate to construction and maintenance of tanks, open wells and tube wells besides small irrigation works under streams. Apart from this, Special Minor Irrigation Programme (SMIP) contemplates formation of tanks, construction of anicuts, excavation of link channels, restoration of abandoned tanks, formation of percolation ponds, river pumping schemes, etc. Another minor irrigation scheme viz., Desilting-cum-Reclamation (DCR) which included desilting of tanks to restore the capacity by reclamation of foreshore lands is also undertaken regularly. Tank modernization programme with European Economic Community (EEC) aid was also implemented from 1984 to 1992. The modernization works mainly included repairing tank bunds, sluices and surplus weirs and lining the field channels. But the catchment treatment part and partial desilting components have not been considered. Further, the modernization programs were implemented as routine government programs without the participation of the tank beneficiary farmers. Performance of the modernized tanks which included farmers participation was comparatively better than those tanks without farmers participation (CWR, 1998). Now several lending agencies such as World Bank and other international organizations such as JICA are exploring the possibilities for taking up the tank modernization studies.

However, it is still not known what exactly needed for the tanks in terms of tank modernization as each agency prefers their own agenda for tank modernization, which is highly biased. Hence, a tank irrigation simulation model was developed to identify exactly what modernization options are relevant for tank improvement using Srivilliputhur Big Tank as an example, as relevant data were available for this tank for the past fifteen years. The modernization options included the sluice modification, canal lining, provision of additional wells in the command area, sluice management[2] and rotation management[3]. The objective of the

[2] Water withdrawal from most tanks is continuous; sluices remain open even when there is no demand for water such as on days following a heavy rainfall. Farmers generally agree that it is desirable to close the sluices during wet weather to conserve tank water. This rather simple type of tank water management would be possible if an operator were to regulate water releases. Therefore, a decision rule was included in the analysis that specified sluice closing for 2 days following a daily rainfall in excess of 60 mm. This rule, in practice, is conservative since a typical field water requirement is 10-12 mm/day.

simulation is to identify the strategies which could improve overall tank performance. Normally, performance is measured in terms of aggregate rice production (i.e. tons of rice from a given command area). However, a reduction in the differences in the net return between farms, i.e., equity in water allocation, is also an important concern of the government. This objective is consistent with the realization that the critical issue in food policy in India is access to food and increased income for poorer households. Thus, tank performance was evaluated both in terms of rice production and equity in income distribution. To measure performance, a productivity ratio was defined as the ratio of the tons of rice produced in the tank with system improvements to the tons of rice production in the same tank before improvement. A ratio greater than 1 implies an increase in system performance and the larger the ratio, the greater the improvement in performance. An equity ratio was defined as the ratio of net returns per ha of head-end farms to net returns per ha of tail-end farms. A ratio of 1 indicates equity in the distribution of irrigation benefits across the tank irrigation system. A ratio that deviates markedly from 1 implies poor performance in term of equity.

A range of improvement strategies, both singularly and in combination, were introduced into the model to assess their impacts on overall system performance. The options are listed in Table 10. Among these options, sluice modification did not improve system performance. Sluice management (closing for three days after heavy rain) reduced yield loss (that occurred before improvements due to stress) by 25 per cent and increased total rice production by 14 per cent. The options of canal lining, providing additional wells, and sluice rotation reduced yield losses by between 56 per cent and 66 per cent, and increased total rice production by between 30 per cent and 36 per cent.

The greatest saving due to reduced losses in rice yield and production occurred when management and physical investment strategies were used in combination. These combined strategies resulted in minimal yield loss due to water stress and resulted in rice production that was 50 per cent higher than under existing conditions. Each option, other than sluice modification, increased net returns in both the head- and tail-end sections of the system. However, each strategy, by itself, increased head-end net returns more than tail-end net returns, resulting in comparatively unfavorable equity ratios (1.5 or greater). The strategy with the most favorable equity ratio (1.0) was canal lining and well development. However, equity was achieved partly by reduced head-end net returns, rather than singularly through higher tail-end net returns. Strategies which combine sluice management or sluice rotation with well development and canal lining generated the highest returns to both head-end and tail-end farmers, resulting in an equity ratio of 1.2. These strategies would probably be preferred as both groups of water users are better off in terms of net income per ha than with the canal lining and well

[3] Water rotation involves the impact of opening and closing sluices on alternate weeks. The main purpose of this management strategy is to extend the period of tank water supply. It would increase the supply of lower cost tank water to later in the season and also would increase groundwater recharge. Although farmers would have to pay for groundwater in the alternate weeks when the sluices were closed, the reduction in yield loss due to water stress, and lower late-season pumping costs may compensate for this extra cost. Thus there is a trade-off between continually leaving the sluices open and opening the sluices on alternate weeks (i.e., rotation management). The rotation of two sluices open each week for water delivery was, therefore, included in the model to study the impact of such a rotation on tank performance and rice production.

development strategy with a ratio of 1.0. These strategies also have the highest productivity ratios.

5.1. Financial Evaluation of Improvement Strategies

Alternative management and improvement in irrigation structures lead to farmer gains. However, they require expenditures of resources and should be evaluated in terms of net gain to society. At a minimum, strategies should generate enough benefits to cover their costs. The two management strategies, e.g. sluice management and rotation of water deliveries, had high B/C ratios and IRRs (Table 11). The reason these practices exhibited such high returns is their low investment cost. For example, the sluice operation costs of Rs 21,250, compared to an annual benefit of nearly Rs. 512,500. Similarly, the annual benefit of rotation management exceeds Rs 885,000, at an annual cost of only Rs. 42,500. Physical improvements alone, or in combination with management improvements, also generated substantial IRRs, although the B/C ratios, are less than 2.0. From an equity viewpoint, the option of combining management (sluice or rotation management) with canal lining and well development is the most likely choice. From a strictly economic viewpoint, the management strategies alone are the most attractive, but because of equity concerns, a mixed strategy appears even more attractive.

6. Warning Signals

There are as many obstacles to tank irrigation as there are benefits, due to their large number and the differences in water demand, managerial experiences, and investment needs for maintenance. During meager rainfall years, the tanks could store only small quantities of water, and the chain of tanks except the first tank, used to receive little supply. But during floods, the heavy discharge, often resulted in uncontrolled flow of water into the paddy fields nearby, heavy soil erosion, and damage to crops, and waste of precious water. Since about 90 per cent of the tanks are non-system tanks, the effect on area reduction will be more significant. For example, the share of tanks to the total net area irrigated has declined both at national and state levels. The share of tanks in the net irrigated area has decreased from 16.51 per cent in 1952-53 to about 5.18 per cent in 1999-2000 at all-India level while it has declined from 37.77 per cent to about 19.47 per cent in Tamil Nadu state during the same period**.** Besides variations in rainfall and tank filling, several factors such as siltation, encroachment, and channel obstruction had reduced the tank irrigated area. Considering the importance of tanks, Government is making efforts in improving the performance of the tanks through modernization (Palanisami and Easter 2000). However, still the following are the warning signals to the Government and local community about the disappearance of tank irrigation in the state.

- Mostly tanks are reported to be functioning only in normal / excess rainfall years and not so in poor / low rainfall years. The consequences are: many farmers have started abandoning tank agriculture due to its continuous uncertainties in water supplies and moving to the nearby towns for other jobs and only the older people are staying back in the tank villages. The lands are not maintained properly and the prosophis trees are growing freely in the cultivated lands, thus making the lands unsuitable for cultivation during years when the tank has adequate water. Due to the declining commitment on the maintenance of the tank structures, the upkeep of the structures is a cost affair for the farmers when they really want to use the tank for irrigation during normal supply periods.

- The livestock support activities are also completely gone in the village eco-system thus eroding the livelihood options in the village. Farmers used to take the silt using bullock carts and after the introduction of the social forestry scheme in the 1980s in the water spread area, silt removal from the tanks was prevented thus making the bullock operations limited. Somehow in the recent years, the micro-finance concept has emerged among the rural women who are managing the families with livestock and credit integration. But livestock also needs adequate fodder. Hence, if the tanks are not properly managed then the entire tank-ecosystem based rural economy will completely collapse.

- The impact of the social forestry was already felt in terms of increasing silt accumulation in the tank water spread area and it will be difficult to sustain the tanks if the social forestry is allowed to continue. But at the same time, even without social forestry in the tanks, there are possibilities that the prosophis trees will be spreading fast and it will have severe impact than the social forestry with accasia trees which have market (timber) value.

- It is seen in several locations, due to intensification of watershed development programs by the Government, several structures such as small check dams and percolation ponds are developed in the upstream of the tanks thus affecting the inflows into the tanks. Hence a clear demarcation should be done between the watershed programs and tank improvement programs.

- Disappearance of the supply channels is very common. House construction works due to population increases and village development activities such as roads, schools, buildings are concentrated in the government poramboke (common) lands which are the main sources of inflow to the tanks as well as interlinking the tanks in the chain. This is one of the reasons why tanks are not getting adequate storages even though the rainfall is normal.

- The traditional village institutions like needkatti or madayan thotti who looked after the tank catchment and tank structures and facilitated the inflows into the tanks regularly during rainy seasons also disappeared, as they could not be paid by the farmers due to frequent tank failures.

- The growing nexus between castes and politics among the younger generation in the village also played their role in making the traditional leaders in the village (who looked after the tank management) inactive. Several regional political parties are coming up and since the voting percentage is higher in the villages, these parties concentrate on the rural villages for their benefits and in the process, the households are divided among the political and caste related groups.

- The growing self-interest and non-cooperation by the well owners in the routine tank maintenance also make the tank management a difficult task. This is because in several villages, well owners feel that the tanks will not be much useful, as for most of the periods they are dry. Also the reliability of the tanks for recharging the wells has also gone down due to siltation and encroachment.

- The rice supplies in the village ration shops to some extent make the poor farmer households to prolong their livelihood with the dried-up tanks. But the major issue is how long the ration shops will sustain the villages and the tanks. Unless the livelihood of the households is improved, it will be very difficult to revive the tanks.

- Many people now raise the question: Do we really need the tank bund which makes 1:2 or 1: 4 water spread : command area? The 1:2 ratio (i.e. for every one hectare of water spread, only 2 hectares of command area is available) is very attractive for making the rainfed tanks into rainfed land as there is not much difference between the tank irrigation and rainfed agriculture. This aspect is gaining importance since in most of the time, the tanks are empty and people think about using the water spread area for rainfed cultivation due to its fertile silt. Also the growing encroachment gives encouragement for such conversion particularly where the tank is shallow.

In spite of these issues and the overall declining tank performance, tank irrigation still offers vast scope for future expansion in irrigation, as the constraints in large scale projects and groundwater development are increasing due to competition from non-agricultural uses, pollution, over-exploitation etc. Further, any investment made on tanks will be justifiable and equitable given the vast majority of small and marginal farmers benefited from tank irrigation. However, the major questions are: What policies are appropriate and what will be their likely implications on the society? Some of the policies are discussed below.

7. Policies for Improving Tank Systems

7.1. Investment

Tank rehabilitation options that restore the original standards should be given priority. Desilting is an important option. However, it was observed, that in a ten year cycle, only in three years, the tanks get full storage, five years deficit storage and in two years the tanks fail. Hence, desilting the tank fully will not be economical, as the benefits due to desilting will be in three years only, in which the tanks get full supply. Also disposal of the entire desilted material is difficult, as the fertile silt is found only in the top (0.4 metre) layer. Therefore, full scale desilting may not be warranted. Considering the high cost of Rs. 120 per m^3 of silt, partial desilting that helps to restore original (10 per cent) dead storage could be attempted as part of tank rehabilitation options as this will help increase non-irrigation benefits of tank water particularly in the non-tank-irrigation season. Also recharging of wells will be improved. Partial desilting can be done nearer to the lower sluice as well as around the periphery of the tank water spread area.

Most of the tanks are not getting adequate water supply and the chain system of tanks has almost broken. Hence, there is an urgent need to revive the tank-chains through appropriate modernization strategies for improving the supply channels connecting different tanks. This highlights the need for taking up modernization works at chain-level i.e. by considering the entire hydrological boundary as a single unit rather than viewing individual tanks as separate entities for new investment.

Community wells should be installed in the tank water spread area to provide few supplementary irrigations to the non-well farmers during critical periods.

7.2. Management

In general, the duration of water supply in PU tanks was lower (two and a half months) than the PWD tanks (three months). In both PU and PWD tanks, the mean duration of conjunctive use of tank and well water was about two months. The well density is relatively higher in PU tanks compared to PWD tanks. Where water supply is so scarce, the density of wells is very high and in such situations, such tanks could be easily converted as percolation tanks with the main aim of recharging wells, providing water to other village needs. This will help the tank farmer to go for non-rice crops in the command. Government panchayats should make a list of such tanks and convince the farmers for using the tank water in a more productive way. The interest of the non-well owners should however be protected by providing the necessary supplemental irrigations for non-rice crops in the tank season.

Farmers in few water scarcity tanks have already been adopting crop diversification strategy involving groundnut, pulses, cotton and other crops and this practice should be extended to tanks whose water storage is 50-60 percent. The water required to produce one kilogram of rice ranges from 4,500 – 5,000 litres compared to 1,500 – 2,000 litres in the case of non-rice crops such as groundnut. Hence, using the 50 per cent tank storage, the entire command area can be covered with non-rice crops. Extension efforts and marketing support to farmers should be strengthened to introduce crop diversification particularly in the wet season. Crop demonstrations by the Department of Agriculture should help speed up the process. To complement the above options, tank structures should be repaired for effective water control.

Water losses in the canals are about 30 per cent besides creating inequity in distribution between head and tail farms. Lining the main canals can be followed without disturbing the field boundaries. Tank management strategies such as sluice rotation will help save the tank water by 20 per cent. Instead of continuous water withdrawal from tanks, sluices can be opened and closed on alternate weeks (rotation of sluices). The main purpose of this management strategy is to extend the period of tank water supply. Earlier studies (Palanisami and Flinn 1988) indicated that closing and opening the alternate sluices in alternate weeks had saved the tank water by about 20 per cent besides extending the tank irrigation supplies to 2.5 months instead of the present supply of 1.5 months with continuous opening of the sluices. It would also increase ground water recharge.

Though most of the tanks have informal WUO, only about 30 percent of them in PWD tanks and 10 per cent of them in PU tanks are found to be active. The existing informal WUO should be given incentives by the Government in such a way that they will become formal and could generate more resources for tank management. This will also give scope for the revival of *Kudimaramath.*

Currently the rain-gauges are available in the block offices only and periodical measurement of the intensity of the rains is not followed. Rain-gauge stations should be established at different locations of the tank-chains, so that the exact relationship between tank storage and rainfall can be captured. Also rainfall intensity in various locations should be measured.

The women self-help groups in the villages should be encouraged to go for intensifying the livestock activities so that some employment opportunities to the households will be ensured and also it will help maintain their links with the tanks.

Adequate attention should be given for development of charcoal making local units in the tank regions, as this will help cut down the prosophis tress in the tank water spread area. Local people should also get adequate employment opportunities within the village.

Since the water spread area is very poorly managed and it is important that local people should be encouraged to use the tank water spread area for cultivation of seasonal crops like water melon, vegetables soon after the tank water is exhausted. This will facilitate the cleaning up of the water spread area by themselves. The water users organizations should be empowered to implement this option without affecting the normal functioning of the tank systems during the rainy season.

7.3. Legal

More tanks have become defunct in recent years due to encroachment, siltation, choking of supply channels and pollution from industries. Tanks close to the cities should be protected from environmental pollution and further be made as groundwater recharges structures for domestic purposes. Strict regulations and penalty mechanisms should be imposed on the encroachers of catchment, supply channel, and foreshore area. Panchayats should be given powers to evict the encroachers as well as to prevent further encroachment even by the Government departments.

References

Agarwal, A. and Narain, S. 1997. *Dying Wisdom: Rise, Fall and Potential of India's Traditional Water Harvesting Systems.* State of India's Environment, A Citizen's Report, Centre for Science and Environment, New Delhi.

Centre for Water Resources (CWR) 1998. *Participatory Tank Management*, various reports. Anna University, Chennai.

Narayanmoorthy, A. 2004. "Tank Irrigation in India: Can the Oasis be Rejuvenated?", Unpublished paper, Gohale Institute of Politics and Economics, Pune.

Palanisami, K., Balasubramanian, R., & Ali, A. M. 1997. *Present Status and Future Strategies of Tank Irrigation in Tamil Nadu.* Bulletin 97, Water Technology Centre, Tamil Nadu Agricultural University Press, Coimbatore.

Palanisami, K., & Flinn, J. C. 1988. "Evaluating the performance of tank irrigation systems", *Agricultural Systems* 28:161-177.

Palanisami, K., 2000. *Tank Irrigation - Revival for Prosperity*, New Delhi: Asian Publication Services.

Palanisami, K. & Easter, K. W. 2000. *Tank Irrigation in the 21st Century - What next?*, New Delhi: Discovery Publishing House.

Palanisami, K. and Easter, K. William 1987. "Small Scale Surface (Tank) Irrigation in Asia", *Water Resources Research*, Vol. 23, No.5, pp.774-780.

Palanisami, K. and Easter, K. William 1991. "Hydro-economic Interaction in Tank Irrigation Systems", *Indian Journal of Agrl. Economics*, Vol. XLVI, No.2, April-June, 1991.

Table 1 Distribution of Tanks according to types, Tamil Nadu state

Tank types	Command area (ha)	Per cent
1.**Non-system (rainfed) tanks under:**		
a)Panchayat union (PU)	<20	43
	20-40	10
b)Public Works Dept. (PWD)	>40	13
II. System tanks under:		
Public Works Dept. (PWD)	>40	9
III. Ex-zamin tanks	-	25

Note: Total number of tanks in the state is 39,200.

Table 2 Tank Management Responsibilities in Four Indian States

State	Tank command area (ha)	Public Works Department	Revenue Department	Village
Andhra Pradesh	<40 ha	--	Revenue Collection	Maintenance Repair & Water Regulation
	40-400 ha	Maintenance and Repair	Revenue Collection Water Regulation	--
	> 400 ha	Maintenance & Repair Water Regulation	Revenue Collection	--
Karnataka	< 40 ha	--	Revenue collection	Maintenance & Repair Water Regulation
	40-80 ha	Maintenance & Repair	Revenue Collection	Water Regulation & Supervision
	> 80 ha	Maintenance & Repair Water Regulation	Revenue Collection	--
Tamil Nadu	< 40 ha	--	Revenue Collection Water Regulation	maintenance & Repair
	> 40 ha	Maintenance & Repair	Revenue Collection Water Regulation	--

Source: Palanisami 2000.

Table 3 Rainfall and Tank Irrigation Probabilities

Average wet-season rainfall (mm)	State of tank storage	Probability of occurrence
> 500	Surplus or normal	0.10
450 - 500	Full or normal	0.20
300 - 450	Deficit	0.50
< 300	Failure	0.20

Note: Based on 46 years rainfall data.

Table 4 Share of Different Sources of Irrigation in India and Tamil Nadu (per cent)

	Source	1960-61	1970-71	1980-81	1990-91	1999-2000
India	Canals	42.05	41.28	39.40	35.63	31.29
	Tanks	18.50	13.22	8.24	6.84	5.18
	Wells	29.56	38.22	45.70	51.04	57.81
	Others	9.89	7.28	6.66	6.49	5.73
	All	100	100	100	100	100
Tamil Nadu	Canals	35.80	33.90	32.70	32.40	27.58
	Tanks	38.00	34.50	32.10	22.38	19.47
	Wells	24.20	29.80	33.80	44.61	52.88
	Others	2.00	1.80	1.40	0.61	0.37
	All	100	100	100	100	100

Source: *Tamil Nadu - An Economic Appraisal* (Various issues).

Table 5 Frequency Distribution of Sample Tanks based on Well Density

Tank type	Well density (No. of wells per ha of command area)				
	0	0.01-0.10	0.11-0.50	>0.50	Mean well density
PU	96 (24.81)	39 (10.08)	150 (38.76)	102 (26.36)	0.42
PWD	8 (4.55)	39 (22.16)	86 (48.86)	43 (24.43)	0.35

Note: Figures in parentheses are percentage to total number of tanks.

Table 6 Parameters Influencing Tank Performance under Different Levels of Adjusted Tank Performance

Tank Type	Adjusted Tank Performance (per cent)	Well Density (No. per ha)	O & M Expenditure (Rs. per ha per year)	Resource Mobilised (Rs. per ha per year)	Encroach-ment (per cent of water spread area)	Farmers' Participation (man days per ha per year)
PU	<25	1.30	73.80	28.00	34.44	0.28
	25-50	1.00	12.07	0.60	20.26	0.20
	50-100	0.30	154.00	8.25	12.24	0.56
	>100	0.00	24.00	0.00	8.22	0.72
Mean	75.70	0.42	154.00	9.00	16.23	0.54
PWD	<25	1.25	28.50	68.80	19.76	0.09
	25-50	1.00	108.00	61.30	11.66	0.35
	50-100	0.30	73.20	9.45	6.99	0.49
	>100	0.00	No tanks under this category			
Mean	83.30	0.35	74.00	14.00	10.23	0.30

Note: 1 US $ = Rs 44

Table 7 Average Revenue Realization at Tank Level from Multiple Tank Uses

(Rs. per ha)

Tank Type	Irrigation	Fishing	Ducks	Bricks	Social Forestry	Trees	Silt	Total
PU, Head	80.38	6.67	0.24	0.47	228.09	2.55	0.00	318.40
PU, Tail	51.66	17.00	0.41	0.08	284.01	2.70	0.00	355.85
PU	66.02	11.83	0.32	0.28	256.05	2.62	0.00	337.12
PWD, Head	101.04	3.36	0.07	0.21	242.22	0.41	0.00	347.31
PWD,Tail	88.21	20.83	1.42	0.10	49.27	1.07	0.00	160.88
PWD	94.05	14.62	0.60	0.14	160.10	0.77	0.00	270.29
Average	88.00	14.87	0.48	0.15	170.85	1.05	0.00	275.40

Note: 1 US $ =Rs 44

Table 8 Per cent Income Realization to Value of Output from Multiple Uses of Tanks

Tank type	Irrigation	Fishing	Ducks	Bricks	Social Forestry	Trees	Silt	Total
PU, Head	1.26	17.78	1.35	0.23	100.00	17.42	0.00	4.61
PU, Tail	1.03	16.86	0.67	0.73	100.00	11.86	0.00	6.45
PU	1.16	17.11	0.83	0.26	100.00	14.03	0.00	5.43
PWD, Head	4.42	9.79	1.91	0.53	100.00	16.14	0.00	13.31
PWD, Tail	3.79	11.42	6.65	3.51	100.00	3.75	0.00	6.15
PWD	4.02	10.60	4.17	1.00	100.00	4.82	0.00	10.06
Average	3.20	11.43	2.68	0.60	100.00	6.37	0.00	8.85

Source: Palanisami et al. 1999.
Notes: PU = Panchayat Union; PWD = Public Works Department

Table 9 Average Revenue Realized by Different Agencies from Various User Groups of the Tanks (Rs. per ha)

Tank type	Revenue Department	Panchayat Union	Village	Fishery Cooperative societies	Forestry Department	Total
PU, Head	12.96	206.96	6.37	0.00	91.24	317.53
PU, Tail	8.74	215.85	16.75	0.00	113.60	354.94
PU	10.85	211.40	11.56	0.00	102.42	336.24
PWD, Head	14.63	232.62	3.02	0.04	96.89	347.20
PWD, Tail	12.63	105.95	20.82	1.61	19.71	160.72
PWD	13.52	177.43	14.10	1.05	64.04	270.15
Average	12.84	178.75	14.27	0.96	68.34	275.16
Percent to total	4.67	64.96	5.18	0.35	24.84	100.00

Note: 1 US $ = Rs 44

Table 10 Production and Equity Impacts of Alternative Tank Improvement Strategies, Tamil Nadu

Strategy	*Production impacts*			*Equity impacts*		
	yield reduction	total production	Productivity ratio	NI per ha hf	tf	Equity ratio
	-- in tons --			-- in Rs --		
1.Existing condition	448	821	-	2,900	-75	-
2.Sluice modification	445	824	1.0	2,900	-75	-
3.Sluice management	336	932	1.1	3,900	1,475	2.6
4.Canal lining	196	1,072	1.3	4,625	2,875	1.6
5.Additional wells	185	1,083	1.3	5,050	3,325	1.5
6.Sluice rotation management	152	1,116	1.4	4,350	2,825	1.5
7.canal lining + additional wells	84	1,184	1.4	3,900	3,750	1.0
8.Sluice mgt+ canal lining + additional wells	61	1,207	1.5	6,150	5,000	1.2
9.Rotation mgt + canal lining + additional wells	33	123	1.5	5,775	4,800	1.2

Notes: NI = net income; hf = head farms; tf = tail farms.

Table 11. Benefit-Cost Ratios and Internal Rates of Return for Different Tank Improvement Strategies, Tamil Nadu.

Strategies	Project Life (years)	B/C ratio[a]	IRR (%)
Sluice modification	6	0.5	0
Sluice management	10	10.0	2,204
Canal lining	6	1.8	54
Additional wells	8	1.7	35
Rotation management	10	10.8	974
Canal lining + additional wells	8	1.5	30
Sluice management + additional wells + canal lining	l8	1.7	37
Rotation management + additional wells + canal lining	8	1.4	27

[a] discount rate = 12.5 per cent

Glossary

Ayacut = command area
Defunct tanks = not functioning tanks due to poor water sources or encroachment
Ex-zamin tanks = non standardized tanks and earlier controlled by the Zamindars. After standardization they will be classified under PU or PWD tank category.
Kudimaramath = Co-operative repair work of the irrigation systems involving the local community
Panchayat = village level administrative unit
Panchayat Union (PU) = administrative unit for a group of villages/panchayats
PWD = Public Works Department.
Non-system tanks = tanks that depend on the rainfall in their own catchment area and not connected to the streams or reservoirs for getting additional water supplies.
System tanks = tanks that receive supplemental water from major streams or reservoirs in addition to the yield from their own catchment from rainfall.run-off.

Tank = small gravity irrigation system constructed across a gentle slope using earthen bunds to arrest and store rainfall run-off for providing mainly supplemental irrigation in the post rainy months.
Zamindars = landlords.