Institutional Landscapes in Common Pool Resource Management:

A Case Study of Irrigation Tanks in South India

R.Balasubramanian
Associate Professor
Department of Agricultural Economics
Tamil Nadu Agricultural University
Coimbatore
Postal code 641 003
India

E-mail: rubalu@gmail.com

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Abstract

Irrigation tanks, which are one of the oldest common pool water resources in the coastal plains of South India, have been declining rapidly in recent years due to several factors. In response, people adopt various coping strategies such as migration, non-agricultural employment, and private tube-wells. This paper analyses the causes of tank degradation and the interrelationships among poverty, private coping mechanisms and collective action towards tank management. This paper shows that the increase in private wells has a strong negative effect on collective efforts for tank management. Poor people, who are more dependent on tanks, contribute more towards tank management compared to non-poor households. The study proposes several policy measures to revive and sustain the tanks.

Key Words: irrigation tanks, collective action, coping mechanisms, poverty, common pool resources, South India

1. Introduction

One of the most important common property resources in the relatively resource poor regions of South India is irrigation tanks. Until recently, irrigation tanks accounted for more than one third of the area irrigated in the South Indian states of Tamil Nadu, Karnataka and Andhra Pradesh. The tanks are ancient, and serve the needs of the poor. Their conservation and proper management is crucial for sustainable water use, soil conservation, and agricultural production in many arid and semi-arid areas. Tank maintenance is also important from an ecological point of view. Unfortunately, tank irrigation has been in a process of rapid decline over the last several decades. Much of this decline can be attributed to macro-economic changes and institutional failures. Traditional communitarian institutions have come under tremendous pressures because of state and market interventions, person-oriented political patronage, and political encouragement for encroachment (Nadkarni, 2000). As noted by Dasgupta (2005), several external factors such as population growth (causing encroachments), state intervention and increased uncertainties in property rights (due to the emergence of private wells in tank commands) are some of the important reasons for the neglect of tanks. Further, economic development and government subsidies for alternative forms of irrigation have gradually eroded the importance of tanks in agriculture.

In response to resource degradation, people often develop both collective and individual coping mechanisms (Scherr, 2000). These individual and collective coping strategies, together with the group, resource, and household characteristics, determine the level of collective action to conserve and manage the tanks. The extent of collective action affects resource condition and water availability and, hence, has a direct bearing on agricultural productivity and household income. Thus, it is useful, for policy purposes, to investigate the nature of tank degradation in terms of its linkages to collective action and coping strategies. This paper is based on a study undertaken in the South Indian state of Tamil Nadu in which the nexus among poverty, private coping mechanisms and collective action for tank management was analyzed.

2. The problem of dwindling tank irrigation

Tanks are one of the oldest sources of irrigation in India, and are particularly important in South India, where they account for about one third of the area irrigated under rice. There are many benefits associated with tank irrigation. For example, tank irrigation systems are less capital-intensive, have wider geographical distribution than large irrigation projects and smaller in size thus enabling decentralized management. Tanks are eco-friendly—they serve as flood moderators in times of heavy rainfall and as drought mitigating mechanisms during long dry spells. They recharge groundwater, which is a major source of drinking water for numerous rural and urban communities. Tank beds provide a place for forestry activities, which provide timber, fruits, fuel, and habitat for wildlife, particularly birds. Furthermore, fish grown in the tank water provides nutritious and affordable food for rural people besides being a source of income to fishermen. Thus, prosperity levels and size of villages in many semi-arid regions are directly proportional to the size and performance of irrigation tanks (Someshwar, 1999).

In spite of these economic and ecological benefits, Tamil Nadu has witnessed over the years a diminishing role for tanks in its rural economy. The share of area irrigated by tanks to total irrigated area in Tamil Nadu has declined from about 40 percent in 1955 to less than 25 percent in 2000 reflecting many problems besetting tank irrigation. The conditions and performance of thousands of tanks are poor due to inadequate operation and maintenance investments, disintegration of traditional irrigation institutions responsible for managing tanks, heavy siltation, and private encroachments into tank foreshore and water spread areas. Large-scale development of private irrigation wells has also led to the neglect of tanks. Furthermore, most of the tanks in Tamil Nadu are located in a chain of hydrological networks called tank chains or tank cascades where water from upstream tanks flows to downstream tanks and so on for a large number of tanks, which are interconnected with one another through a feeder channel. The number of tanks in a chain may be as high as a few hundred thus complicating the process of sharing water from a single feeder channel among a group of tanks, which often lead to inter-tank conflicts among farmers.

Tank management problems tend to fall into two distinct categories—the problem of provision and the problem of appropriation. The provision problem relates to problems associated with bringing adequate water to the tank and making it available for use at the outlet. It involves multiple tasks such as conservation of the catchments, maintenance of supply channels, removal and prevention of encroachment into tank water spread areas, de-silting, and maintenance and repair of the bunds, surplus weir and sluices. Appropriation problems, on the other hand, relate to sharing of various benefits from tanks such as water for agriculture and non-agricultural purposes, fishes and trees grown in tanks, silt collected from the tank bed, and grasses and other minor benefits from tanks.

3. Cooperative behaviour and private action – an overview

Though there are several studies addressing the issue of the interrelationship among the extent of dependence on CPRs, the social and economic heterogeneity of rural communities, and migration and collective action for managing the commons, there are no systematic attempts to understand these relationships in the context of irrigation tanks in South India. Most of the previous studies that have focused on problems confronting tank irrigation address below outlet issues, i.e., the appropriation problem. They are: water allocation and distribution (Palanisami and Flinn, 1989); modernization of tanks (Balasubramanian and Govindasamy, 1991); and the interaction between private wells and tanks (Palanisami and Easter, 1991; Janakarajan, 1993; Sakurai and Palanisami, 2001). A recent study (Palanisami and Balasubramanian, 1998) addresses the issue of the impact of private wells on the performance of tanks (measured as the ratio of area irrigated by tanks to the total registered command area of tank) using data collected from a cross-section of 690 tanks spread over four districts in Tamil Nadu. This study, however, suffers from two major shortcomings as far as tank-well interactions and their implications for collective action are concerned. First, it does not directly address the issue of the interrelationship between the whole set of private coping mechanisms available to the village community and its impact on collective action. Secondly, the measurement of tank performance (used as a dependent variable in the study) is plagued with serious problems in the presence of wells.

A more recent study on collective action and property rights when it comes to the irrigation tanks of Tamil Nadu (Palanisami, *et al*., 2001) attempts to investigate the relationship between property rights arrangements and the extent of collective action. Though this study has made important contributions to the measurement of tank performance by including non-agricultural uses of tanks, there is no systematic effort to understand the link between private coping mechanisms and common property resource management. There is no theoretical or conceptual model that has been tested and the empirical relationship between property rights and collective action has not been clearly addressed yet. On the whole, a careful review of past studies on tanks reveals a significant gap in the literature. Most studies focus on the appropriation problem (the sharing of tank water below the outlet) rather than the provision problem (bringing more water to tanks through collective effort) even though they recognize the chronic problem of the decline in tank irrigation together with a decline in community's participation in tank maintenance. The studies that addressed the issue of interaction between private wells and tanks have not focused on private coping strategies such as non-farm income and migration vis-à-vis the level of poverty and collective action for tank management. Overall, the complex nexus among poverty, private coping mechanisms and collective action towards tank management has not been systematically addressed by any of the previous researchers.

This paper is an attempt to bridge this gap in tank irrigation literature by analyzing the factors responsible for tank degradation at macro level and to more systematically address the issue of the factors affecting collective action for tank management at the micro level. We also address the issue of the relationship between exit options and collective action.

The hypotheses and methodology for the study were developed based on the conceptual and empirical works on cooperation and collective action by Baland and Platteau (1996), White and Runge (1994), Ostrom (1990, 2000), and Wade (1988). A careful review of these studies reveals that the important variables affecting collective action are: a) resource characteristics such as size and boundary; b) characteristics of beneficiary group such as size (number of users), inequality in their wealth (land, etc.), and the level of dependence of group members on the resource in question; c) institutional arrangements such as the procedures to devise rules, simplicity of rules, ease in enforcing rules and monitoring the adherence to rules; and d) the external environment, for instance, technology and state intervention in resource management.

White and Runge (1994) address the issue of collective action in common property watersheds by conducting a set of statistical analyses to test the correlation between various socio-economic parameters and the extent of cooperation. They find that the physical distribution of land parcels in the watershed, percentage of landholders who have adopted soil conservation techniques, and the manner in which both landholders and non-watershed participants acquire labor are the important factors explaining levels of collective action. Similarly, Lise (2000) investigates the question of peoples' participation in joint forest management and finds that there is an increase in the participation of resource management and conservation when the condition of the resource is good and/or when the people's dependence on the resource is higher. Chopra and Gulati's study (1998) on the nature of linkage between deforestation, land degradation and migration reveals that the household's decision to migrate and/or to participate in common property resource management are interrelated, since it is a part of household's labour allocation decision. Though this study highlights the interconnectedness of the decisions made with regard to migration and participation in the commons, it does not clearly bring out the direction of influence of migration on the participation in the management of the commons.

Ostrom (2000) suggests that out-migration, changes in technology and factor availability, frequent dependence on external sources, international aid that does not take into account indigenous knowledge and institutions, and an increase in corruption and other forms of opportunistic behaviour are the major threats to the survival and sustainability of local institutions responsible for resource management. When it comes to sustainable collective action vis-a-vis irrigation tanks in Tamil Nadu, too, these factors pose the real threat. For example, the technological factor impinges on tank management in the form of modern well-drilling and water-extraction technologies that promote and sustain private wells for groundwater extraction. This reduces the dependence on tanks for some farmers. Remittance income from migrants in a similar manner act as a private coping strategy that reduces the dependence on tanks while international aid that helps improve the physical structures of tanks has been misconceived as a solution for collective action problems[1].

Recent empirical work by Bardhan (2000) on 48 irrigation communities in Tamil Nadu is of special significance to the analysis offered in this paper. Bardhan (2000) investigates the factors affecting cooperation among households in maintaining irrigation systems using data collected from 48 irrigation communities in Tamil Nadu. The main shortcoming of this study is that it attempts to capture the extent of cooperation through proxy variables such as the index of the quality of maintenance of distributaries and field channels, the absence of conflicts over water within a village in the last five years, and the frequency of violation of water allocation rules. These are, on the one hand, poor indicators of cooperation. On the other hand they are hard to measure. For example, it is difficult to say what is a conflict or what is meant by better or poor quality of irrigation channels. This is especially so when one collects data *across tanks* characterized by different sets of people facing different *quality attributes* of tank structures. Moreover, when alternative measures of cooperation, such as the actual amount of labour and money contributed for tank

[1] The European Community has funded a major tank modernization project in Tamil Nadu, under which emphasis is placed on improvements to physical structures of the tanks rather than reviving and sustaining the institutional mechanisms for tank management. Little attention is paid to traditional knowledge about the conservation and management of tanks and to traditional institutions.

management, are available, the use of such vague proxies for cooperation becomes questionable. Further, Bardhan’s is a pooled analysis of irrigation communities in traditional tank and modern canal irrigation systems. Hence, the results from his analysis are not specifically applicable to tank management.

Given this background, the rest of the paper is divided as follows: Section 4 describes the study region and data collection methods. Section 5 presents the econometric models used to analyze tank degradation in Tamil Nadu and the district of Ramanathapuram and to understand collective action and its effectiveness. The results of the tank degradation analysis are presented in Section 6. This is followed by a discussion on poverty, dependence on tanks, and private coping mechanisms in section 7, and the role of village communities in the conservation and management of tanks in section 8. Section 9 of the paper presents the conclusions and policy recommendations.

4. Description of the study region and data collection

In attempting to understand tank degradation at the macro level, the paper first focuses on the state of Tamil Nadu and then on the district of Ramanathapuram in Tamil Nadu. The district of old Ramanathapuram (comprising present Ramanathapuram, Sivagangai and Virudhunagar districts) was selected because of the predominance of tank irrigation in the district as compared to the other districts in Tamil Nadu. Further, underdeveloped agriculture, a poor resource base, and low commercialization and industrial development make it a typical poor district that fits in with the objectives of the study.

An analysis of decadal trends in the area irrigated by irrigation tanks and private wells in Tamil Nadu and Ramanathapuram reveals that there has been a sharp decline in the area under tank irrigation in the state as well as in Ramanathapuram. The share of tanks in the total area irrigated by all sources in Ramanathapuram declined from about 88 percent during the 1960s to 75 percent during the 1990s while the corresponding figures for Tamil Nadu show a decline from 37 percent to 22 percent. While both the area irrigated by tanks and the total area irrigated by all sources declined over the last four decades in Ramanathapuram, the total area irrigated by all sources in Tamil Nadu increased in spite of the decline in area under tanks. This is due to the fact that the decline in area irrigated by tanks in Tamil Nadu has been more than offset by the increase in the area irrigated by wells in the state. However, the emergence of private wells in the district of

Ramanathapuram could not catch up with the rest of Tamil Nadu, primarily because of the prevalence of saline aquifers in many parts of the district. The presence of a very loose soil structure that prevents the establishment of wells in several other parts of the district is another reason for the inadequate expansion of wells. The dwindling tank performance and concomitant decline in irrigated acreage in the district may have adverse impacts on the rural communities. Hence, revival of tanks in the district may play a vital role in stabilizing irrigated acreage and rural income.

Ramanathapuram is an agricultural district with about 830 mm of average annual rainfall, a net sown area of about 35 percent, and forests accounting for only four percent of the geographical area. Tanks account for more than 70 percent of the total area irrigated by all sources in the district while there is no land under canal irrigation. Rice is the major crop under tank irrigation in this district with an average yield of about 2500 kg/ha as compared to about 3500 kg/ha in Tamil Nadu. Even though the district has a very high density of tanks, the dependability of tanks is very poor. For example, an analysis of 45 years of rainfall data for the district of Ramanathapuram shows that in a 10-year period, the tanks received a full supply of water for four years, an inadequate supply for two years, a very poor supply for two years, and an above-normal supply for another two years. Within the district of Ramanathapuram, the study focuses on two blocks, each representing two diverse agro-economic situations – Paramakudi and Rajapalayam. The former represents a very poor region with the agricultural sector serving as the major source of livelihood while the latter represents a comparatively well-developed non-agricultural sector. From each of these two blocks, 15 tanks were selected for detailed study. A household survey was then undertaken by selecting 10 farm households and five non-farm households associated with each tank. Two rounds of detailed interviews were undertaken. In the first round, information was collected on the general characteristics of the village community, village infrastructure, community efforts in tank management, institutional arrangements, income from tank usufructs, community coping mechanisms to overcome problems of poor water supply, and the presence and resolution of conflicts. In the second round of the survey, detailed household information on socio-economic factors, land ownership, agricultural practices, perceptions on the problems of tank degradation, private coping mechanisms, participation in tank management activities, etc., were collected.

The demographic profile of the two study sites (Paramakudi and Rajapalayam) shows that both the percentage of rural population and the share of agricultural workers to total workers are higher in the Paramakudi block than in the Rajapalayam block, which is relatively more industrialized. There are a number of cotton textile industries which serve as a major source of non-farm employment opportunity in Rajapalyam, whereas Paramakudi is industrially backward and hence the major coping mechanism for rural people during periods of drought is temporary or permanent migration. The duration of water supply from tanks, the availability of supplemental sources of water, namely wells, and the extent of crop diversification and cropping intensity are the major factors affecting agricultural profitability in the study region. Tanks supply water normally for a period of 3-5 months immediately after the northeast monsoon season. A few large tanks supply water for two seasons thus facilitating two crops – mainly rice in both seasons, or a long-duration crop like sugarcane or banana. In general, the cropping pattern in tank-irrigated areas is dominated by rice during the tank season, followed by crops such as vegetables, cotton or sugarcane depending on the availability of alternative sources of water and soil type. Rajapalayam, where there are more private wells, has a higher degree of crop diversity as well as cropping intensity.

5. Degradation, poverty and collective action - An analytical framework

This paper seeks to undertake three types of analyses. The first is a macro analysis of the determinants of tank degradation. In order to do this attention will be focused on degradation at the state and district levels and an econometric model developed to identify the determinants of degradation. The second part of the analysis focuses on the linkages between poverty, private coping mechanisms and collective action at the village and household levels. The last part of the analytical problem is to understand the determinants of collective action. This section will discuss the analytical framework in detail.

5.1. Econometric analysis of tank degradation

In order to study the factors affecting tank degradation, a careful econometric analysis of tank degradation in the state of Tamil Nadu and the district of Ramanathapuram was undertaken using time-series data. In the econometric model, the dependent variable is defined as an index of tank degradation—the ratio of the gap between the *potential* area and *actual* area irrigated by tanks each year to the *potential* area that could be irrigated by the tanks. The designed command area of all tanks has been used as potential irrigable area.

It is hypothesized that development of well irrigation was a critical factor that affected how communal tanks were viewed and used. The rush to private wells was encouraged by the reality that tanks were becoming an unreliable source of irrigation while the advent of green revolution crops made it a requirement to have assured water deliveries to match increased fertilizer usage. As a result, the national and state governments launched a major initiative to promote the use of wells through subsidized credit for investment on wells and government financing of rural electrification. Previous research has shown that the growth of private wells and the extensive development of water markets in tank commands have had a negative effect on the performance of tanks (Palanisami and Balasubramanian, 1999). In this model, the impact of private wells on tank degradation is captured by the well density (WELLDEN) defined as the number of wells per ha of geographical area. A quadratic term is also used for well density (WELLDSQ) so as to identify whether there is a non-linear relationship between growth in wells and tank degradation. Population pressure leading to increasing encroachment into the tank water spread areas, supply channels, and catchments is a serious problem threatening the survival of most of the tanks. In the absence of reliable macro-level information on the extent of encroachment, population density (POPDEN) is used as a proxy for encroachment. It is hypothesized that this variable will have a positive impact on tank degradation. In spite of the declining role of community in managing tanks, there is one possible factor, viz., the profitability in rice production, which could revive or sustain the community's interest in tank management. Therefore, it is hypothesized that technical progress in rice[2] production could have a positive impact on tank performance or that it could halt the process of tank degradation over a period of time. Hence, a one-year lagged rice yield (LRICEYD) is used as one of the independent variables to capture the impact of technical progress in rice production on tank degradation. Tank performance is critically dependent on rainfall (RAIN) and it is

[2] Rice is the single most important crop in most of the tank-irrigated areas. Rice accounts for more than 90 percent of the tank-irrigated areas in the regular tank season cultivation.

hypothesized that the effect of rainfall on tank performance will be positive. Finally, a trend variable (TREND) has been added to the regression equation to represent the left-out variables. Data to estimate this equation come from the Season and Crop Reports for Tamil Nadu published by the Government of Tamil Nadu for a period of 40 years from 1960 to 2000. The summary statistics and definition of variables used in the analysis are provided in Table 1. The econometric model is specified as a multiple linear regression equation of the following form:

$$TANKDEG = \beta_0 + \beta_1\, WELLDEN + \beta_2\, WELLDSQ + \beta_3\, POPDEN + \beta_4\, TREND + \beta_5\, LRICEYD + \beta_6\, RAIN \quad (1)$$

Table 1. Definition of variables used, descriptive statistics and hypotheses

Variable	*Description*	*Tamil Nadu*		*Ramanathapuram*	
		Mean	*Standard deviation*	*Mean*	*Standard deviation*
TANKDEG	Index of tank degradation	0.21	0.17	0.17	0.14
WELLDEN	Well density defined as number of wells per ha of geographical area	0.117	0.0225	0.05	0.01533
WELLDSQ	Square of well density	0.0142	0.00487	0.0027	0.00131
POPDEN	Population density	369.10	73.6	262.67	38.2
LRICEYD	Lagged rice yield (kg/ha)	2206.25	679.25	1256.57	501.04
RAIN	Annual rainfall (mm)	909.26	134.31	830.17	183.58

5.2. Factors affecting persistence of traditional tank institutions and contribution towards collective action – An econometric analysis

A detailed descriptive analysis of the extent of dependence of poor and non-poor households on tanks has been carried out so as to have a broad understanding about the nexus between poverty, private property (access to land and private wells under the tank command), and the nature and extent of dependence on tanks for various agricultural and non-agricultural purposes of the households. The dependence on tanks have been quantified in terms of agricultural income from tank irrigated lands and the amount of non-agricultural revenue mobilized from tank usufructs such as trees, fishes, silt and crops raised on tank bunds. The descriptive statistical analysis is followed by econometric analysis of factors affecting the persistence of traditional institutions and the extent of collective effort for tank maintenance with these two variables serving as dependent variables. The persistence of traditional tank management institutions is captured through the presence of common irrigator for water distribution (WATMAN) in tank command area and the extent of contribution to collective action (COLLEFF) is quantified by summing up the monetary value of labor and money contributed for collective work. While the variable WATMAN is an indicator of overall village-level cooperation, the dependent variable in equation (3) COLLEFF is a household's contribution to the collective effort for tank maintenance. While the former (WATMAN) is a discrete choice—a village can either have it or not—and requires the cooperation from all households to have it, the amount of collective effort (COLLEFF) is a continuous choice variable which can be provided at any quantity and it does not require unanimous cooperation from all villagers—there could be suckers and free riders. Hence, we resort to estimating these two equations individually using probit model for equation (2) and tobit model for equation (3). Further, the estimation of equation (2) is based on tank-level variables, while the latter is based on both tank-level and household-level data collected from 300 farm households spread over 30 villages (tanks).

$$\text{WATMAN} = \beta 0 + \beta_1 \text{REGION} + \beta_2\ \text{CASTE} + \beta_3\ \text{NWELLS} + \beta_4\ \text{TKSIZE} + \beta_5\ \text{GINI} + \beta_6\ \text{GINISQ} \quad (2)$$

$$\text{COLLEFF} = \beta_0 + \beta_1 \text{REGION} + \beta_2\ \text{CASTE} + \beta_3\ \text{FSIZE} + \beta_4\ \text{FSIZESQ} + \beta_5\ \text{NWELLS} + \beta_6\ \text{TKSIZE} + \beta_7\ \text{REACH} + \beta_8\ \text{GINI} + \beta_9\ \text{GINISQ} + \beta_{10}\ \text{NFISHARE} \quad (3)$$

The independent variables for the analyses were selected after a careful review of the literature on factors affecting collective action. Firstly, group size is an important factor determining the extent of cooperation in the commons. Small groups are considered to be conducive for the emergence and stability of cooperative behaviour in view of lower heterogeneity and transaction costs associated with organizing group action (Wade, 1988).

As data is not available on the exact number of farmers in each of the sample tanks, tank size (command area) is used as a proxy for group size (TKSIZE). Given the fact that the average land holding size under tanks does not show much variation across tanks, tank size provides a good proxy for group size.

The literature on common property resources is replete with analyses of the impact of income inequality among users as one factor affecting cooperation among village communities. A review of both theoretical and empirical work (Olson 1965, Baland and Platteau, 1997 and 1999, Dayton-Johnson and Bardhan, 1998 and Bardhan, 2000) on the relationship between inequality and collective action reveals no definite clues about the direction of its impact. We use the Gini ratio for land owned under tank commands (GINI) as a measure of inequality in power and wealth as well as a quadratic term for the Gini ratio (GINISQ) in order to verify whether the inverted U-shaped relationship between wealth inequality and participation in collective action holds good in the context of tanks.

People in tank irrigated villages have three types of private coping strategies, viz., private wells, and non-agricultural options such as migration and non-farm employment. All of these private coping strategies reduce the dependence on CPR tanks. The shift to non-farm employment and migration also reduces the labour availability at household level for CPR maintenance work. We attempt to capture the impact of these private coping strategies on the cooperative behaviour of the people using two variables—the number of private wells (NWELLS) per hectare of command area owned by the households and the percentage of households having non-farm income and remittance income (NFISHARE). It is hypothesized that both NWELLS and NFISHARE would have negative effect on the institutions for tank maintenance and management and hence the extent of contribution towards collective effort for tank maintenance. The definition, summary statistics and the hypothesis on all the variables used in this econometric analysis are provided in Table 2 below.

Table 2. Summary statistics, definitions and hypotheses for the variables used

Variable	*Description*	*Mean*	*Standard deviation*	*Hypotheses*
COLLEFF	Collective effort defined as the amount of money and value of labour contributed for tank maintenance works	195.96	313.52	Dependent variable
REGION	Dummy for region, which takes a value of 1 for poorer region and zero for relatively non-poor region	0.50	0.50	Positive
CASTE	Dummy for caste homogeneity, which takes a value of one if more than 75 % of agricultural households in the village belong to the same caste, and zero otherwise.	0.27	0.44	Positive
FSIZE	Farm size in ha	2.09	10.23	Positive
FSIZESQ	Square of farm size	13.34	16.47	Negative
NWELLS	No. of wells owned per ha of land	0.21	0.54	Negative
TKSIZE	Command area of the tank in ha	44.59	63.47	Negative
REACH	Location of the sample farm in the tank command which takes a value of one for tail reach and zero for head reach	0.5	0.5	Positive
GINI	Gini ratio of inequality in land operated under sample tanks	0.71	1.67	Negative
GINISQ	Square of Gini ratio	0.51	2.36	Positive
NFISHARE	Share of non-farm income in the total household income	0.41	0.74	Negative

6. Results and discussion

6.1. Factors affecting tank degradation – An econometric analysis

The results of the econometric analysis presented in Table 3 reveal that both in Tamil Nadu state and in Ramanathapuram district the variables included in the regression analysis could explain more than two-third of the variation in the dependent variable—tank degradation. The results show that in Tamil Nadu state all the independent variables except lagged rice yield were found to be statistically significant with expected signs for the regression coefficients, while in Ramanathapuram only three of the six variables were statistically significant. An interesting result is the negative relationship between well density and tank degradation both in the state of Tamil Nadu and the district of Ramanathapuram. This result has an interesting policy implication in that the number of private wells has a positive (negative) impact on tank degradation (tank performance). When the number of private wells is sufficiently large, not only do the well owners reduce their participation in tank management, but it also promotes the emergence of competitive groundwater markets in tank commands, which further contributes to reduced dependence on tanks for even non-well owners (since they will become water buyers). Therefore, emergence of private wells in large numbers in tank commands contributes for the declining performance of tanks. As expected, rainfall reduces the pace of tank degradation in both Ramanathapuram district and in Tamil Nadu state. Even though population density was not significant in Ramanathapuram, it is highly significant with a positive impact on tank degradation in Tamil Nadu. This implies that population pressure is one of the important factors hastening the process of tank degradation, perhaps through increased pressure on the resource, mainly in the form of encroachments into catchments and water spread areas.

Table 3. Factors affecting tank degradation in Tamil Nadu state and Ramanathapuram district

Variable	*Tamil Nadu*			*Ramanathapuram*		
	Coefficient	t-ratio	Prob. of significance	Coefficient	t-ratio	Prob.of significance
Constant	-4.78009	-1.997	0.0544	-0.58844	-0.682	0.5003
TIME	-0.1032*	-2.004	0.0536	-1.05E-02	-0.668	0.509
RAIN	-4.92E-04**	-4.8	0.00	-3.80E-04**	-7.014	0.00
WELLDEN	-6.8030*	-1.735	0.0424	-18.0712**	-3.969	0.0004
WELLDSQ	694.3159*	2.032	0.0505	1806.524**	3.101	0.004
POPDEN	2.02336*	2.176	0.0371	0.502029	1.129	0.2673
LRICEYD	3.72E-05	0.993	0.328	1.62E-05	0.686	0.4977
Adj. R-squared	0.8287			0.8219		
F-statistic	33.03			13.88		
DW statistic	1.29			1.8544		

*Note: ** and * indicate significance at 1 % level and 5% level, respectively.*

6.2. Poverty, distribution of tank benefits and private coping strategies

Given a broad overview of the factors affecting tank degradation at a macro-scale, in this and subsequent sections, the paper discusses crucial issues such as poverty, private coping strategies and dependence on tanks and their implications for collective action at the micro-level. The analyses are based on village and household level data associated with 30 tanks in two administrative blocks of the district of Ramanathapuram. To understand the nature and extent of dependence of poor and non-poor households on tanks, sample households are classified into two income categories, viz., households below poverty line (which are called poor households) and households above poverty line (called non-poor households). This difference helps in understanding their contribution to collective tank management work. This classification is based on the Government of India's norm for the poverty line, which is currently fixed at an annual per capita income of Rs. 18,000.

Table 4 shows the link between poverty and dependence on tanks. It is obvious from the table that the poor are much more dependent on tanks relative to the non-poor both for agricultural crop production and for non-crop activities such as livestock husbandry and fuel-wood collection. More than 90 percent of poor households depend solely on tanks for agricultural water while only two-thirds of the non-poor households depend solely on tanks for water. Further, over 85% of poor households are completely dependent on tank water for rearing livestock while only less than 25% of the non-poor said that they used only tank water for livestock needs. It is also interesting to note that approximately 50% of poor households are dependent on tanks to meet their fuel-wood and grazing needs.

Table 4. Poverty and dependence on tanks

Household category	*Land owned (ha.)*		*Extent of dependence on tanks (% households reporting complete dependence)*		
	Tank command	*Non-tank command*	*Agriculture*	*Collection of fuel wood and grasses*	*Watering livestock*
Poor	0.48	0.23	92	49	87
Non-poor	2.19	0.92	67	21	24

6.3. Revenue from tank usufructs and tank maintenance

In addition to crop production, tanks support a host of other related activities such as provision of water for drinking by humans and livestock, washing, bathing, etc. Tanks are useful for provision of water and fodder to livestock, tree cultivation, fish culture and duck rearing. Tank silt is used for brick making. Though there is a vast potential for growing fish and trees in view of their non-consumptive use of tank water, the current levels of such use is low[3]. Data presented in Table 5 shows the importance of trees and fishery as

[3] Non-agricultural uses of tanks are beset with problems related to lack of clear rules and rights. When the state took over tank management, it made significant intrusion into community rights over non-

sources of non-agricultural income from tanks. Further, poorer households obtain higher non-agricultural revenues relative to non-poor. This reinforces our earlier finding that the poor are much more dependent on tanks than the relatively better off households. Both poor and non-poor households spend a high proportion of the income generated from tanks on non-tank related activities such as renovation of temples or other common purposes. However, poorer households spend a relatively higher percentage of tank income on tank maintenance activities compared to the non-poor. Thus, poor people, whose dependence on tanks is higher, are also the major contributors to tank maintenance.

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agricultural uses of tanks. Yet, the state does not have a clear and uniform policy related to the sharing of non-agricultural revenues. This has led to a system of perverse incentives resulting in unauthorized use of tank usufructs by politically powerful groups and the use of the revenue from tank usufructs for purposes other than tank maintenance. In cases where income from tank usufructs accrues to the government, it is invariably added to the general financial accounts and not spent on tanks. The income from tank-bed tree plantations was generally shared among the local *panchayats* (under the jurisdiction of which the particular tank falls) and the State Government. However, neither of these organizations spends the revenue realized from trees exclusively on tanks. The rules for sharing income from tank fishery are more complicated. Though, historically, the rights to fishery benefits were vested with the respective village *panchayats*, there are no systematic and / or uniform rules governing the exploitation of fishery resources. In some places, fishery rights are held by individual farmers, while in some other tanks the *panchayats* or the State Government has the right to sell the fishery rights through auctioning. In view of the absence of uniform / systematic rules governing tank fishery, unauthorized (open access) fishing is a common practice in many tanks. In spite of state intervention and the absence of well-defined property rights over tank usufructs, some village communities are successful in realizing non-agricultural revenues from tanks. The extent to which the village communities are successful in mobilizing revenues from non-agricultural uses of tanks is an important indicator of the effectiveness of tank management institutions.

Table 5. Revenue obtained from tank usufructs and its utilization

(Rs./ha of command area)

Sources of revenue	*Poor*	*Non- poor*
I. Revenue mobilized		
a) Fishery	69.50 (59.41)	38.30* (16.42)
b) Trees	91.00 (62.65)	57.00* (55.74)
c) Sale of silt	0	0
d) Crops on tank bunds	14.50 (18.45)	4.10* (15.61)
Total	175.00 (47.5)	99.40* (28.3)
II. Utilization of revenue from tanks		
a) Added to village common funds	58.8	77
b) Spent for tank maintenance	41.2	23
Total	100	100

Note: Figures in parentheses are standard deviations.
* denotes significant difference between poor and non-poor households.

6.4. Private wells in tank command and market for water

Private wells are emerging as a major supplementary source of irrigation in many of the tank irrigated areas. Emergence of wells is influenced by many factors such as the advent of green revolution technology, which created the need for assured irrigation, commercialization of the village economy, and the increasing uncertainty and instability in water availability from common pool irrigation tanks. The perverse incentives created by state policies such as provision of electricity for agriculture at full subsidy served as a major external impetus for the emergence of wells. These wells are mainly recharged through the seepage flow from tanks and hence there is a close hydrological linkage between tanks and wells. The hydro-economic interaction between the performance of tanks and the number of wells per unit of tank command area is a complex issue. However, a closer look at the role of private wells in common pool tank command areas though wells complement tank performance through reducing the uncertainties in tank water supply in the short run, wells negatively affect, or act as a potential challenge to, tank performance through reduced dependence of well-owners on tanks and their vested interest in increasing their income through sale of well water. Quite often the well-owners act as local monopolists in view of the strategic location of their wells in relation to lands belonging to non-well owners.

Table 6. Private wells in tank command and the extent of dependence on community tanks

Particulars	*Poor*	*Non- poor*
No. of private wells per ha of land owned	0.11 (0.54)	0.32 (1.20)
Total no. of irrigation done for rice crop using		
a) Tank water		
b) Own well-water	28.6 (34.89)	30.81 (29.63)
c) Well-water purchased from others	3.62 (26.14)	13.36 (8.08)
	9.57 (12.33)	3.70 (7.37)
Percentage of water sellers to total number of farmers	14.21 (22.50)	43.20 (26.8)

Note: Figures in parentheses are standard deviations.

The data on private wells and the extent of dependence on tank vs. well water for crop production presented in Table 6 reveal that the number of wells per ha of land area was 0.32 for non-poor households, while it was only 0.11 for poor households. Consequently, dependence on others – both in terms of the number of households purchasing well-water and the average number of irrigations done using purchased well-water – was higher for the category of poor households.

6.5. The role of village communities in tank conservation and management

Though the tanks in Tamil Nadu have been taken over by the government, the village communities still play a crucial role in the maintenance of tanks. Farmers contribute both physical labour and money for various tank management works. The *modus operandi* of mobilizing the required labour/money generally take the form of an informal meeting of farmers (not all the villagers) at the beginning of the season in order to decide what kind of maintenance work should be taken up and how to mobilize funds/labour. In most cases, the exact contributions are decided on the basis of the nature and urgency of the work to be taken up and the physical condition of different tank structures. Activities of significance that are taken up very frequently and recurrently are the cleaning up of supply channels and diverting water from the upstream, and minor repairs to sluices, surplus weirs and tank bunds. Labour-intensive activities such as cleaning supply channels are done by the farmers themselves, the labour of which is equally shared among all farmers irrespective of the extent of land owned under the tank command. Minor activities such as repairs to sluices, surplus weirs and bunds, which do not require labour from all farmers, are done by hired labour and the expenditure towards such works is met from the funds mobilized for the purpose. The amount of money mobilized for such special work is typically based on the extent of land owned by the individual farmers in the tank command (which is called "acre-levy" since it is based on the acres of land owned under the tank command). Labour- and capital–intensive activities such as removal of encroachments and silt in tank water spread areas are very rarely done.

Table 7. Extent of participation of households in tank maintenance work

(Average for the years 1999-2000 and 2000-01)

Collective contribution for tank maintenance	*Poor*	*Non-poor*
I. Labour spent on (in man-days / ha of command area)		
a) Supply channel maintenance	4.72 (6.16)	2.48* (8.27)
b) Diversion of water for the tank	0.61 (1.20)	0.17 (4.3)
c) Field channel maintenance	1.82 (0.68)	0.94 (1.34)
Total labour spent	7.15 (2.68)	3.59 (2.71)*
Total value of labour spent on all the activities (Rs./ha of command area)	228.8 (23.71)	125.65 (37.15)*
II. Cash contributed for tank maintenance (Rs./ha of command area)	18.45 (21.66)	11.70 (19.42)
III. Total monetary value of contribution for tank maintenance (Rs./ha of command area)	247.26	137.34

Note: i) Figures in parentheses are standard deviations

[i)] * denotes significant difference between poor and non-poor households.

The data on collective contributions to tank maintenance and management by the two income categories presented in Table 7 indicate that supply channel maintenance is an important activity to which both categories of households contribute. The extent of participation in tank management is significantly higher among poor households as compared to non-poor households. Labour was the major form of contribution to the collective effort towards tank maintenance. The total amount of labour expended by poorer households was almost 100 percent more than that by the non-poor households. The field channels serving individual parcels of land belonging to different farmers have to be maintained by the respective farmers. Households were requested to report time spent on this activity too as a component of the extent of participation since the researchers were concerned with all activities related to tank maintenance.

6.6. Determinants of persistence of traditional tank institutions and the extent of collective action for tank maintenance

6.6.1. Factors affecting persistence of traditional tank management institutions

The results of probit regression analysis of variables affecting the persistence of traditional tank management institutions are presented in Table 8. All the variables except caste homogeneity are found to be statistically significant in determining the persistence of traditional tank management institutions. As expected both private wells and group size (tank size) are found to have negative impact on traditional institutions while inequality has U-shaped relationship with institutional set up, which is in conformity with the results obtained by Bardhan (2000). Poorer region has significant probability of persistence of traditional tank institution as compared to non-poor region.

Table 8. Factors affecting persistence of traditional irrigation institution – Results of Probit Regression Analysis

S.No.	Independent variables	Coefficients	Marginal effects	t-value	Level of significance
1.	Constant	32.65819	12.38099	2.387	0.017
2.	CASTE	0.389669	0.147727	1.51	0.1312
3.	WELDEN	-1.78303	-0.67596	-2.24	0.0251
4.	TKSIZE	-1.35E-03	-5.13E-04	-1.884	0.0595
5.	GINI	-90.1624	-34.1813	-2.315	0.0206
6.	GINISQ	60.65915	22.99638	2.196	0.0281
7.	REGION	1.156892	0.438587	4.671	0.00

6.6.2. Factors affecting extent of collective action for tank maintenance

The results of the Tobit regression analysis of factors affecting the contribution to collective action towards tank maintenance are presented in Table 9. The results are, in general, consistent with the economic theory and empirical literature on the factors affecting collective action in local commons. The regression coefficients indicate that one of the important local private coping mechanisms, viz., the number of private wells owned by a household in tank command area, was found to be statistically significant in negatively affecting the extent of collective action for tank maintenance. This result provides stronger evidence to the argument that private coping strategies operate against community interests when it comes to sustaining collective action for tank management. Since wells in tank commands are used to privatize common pool tank water because of the physical interdependence between tank storage and well-water recharge, those who have private wells are less motivated to participate in tank maintenance (Sakurai and Palanisami, 2001). However, poor people who cannot afford to invest in wells and hence are directly and solely dependent on tank water contribute more for tank maintenance. Therefore, the tank management policy should aim at promoting community wells for poor people. Another avenue for safe-guarding the poor is to promote policies that encourage diversification of cropping patterns away from rice. Crop diversification may increase incomes and reduce the demand for water, which may enable poor farmers to purchase water from the emerging competitive water markets.

Table 9. Factors affecting collective action in tank maintenance

S.No.	Variables	Coefficients	Marginal effects	t-value	Level of significance
1.	Constant	-992.421	-399.398	-0.324	0.7462
2.	REACH	22.55	9.076587	0.494	0.621
3.	FSIZE	99.69**	40.12154	2.423	0.0154
4.	FSIZE_SQ	-11.11*	-4.4708	-2.003	0.0452
5.	REGION	-180.10**	-72.4826	-2.426	0.0153
6.	CASTE	1030.97**	414.9107	12.312	0.00
7.	WELLDEN	-590.47**	-237.636	-3.205	0.0013
8.	NF_SHARE	-261.66**	-105.303	-3.44	0.0006
9.	TKSIZE	-1.13**	-0.45671	-5.837	0.00
10.	GINI	2694.38	1084.346	0.303	0.762
11.	GINISQ	-1761.38	-708.865	-0.274	0.7839

Note: * and ** indicate the statistical significance of the variable at five percent and one percent levels respectively.

The tank size, which is a proxy for group size, has negative influence on the extent of collective action probably due to the fact that the larger tanks involve a higher number of beneficiaries. In many cases these tanks serve more than one village thus increasing socio-economic and cultural heterogeneity that discourages cooperative action among farmers. The negative impact of group size is in contrast to results obtained by Heltberg (2001) in the context of forest conservation in Rajasthan, India. However, our results are in congruence with the theoretical literature on the relationship between group size and the extent of collective action. Surprisingly inequality in land ownership has not been found to have significant impact on extent of contribution for collective effort towards tank maintenance.

9. Conclusions and policy implications

The dependence of poor people on tanks is found to be an important driving force behind their active participation in tank maintenance. More than 80 percent of the poor households depend on tanks for crop and livestock husbandry while approximately 50 percent of them depend on tanks for grazing and fuel-wood. Consequently, these poor households generate significant amounts of revenue from various tank usufructs such as fishery and trees and spend significant portions of this income on tank maintenance. Poorer households spend 100 percent more labour than their non-poor counterparts on tank maintenance activities. Econometric analysis of tank degradation provides strong evidence that there has been a secular decline in the performance of tanks. This decline is mostly due to the decline of the local institutional set-up responsible for tank maintenance as well as changes in the overall socio-economic environment in which the tanks are managed. The negative relationship between the number of private wells and tank degradation has important policy implications. Given the hydrological dependence of wells on tanks as a major recharge mechanism[4], it could be argued that the wells are, partly, a mechanism to 'privatize' common pool tank water. However, given the heavy investment and uneconomical size of their land holdings, the poor are unable to go for this private option.

The above results are reinforced by the micro-level econometric model of collective action, which indicates that the increase in the number of private wells has a negative impact on both the persistence of traditional irrigation institutions and collective action for tank management. However, even though the wells pose a threat to collective action in conserving tanks, supplemental well irrigation has a strong positive influence on rice yield. Hence, farmers have strong private interest in digging wells, which is in conflict with the collective interest in tank management. The importance of both collective action and private wells in increasing agricultural productivity and the negative relationship between collective action and private wells throw up an important policy issue—the

[4] A detailed discussion with the farmers in the tank commands indicates that the wells are highly dependent on tanks for recharging. The water table in most wells goes down dramatically within a few weeks after the tanks go dry.

question of the optimal number of wells and an institutional mechanism to regulate the number of wells. Given the increasing risk in tank water availability, wells have become indispensable for successful crop production in tank command, though the excessive dependence on private wells threaten sustainable tank management. Therefore, promoting community wells instead of private wells is a win-win strategy in the sense that any cooperative effort to manage tanks will complement the cooperative effort needed to provide and operate community wells (and vice-versa), which would in turn reduce the dependence on private wells. Proportionate reduction in cropping area depending on tank water availability together with emphasis on intensive, commercial fish culture and tree cultivation in tanks would not only mitigate risks of crop failure in low rainfall years but also help supplement household incomes during years of water scarcity.

Inequality among tank users has been found to have U-shaped relationship with traditional tank institutions while it does not have significant impact on contribution towards collective action. As the persistence of traditional governance structures is an important factor affecting the success of sharing scarce tank water and user management of tanks, strengthening the governance structure in areas where the system is in operation and reviving the system in areas where it has become defunct absent will enhance collective action. Turning over tank management to village communities together with the rights over tank usufructs and empowering local government to remove and prevent encroachments in the tank commons are the important steps towards strengthening the governance structure that will promote a sustainable tank management regime.

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