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Sustainable Management of Tank Irrigation Systems in India

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Tank irrigation systems of India are a century old. 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 systems to enforce the institutional arrangements under the common property resources management regime. About 2% of the tanks in the tankless intensive region and 67% of the tanks in the intensive region have become defunct. Wells that are supposed to be security against late season tank water scarcity have of late become a major threat to the very survival of the tanks. Taxes from multiple uses of the tanks, if collected by a single agency are sufficient to meet the operation and maintenance expenditures of the tanks both in the short run and in the long run. The modernization options derived from a simulation model indicate that software strategies such as sluice management will have a higher pay-off than hardware strategies such as canal lining and additional wells. Policy interventions include physical investments, management and legal aspects.

Key words: Tank irrigation, Social forestry, Rehabilitation, Resource mobilization, Tank performance

1. Tank Irrigation Systems of 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 a large number of marginal and small scale farmers that essentially depend on tank irrigation because these systems are less capital-intensive and have a 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 the rainy season so it can be used for irrigation during the dry season. Tank irrigation systems also act as an alternative to pump projects, where energy availability, energy cost and ground water supplies are constraints for pumping. The distribution of tanks has been dense in some areas. However, over the years the performance of the tanks has been declining.

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

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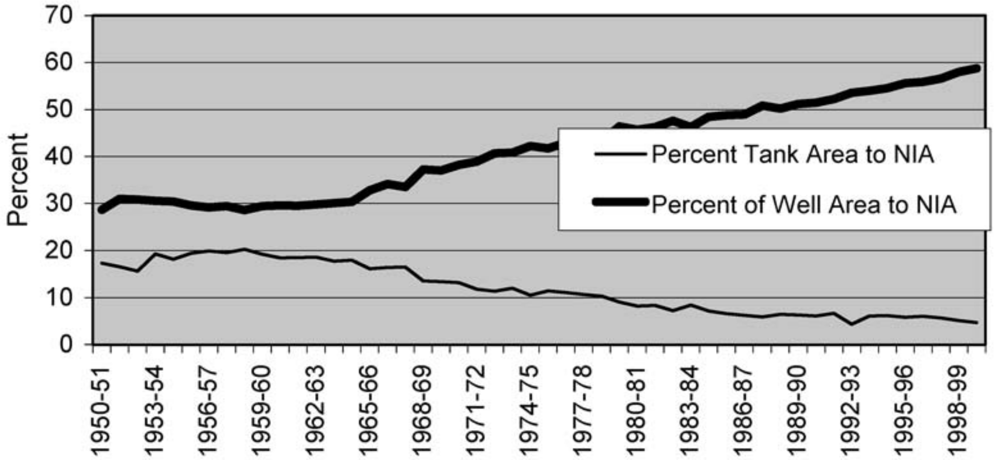

Fig. 1. Share of Tank and Well Irrigated Area to Net Irrigated Area (NIA), India.

net irrigated area.

Data from the Agricultural Census of India for five periods, namely 1970–71, 1976–77, 1980–81, 1985–86 and 1990–99 indicate that the resources of poor farmers (owning less than 2 hectares) still accounts for a major share of tank irrigated areas in India. Marginal (less than 1 ha.) and small farmers (1–2 ha) together accounted for about 40 percent of tank irrigated areas in 1970–71, which further increased to nearly 55 percent in 1990–91 thus accounting for nearly two thirds of the 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 groups are mostly poor, they can't afford cost-intensive irrigation sources like groundwater like the medium and large farmers and tank irrigation continues to play a crucial role for small and marginal farmers even today. This is also true across different states where tank irrigation has considerable presence even today (Narayanamoorthy, 2004).

2. Management of Tanks

In ancient days, tanks were considered to be the property of the rulers. The farmers paid a portion of their produce to the ruler. Farmers also were in charge of maintenance of the tanks, and supply channels. Zamindars ensured the proper maintenance of the tanks and channels, because they reaped benefits to farm large areas. However, when the British introduced the ryotwari system in 1886, tanks with an ayacut of 40 ha and above were brought under the control of the Public Works Department (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 outlined, the system of the farmers themselves taking up the maintenance work known as *kudimaramathu* work slowly declined. Tanks became 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 little voluntary community labor involved in tank maintenance, and it reported that in all districts laborers were 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 goal to legalize compulsory labor for certain aspects of maintenance, and also to penalize the lack of *kudimaramath* labor. The entire administration of the act for levying and collection of fines was left with the irrigation panchayats. The Famine Commission of 1878 forcefully brought to light the deteriorating conditions of tanks and advocated a systematic policy of maintenance. However, the local villages are presently responsible for water distribution and management of only tanks with a command area of less than 40 ha.

3. Performance of Tanks Over the Years

Over a 10-year period, the tanks provide a normal supply for three years, a deficit supply for five years and completely fail for the last two years (Palanisami, 2000). Given rainfall uncertainties, the tank performance has decline over the years. In addition, there are problems such as poorly maintained structures (bunds, surplus weirs) above the outlet. Catchment is mismanaged and forest land adjacent to the catchment has already been converted to human settlements by the Government. There is severe encroachment in the tank foreshores. Siltation of the tank beds has reduced their water storage capacity from 20 to 30 percent. In the case of problems below the outlets, channels are not maintained and break resulting in heavy water losses. Well irrigation has often dominated tank irrigation where an increase in the number of wells in the tank command signals the inability of the tank systems to provide reliable water supplies. In fact, it had been found that a large number of tanks have become defunct in less tank intensive districts (i.e., 76% of Panchayat Union tanks and 64% of Public Works Department tanks) compared to tank intensive regions, where the percentage of defunct tanks is lower[1] (Palanisami, 2000).

In the Tamilnadu state, the share of tank irrigated area compared to net irrigated area by marginal farmers has decreased from 39.53 percent in 1970–71 to 35.17 percent in 1990–91, by small farmers from 32.02 to 0.23 percent, medium farmers (2–4 ha) from 30.03 percent to 21.47 percent and large farmers (more than 4 ha) from 28.46 percent to 19.40 percent during the above periods indicating the poor performance of the tank irrigation systems in this state (Table 1).

The neglect of tanks has resulted in most farmers receiving 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% of the farmers in the tank command area own wells and there is a growing demand for well water, most well owners act as local monopolists and are able to charge high prices for well water. However, profit-making through privately owned water sources (i.e. wells) within the hydrological boundary of the common property resources (tanks) poses a serious threat to the very survival of the tanks, because of the declining interest of well-owners in proper upkeep of tank structures.

Even though several factors have influenced tank performance, the levels of their influences vary across locations. The major factors influencing tank performance are given in Table 2. The well density has a negative influence on tank performance. It has been observed that higher well density results in lower tank performance. Tanks without well supplementation in the tank season have performed well and this clearly indicates the availability of adequate tank water supplies.

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

4. Multi-uses from Tanks

Even though tanks originally served irrigation and other village needs, such as domestic, livestock, except fish production, due to changes in the village profile over the years, tanks are now mostly serving only irrigation needs. However, judging tank performance by only the irrigation component may be inadequate, as it does not reflect the true performance of the tank to benefit the village in various ways. Hence, multi-uses of the tank should be considered in determining 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 that can be

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

Table 1. Share of different sources of irrigation in India and Tamil Nadu (%)

	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 2. Parameters influencing tank performance under different levels of adjusted tank performance

Tank Type	Adjusted Tank Performance (%)	Well Density (No./ha)	O&M Expenditure (Rs./ha/year)	Resource Mobilized (Rs/ha/year)	Encroachment (%) of water spread area)	Farmers' Participation (man days/ ha/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

1 US$ = Rs 44

effectively used for tank maintenance.

In absolute terms, as given in Table 3, social forestry raises the most revenue (averaging Rs 170/ha), followed by irrigation (Rs 88/ha) and fisheries (Rs 15/ha). Social forestry collects the highest revenue (100%) as a proportion of total value of output, but irrigation pays a relatively small proportion of the value of output (3.2%) in various fees. Social forestry appears to perform well in absolute, as well as relative revenue realization 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 realized is presented in Table 4. Among the various agencies, Panchayat Unions receive the maximum revenue (64.96%), followed by the Social Forestry Department (24.84%), village community (5.18%) and the Revenue Department (4.67%). However, 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 is the responsibility of the state government to pay for the maintenance, and therefore have not put 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

Table 3. Average revenue realization at tank level from multiple tank uses

(Rs/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

1 US$=Rs 44

Table 4. Average revenue realized by different agencies from various user groups of the tanks

(Rs/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

1 US$=Rs 44

the entire revenue collection authority is given to a single institution such as local panchayats or water user associations.

It is important to note from the tables that the total revenue realized in terms of taxes, fees etc., ranges from Rs 337.12/ha in PU tanks to Rs 270.29/ha in PWD tanks, with an average realization at the tanks of Rs 275.40/ha (Palanisami *et al.*, 1997). This is higher than the government allotment of Rs 140/ha for tank O&M. Hence, instead of receiving heavy small allotments from the government, tanks themselves can generate more resources for maintenance. Present practices do not even exploit the full potential of tapping all the uses of tanks for revenue to support them and hence tanks suffer from a lack of maintenance funds, which is one of the major reasons for the 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 complimentary in nature.

5. Warning Signals

The following are warning signals to the Government and local communities on the declining tank irrigation in the states

・Most tanks are reported to function only in normal and excess rainfall years and not in poor and low rainfall years. The consequences are: many farmers have started abandoning tank agriculture due its continuous uncertainties in water supplies and moving to the nearby towns for other jobs and only the older people are remaining 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 to the maintenance of the tank structures, the upkeep of the structures is a cost for the farmers when they really want to use the tank for irrigation during normal supply periods.

・Livestock support activities are also completely gone in the villages, thus eroding the livelihood options for the village. Farmers previously removed 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 has been prevented thus making the bullock operations limited. Somehow in recent years, the micro-finance concept has emerged among rural women that manage families with livestock and credit integration. However, the livestock also need adequate fodder. Hence, if the tanks are not properly managed then the entire tank ecosystem based rural economy will completely collapse.

・The impact of social forestry has already been felt with an increase of silt accumulation in the tank water area and it will be difficult to sustain the tanks if social forestry is allowed to continue. However at the same time, even without social forestry in the tanks, there are possibilities that the prosophis trees will quickly spread and have more severe impact on the tanks than social forestry with accacia trees that have a market (timber) value.

・Due to intensification of watershed development programs by the Government, several structures such as small check dams and percolation ponds have been developed upstream of the tanks in several locations affecting inflows into the tanks. Hence a clear demarcation should be made between the watershed programs and tank improvement programs.

・Disappearance of the supply channels is very common. House construction due to population increases and village development activities such as roads, schools, and other buildings are concentrated in the government poramboke (common) lands that are the main sources of inflow to the tanks as well as interlink the tanks in a chain. This is one reason tanks are not receiving adequate inflow even though rainfall is normal.

・The traditional village institutions such as needkatti and madayan thotti that looked after the tank catchment and tank structures regularly facilitating inflows into the tanks during the rainy seasons have also disappeared, because they could not be paid for by the farmers due to frequent tank failures.

・The growing nexus between castes and politics of the younger generation in the village has also played a role in making the traditional leaders in the village (that looked after the tank management) inactive. Several regional political parties are emerging and relieving a higher vote percentage in the villages, because these parties concentrate on the rural villages for their benefits and in the process the households become divided into political and caste related groups.

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

・Rice supplies in the village ration shops to some extent prolong the livelihood of the poor farmer households despite the dried-up tanks. However, the major issue is how long can the ration shops sustain the villages and the tanks.

・Many people now raise the question: Do we really need the tank bund that provides a water spread: command area of 1: 2 or 1: 4? 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 tank irrigation and rainfed agriculture. This aspect is gaining importance because most of the time, the tanks are empty and people think of using the water spread area for rainfed cultivation due to its fertile silt.

6. Policies for Improving Tank Systems

Investment

Tank rehabilitation options that can restore the original standards should be given priority. Desilting is an important option. However, it has been observed that in a 10 year cycle, for only 3 years the tanks reach full storage, for five years deficit storage and for two years the tanks fail. Hence, desilting the tank fully is not economical, as the benefits of desilting will be for only three years with tanks at full supply. Also disposal of all the desilted material is difficult, because the fertile silt is found only in the top (0.4 meter) layer. Therefore, full scale desilting may not be warranted. Considering a high cost of Rs 120/m^3 of silt, partial desilting that helps to restore the original (10%) dead storage could be attempted as part of tank rehabilitation options to increase non-irrigation benefits of tank water particularly in the non-tank-irrigation season. Also recharging of wells could 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 do not receive an adequate water supply and the chain system of tanks has almost become 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 the 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 some supplementary irrigation to the non-well farmers during critical periods.

Management

Farmers in a few water scarcity tanks have already adopted crop diversification strategies involving groundnuts, pulses, cotton and other crops and this practice should be extended to tanks for which water storage is 50-60 percent. The water required to produce one kilogram of rice ranges from 4500 - 5000 litres compared to 1500 - 2000 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 would 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 and these canals create inequality 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 can help save 20% of the tank water. Instead of continuous water withdrawal from tanks, sluices can be opened and closed on alternate weeks (rotation of sluices).

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 improved as groundwater recharge structures for domestic purposes. Strict regulations and penalty mechanisms should be imposed on the encroachers of catchment, supply channel, and foreshore areas.

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