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Tank Irrigation in Southern India: Adapting a Traditional Technology to Modern Socioeconomic Conditions[1]

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Abstract

Tank irrigation is a long established technology to manage runoff water for irrigation. In India the area under tank irrigation is decreasing. This paper presents two concepts to adapt or transform the traditional water management system to suit modern socioeconomic conditions (a) improved tank management with water control, and (b) an alternative land management system to control runoff and erosion to recharge groundwater and sustain irrigation wells. Model calculations for the first concept show that improved tank management with a water control system of closing sluices on rainy days would save enough water to irrigate an additional 20% of the command area at a 17% lower risk of crop failure. Investment in an organization to employ and supervise tank water controllers can be justified by the expected returns from the increased area under irrigation. The second concept can be expected to generate substantial increases in net returns and employment. Further research is required to verify these findings.

Introduction

Water management holds the key to improved productivity of agricultural land in the semi-arid tropics (SAT). Tanks and open wells are traditional sources for small-scale irrigation in Indian agriculture. With increasing population pressures, however, difficulties arise: tanks degenerate because of inefficient maintenance and water control, and, with well irrigation becoming increasingly more attractive, construction of wells increases while tanks disappear. Groundwater levels fall because of overexploitation and reduced recharge from tanks. As costs and availability of conventional energy sources (diesel, electricity) become more restrictive, well irrigation meets with problems.

Improvement of Water Control in Existing Tanks

Research on irrigation tanks in southern India has shown that tank irrigation can be profitable (von Oppen and Subba Rao 1980b). But the performance of a majority of irrigation tanks has been poor, and this is reflected in the overall decline of tank-irrigated areas and growing instability.

Even in the case of tanks that may have some rudimentary management form of water distribution, e.g., a set date for opening of the sluice, the water is generally let out continuously once the sluice has been opened. Water controllers in charge of operating the sluice in the past have now almost disappeared. Better water management could be achieved through such simple measures as the following: (1) Reducing the outflow at night, since crop water requirements are less at that time. (2) Keeping the sluice closed on rainy days, assuming that rainfall will be sufficient to supply the requirement on those days. And (3) a combination of these two.

None of these measures will require any physical changes to be made to the tank as such. The water outlet structures will remain as they are because the outlets are traditionally fitted with a round hole that can be closed with a conical wooden plug from the top of the sluice. There will be no need for improved

1. Abridged version of an earlier paper: von Oppen et al. 1983.
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distribution channels for new cropping systems; paddy irrigation and field-to-field flow will continue.

A simulation model was built to compute the amount of water that can be saved, for instance, if the sluice remains closed on rainy days. Based on daily rainfall data the model computes the effects of various water-control rules. It calculates: (1) the chances of successfully growing a crop in the rainy season (there is still water in the tank during the 43rd week), and (2) the amount of water available for growing a second crop (at the end of the 43rd week). The 43rd week is assumed to be the end of the first season for a rice crop that takes about 120 days to mature.

The results are presented in Table 1. They show that, in a 10-ha command area, water control by closing the sluices on rainy days will reduce the number of years during which the tank runs dry before harvest from 50 years to 40, i.e., the probability of crop failure in the command area of this particular tank will drop from 0.69 to 0.56. Assuming an increase in the command area of 20%, water control would bring down the risk of crop failure from 0.73 to 0.59. These probabilities of crop failure are relatively high because of the small tank size assumed. Larger tanks have relatively lower evaporation and seepage losses, and therefore would benefit even more from water control involving water storage over longer periods.

In summary, water control of the kind described will permit irrigation of a command area that is 20% larger and at a 17% lower risk of crop failure. The water left in the tank at the end of the rainy season will be 24% above the amount under no water-control conditions in the existing tank.

Water control will, of course, not be cost-free. An organization to employ and supervise tank controllers will have to be established. This organization has to be planned for individual states in India and in such a way to make it fit into the existing structure of the respective department responsible for tank irrigation.

For assessing the costs of such a water-control system, a study was carried out by an ICRISAT consultant (Venkatram 1980). Conditions prevailing in the states of Maharashtra, Andhra Pradesh, Karnataka, and Tamil Nadu were studied, and the most feasible organization was projected. The costs of the water-control systems projected for each state were compared with the expected returns from a 20% larger tank-irrigated area. These comparisons are presented in Table 2. For each of the states included in the study it shows the expected total returns from a water-control system to farmers and to the state governments. The returns to farmers, of course, exceed those to the state governments by a multiple of over 15, as the farmers' average net returns from tank-irrigated agriculture exceed the present water rates by the same multiple.

The alternatives for financing the schemes in the different states and the likely expenditures are also presented in Table 2. It was assumed that for water regulators, 20% of the salary could be borne by the

Table 1. Tank simulation model results (with irrigation on Alfisols) using 70 years of daily rainfall data (Hyderabad, 1901-1970).

	10-ha command area 1000 m³ outlet		12-ha command area 1200 m³ outlet	
Details	Daily outlet without water controller	Nonrainy day outlet with water controller	Daily outlet without water controller	Nonrainy day outlet with water controller
Number of years the tank runs dry at the end of 43rd week (27 October)	48/70 (0.69)[1]	39/70 (0.56)	51/70 (0.73)	41/70 (0.59)
Average water stored in the tank (in m³) at the end of 43rd week	23800 (100)[2]	33000 (139)	22200 (100)	29600 (133)

1. Probability of tank being dry.
2. Percentage figure.

Table 2. Expected returns and expenditures (in million rupees) from improved water-management alternatives in tank-irrigated areas of selected states in India.

			Alternative expected expenditures				
					Supervision and water regulation		
						Government[6]	
	Expected returns		Grant for water regulator			Inspectors	
State	Farmers[1]	Govt[2]	Farmers[3]	Govt.[4]	Farmers[5]	& supervisors	Supervisors
Andhra Pradesh	140.0	6.8	24.0	6.0	30.0	6.24	4.80
Karnataka	65.6	5.2	19.2	4.8	24.0	3.12	2.40
Maharashtra	19.3	6.2	NA[7]	NA	NA	NA	NA
Tamil Nadu	129.7	9.4	9.9	6.6	16.5	4.78	3.67

1 From 20% additional irrigated area at average farmers' net returns
2 From 20% additional irrigated area at present water rates
3 Farmers pay 80% of salary (Rs 100/month) for water regulators
4 Government pays 20% of salary (Rs 25/month) for water regulators
5 Farmers pay full salary (Rs 125/month) of water regulator
6 Government pays for special supervisory staff, either (a) inspectors (1 per 50 tanks) and supervisors (1 per 20 inspectors), or (b) supervisors (1 per 100 tanks).
7 NA = not available
Source: Venkatram 1980

state government and the remaining 80% by the farmers who supervise; or, the farmers could pay the full water controllers' salary and the governments could provide supervision by inspectors and supervisors, or supervisors only. The expenditure for farmers would in all cases be only a fraction of the returns from a 20% additional command area. The expenditures for the governments would in no case exceed their returns from increased income as derived from existing water rates from 20% additional irrigated areas.

This exercise is indicative of the feasibility of the scheme at the aggregate level. The scheme is feasible and economically highly profitable to farmers while at the time being moderately remunerative to state governments.

The implementation of the scheme at the village level may initially pose some problems. Those who now have access to water may be apprehensive about its availability when the command area is extended. But, their experience with more stable water supplies during the first season and 24% more water during the second season (which has not been accounted for in terms of additional irrigated area) should convince those reluctant to collaborate.

Further study, including experimental research in villages, is required to decide how best and where to implement this concept. There may be cases where the concept described below is more applicable.

A Composite Water Management System for Alfisol Watersheds

Historically, one can observe a nonlinear relationship between population density and tank irrigation in large parts of India. Tanks tend to be established at population densities of 50-60 persons km^{-2}; higher population densities lead to creation of more tanks up to a maximum of about 220 persons km^{-2}. But beyond this point, an increase in population leads to a decreased number of tanks (von Oppen and Subba Rao 1980a). This observation is based on the simple truth that, with increased population pressure, the value of the land that a tank occupies rises. Consequently, the rationale for use and maintenance of a tank as an object of common property is increasingly being questioned by farmers and landless people. Private claims on the fertile tank land are followed by encroachments, which in turn lead to lower water levels and decreased irrigation efficiencies.

At the same time, irrigation wells around the tank provide water for irrigation. If tapped and recharged

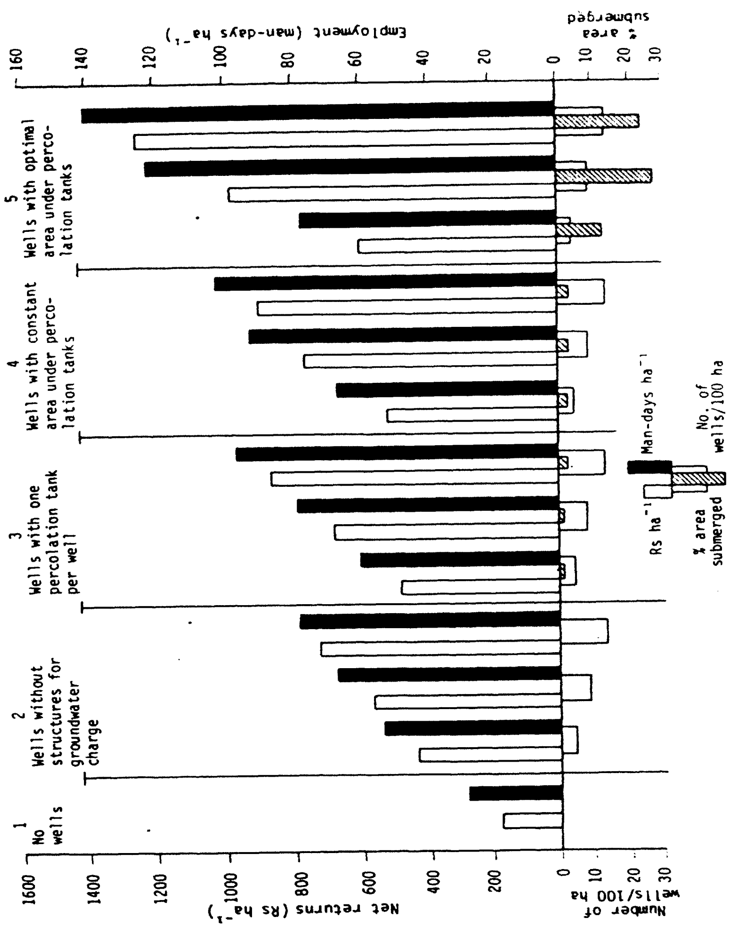

Figure 1. Net returns and employment on an Alfisol watershed under alternative water-management systems (results based on a model).

efficiently, this groundwater can [illegible]te all or most of the land formerly served by the tank, assuming favorable hydrogeologic characteristics.

Research at ICRISAT was initiated in 1981 to assess the potential of this concept, keeping in view the cost factors listed above and comparing these with the expected advantages in an optimization framework (Engelhardt 1983). This research was based on field surveys and a discrete stochastic linear model. The model allows the user to assess the impact of composite watershed management on SAT agriculture, which is constrained by the stochastic nature of its water supply. Parametric changes and sensitivity analysis of critical and unknown technical and economical parameters such as well density, factor cost, and product prices enable identification of the natural and socioeconomic environment for implementing the new concept.

Results from the model are summarized in Figure 1, which shows the benefits from water management were calculated in net returns (Rs ha⁻¹) and employment (man-days ha⁻¹). For comparison, the benefits of five alternative systems were calculated, ranging from rainfed agriculture with no wells to systems with wells (at different levels of well densities), but with no or only limited groundwater recharge.

While rainfed agriculture without wells produces net returns of Rs 200 ha⁻¹ and provides employment for about 30 man-days ha⁻¹, well irrigation drastically increases benefits to double (at 5 wells/100 ha) or more than triple (at 15 wells/ 100 ha) the levels of rainfed agriculture. But at higher densities well water is restricted by limited groundwater. Substantial increases in net returns can be generated at high well densities through groundwater recharge. At optimum levels of groundwater recharge, about 15-25% of the cultivated area would be submerged by percolation tanks and the increase in productivity would be about 30% at low well densities of 5 wells/100 ha, but 70% at densities of 15 wells/100 ha.

Conclusions

The two concepts proposed for improved watershed management on Alfisols are: (1) improved tank management with water control, and (2) an alternative system of runoff- and erosion-controlling land management for groundwater recharge and sustained well irrigation. These two concepts were analyzed at ICRISAT in an exante framework and found to have considerable potential. Therefore, applied experimental work is justified to confirm these results and specify the changes required for introducing the new concepts. Research proposals are being considered by funding agencies for follow-up experimental work.

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