Quantification and Valuation of multiple uses in tank irrigation systems, Tamil Nadu, South India

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Tank Performance and Multiple-uses

The tanks support not only crop production but also a host of other related activities such as providing water for drinking, washing, bathing (domestic uses), fodder and drinking water for livestock, fish culture, duck rearing, bricks making, social forestry and silt collection (Palanisami et al., 1997). Thus, considering agricultural uses alone does not reflect the real situation, nor provide adequate information, particularly when the interest is in assessing overall tank performance. Hence the performance of tanks needs to be re-evaluated in terms of the tanks' impact on the village economy in a holistic framework. Even among the various uses, some will be more important in sustaining the village economy.

Normally, performance is measured as a ratio of actual use to the potential. This simple average of the performance of all the multiple uses will give one measure of overall tank performance. But in practice, all multiple uses do not occur in every tank in every year, and the probability of occurrence may vary for each use. In addition, the villagers' perceptions regarding the importance of each use may also vary. Hence taking a simple average to compute performance may be subject to aggregation bias. To avoid this problem, a weighted average measure of performance is used.. Accordingly, the Overall Tank Performance by use share (OTP_{US}) is defined as follows:

$$\mathbf{OTP}_{\mathbf{US}} = \left[\frac{\sum_{i=1}^{m} [PF_i][PR_i]\left[\frac{AC_i}{PO_i}\right] + \sum_{i=m+1}^{n} [PF_i][PR_i]\left[\frac{CN_i}{PC_i}\right]}{n\sum_{i=1}^{n}[PF_i]} \right] * 100$$

where,

PF_i = Scoring given based on the villagers' perceptions regarding the preference for the i^{th} multiple use

PR_i = Probability of occurrence of i^{th} multiple use

AC_i = Mean Actual use units occurred in a tank, for the i^{th} multiple use

PO_i = Potential use units possible in a tank, for the i^{th} multiple use

CN_i = Mean capacity used by the villagers with regard to the i^{th} multiple use

PC_i = Potential capacity available for the villagers of the tank command with regard to the i^{th} multiple use

i = 1 to m = Number of multiple uses (agricultural and other productive uses, excluding livestock)

i = (m+1) to n = number of multiple uses (domestic and livestock uses)

Description of the Variables:

Mean Actual Use [ACi]

There is large year-to-year variation in water supply from tanks. It was estimated using 45 years of rainfall data that in 5 out of 10 years, tanks will experience deficient supply; in 3 years the tanks will fail; in one year the tanks will have surplus storage; and in one year the tanks will be getting full supply. If data are collected on the level of use for any one-year, one may get a biased picture since that particular year may be deficit, surplus, normal or failure year. It is better to collect data for the past 10 years or at least 5 or more years if the data are not available. The average will provide the mean actual use (in relative terms) of the particular multi-use.

Potential Use (POi)

The potential use with regard to use as far as a particular tank is concerned is the maximum possible level of that multiple use when all the situations are favorable,

provided that maximum level of multiple use does not create any conflict nor exploit the other user groups in the same tank command. This is assessed based on discussion with the respective user group of that use, in consultation with the competitive or conflicting user groups.

Probability of Occurrence (PR_i)

In tank commands, though there is a possibility for several different uses, these uses may not be regularly occurring in every year. To account for all these variations, the tank performance with regard to each use is weighted by its corresponding probability of occurrence. Details of the probabilities of the occurrence of different uses are given in Table 1. Domestic uses such as drinking, bathing, and washing occur in every year, irrigation and fishing have a probability greater than 0.5, uses due to trees will occur once in four or five years, and other uses are less likely to occur.

Multiple Uses and Total Value of Output [OTP_{VO}]

Since the performance index based on the use-share reveals only the relative use of one use over the other, it is difficult to derive strong conclusions. The appropriate variables may be the value of the output generated, as well as the income generated from each use to the village or tank authorities. Hence, value of the output from each use was computed and aggregated to determine the total value at the tank level. Since such total value will vary according to the size of the tank, the total value was normalised by the ayacut area and expressed as value of output per unit command area

$$OTPvo = \sum_{I=1}^{N} [PR_i][UVO_i]$$

where,

OTP_{VO} = value of output in Rs / ha
UVO = Use-wise value in Rs / ha

The OTP_{VO} attempts to quantify the value of benefits accruing to all tank users. Household uses (drinking, washing and bathing) and livestock drinking are quantified at their opportunity costs. Since they are sensitive to the assumptions involved and also constitute only a minor proportion of the total value generated, these uses were omitted in the final calculation of the $OTP_{VO.}$

The details of the value of the output from different productive uses of tanks (excluding domestic and livestock uses) are presented in Table 2. Including all other uses raises the estimated total value of output for tanks by 13.3 percent, compared to the value from irrigation alone.

Mutiple Uses and Revenue (Tax) Realisation [OTP_{RT}]

The overall performance of the tanks is likely to be closely related to tank maintenance. This in turn depends on the revenue from its users that is ploughed back to the tank management (PU, PWD etc), and the efficiency of its appropriation. The receipt at the tank level is through formal and informal payments. Thus the final ranking of the tank performance based on the revenue realised at the tank level (OTP_{RT}) is calculated as follows:

$$OTP_{RT} = \sum_{i=1}^{N} RT_i$$

Where, RT_i = revenue receipts (taxes, fees) at tank level in Rs/ha from the i^{th} use. This includes both official charges collected by government agencies, as well as resources collected by non-formal local groups, from user fees or penalties.

The revenue realised from these different sources in terms of taxes, fee etc., is presented in 3 . In absolute terms, social forestry raises the most revenue (averaging Rs 170/ha), followed by irrigation (Rs 88/ha) and fisheries (Rs 15/ha). Table 4, which

presents revenue as a percentage of value of output from each use, gives a different picture. 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 realisation at the tank level. An important factor in this is that state agencies (rather than private sector) is the producer, returns are fairly well understood, and the revenue mobilized is legally shared between the Forestry Department and the panchayats. Compared to other uses, the social forestry has the advantage as the inputs used in the process had negligible costs. For example, the opportunity cost of the tank foreshore land is almost negligible, as tanks are dry in most of the years after the tank season is over. In fact, the social forestry protects the lands which otherwise will be encroached upon by the farmers for illegal cultivation. The forestry department spent Rs 2 per plant and the trees are growing automatically in the tank foreshore and waterspread area. The cost of the watch for protecting the trees is incurred by the Panchayats during the first two years and then the trees need no protection. Hence in terms of land, labour and material costs, social forestry incurred far less expenditure compared to other uses such as irrigation, duck, or silt, and government (forestry department), rather than private producers, bear those costs. Hence those government agencies are able to collect the entire sale proceeds under social forestry, and this revenue is attributed to the tank. The benefits due to social forestry could increase directly with respect to size of the tank waterspread. Hence in tanks with vast waterspread, the uncertainty over revenue generation from tanks due to frequent droughts is compensated to some extent by the social forestry which manages both the droughts and floods in the tank irrigation cycle.

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 5. Among the various agencies, Panchayat Unions receive the maximum realized revenue (64.96%), followed by the Social Forestry Department (24.84%), village community (5.18%), and the Revenue Department (4.67%).

It is important to note from the tables that the total revenue realized in terms of taxes, fee 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 as Rs 275.40 /ha. This is higher than the government allotment of Rs 140/ha for tank O&M. This analysis changes the picture on tanks: instead of receiving heavy subsidies from the government, in fact they generate more resources than the budget allocation for tanks (and much more than the Rs. 74/ha which our sample tanks actually received in terms of O&M expenditures from the PWD, or the Rs 55/ha for PU tanks).

Table 1 Average preference score for multiple tank uses

Tank type	Irrigation	Fishing	Ducks	Bricks	Social Forestry	Trees	Silt	Drinking	Bathing	Washing	Livestock Drinking	Livestock Grazing
PU Head	8.71	4.47	1.12	1.06	2.41	2.29	0.94	3.53	4.47	4.82	6.29	4.29
PU Tail	9.00	4.47	0.41	0.53	1.35	2.53	1.47	5.12	5.06	5.24	6.59	3.82
PU Total	8.85	4.47	0.76	0.79	1.88	2.41	1.21	4.32	4.76	5.03	6.44	4.06
PWD Head	8.43	3.87	0.39	0.48	1.35	1.91	1.22	4.48	4.26	4.74	6.65	3.96
PWD Tail	9.04	5.83	2.87	0.65	1.26	1.78	1.09	4.00	4.09	5.26	5.65	5.70
PWD Total	8.74	4.85	1.63	0.57	1.30	1.85	1.15	4.24	4.17	5.00	6.15	4.83
Average	8.79	4.69	1.26	0.66	1.55	2.09	1.18	4.28	4.43	5.01	6.28	4.50

Source: Palanisami et al. 1999.
[1]PU = Panchayat Union
[2]PWD = Public Works Department

Table 2 Average probability of occurrence of multiple tank uses over the past ten years

Tank type	Irrigation	Fishing	Ducks	Bricks	Social Forestry	Trees	Silt	Drinking	Bathing	Washing	Livestock Drinking	Livestock Grazing
PU Head	0.62	0.51	0.11	0.13	0.15	0.53	0.09	1.00	1.00	1.00	1.00	1.00
PU Tail	0.54	0.57	0.15	0.09	0.06	0.58	0.09	1.00	1.00	1.00	1.00	1.00
PU Total	0.58	0.54	0.13	0.11	0.11	0.56	0.09	1.00	1.00	1.00	1.00	1.00
PWD Head	0.66	0.50	0.09	0.14	0.13	0.40	0.16	1.00	1.00	1.00	1.00	1.00
PWD Tail	0.60	0.46	0.40	0.13	0.22	0.47	0.30	0.74	1.00	1.00	1.00	0.96
PWD Total	0.63	0.48	0.24	0.13	0.17	0.43	0.23	0.87	1.00	1.00	1.00	0.98
Average	0.61	0.51	0.19	0.13	0.15	0.49	0.17	0.93	1.00	1.00	1.00	0.99

Source: Palanisami et al. 1999.
[1]PU = Panchayat Union
[2]PWD = Public Works Department

Table 3 Average total value of output of the tank from multiple tank uses (Rs/ha)

Tank type	Irrigation	Fishing	Ducks	Bricks	Social Forestry	Trees	Silt	Total
PU, Head	6393.32	37.49	17.98	202.34	228.09	14.61	5.46	6899.30
PU, Tail	5021.70	100.84	60.28	10.86	284.01	22.76	20.22	5520.67
PU Total	5707.51	69.16	39.13	106.60	256.05	18.69	12.84	6209.98
PWD, Head	2284.46	34.34	3.48	40.25	242.22	2.52	2.76	2610.03
PWD, Tail	2330.21	182.40	21.32	2.75	49.27	28.38	2.27	2616.60
PWD Total	2341.00	137.90	14.38	14.24	160.10	16.03	2.53	2686.19
Average	2746.26	130.06	17.88	24.81	170.85	16.50	5.55	3111.91

Source: Palanisami et al. 1999.
[1]PU = Panchayat Union
[2]PWD = Public Works Department

Table 4Average tax and fees realized at tank level from multiple tank uses (Rs/ha)

Tank Type	Irrigation	Fishery	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 Total	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 Total	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

Source: Palanisami et al. 1999.
[1]PU = Panchayat Union; [2]PWD = Public Works Department

Table 5 Percent 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 Total	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 Total	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.
[1]PU = Panchayat Union; [2]PWD = Public Works Department

Table 6Average income (tax, fee) 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 Total	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 Total	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

Source: Palanisami et al. 1999.
[1]PU = Panchayat Union; [2]PWD = Public Works Department