WORKING PAPER

No. 2-03

Poverty, Private Property and Common Pool Resource Management: The Case of Irrigation Tanks in South India

R. Balasubramanian
K.N. Selvaraj

South Asian Network for Development and Environmental Economics

August, 2003

Poverty, Private Property and Common Pool Resource Management: The Case of Irrigation Tanks in South India

R.BALASUBRAMANIAN
K.N.SELVARAJ

Associate Professors
Department of Agricultural Economics
Tamil Nadu Agricultural University
Coimbatore-641 003
India
Emsil: rubalu@yahoo.com

August 2003

South Asian Network for Development and Environmental Economics (SANDEE)
PO Box 8975, EPC-1056
Kathmandu, Nepal

Working Paper No. 2-03

Published by the South Asian Network for Development and Environmental Economics (SANDEE), PO Box 8975, EPC-1056 Kathmandu, Nepal.

Telephone: 977-1-552 8761, 552 6391

Fax: 977-1-553 6796

SANDEE research reports are the output of research projects supported by the South Asian Network for Development and Environmental Economics. The reports have been peer reviewed and edited. A summary of the findings of SANDEE reports is also available as *SANDEE* Policy Briefs. SANDEE Policy Briefs are written for non-technical audiences, mainly policy makers and implementing agencies, and are available upon request.

National Library of Nepal Catalogue Service:

R.Balasubramanian

K.N.Selvaraj

Poverty, Private Property and Common Pool Resource Management: The Case of Irrigation Tanks in South India

ISBN : 99933-826-2-0

1. Irrigation tanks,
2. Collective action,
3. Coping mechanisms,
4. Poverty,
5. Common pool resources,
6. South India.

The South Asian Network for Development and Environmental Economics

The South Asian Network for Development and Environmental Economics (SANDEE) is a regional network that brings together analysts from different countries in South Asia to address environment-development problems. SANDEE's activities include research support, training, and information dissemination. SANDEE is supported by contributions from international donors and its members. Please see www.sandeeonline.org for further information about SANDEE.

Technical Editors:
Herath Gunatilake
Priya Shyamsundar

English Editor:
Carmen Wickramagamage

Comments should be sent to R. Balasubramanian, Department of Agricultural Economics, Tamilnadu Agricultural University, Coimbatore-641 003, India. Email: rubalu@yahoo.com

TABLE OF CONTENTS

LIST OF TABLES

ABSTRACT

Irrigation tanks are one of the oldest and most important common property water resources in the resource-poor regions of South India. Tanks are also important from an ecological perspective because they serve as a geographically well-distributed mechanism for the conservation of soil, water and bio-diversity. Unfortunately, tank irrigation has undergone a process of rapid decline in the recent past, much of which can be attributed to the disintegration of traditional irrigation institutions. In response, people adopt various coping strategies such as migration, non-agricultural employment, and private tube-wells. Adoption of private coping mechanisms has serious implications for community coping mechanisms, i.e., for collective conservation efforts. Against this background, this study tries to understand the main causes of tank degradation and the complex interrelationships among poverty, private coping mechanisms and community coping mechanisms that affect tank performance. Primary and secondary data are used to estimate three regressions models: a macro model on tank degradation, a household-level model on collective action, and a production function incorporating collective action as an input.

In general, poor people are more dependent on tanks for various livelihood needs and hence they contribute more towards tank management compared to non-poor households. The analysis of tank degradation shows that there has been a decline in the performance of tanks. Population pressure is found to have accelerated the process of tank degradation. Though the emergence of private tube-wells contributes towards mitigating tank degradation within a narrow range, a continuous increase in the number of wells beyond limits exacerbates the process of tank degradation. This result is further validated by the micro-level econometric model of collective action towards tank management, which indicates that the increase in the number of private wells has a strong negative effect on the participation of rural communities in tank management. The size of the user group has a negative impact on cooperation, while the existence of traditional governance structures, such as rules for water allocation, promotes collective action. Wealth inequality is found to have a U-shaped relationship with collective action. The production function analysis shows that collective action has a positive and significant impact on the rice yields. Therefore, collective action is important for higher productivity and income. The study proposes several policy measures to revive and sustain tanks so as to provide livelihood security to the poor, who are the most affected by resource degradation.

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

1. Introduction

Poverty, low agricultural production, and natural resource degradation are severe interrelated problems in the less-developed areas of the tropics (Pender and Hazell, 2000). Resource degradation not only erodes the assets and productivity of individual households but also impoverishes entire communities (Narayan, 2000). In India, environmental degradation has manifested itself in the rapid rate of natural capital depletion as exemplified by forest degradation and soil erosion (Chopra and Gulati, 1998). To this one can add the problem of the degradation of common property water resources – both surface and underground. Since common property water resources play a vital role in providing income and employment to rural people in many different ways, the degradation of these resources has a direct negative impact on the livelihoods of the poor. But it must be borne in mind that such degradation also poses serious environmental problems to the society and country at large in the long run.

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). 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. The specific objectives of the investigation are: i) to assess the impact of macro-economic variables on tank degradation; ii) to analyze the relationship among poverty, tank use and distribution of tank benefits, and private (individual) and communal coping mechanisms adopted by rural communities to circumvent the problem of scarcity; iii) to assess the impact of household-level socio-economic variables, group characteristics, resource characteristics and institutional arrangements on the extent of collective action; and iv) to assess the impact of collective action on agricultural productivity. Based on an analysis of 30 tank systems, a number of policy recommendations are offered to rehabilitate, and curtail further degradation of, this valuable commons resource.

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 and have wider geographical distribution than large irrigation projects. Being innumerable and small in size, they lend themselves to decentralized management. Moreover, tanks are especially important to marginal and small-scale farmers who largely depend on them. Tanks are eco-friendly – they serve as flood moderators in times of heavy rainfall and as drought mitigating mechanisms during long dry spells (Vasimalai, *et al*., 1996). 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 the 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. This decline in tanks reflects many problems that beset 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 (Palanisami and Balasubramanian, 1998). Large-scale development of private groundwater sources (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. These problems 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.

The institutional landscape in tank-irrigated areas of Tamil Nadu varies from very weak informal water management mechanisms to strong formal institutional set-ups. In the case of very weak informal institutional set-ups almost nothing is done to improve the performance of tanks except for the formulation of a few ad hoc rules for sharing water, which are enforced and monitored by farmers themselves or through appointing common irrigators on a temporary basis. At the other extreme, there are strong formal institutions in some places, where management rules, water diversion from the upstream supply channel, the cleaning of field channels below the tank outlet, and revenue mobilization from tank usufructs and its utilization are clearly specified and enforced. There is a wide array of institutional landscapes between these two extremes, each characterized by stronger management components in one or more aspects of tank management and weaker components in some other aspects. State intervention in tank management was initiated through the take-over of tanks by the Public Works Department during the latter part of British rule. The resulting loss of the community's rights over tank usufructs and the consequent breakdown in the traditional system of management (called *'Kudimaramath'*) are often cited as a major cause of the neglect of tanks.

Partly in response to the degradation in tank irrigation and the consequent decline in agriculture, rural communities have devised various community and private coping mechanisms to sustain their livelihoods. Coping strategies at the community- and household-levels depend upon a number of factors including institutional arrangements, distribution of land holdings, human capital availability, rural infrastructure, non-agricultural opportunities, access to alternative sources of irrigation, and local political and cultural factors. In many areas of Southern Tamil Nadu, one observes permanent / temporary migration of family members to distant cities and towns to tap non-agricultural opportunities. This can lead to a decline in labor availability at the household-level and, while reducing pressure on CPRs, this also reduces the dependence on and value of common pool resources such as tanks. The relative economic value of CPRs in the village economy is reduced if households receive remittance income from migrant members of the family. Secondly, rich farmers with larger farm holdings choose private solutions to circumvent the problem of tank water scarcity, i.e., extraction of groundwater through private wells. Hence, the participation of powerful sections of the rural community in the management of tanks is declining due to the emergence of private property rights over groundwater within the hydrological boundary of the common property tanks. Further, since groundwater and surface water (tank water) are physically interdependent, expansion of groundwater extraction by the rich may have adverse impacts on the poor and marginalized sectors of the community. Therefore, the extent to which rural households' have access to private coping mechanisms has serious implications for community coping mechanisms, i.e., the revival and conservation of common pool tanks through collective effort. This is one of the basic hypotheses that this paper seeks to test.

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 within the tank command area (Palanisami and Flinn, 1989); modernization of tanks (Balasubramanian and Govindasamy, 1991); efficiency in crop production under tanks (Shanmugam, 1994); 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 the tank through collective effort) even though they recognize the chronic problem of the decline in tank irrigation together with a decline in community's interest in tanks. Those studies that address the issue of interaction between private wells and tanks have not focused on the other private coping strategies such as non-farm income and migration vis-à-vis the levels of poverty and collective action for tank management. Overall, the complex nexus among poverty, private coping mechanisms and collective action when it comes to 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), Wade (1988) and Agarwal (2001). A review of studies by Wade (1988), Ostrom (1990), and Baland and Platteau (1996) 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 (forest) is good and/or when the people's dependence on the resource is higher. Education levels within the family, that is, a higher level of education for the head of household and lower levels of education for the other members in the family, too, influence, in this instance positively, the probability of participation. 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 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 in the context of tank irrigation.

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.

[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.

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.

Table 1. Comparison of decadal trends in tank irrigation in Ramanathapuram district and Tamil Nadu

Particulars	*Ramanathapuram*				*Tamil Nadu*			
	Net irrigated area by tanks	*Net irrigated area by wells*	*Net irrigated area by all sources*	*Annual rainfall*	*Net irrigated area by tanks*	*Net irrigated area by wells*	*Net irrigated area by all sources*	*Annual rainfall*
1960s								
Mean	207177 (87.86)	28152 (11.94)	235809 (100)	847	911663 (36.72)	644272 (25.96)	2482433 (100)	928
C.V.	6.84	17.96	5.87	17.38	7.23	8.08	2.80	14.66
1970s								
Mean	192003 (82.88)	38987 (16.83)	231666 (100)	805	849276 (31.50)	918515 (34.07)	2695823 (100)	932
C.V.	17.21	9.89	14.52	24.34	12.89	11.81	7.74	14.38
1980s								
Mean	161966 (76.47)	48627 (22.96)	211800 (100)	826	607364 (24.42)	1037465 (41.72)	2486703 (100)	880
C.V.	17.78	9.71	12.33	26.19	17.68	6.63	5.42	19.77
1990s								
Mean	159852 (74.92)	52113 (24.42)	213364 (100)	894	621333 (22.39)	1313538 (47.33)	2775200 (100)	917
C.V.	10.68	12.67	9.01	23.31	10.01	10.20	7.25	11.24

Note: Figures in parentheses are percentages to the net irrigated area by all sources in the respective years in the respective regions.
C.V. = Coefficient of variation during the decade

As Table 1 shows, there is a sharp fall in tank-irrigated area coupled with a higher instability in tank irrigation during the 1970s and the 1980s both in Tamil Nadu and Ramanathapuram. However, there are sharp differences between Tamil Nadu and the district of Ramanathapuram when it comes to the changes in the area irrigated over years. While both the area irrigated by tanks and the total area irrigated declined 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 increasing 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 inclusion in a total of 30 tanks in the 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[2] .

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

[2] The questionnaires used for collecting data at tank level and at household level are provided in Appendices 1 and 2 respectively.

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 both the determinants of collective action and how collective action affects farm output. This section will discuss the analytical framework in detail.

5.1. Macro analyses of tank degradation

In order to study the linkages between tank degradation, cooperation and private action, a careful econometric analysis of tank degradation in the state of Tamil Nadu and the district of Ramanathapuram will be undertaken. 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 potential irrigated area is calculated as the triennium average of area irrigated by tanks from 1960-61 to 1962-63. [3]

It is hypothesized that, at the macro level, development of well irrigation was a critical factor that affected how communal tanks were viewed and used. The advent of green revolution crops made it a requirement to have assured water deliveries to match increased fertilizer usage. As a result, the government of India launched a major initiative to promote the use of wells. Government financing of rural electrification promoted an even more rapid diffusion of wells throughout Tamil Nadu. The rush to private wells was encouraged by the reality that tanks were becoming an unreliable source of irrigation. Even in years of very good monsoon rains, farmers were restricted to a single crop (rice) below most rain-fed tanks. In addition, increasing commercialization of the village economy with augmented agricultural income provided new investment funds for digging wells. Government policies such as cheaper credit for well-digging and a subsidized electric power supply for pumping have also encouraged the spread of private wells. 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 growth of wells on tank

[3] The potential area that could be irrigated by tanks has been defined as the average area irrigated by tanks during the triennium 1960-61 to 62-63 since this is the starting triennium of our data set. Hence, as tank degradation proceeds over the years, it is logical to specify the actual area irrigated during the starting point of the data set as the potential area that could be irrigated by tanks.

degradation is captured by the number of additional wells (ADWELL) sunk in the preceding year in the state or the district. This is computed by taking the difference between the number of wells in year (t) and year (t-1). A quadratic term is also used for the additional wells (AWELLSQ) so as to identify whether there is a non-linear relationship between growth in wells and tank degradation.

Another major problem threatening the survival of tanks is increasing encroachment into the tank water spread areas, supply channels, and catchments. The encroachments into supply channels and water spread areas, together with silt deposition in water spread areas, is a major upstream problem for most of the tanks. Removal of these encroachers involves substantial social, economic and political costs and hence very rarely is anything done to retrieve the tank areas lost to the encroachers. Encroachment into tank water spread areas is mainly due to the increase in population pressure and the lack of institutional mechanisms to prevent the encroachment. Absence of precise boundaries for tank water spread and catchments is another major facilitating factor responsible for large-scale encroachments. In the absence of reliable macro-level information on the extent of encroachment, population pressure is used as a proxy for encroachment, which is measured as the ratio of rural population to total population (RPTOTP). It is hypothesized that this variable will have a positive impact on tank degradation.

Tank performance is of course critically dependent on rainfall. Rainfall (RAIN) affects tank performance in two ways: (1) directly through its effect on catchment runoff to tanks; and (2) indirectly through its effect on the performance of other sources of irrigation such as wells and canals. The consequent impact of the second on tanks is ambiguous. It is hypothesized that the direct effect of rainfall on tanks will be stronger and hence the effect of rainfall on tank performance will be positive. In spite of the declining role of community in managing tanks, there is one possible factor, viz., the profitability in rice production, that could revive or sustain the community's interest in tank management. Therefore, it is hypothesized that technical progress in rice[4] 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 so as to capture the impact of technical progress in rice cultivation on tank degradation and it is hypothesized that it will have a negative impact on the index of tank degradation. Finally, a trend variable (TREND) has been added to the regression equation to represent the left-out variables.

The macro-econometric analysis was carried out for the state of Tamil Nadu as well as for the district of Ramanathapuram separately. The econometric model is specified as a multiple linear regression equation of the following form:

$$\begin{aligned} TANKDEG = &\ ß_0 + ß_1\, ADWELL + ß_2\, ADWELLSQ + ß_3\, RPTOTP + ß_4\, TREND \\ &+ ß_5\, LRICEYD + ß_6\, RAIN \end{aligned} \qquad (1)$$

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.

[4] 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.

Table 2. Definition of variables used, descriptive statistics and hypotheses

Variable	*Description*	*Tamil Nadu*		*Ramanathapuram*		*Hypotheses*
		Mean	*Standard deviation*	*Mean*	*Standard deviation*	
TANKDEG	Index of tank degradation	0.21	0.17	0.17	0.14	Dependent variable
ADWELL	Additional wells dug during the year	22473.37	50167	1112	4029	Negative
ADWELLSQ	Square of ADWELL	2955546335	6874390494	17041502	39500508	Positive
RPTOTP	Share of rural population to total population	0.6705	3.736E-02	0.7173	2.38E-02	Positive
TREND	Time	20.50	11.11	20.50	11.11	Positive
LRICEYD	Lagged rice yield (kg/ha)	2206.25	679.25	1256.57	501.04	Negative
RAIN	Annual rainfall (mm)	909.26	134.31	830.17	183.58	Negative

5.2. Poverty, tank use and distribution of tank benefits

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.

5.3. Micro-economic analysis of collective action for tank maintenance

An important question that has been asked in this study is what are the determinants of collective action in tank management? Participation of households in tank maintenance activities is decided at village meetings. Of the 30 tanks studied, the collective effort towards maintenance of tanks was observed only in 18 tanks. In the remaining 12 tanks, no common maintenance activities were taken up during the survey years, viz., 1999-2000 and 2000-01. Even in these 18 tanks where there was some collective effort to maintain the tanks, the actual contribution was grossly inadequate for complete removal of silt and encroachment from tank water spread area and supply channels. There appears to be an overwhelming feeling among rural communities that tank maintenance is the state's duty since the state took over the responsibility of managing tanks decades back[5] .

In all these 18 tanks where maintenance work was carried out, it was observed that the decisions regarding the nature and extent of tank maintenance activities are taken at village meetings. These decisions are mostly based on consensus among the farmers, provided there is sufficient participation of farmers at these meetings. Detailed discussions with the villagers revealed that participation in tank maintenance activities is not based on strategic interaction among the farmers but based on consensus regarding what has to be done and how much has to be spent on tanks. In some tanks where large numbers of private wells are found, voluntary participation by well-owners is relatively low. In the case of a few tanks, well-owners do not participate in collective action but take water from tanks. Non-well owners do not object to this because of their dependence on well-owners during periods of tank water scarcity.

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 size of land owned under tanks does not show much variation across tanks, tank size provides a good proxy for group size.

An important aspect of traditional irrigation institutions in tank areas (where the traditional institutions are still active) is the appointment of a common irrigator. The common irrigator is responsible for operating the sluice, irrigating the field, guarding the tanks against breaches due to floods and/or damages to the surplus weir of the tank by downstream farmers. They are sometimes responsible for protecting the crops raised during tank season against damage by cattle. These common irrigators, called *neerkatti*, are either appointed by the water users' associations, or are members of scheduled castes who have inherited the right to serve as *neerkatti* over generations. In tanks where the *neerkatti* system is prevalent, individual farmers are not allowed to operate the sluice or irrigate the field. Hence, the presence of the *neerkatti* is an important indicator of the effectiveness of the local institutional arrangement for tank management and for the enforcement of rules governing water distribution. Thus, we include a dummy variable (WATMAN) for institutional effectiveness that represents the presence or absence of *neerkatti* for irrigation water management under tanks. Education is another important factor that is likely to promote the participation of households in tank management work and hence the years of schooling (YSCHL) of the household head is used as one of the independent variables in our econometric model of collective action.

Poverty is another important determinant of participation in collective action in the local commons since it is quite often suggested in the literature that household income has a negative effect on participation in the commons (Lise, 2000). Hence, we attempt to use farm size (FSIZE) as a proxy for

---

[5] This observation is based on the opinion survey we conducted during the course of the study, wherein we asked the villagers to rank the reasons for neglect of tanks. In more than 80 percent of the tanks studied, the reason tank maintenance is the state's duty was ranked first by the villagers.

income that will capture the effect of poverty on collective action in the commons[6]. Thus, we are using asset ownership as an indicator of poverty instead of income. While expecting a positive sign for farm size as it is likely to increase the dependence of the households on the tank and hence a higher level of participation by households with large farm size, we also use a quadratic term (FSIZESQ) for farm size as an additional regressor so as to identify whether there is a non-linear relationship between farm size and participation in collective action.

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 owned (NWELLS) by the households and the share of non-farm income to the total household income (NFISHARE). It is hypothesized that both of these factors would negatively affect the extent of collective action for tank maintenance.

The dependent variable is the total value of collective effort, which is calculated by summing up the monetary value of labour and money contributed for collective work. Since there was no contribution by many of the sample households, the dependent variable takes a zero value for all these observations. In view of the truncated nature of the dependent variable, the Tobit regression was used for this analysis. Thus, we model collective action in the following manner:

$$\begin{aligned} COLLEFF = \; & ß_0 + ß_1 WATMAN + ß_2 YSCHL + ß_3 FSIZE + ß_4 FSIZESQ + \\ & ß_5 NWELLS + ß_6 TKSIZE + ß_7 GINI + ß_8 GINISQ + \\ & ß_9 NFISHARE \end{aligned} \qquad (2)$$

This analysis is based on household data from all 300 farm households on the amount contributed by the household towards collective action and other related variables associated with households and tanks. The summary statistics of the independent variables used in the model are given in Table 3.

---

[6] There are two reasons for using farm size rather than income as an explanatory variable: First, it is not the current period income alone that decides the extent of participation in collective action. Secondly, even if we assume that use of current period income as an explanatory variable, the endogeneity problem arises because current period agricultural income is influenced by tank water availability which is partly due to the level of collective action.

Table 3. Summary statistics, definitions and hypotheses for the variables used

Variable	*Description*	*Mean*	*Standard deviation*	*Hypotheses*
WATMAN	Dummy for common irrigator as a proxy for effectiveness of local institutional mechanism	0.40	0.49	Positive
YSCHL	Education measured as years of schooling of household head	4.34	5.79	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
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

Another way in which we try to estimate the importance of collective action is by identifying its impact on rice yield. Rice yield during the tank season (September to January) is the single most important yardstick by which tank performance can be quantified since rice is the most important crop cultivated during the tank season in all the tank commands of Tamil Nadu. Hence, the impact of collective effort on tank performance can be captured estimating a production function for rice during the tank season, with the extent of collective action as an independent variable among other important factors affecting rice yield such as fertilizer used, availability of alternative irrigation sources, labour, and expenditure on plant protection chemicals. The analysis is based on cross-section data from 212 farm households[7] spread over all the 30 tanks selected for the study. The estimated equation is:

$$\begin{aligned} ln(RICEYD) = ln\, b_0 + b_1 ln(FERTZR) + b_2\, ln(LABOUR) + b_3\, ln(NPCIDE) + \\ b_4\, ln(SWIRRI) + b_5\, ln(COLLEFF) \end{aligned} \qquad (3)$$

[7] Out of the total number of 300 sample farms selected for the study, a rice crop was cultivated in only 212 farms.

Table 4. Definition and summary statistics of the variables used in rice production function analysis

Variables	*Definition*	*Mean*	*Standard deviation*
RICEYD	Rice yield (kg/ha)	2112	462.31
FERTZR	Value of fertilizers used (Rs./ha)	625	124.65
LABOUR	Value of human labour used (Rs./ha)	973	256.97
NPCIDE	Number of pesticide spraying	2.7	1.98
SWIRRI	No. of supplemental well irrigation	12.14	13.24
COLLEFF	Monetary value of collective effort (Rs./ ha)	192.34	54.16

6. Determinants of tank degradation

An econometric analysis of degradation of tank irrigation at macro-level will shed light on the important factors affecting tank degradation. Further, since this analysis is based on time series data over a period of 40 years, it would greatly help in the understanding of the dynamics of tank degradation from a temporal perspective, which is a crucial feature of degradation of common property resources such as tanks. This analysis therefore aims to investigate the impact of factors such as the growth of private irrigation sources, especially wells, which is a major challenge to the survival of tanks, encroachments into catchment area, water spread area and supply channel, and technological progress in rice production and rainfall. The results of the econometric model for both the state of Tamil Nadu and the district of Ramanathapuram are presented in Table 5.

Table 5. Determinants of degradation of tank irrigation in the state of Tamil Nadu and Ramanathapuram

Variables	*Tamil Nadu*			*Ramanathapuram*		
	Coefficients	*Std. error*	*t-value*	*Coefficients*	*Std. error*	*t-value*
Constant	-2.602	0.797	-3.263**	-1.882	1.729	-1.088
ADWELL	-5.055 E-07	0.000	-1.892*	-1.568 E-05	.000	-3.984**
ADWLSQ	5.132 E-12	0.000	2.810**	1.172 E-09	.000	2.954**
RPTOTP	4.051	1.059	3.827**	2.908	2.261	1.286
TREND	2.367 E-02	0.004	5.447**	1.358 E-02	.005	2.828**
LRICEYD	1.168 E-05	0.000	0.341	1.758 E-05	.000	.692
RAIN	-4.608 E-04	0.000	-5.071**	-4.050 E-04	.000	-6.923**
Adjusted R-squared		0.865			0.811	
F-value		41.618**			27.379**	

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

The adjusted R-square for both Tamil Nadu and Ramanathapuram reveal that the variables included in the regression analysis could explain more than 80 percent of the variation in the dependent variable – tank degradation. The results for Tamil Nadu show that all the independent variables except lagged rice yield were found to be statistically significant with expected signs for the regression coefficients, while in Ramanathapuram all the variables except lagged rice yield and the ratio of rural population to total population were statistically significant. An interesting result is the U - shaped relationship between the number of wells 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 negative (positive) impact on tank degradation (tank performance) up to a certain threshold number of wells and then its impact on tank degradation (tank performance) turns positive (negative). Thus, the tanks and wells have a complementary relationship over a limited range (of number of wells) after which the relationship becomes competitive. This is possibly because the emergence of private wells in limited numbers contributes to agriculture by providing supplementary irrigation during tank water scarcity.

The priority for the vast majority of villagers (the non-well owners) still appears to be the careful maintenance of tanks since these non-well owning farmers have to depend on tanks for irrigating their crops. Further, in view of their majority number, they may be able to solicit the active cooperation of the few well-owners for tank management. However, if the number of private wells exceed a certain threshold level, the investment in private sources of irrigation and the dependence on it will take precedence over the collective interest in maintaining the common pool tanks. When the number of private wells is sufficiently large, competitive groundwater markets emerge in the tank commands, which further contributes to reduced dependence on tanks for even non-well owners (since they will become water buyers).

As expected, rainfall has the effect of reducing the pace of tank degradation in both the district of Ramanathapuram and the state of Tamil Nadu. Even though the ratio of rural population to total population was not significant in Ramanathapuram, it is found to be 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[8] . Although the econometric analysis sheds light on several important aspects of the process of tank degradation, it does not provide any insights into the extent of dependence of different groups of village communities on tanks, their role/participation in tank maintenance, and the factors that impact on the participation. In the following sections, we present the results of a tabular analysis at the household and village levels in order to understand what is happening at the micro-level.

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

In this and subsequent sections, the paper discusses 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.

7.1. Demographic particulars of sample households and their dependence on tanks

The details on demographic aspects and the dependence of households on tanks are presented in Table 6, which reveal that the non-poor households have smaller family size and comparatively higher levels of literacy than poor households. This is true for men and women. The worker-population ratio as well as the percentage of permanent migrants and family members engaged in non-agricultural activities is higher in poor households.

[8] Encroachment is a serious problem in many of the tanks. Our discussions with key informants and revenue authorities reveal that there are significant encroachments into the supply channel and water spread areas of tanks which reduce the quantum of water that reaches the tanks and also the storage capacity of tanks. This problem has already been documented by many of the studies on tanks quoted earlier.

Table 6. Demographic details of sample households

Particulars	*Poor*	*Non- poor*
Average family size	6.38 (3.12)	5.15 (2.58)
Literacy rate		
a) Male	64.5 (48.12)	73.7 (55.13)
b) Female	27.5 (12.59)	41.2 (24.34)
Worker-population ratio	0.52 (0.12)	0.46 (0.59)
% of permanent migrants to total number of family members	22.35 (14.45)	11.37 (18.6)
% of family members engaged in non-agricultural activities to total number of family members	22.00 (13.5)	17.00 (24.5)

Note: Figures in parentheses are standard deviations

Table 7 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 7. 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

7.2. Revenue from tank usufructs and tank maintenance

Tanks support not only crop production but a host of other related activities such as provision of water for drinking by humans and livestock, washing, bathing, etc. Tank water also facilitates provision of fodder to livestock, tree cultivation, fish culture and duck rearing. Moreover, tank silt is being used for brick making. However, 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[9] . Data presented in Table 8 shows the importance of trees and fishery as sources of non-agricultural income from tanks. A further important finding is that poorer households obtain higher non-agricultural revenues relative to the less 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.

---

[9] 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 also made significant intrusion into community rights over non-agricultural uses of tanks. Yet, it did not come out with 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.

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. The rules for sharing income from tank fishery are even 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.

Table 8. 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.

7.3. Private coping strategies

Most of the tanks are solely dependent on catchment run-off during monsoon for water, which results in an uncertain and inadequate supply of water. This dependency on rainfall compels the farmers to devise community and individual coping mechanisms to circumvent the failure of crops due to water scarcity. Recurrent failure of tanks have led farmers in many of the dry regions to search for permanent solutions which mostly take the form of individual (private) solutions such as construction of private wells within the tank command, non-farm employment, permanent migration, etc. These exit options have significant impact on the opportunity costs of conservation efforts. Further, migration is always a threat that may change the economic viability of a conservation regime due to loss of those who contribute needed resources (Ostrom, 2000). Given the expansion in non-agricultural employment opportunities and migration, the neglect of tanks has to be viewed in the broader context of their declining role in agriculture in many areas, especially in areas where there are alternative income-earning opportunities.

Table 9. Private coping mechanisms by the sample households

S.No.	*Particulars*	*Poor*	*Non- poor*
1.	Percentage of farm households with non-farm employment	32.20 (19.7)	59.14 (41.3)
2.	Percentage of farm households with permanent migrants	24.75 (13.59)	12.37 (16.23
3.	Percentage of farms with own wells	20.12 (33.72)	57.01 (28.12

Note: i) Figures in parentheses are standards deviations
ii) The percentages do not add to 100 since most of the coping strategies are not mutually exclusive

The extent to which various coping mechanisms are adopted by the village community to manage the poor performance of tanks depends on the extent of land holding, the human capital availability of the households, access to groundwater, and other socio-economic conditions of the family. As Table 9 shows, both poor and non-poor households adopt various strategies to cope with the failure of agriculture and inadequate water. Fewer poor households own private wells (20% compared to over 55% for the non-poor) because of the small size of their land holdings and inadequate capital for digging wells. The groundwater market – purchase of well water from neighbouring farmers who own wells – in tank command areas is a major coping strategy among poorer households. Migration is another important strategy. The non-poor appear to be coping with water and agricultural problems by finding off-farm employment.

7.4. 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, the transition from subsistence to market-based agriculture, 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 reveals that the wells play a negative role vis-a-vis tank performance and the sustainability of tanks in the long run. The impact of private wells on tanks has two kinds of impacts:

a) In any given year, the wells complement tank performance through reducing the uncertainties in tank water supply;

b) In the long -run, however, 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.

The data on private wells and the extent of dependence on tank vs. well water for crop production presented in Table 10 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 .

Table 10. Details of 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 tank season rice crop using		
a) Tank water	28.6 (34.89)	30.81 (29.63)
b) Own well-water	3.62 (26.14)	13.36 (8.08)
c) Well-water purchased from others	9.57 (12.33)	3.70 (7.37)
Percentage of private water sellers to total number of farmers	14.21 (22.50)	43.20 (26.8)

Note: Figures in parentheses are standard deviations.

7.5 Sources of Income

The data provided in Table 11 show the income from agricultural and non-agricultural activities of sample households. The income from various sources for poor and non-poor households show significant differences both in terms of the income received and the share of different income sources in total income. The non-poor households received more income from both agriculture and non-agricultural activities as compared to the poor households. The poor households received more remittance income from migrants. However, the share of total agricultural income as well as that of tank-based agricultural income in the total income of households is higher for poor households than for non-poor households. Thus, Table 9 reinforces our general conclusion that poor households depend more on income from activities supported by common property resources relative to the less poor. Thus, the livelihood security of the poor greatly depends on the success or failure of CPRs.

Table 11. Source-wise income of sample households[10] (income in Rs./year)

S.No	*Particulars*	*Poor*	*Non-poor*
1	Income from crops raised in tank command	13050 (1857)	18487* (2554)
2	Income from crops outside tank command	2178 (1345)	4930** (1886)
3	Income from subsidiary farm enterprises	7586 (3481)	9855 (2562)
4	Income from water sale	146 (123)	984* (561)
5	Total income from agriculture	22960 (1346)	34256* (7892)
6	Remittance income from permanent migrants	5017 (691)	3885* (1238)
7	Income from seasonal migration	4650 (789)	2956* (1103)
8	Income from white and blue collar jobs	8605 (1945)	35980** (11497)
9	Income from non-farm business	4348 (987)	17056** (9231)
10	Total non-farm income	22620 (4779)	59877* (6798)
11	Total household income from all sources	45580 (5489)	94133** (18791)
12	Per capita income from all sources	7144 (912)	18278** (2598)
13	% of agricultural income to total household income	50.37 (38.23)	36.39* (23.48)
14	% of tank-based agricultural income to total household income	28.63 (22.12)	19.64* (14.78)

Note: * and ** indicate that that the values are significantly different between the two groups of households at 5 % and 1 % levels respectively. Figures in parentheses are standard deviations.

8. 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 work. 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

[10] Household income from various sources have been quantified by collecting detailed information on crop production aspects, income from livestock husbandry, non-farm employment, non-farm business, and remittances received from migrants. Detailed interviews were conducted with the household head as well as the other household members who are actually engaged in farm and non-farm activities to elicit reliable information on income from various occupations.

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.

8.1.Extent of participation in collective action

The data on collective contributions to tank maintenance and management by the two income categories presented in Table 12 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.

Table 12. 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.

8.2. Determinants of collective action for tank maintenance

The results of the Tobit regression analysis for identifying the factors affecting collective action are presented in Table 13. 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 13. Factors affecting collective action in tank maintenance

Variable	*Coefficient*	*Standard error*
Constant	25513.15	4110.64
WATMAN	912.74**	100.83
YSCHL	-3.49	12.59
FSIZE	141.07**	56.71
FSIZESQ	-13.63*	6.90
WELLDEN	-598.54*	277.77
TKSIZE	-0.8616**	0.28
GINI	-77021.83**	12032.97
GINISQ	56442.76**	8682.14
NFI_SHARE	-0.3798	1.29
Log likelihood function	-896.84	-
Sigma	470.85	35.23
Sample size	300	

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

The regression coefficients for inequality in land ownership (GINI and GINISQ) reveal that there is a U-shaped relationship between inequality in land ownership and the extent of cooperation, which is in conformity with the results obtained by Bardhan (2000). 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 heterogeneity that discourage cooperative action among farmers. The presence of a common irrigator, which represents vestiges of traditional institutional mechanisms (or prior institutional experience), is found to play a strong positive role in sustaining cooperation among tank farmers. Hence, the presence or otherwise of common irrigators in tanks signals cooperation among village communities in managing the tanks. The share of non-farm income to total income and the educational status of the households do not affect the extent of collective action significantly. These two results— the negative impact of group size and the positive impact of prior institutional experience on collective action— are the complete opposite of 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, prior institutional experience and the extent of collective action.

8.3. Economic impact of collective action

The collective efforts when it comes to tank maintenance are aimed at improving the performance of tanks. Hence it is important to investigate the impact of collective action on the performance of tanks. The yield of crops cultivated during a tank season could serve as an important indicator of tank performance. Therefore, the production function analysis was carried out for the tank-season rice crop by explicitly incorporating the extent of collective effort as an explanatory variable. The results are presented in Table 14.

Table 14. Impact of collective action on rice yield

Variable	*Output elasticity*	*Std. Error*	*t*
Constant	5.353	.472	11.337
FERTZR	0.161*	.072	2.231
LABOUR	-4.348E-02	.061	-.710
NPCIDE	5.600E-02	.036	1.557
SWIRRI	0.298**	.062	4.771
COLLEFF	0.486**	.130	3.744
Adj. R-squared		0.5126	
F-value		38.71 (N=212)	

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

The production function analysis reveals that the number of supplemental irrigation from private wells and fertilizer inputs have a statistically significant positive impact on rice productivity. The extent of collective efforts when it comes to tank maintenance also had a similar impact thus implying the importance of tank management institutions in sustaining rice productivity. The significance of both the number of supplemental well irrigation and the extent of collective action in increasing rice productivity has important policy implications for tank management and the regulation of private wells in tank commands. Even though the increase in number of wells is a threat to the collective effort at macro level, supplemental well irrigation is a crucial determinant of rice yield at farm level. This is due the fact that tank water becomes very scarce during the end of the season while the water applied during the last few weeks of the rice season is a critical factor determining rice yield.

9. Conclusions and policy implications

The central concern of the present study has been to explore the nexus among poverty, private coping mechanisms and collective action towards tank management and its implications for agricultural productivity and sustainability of tanks. Besides contributing to policy, our study tests several important theoretical hypotheses—the relationship between poverty, inequality, group size and exit options on the one hand and community participation in collective action on the other. The results of our study broadly agree with theoretical expectations as well as most previous empirical works on the issue the world over.

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 these households depend on tanks for grazing and fuel-wood. Consequently, not only do these poor households generate significant amounts of revenue from various tank usufructs such as fishery and trees but also spend significant portions of this income on tank maintenance. Poorer households also spend 100 percent more labour than their non-poor counterparts on tank maintenance activities.

The macro-level econometric analysis of tank degradation in both the state of Tamil Nadu and in the district of Ramanathapuram provide strong evidence that there has been a secular decline in the performance of tanks. This decline is most likely 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. More importantly, the U-shaped 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[11] , it could be argued that the wells are, partly, a mechanism to 'privatize' common pool tank water. However, given the heavy investment, the poor are unable to go for this private option. This points to the need for institutional intervention in order to regulate well-irrigation in tank commands so as to sustain collective action towards tank management. The existing government-enforced norms for regulating the digging of new wells, such as the minimum distance between two wells and the licensing of well digging, have to be strictly

[11] A detailed discussion with the farmers in the tank commands indicate 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.

enforced in tank commands taking into consideration the local conditions and their implications for sustaining cooperation among tank users[12] .

The above policy suggestion is further 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 collective action for tank management. However, even though the wells pose a threat to collective action in conserving tanks, farm-level production function analysis for rice indicates that supplemental well irrigation has a strong positive influence on rice yield. Hence, farmers have a strong private interest in digging wells, which is in conflict with their collective interest—the sustainability of tanks. 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 question of the optimal number of wells and an institutional mechanism to regulate the number of wells.

Diversification of cropping patterns away from the water-intensive rice crop is another strategy that will reduce the dependence on wells. Government and/or NGO support for community wells would also mitigate the negative impacts of private wells on collective action. 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 property water resources. Given that the community- managed wells also provide positive externalities, provision of government or other assistance for digging community wells can be justified on efficiency grounds.

Collective action by the poor and its importance for sustaining livelihoods should receive due policy attention so as to ensure that those who contribute labor and other resources for tank management should be vested with the right to enjoy the non-agricultural benefits of tanks. This helps sustain poor people's livelihoods as well as their interest in tank management. To ensure this, it is necessary to develop a suitable property rights structure over the various economic attributes of tanks that will benefit a wider spectrum of rural communities by broadening the stakeholder base of the tanks.

The other important lesson that can be elicited from the study is that the persistence of traditional governance structures (for instance, the presence of common irrigators for enforcing and monitoring water allocation rules) seems to promote collective action. This has an important policy implication. Strengthening the governance structure (say by common irrigators) in areas where the system is in operation and introducing the system in areas where it is absent will enhance collective action. Turning over tank management to village communities, together with the rights over tank usufructs and the authority to prevent and remove encroachments, is an important step towards strengthening the governance structure that will promote a sustainable tank management regime. Finally, there is a lot of scope for linking the on-going government programmes, such as the watershed and wasteland development programmes, with tank rehabilitation work, so as to promote an integrated water harvest and management regime for the overall development of the tank-irrigated areas.

---

[12] The state government has recently introduced a Groundwater Law, which stipulates that all farmers in the state should get prior permission from the government for digging new wells or deepening old wells. There is also a norm called the "well-spacing norm" stipulated by the National Bank for Agricultural and Rural Development according to which a minimum distance of 200 metres between the wells has to be maintained so as to avail oneself of institutional credit for digging wells.

Acknowledgement

We wish to place on record our sincere thanks to the South Asian Network for Development and Environmental Economics (SANDEE) for funding the research project which led to this working paper. We immensely thank all the members of technical advisory committee and management committee of SANDEE at various points of time, specifically Professors Partha Dasgupta, Narpat Jodha, Kanchan Chopra and Priya Shyamsundar, and numerous participants in various SANDEE research meetings held at Kathmandu, New Delhi, Bangkok and Dhaka for their critical comments and suggestions to improve the focus and methodology of the study. Herath Gunatilake and Priya Shyamsundar have shown immense patience in critically going through several preliminary drafts to offer incisive comments that greatly helped to improve the quality of this working paper in many dimensions. It is a great pleasure to thank them profusely. The SANDEE family members in the headquarters - Manik Duggar, Anuradha Kafle and Kavitha Shreshtha - provided unstinting cooperation and logistic support in administering the project. We thank them very deeply and sincerely.

Farmers in tank irrigated areas of south Tamil Nadu and many officials of Water Resources Organization of the Government of Tamil Nadu provided excellent cooperation in discussing with us and our field staff at various stages of data collection for this research work. We are deeply indebted to them. Prof. C.Ramasamy, Vice Chancellor, Tamil Nadu Agricultural University has been a source of inspiration and encouragement to carry out the study successfully. It is our sincere duty to thank him immensely.

Coimbatore,
August, 2003

R.Balasubramanian
K.N.Selvaraj

References

Agrawal, A. (2001), 'Common property institutions and sustainable governance of resources', *World Development*, 29(10): 1649-1672.

Baland, J.M. and J.P.Platteau (1996), *Halting Degradation of Natural Resources: Is there a Role for Rural Communities?* Oxford: Clarendon Press.

Baland, J. and J. Platteau (1997), 'Wealth inequality and efficiency in the commons Part I: the unregulated case', *Oxford Economics Paper,* 49: 451-482.

Baland, J.M. and J.P. Platteau (1999), 'The ambiguous impact of inequality on local resource management, *World Developmen*t, 27(5): 773-788.

Balasubramanian, R. and R.Govindasamy (1991), 'Ranking Irrigation Tanks for Modernisation', *Agricultural Water Management*, 20: 155-162.

Bardhan, Pranab (2000). 'Irrigation and Cooperation: An Empirical Analysis of 48 Irrigation Communities in South India', *Economic Development and Cultural Change,* 847-864.

Chopra, Kanchan and S.C.Gulati (1998). 'Environmental Degradation, Property Rights and Population Movements: Hypotheses and Evidence form Rajasthan (India)', *Environment and Development Economics*, 3 (Part 1): 35-57.

Dayton-Johnson, J. and P. Bardhan (1998), 'Inequality and conservation on the local commons: A theoretical exercise', *CIDER Working Paper no. 096-071,* Berkeley: Department of Economics, University of California, USA.

Heltberg, R. (2001), 'Determinants and impact of local institutions for common resource management', *Environment and Development Economics,* 6: 183-208.

Janakarajan,S. (1993). 'Economic and Social implications of Groundwater Irrigation: Some Evidences from South India', *Indian Journal of Agricultural Economics*, 48(1): 65-75.

Lise, W. (2000). 'Factors influencing people's participation in forest management in India', *Ecological Economics*, 34: 379-392.

Nadkarni, M.V. (2000), 'Poverty, environment, development: A many-patterned nexus', *Economic and Political Weekly,* 1184-1190.

Narayan, D. (2000), *Voices of the poor: Can Anyone Hear Us?,* New York: Oxford University Press.

Olson, M. (1965), *The Logic of Collective Actio*n, Cambridge, Mass.: Harvard University Press.

Ostrom, Elinor (1990). *Governing the Commons: The Evolution of Institutions for Common Action*, Mass: Cambridge University Press.

Ostrom, Elinor (2000). ‘Collective Action and the Evolution of Social Norms’, *Journal of Economic Perspectives*, 14(3): 137-158.

Palanisami, K. and J.C.Flinn (1989), ‘Impact of Varying Water Supply on Input Use and Yield of Tank-Irrigated Rice’, *Agricultural Water Management*, 15:347-359.

Palanisami, K. and R. Balasubramanian (1998), ‘Common Property and Private Prosperity: Tanks Vs. Private Wells in Tamil Nadu’, *Indian Journal of Agricultural Economics,* 53(4): 600-613.

Palanisami, K. and K.William Easter (1991), ‘Hydro-Economic Interaction Between Tank Storage and Groundwater Recharge’*, Indian Journal of Agricultural Research*, 46(2): 174-179.

Palanisami, K., P.Paramasivam, D.Karthikeyan and A.Rajagopal (2001), *Sustainability of Tank Irrigation Systems in South India*, Coimbatore: Tamil Agricultural University Press.

Pender, J. and P.Hazell, eds. (2000), *Promoting sustainable development in less-favoured areas*, 2020 Vision, Focus 4, IFPRI, Washington, D.C.

Sakurai, T. and K.Palanisami (2001), ‘Tank Irrigation Management as a Local Common Property: the Case of Tamil Nadu, India’, *Agricultural Economics*, 25: 273-283.

Scehrr, S.J. (2000), ‘A downward spiral? Research evidence on the relationship between poverty and natural resource degradation’, *Food Policy*, 25: 479-498.

Shanmugam, T.R. (1994), ‘Measurement of Technical Efficiency in Rice Production’, *Margin*, 26(3): 756-762.

Someshwar, K. (1999), ‘Panchayat Raj Tanks - A Potential for Future Expansion for Irrigated Agriculture in Andhra Pradesh’, *Journal of Indian Water Resources Society*, 19(5):1-14.

Vasimalai, M.P., C.R.Shanmugam and R.Seenivasan (1996), ‘Steering the Process of Turnover: A Perspective’, in *Proceedings of the Workshop on Turnover of Tank Irrigation Systems to Farmers*, Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore.

Wade, R. (1988), *Village Republics: Economic Conditions for Collective Action in South India*, Oakland: ICS Press.

White, T.A. and C.F.Runge (1994). ‘Common property and collective action: Lessons from cooperative watershed management in Haiti’, *Economic Development and Cultural Change*, 43(1):1-41.

APPENDIX 1

Analysis of Interrelationship between Poverty, Private Property and Common Property Natural Resource Management in South India

(Research Project funded by the South Asian Network for Development and Environmental Economics, Nepal)

Principal investigator: R.Balasubramanian, Associate Professor
Department of Agricultural Economics
Tamil Nadu Agricultural University
Coimbatore – 641 003

Questionnaire for tank level survey

1. Name of the tank:
2. Block: District:
3. Village and Beneficiaries:

S. No	Name of the villages	Total ayacut area	Actual area irrigated			
			2000-01	1999-2000	1998-99	1997-98
1.						
2.						
3.						
4.						

4. Demographic details:

Sl. No.	Villages	Total population			Number of households
		Male	Female	Total	
1.					
2.					
3.					
4.					

5. A) Caste composition:

Caste	Number of households	Approximate % of land owned by these households in the tank command
i.		
ii		
iii		
iv		
v Others		
Total households		

5. B) Non-agricultural employment

Particulars	No. of persons engaged	Approx. income/ person	No. of days engaged
I) Throughout the year			
II) If seasonal, how many (approximate) no. of days engaged: a) During normal year b) During current year (Drought year)			

5. C) Migration

Caste	No. of families completely migrated	No. of families in which one or more members have migrated	Reason for migration
1.			
2.			
3.			
4.			
5.			
6.			
7.			

6. Indicators of prosperity levels and village infrastructure

i.. No. of houses with RCC ceilings
ii. No. of tiled houses
iii. No. of thatched houses
iv. No. of following items owned by the households in the village:
  a) Tractors
  b) Power tillers
  c) Threshers
  d) Bullock carts
  e) Motor cycles / scooters
  f) Mopeds
  g) Power sprayers
  h) Household telephone connections
  i) Grinders or Mixers
  j) L.p.gas connection
  k) Bio-gas plant
  l) Household television sets
  m) No. of households with cable connection
  n) No. of children studying in English medium school
v. Village infrastructure
  a) No. of petty shops (within the village)
  b) No. of tea stalls (within the village)
  c) Distance to nearest town
  d) Distance to the nearest bus stop
  e) No. of bus trips per day
  f) Distance to primary health center
  g) Distance to commercial bank
  h) Distance to Cooperative trade society
  i) Distance to agricultural input depot
  j) Distance to cooperative milk society
  k) Distance to post office
  l) Distance to village office
  m) Distance to

Primary school:

Middle school / high school:

Higher secondary school:

College:

7. Cropping Pattern in a normal Year

Name of the village	Season - I		Season - II		Season - III	
	Crop	Area	Crop	Area	Crop	Area

8. Land transfers and tenancy

a) Were there any significant land transfers (buying and selling of land) in the village: Yes \ No
b) If yes, in which year did significant transfers take place?
c) What were the reasons?

d) Approximate extent of tenant cultivation in the tank command area :
e) Average rent paid for leased-in land (Rs/acre) :
f) Mode of payment of rent : Kind \ cash

9. Details of wells in the tank command area

a) No. of wells in the tank command area : Head reach :_____ Tail reach : _______
b) Depth of wells (in feet) **: Min._______ Max.________**

Normal year **Drought Year**

c) Duration of water supply available from wells for irrigation (in months) :
d) Approximate area irrigated per well :
e) Area under different crops cultivated with well-water during non-tank season (for the tank common as a whole) :
f) Extent of sales /purchase of well water during tank-water scarcity :
   i) No. of buyers :
   ii) No. of sellers :
   iii) Price of well-water :

10. Community well

i) No. of community wells :
ii) Year of digging :
iii) Dug by : Govt. / P.U / Farmers / NGO assisted
iv) Describe its usefulness in terms of
   a) No. of users :
   b) Extent of usage in normal year :
   c) Extent of usage in dry year :
   d) Extent of usage during the beginning and end of the season :
   a) What are the operational rules regarding:
      - Timing of usage
      - Pump set operated by
      - Decision-making on the
      - Operation and the management
      - How the costs are shared?
      - How the accounts are maintained?

11. Are the farmers knowledgeable about tanks in chain? Yes / No

12. If yes, how many tanks are there in the chain? _________

13. How many in the upstream? _________

14. How many in the downstream? _________

15. Number of tank flooding in the past 10 years. ___________

16. What are the perceived non-agricultural roles of tanks in the village economy? Ask the villagers to rank the various uses of tank on a scale of 1 to 10.

Role	Priority ranks
1.Drinking water-Direct use	
2.Drinking water-indirect use (Recharging wells)	
3.Other domestic uses (Bathing, washing)	
4. Sale of silt	
5.Ground water recharge	
6. Forestry	
7.Grazing ground for livestock during off-season	
8. Source of water for livestock	
9. Fish culture	
10. Duck rearing	

17. Property rights regime over the various tank usufructs
Who has the authority over management of different tank usufructs?

Sl.No	Uses	Assigning Authority	Right holders	First priority to
1.	Social forestry			
2.	Duck rearing			
3.	Fishing			
4.	Silt collection			
5.	Livestock grazing			
6.	Livestock drinking			
7.	Washing and bathing			
8.	Drinking			

18. Perception of problem of deterioration

a. Do the farmers think that the tanks have degraded over years? **Yes / No**

b. If yes, how do they perceive the decline / degradation? Rank the reasons on a 10-point scale)

Reasons	Ranks
1. Reduction in water received by the tank 2. Siltation in the waterspread area 3. Reduction in area irrigated 4. Catchment degradation 5. Poor condition of supply channels 6. Increase in encroachment in waterspread area 7. Increase in encroachment in supply channel 8. Increase in number of private wells in the tank command 9. Weak bunds and sluice 10. Poor distribution network	

19.What are the reasons for lack of maintenance/revival effort? Rank the reasons on 10-point scale.

Factors	Rank
1.Restoration of tank is State's duty 2.Catchments degradation and encroachment are multivillage problem, so villagers cannot take action to remove the encroachments 3.Caste conflict in the village – hence no cooperation 4. Non-cooperation from well-owners 5. Poverty / financial constraints 6. Declining role of agriculture in village economy and hence villagers are not interested in maintaining the tank 7. The tank is a multi-village tank. So, co-operation is difficult 8. Non-agricultural use of tank is meager 9. Income from tank usufructs is not sufficient to take up repair work by the village community. 10. The villagers do not have the authority to take up repairs and the PU/PWD is not taking up repairs.	

20. Maintenance (Give details of improvements/repairs done in the last five years).

Repair / improvement	Farmers	PWD	PU	Quality of work and impact
Catchment improvement Supply channel Tank bund Water spread area Sluice Distribution network Surplus weir				

21. Improvements made to tank structures in the last 10 years (by the farmers)
Who carried out the actual work? Farmers / Hired Labour / both
If work-wise break-up is not available give the total amount spent on (a) thru' (g)

Work	Year	Financial outlay (Rs.)		
		Farmers' contribution	Source of finance	Mobilized thru' NGOs
a. Desilting and repairing supply channels b. Desilting waterspread area c. Eviction of encroachment d. Strengthening the bund e. Repairing the sluice f. Repairing the surplus water g. Others (Specify)				

22. Present condition of different tank structures

a) Catchment : Good \ Eroded\ Encroached \ Barren
b) Supply channel : Good \ Encroached \Silted
c) Tank bund : Strong – no breaches
Weak –Breaches
d) Waterspread area : Silted slightly \ moderately \ heavily
Encroached slightly \ moderately \ heavily
e) Sluice : Good \ moderate \ Poor condition
f) Distribution network : Good \ moderate \ Poor condition
g) Surplus weir : Good \ moderate \ Poor condition

23. Impact of improvements

a) Extent of increase in storage capacity :
b) Extent of increase in cropped area :
c) Increased income due to increase in cropped area \ water availability :

d) Increase in revenue generated through other means . Give details.
1. Fish culture
2. Tree cultivation
3. Herbal \ Vegetable cultivation on tank bund
4. Others (Specify)

24. Water users' association (WUA)
a) Whether water users' association is present? Yes \ No
b) If yes, mention whether the WUA is : Formal/informal
Active/inactive
Traditional / newly formed

c. If there is no WUA, why?
d. What is the structure of the WUA? Who is empowered to formulate and implement rules and regulations for water use and management decisions?
e. What are the functions or role of organization?
f. What are the roles of various social and economic groups in the WUA?
1.Role of social groups (caste based)
2.Role of economic groups (rich or poor)
h. What are the problems faced by WUA?
j. What is your assessment regarding the performance of WUA / farmers' cooperation in tank management?
k. Were there any changes in rules governing tank management in the last 10 years with respect to the following? If so, explain briefly the reasons and the impact of new rules.

	Role	Assessment			Reasons for poor / better performance
		Good performance	Satis-factory	Poor	
1.	Bringing / diverting water to tank				
a.	Catchment management				
b.	Supply channel maintenance				
c.	Removal of encroachment				
2.	Water management				
a.	Sluice operation				
b.	Maintenance of field channels				
c.	Water distribution within the sluice				
3.	Resource mobilization				
a.	Forestry				
b.	Fisheries				
c.	Labour				
4.	Conflict resolution				
5.	Deciding crop choice				
6.	Lobbying with PWD / PU				

	Old rules / norms	Changes made	Impact of changes (Positive / negative)
i. Cleaning supply channel			
ii. Removal of encroachment			
iii. Desilting			
iv. Sluice operation			
v. Cleaning distribution network			
vi. Water distribution			
vii. Fish culture			
viii. Harvesting trees			
ix. Sharing fishes			
x. Sharing income from tank usufructs			

25. Revenue mobilization: (Rupees/year) (Last 3 years)

Year	Farmers' levy / subscription to WUA	Fishing	Duck rearing	Social forestry	Tree crops	Sale of silt	Crops raised on bunds	Grazing on tank-bed
2000								
1999								
1998								

a. How is fish culture practiced in the tank?

b. Who lets fingerlings in the tanks?
   Naturally grown \ FFDA \ Farmers \ All villagers

c. Who harvests the fishes?
   FFDA \ Tank farmers \ All villagers\ Allowed free catch by other farmers

26. Management of village common fund and its utilization.

a. Sources of revenue for village common fund other than tank usufructs.

Source of Revenue	Amount mobilized				
	Year 1	Year 2	Year 3	Year4	Year 5
1.Sale of trees in village common lands 2. Household levy 3. Others (Specify)					

b. Do all the households contribute to the household levy? Yes \ No

c. Who does not? Why?

d. How are the funds maintained?

Deposited in bank / By the village committee

e. Are the funds mobilized from tank usufructs maintained as a separate account or added to village common funds?

f. What are the actual uses for which the village common funds were utilized in .the last 5 years?

Purpose	Amount utilized			
	Year l	Year2	Year3	Year4
Temple renovation				
Tillage festivals				
Lobbying for village infrastructure				
Others (specify)				

27. Water control and management:

a. Is there any restriction for particular use / users in the tank? Give reasons?

b. Who irrigates the field?

Neerkatti / Farmers

c. When is the tank water made available for irrigation?

As soon as tank gets adequate water / Only at the time of preparatory tillage

d. If sluices are opened only at the time of transplanting / preparatory tillage, how do the non-well owners raise nursery? Give number of farmers under each practice

Purchase well water / Purchase seedlings /
Other means for nursery raising / (specify)

e. How many farmers raise nursery before tank gets water? Give number of farmers.

All well-owners / Not all well-owners / Well-owners + some non-well owners as well

f. Who appoints neerkatti / neer paichchi (common irrigator) ?

Water Users' Association appoints him every year / Neerkatti belongs to a particular family which inherits the right over generations

g. Payment for 'neerkatti':
   * Mode of payment
   * Quantity
   * Frequency of payment

h. Is there any water kept in the tank as reserve? Yes/No

i. If yes, when and how much of water (%) is kept as reserve?

j. Who decides it?

k. For what purpose is it used?

Purpose	Priority Rank
a. Recharge wells	
b. Watering livestock	
c. Fish culture	
d. Drinking water / washing	

l. What rights do the landless people have regarding the use of tank water?

28. Coping mechanism

A. Individual Coping Mechanism

How do farmers cope with decline in tank performance / during drought years?

Coping mechanism		Number / percentage of farmers
1.	Own well water	
2.	Purchase of well water	
3.	Non agricultural employment	
4.	Seasonal migration	
5.	Charcoal making	
6.	Wage labour in agriculture	
8.	Reduction in cropped area	
9.	Crop pattern changes	
10.	Remittance income	
11.	Others (specify)	

B. Is there any other CPR / open access resource in the village on which poor people depend during dry seasons / drought years? Give details on extent of such CPRs such as common or open access forests

i) Area under trees

ii) Area under grazing

C. Community Coping Mechanism

Coping mechanism		Extent of participation / compliance	
		Well-owners	Non-well owners
1.	Cleaning supply channels / distribution channels		
2.	Sluice rotation		
3.	Lobbying with upstream tanks for water		
4.	Imposing proportional limitation in command area to be cultivated		
5.	Imposing crop restriction		
6.	Lobbying with PWD/PU to repair tank structure		
7.	Pumping from tank		
8.	Others (Specify)		

D. Collect detailed information on the following aspects:

i) How and who devises the community coping mechanisms?
ii) What is the penalty for non-participation/non-compliance with the coping mechanisms?

29. Conflicts:

a. Are there any conflicts among the water users? Yes / No
b. If yes,
   i. When?
   ii. Between Whom?
   iii. What are the reasons for conflict?
c. How are these settled?
d. If the tank is a multi-village tank is there any inter-village conflicts in sharing water? Yes \ No
e. If yes, when and for what reasons does it arise and how was it solved?
f. Are there any unresolved conflicts, which severely disrupted water sharing \ distribution among users?
g. If yes, give reasons.

30. Details on crop production

a. Paddy yield in the tank command:
Max. :
Min. :
Average :

b. Approximate area cultivated with tank water in the last 3 years.

	2000-01	1999-2000	1998-1999
Tank season (Sep-March)			
Non-tank season (Apr-August)			

c. Market infrastructure

1. Distance to nearest market
   - (i) For inputs :
   - (ii) For outputs :

2. Approximate marketable surplus of

(i) Paddy :
(ii) Cotton :
(iii) Vegetables :
(iv) Others :

3. Any new crops introduced in the last 10 years? Give reasons

4. Sale of crop output

Local (itinerary) merchants : ___________ % of total crop output
Sold in nearest market : _________ % of total crop output

31. Party politics in the village

a. Political activities of the villages
Very active \ Moderate \ Inactive
b. Patronage enjoyed by the village from politicians
MLAs \ MPs \ Minister \ Others
c. Political affiliation of the villagers
- Caste-based affiliation
- No strong relationship between caste and political patronage

32. Power structure in the village

a. Is there a system of village leadership such as
Naattamaikkarar \ Ambalakkar \ Village Headman

b. If so, to which caste does he belong?

c. How is he appointed?

d. Is there any ward member \ panchayat president \ district panchayat member from this village?

e. If so, to which caste he belongs?

f. How do the dalits participate in the village life ?

1. Village festivals
2. Temple maintenance
3. Do the dalits have a stake in village common funds? If yes describe. If no , give reasons
4. What is the major occupation of Dalits?
   Agri. Labour \ Non-agri labour \ others

5. If Dalits own lands in the village,
Dryland \ wetland (tank command)
6. If dalits (scheduled caste people) own land in tank commands where ,
Head \ middle \ tail reach
7. Do the dalits get a share in fishes grown in tank ? How much?

33. Indicators of social capital

a. Do you think that there is all round erosion of local leadership and authority in recent years? Why do you say this?

- Decrease in interdependence among households
- Increase in intra-village conflict
- Decrease in participation in common welfare activities
- Decrease in village meetings (Oor kootam \ Oor panchayat)
- Decrease in Oor kattupaddu
- Increase in open political affiliation and consequent division among households
- Increase in migration

Give reasons:

b. Are there any members in the state-level \ District level farmers' association ? Yes \ No
If so, how many farmers?

c. Is there a system of exchange labour in the village ? Yes / no
d. If yes, extent
√ No. of households engaged in exchange of labour
√ In which season and for which operations
√ Is there a decline in this system in recent years?

e. Is there any hiring in \ hiring out of bullock pair for ploughing within the village
If yes , extent:

APPENDIX 2

Analysis of Interrelationship between Poverty, Private Property and Common Property Natural Resource Management in South India

(Research Project funded by the South Asian Network for Development and Environmental Economics, Nepal)

Principal investigator: R.Balasubramanian, Associate Professor
Department of Agricultural Economics
Tamil Nadu Agricultural University
Coimbatore – 641 003

Questionnaire for Household Survey

PART I (Production)

Code

1. General particulars

a) Name of the village:

b) Name of the block:

c) Name of the respondent:

2. Family particulars

S.No	Relation to head	Age	Sex	Educational status Mention exact std./class up to which the family member has studied	Occupation	
					Primary	Secondary

3. Land holdings

S.No.	Particulars (in acres)				Area in other ayacut areas	Remarks (State whether all the lands are located in the same village / different villages)
		Wet	Garden	Dry		
1	Owned					
2	Leased in					
3	Leased out					
4	Mortgage in					
5	Mortgage out					

4. Assets other than land

S.No	Asset	No.	Value at purchase / construction	Year of purchase / construction	Remarks
1.	Farm machinery & implements a) Tractor b) Power tiller c) Tractor drawn implements d) Pump-set e) Bullock cart f) Thresher g) Other implements				
2.	Farm buildings (Threshing floor/storage godown)				
3.	House Type : Thatched/tiled/RCC				
4.	Television (Colour / B&W)				
5.	Radio				
6.	Two wheelers (Mention type)				
7.	Others (Mention) a) b) c)				

5. Livestock

Sl. No	Particulars	No	Income from sale of milk / hire charges received from draught animals / income from poultry	Present value of animals
1.	Draught animals			
2.	**Milch animals** a.Desi-Cow b.Buffaloes c. Hi-bred cow			
3.	Calves and Heifers (Below 1 year)			
4.	Sheep and goat			
5.	Poultry			

6. Cropping pattern

S.No.	Crops	1998-99		1999-2000		2000-01		Remarks (Reasons for crop failure if any)
		Area(ac)	Yield	Area (ac)	Yield	Area (ac)	Yield	
1	Season I Crop1………. Crop2………. Crop3……….							
2	Season II Crop1………. Crop2………. Crop3………							
3	Season III Crop1………… Crop2………. Crop3……….							

7. Coping mechanisms

a) Particulars of salary income for the household

S.No.	Source of income	No. of persons employed	Income	Remarks
1	Government employees in the family			
2.	Private sector employees in the family			
3	Business			

b) Income from self-employment

Nature of self employment	No. of family members engaged	Duration of employment	Income / month	Income per year
a) Petty business				
b) Charcoal making				
c) Others (mention) i) ii) iii) iv)				

c) Employment pattern in and income from informal sector

S.No.	Particulars	On-Farm		Off-Farm		Non-Farm		Remarks
		Total days employed	Wage rate (Rs)	Total days employed	Wage rate (Rs)	Total days employed	Wage rate (Rs)	
1	Head of the family							
2	Other family members							
	a.							
	b.							
	c.							

d) Out - migration details

S.No	Type of Migration	Period of Migration (months)	Migrant				Remittance income received by family from the migrant
			Male	Female	Age	Wage rate	
1	Seasonal / temporary Place						
2	Permanent Place						

e) Other coping mechanisms

i) If none of the above coping mechanisms (business/non-agri. employment/migration) are followed, then how do you manage the failure of agriculture? Briefly explain.

ii) Do you resort to borrowing to meet consumption expenditure? Yes / No

8. Particulars of wells and water market

S.No	Particulars	Tank command		Non-tank command (garden land)	
		Well 1	Well 2	Well 1	Well 2
1	Year of digging				
2	Cost of digging				
3	Year of deepening				
4	Cost of deepening				
5	Type of well (open, open-cum-bore, bore)				
6	Present depth				
7	Type of lift (electric motor, diesel engine)				
8	Capacity (HP)				
9	Duration of pumping in hours per day a) Normal year b) Dry year				
10	Crops irrigated (acres) a) Normal year b) Dry year				
11	Water level in the well in feet a) Tank season b) Non-tank season				
12	Extent of conjunctive use (in months) in combination with tank a) Normal year b) Dry year				

9. Participation in tank maintenance activities

Nature of activity	Latest year (2000-2001)			Year before latest year (1999-2000)		
	No of days participated	Amount of money contributed	Reason for non-participation	No. of days participated	Amount of money contributed	Reason for non-participation
a) Cleaning & repairing the supply channel						
b) Diverting and bringing more water to your supply channel						
c) Lobbying with upstream farmers to bring more water to your tank						
d) Desilting the tank						
e) Removal of encroachment						
f) Cleaning field channel which brings water to your field						
g) Lobbying with PU / PWD for repairing the tank						
k) Others (Mention)						

10. What do you think are the reasons for the non-cooperation among villagers in tank maintenance?

a) Caste conflict
b) Backward agriculture
c) Uncertainty in tank-water supply
d) No financial resources in the village for tank maintenance activities
e) Non-participation by well-owners
f) People have resorted to non-agricultural employment / migration, so the villagers are not interested in tanks
g) Others (specify)

11. Crop-wise cost and returns from crop cultivated in the tank ayacut (2000-2001)

	Season …………… Crop ……………… Area ………………		Season …………… Crop ……………… Area ………………		Season …………… Crop ……………… Area ………………	
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
A Irrigation Particulars						
1) Frequency of irrigation						
2) Number of irrigations actually given to the crop						
3) Hours to irrigate the crop one time for the entire area						
4) Height of water-level in the field						
5) Who irrigated the field (Neerkatti / farmer himself)						
B. Cost Particulars						
1) Human labour used (man days)						
i) Nursery raising						
a) Family labour						
b) Hired labour						
ii) Preparatory tillage						
a) Family labour						
b) Hired labour						
iii) Weeding						
a) Family labour						
b) Hired labour						
iv) Harvesting						
a) Family labour						
b) Hired labour						
v) Transport						
a) Family labour						
b) Hired labour						
2) Bullock labour (bullock pair days)						
3) Machine hours						
4) Seeds / planting material						
5) Manure (cart loads)						
6) Fertilizer type (Kgs)						
a)						
b)						
c)						
d)						
e)						

	Season ……………… Crop ……………… Area ………………		Season ……………… Crop ……………… Area ………………		Season ……………… Crop ……………… Area ………………	
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
7) Plant protection chemicals						
a) Liquid (ml/litres)						
b) Dust (kg)						
8) Transport, packing, marketing costs						
9) Main product yield (mention the units of measurement)						
10) Price of main product						
11) By product (mention the units of measurement)						
A Irrigation Particulars						
1) Frequency of irrigation						
2) Number of irrigations actually given to the crop						
3) Hours to irrigate the crop one time for the entire area						
4) Height of water level						
5) Who irrigated the field (Neerkatti / farmer himself)						
B. Cost Particulars						
1) Human labour used (man days)						
i) Nursery raising						
a) Family labour						
b) Hired labour						
ii) Preparatory tillage						
a) Family labour						
b) Hired labour						
iii) Weeding						
a) Family labour						
b) Hired labour						
iv) Harvesting						
a) Family labour						
b) Hired labour						
v) Transport						
a) Family labour						
b) Hired labour						
1) Bullock labour (bp days)						
2) Machine hours						
3) Seeds / planting material						
4) Manure (cart loads)						

Contd.

	Season .... Crop .... Area		Season .... Crop .... Area		Season .... Crop .... Area	
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
5) Fertilizer type (Kgs) a) b) c) d) e) 7) Plant protection chemicals a) Liquid (ml/litres) b) Dust (kg) 8) Transport, packing, marketing costs 9) Main product yield (Kgs / qntls / tonnes / baskets) 10) Price of main product 11) By product (Kgs / qntls / tonnes/ baskets)						
A. IRRIGATION PARTICULARS 1) Frequency of irrigation 2) Number of irrigations actually given to the crop 3) Hours to irrigate the crop one time for the entire area 4) Height of water level 5) Who irrigated the field (Neerkatti / farmer himself) **B. COST PARTICULARS** 6) Human labour used (man days) i) Nursery raising a) Family labour b) Hired labour ii) Preparatory tillage a) Family labour b) Hired labour iii) Weeding a) Family labour b) Hired labour iv) Harvesting a) Family labour b) Hired labour						

Contd.

	Season …………… Crop ……………… Area ………………		Season …………… Crop ……………… Area ………………		Season …………… Crop ……………… Area ………………	
	Quantity	Value	Quantity	Value	Quantity	Value
v) Transport						
a) Family labour						
b) Hired labour						
7) Bullock labour (bp days)						
8) Machine hours						
9) Seeds / planting material						
10) Manure (cart loads)						
11) Fertilizer type (Kgs)						
a)						
b)						
c)						
d)						
e)						
12) Plant protection chemicals						
a) Liquid (ml/litres)						
b) Dust (kg)						
13) Transport, packing, marketing costs						
14) Main product yield (Kgs / qntls / tonnes / baskets)						
15) Price of main product						
16) By product (Kgs / qntls / tonnes/ baskets)						

Contd.

11 Contd... Crop-wise cost and returns from crop cultivated in the tank ayacut
(Use separate sheets for each crop)

	Season ……......... Crop ……………...... Area …………….....		Season …............. Crop …...………...... Area …...………...		Season …............. Crop ……………...... Area ………..…….	
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
A. Irrigation Particulars 1) Frequency of irrigation 2) Number of irrigations actually given to the crop 3 Hours to irrigate the crop one time for the entire area 4) Water level in the field 5) Who irrigated the field (Neerkatti / farmer himself)						
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
B. COST PARTICULARS 6) Human labour used (man days) i) Nursery raising a) Family labour b) Hired labour ii) Preparatory tillage a) Family labour b) Hired labour iii) Weeding a) Family labour b) Hired labour iv) Harvesting a) Family labour b) Hired labour v) Transport a) Family labour b) Hired labour 1) Bullock labour (bp days) 2) Machine hours 3) Seeds / planting material 4) Manure (cart loads) 5) Fertilizer type (Kgs) a) b) c) d) e)						

	Season		Season		Season	
	Crop		Crop		Crop	
	Area		Area		Area	
	Quantity	**Value**	**Quantity**	**Value**	**Quantity**	**Value**
12) Plant protection chemicals a) Liquid (ml/litres) b) Dust (kg) 13) Transport, packing, marketing costs 14) Main product yield (Kgs / qntls / tonnes / baskets) 15) Price of main product 16) By product (Kgs / qntls / tonnes/ baskets)						

12. A. Economics of crops on lands other than tank-irrigated land (1999-00)

Type of crop	Dry / wet / garden	Crop Economics								
		Season I			Season II			Season III		
		Acre	output	Net income	Acre	Output	Net income	Acre	Output	Net income
A) Seasonal										
1										
2										
3										
4										
B) Perennial										

B. Economics of crops on lands other than tank-irrigated land (2000-2001)

Type of crop	Dry / wet / garden	Crop Economics								
		Season I			Season II			Season III		
		Acre	output	Net income	Acre	Output	Net income	Acre	Output	Net income
A) Seasonal										
1										
2										
3										
4										
B) Perennial										

PART II (Consumption)

13. Quantity consumed of various food items (Three day recall method)

Food items	Quantity cooked yesterday	Quantity cooked today	Quantity to be cooked tomorrow	Farm produced/ purchased	If purchased, give price per kg	Approx. monthly consumption	Approx. monthly expenditure on the items
Rice							
Wheat							
Cholam							
Ragi							
Cumbu							
Red gram dhal							
Green gram dhal							
Black gram dhal							
Cowpea							
Vegetables							
Cooking oil used							
Egg							
Mutton							
Chicken							
Fish							
Pork							
Milk consumed							
Curd							
Tea							
Coffee							
Milk powder							
Sugar							
Horlicks							
Other baby food							
Other food items (Specify)							

13. Periodicity of consumption

Particulars	Male	Female	Children	Remarks
Total no. of meals / day				
a. Thrice				
b. Twice				
c. Once				

14. Other consumption expenditure

Expenditure items	Expenditure (Rs./month)	If the expenditure details are not available on monthly basis Expenditure (Rs./year)	Others
1.Education			
2.Health (Medical)			
3.Kerosene			
4.Cooking gas (LPG)			
5.Electricity			
6.Telephone			
7.Celebraiton of festival			
8.Entertainment (Cinema, Cable TV charges, etc.)			
9.Dressing			
10. Others (Specify) a) b) c) d) e)			

SANDEE Sponsors

BEIJER

The Beijer International Institute of Ecological Economics –
The Royal Swedish Academy of Sciences

IUCN
The World Conservation Union

DFID Department for International Development

FORD FOUNDATION

MACARTHUR
The John D. and Catherine T. MacArthur Foundation

Sida
Swedish International Development Cooperation Agency

the abdus salam international centre for theoretical physics

WORLD BANK INSTITUTE
Promoting knowledge and learning for a better world

SANDEE

South Asian Network for Development and Environmental Economics

SANDEE
P.O. Box 8975 EPC – 1056
Kathmandu, Nepal

Tel: 977-1-552 8761
Fax: 977-1-553 6789
E-mail: info@sandeeonline.org
Website: www.sandeeonline.org