

**COMPARATIVE ANALYSIS OF SELECTED TANK CHAINS IN
KARUMANIAR RIVER BASIN, TAMIL NADU**

THESIS SUBMITTED IN PART FULFILMENT OF THE REQUIREMENTS OF
MASTER OF SCIENCE (AGRICULTURE) IN AGRICULTURAL ECONOMICS
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1997.

CERTIFICATE

This is to certify that the thesis entitled “**COMPARATIVE ANALYSIS OF SELECTED TANK CHAINS IN KARUMANIAR RIVER BASIN, TAMIL NADU**” submitted in part fulfilment of the requirements for the degree of **MASTER OF SCIENCE (AGRICULTURE) IN AGRICULTURAL ECONOMICS** to the Tamil Nadu Agricultural University, Coimbatore is a record of *bona fide* research work carried out by **Mr. C.PRABHU** under my supervision and guidance and that no part of this thesis has been submitted for the award of any degree, diploma, fellowship or other similar titles or prizes and that the work has not been published in part or full in any scientific or popular journal or magazine.

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**DEDICATED TO
BELOVED PARENTS**

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(PRABHARAN. C)

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INTRODUCTION

CHAPTER I

INTRODUCTION

Water is the elixir of life which has a role to play in every aspect of life starting from our necessities to our luxuries. Indeed human existence is supported and sustained by water. It doesn't require any special intelligence to appreciate the fact that a country with a population of nearly 850 million growing at 2.2 per cent per annum and which threatens to double before it achieves zero growth rate) and which is plagued with seemingly intractable problems of poverty which has no future worthy of mention, unless it can make wise use of its water resources¹.

The irrigation potential in India has increased from 19.5 million hectares in 1947 to about 79 million hectares at the end of the seventh plan (1986-90) registering a 400 per cent increase during last five decades. Agriculture continues to be the dominant sector consuming 95 per cent of available water resources. Of the total precipitation, about 55 per cent can be utilised to

¹Anonymous, "77.5% of Surface Water Wasted Every Year". *Far and Near in Irrigation and Power*, 12(5): 89, Sep-Oct. 1987.

give an estimated (ultimate) irrigation potential of 115 million hectares against a cultivable area of 180 million hectares and a net sown area of 155 million hectares (by 2000 AD). The National Water Perspective Plan envisages stretching irrigation to 148 million hectares at most².

The investment in irrigation during eighth five year plan targets to Rs.32,525 crores as against Rs.456 crores during first plan, increasing the cumulative potential from 22.6 million hectares to 88 million hectares at the end of 1995³. Minor irrigation accounts for about 56 million hectares and includes tanks, tube wells, and dugwells with a command area of less than 2000 hectares. Tank irrigation, the only source of surface water in minor irrigation has been in India since time immemorial and account for one third of the total irrigated area in southern states of India.

²B.D.Dhawan, "The Case of Irrigation". *Monthly Commentary*, 29(9): 50-51 Mar-April, 1988.

³Ruddar Dutt and K.P.M.Sundharam, *Indian Economy*, (Chand and Company Pvt. ltd., New Delhi), Edition, 1996, 36: p.437.

Tank irrigation in Tamil Nadu

Andhra Pradesh and Tamil Nadu have larger area under tank irrigation where the net area irrigated by tanks is 22 per cent each⁴. Tank irrigation in Tamil Nadu was promoted both by the kings who ruled in the different regions of the state and by the local people to impound the runoff from the monsoon rains and regulate supply for agricultural purposes. British rulers also helped to stabilize tank irrigation prior to independence.

In Tamil Nadu, there are 39000 tanks of varying sizes and types. These tanks normally help irrigate one rice crop between September and December⁵. In contrast to canal and well irrigation, tank irrigated area has been dwindling both at all India and State levels⁶.

⁴P.T.Umashankar, Performance Analysis of Tank Irrigation Systems in Tamil Nadu. Unpublished M.Sc.(Ag.) Thesis, 1992. p.2.

⁵K.Palanisami, "Hydro-Economic Interaction Between Tank Storage and Groundwater Recharge". Ind. J. of Agri. Econ. Vol.46, No.2, April-June 1991.

⁶O.Timothy Randir, and S.Krishnamoorthy, "Optimal Crop Planning Under Production Risk in Tank Fed South Indian Farms". Ind. J. of Agri. Econ. Vol.48. No.4, Oct-Dec.1993, pp.678-685.

In Tamil Nadu, Tank irrigation covers 5.1 lakh hectares of net irrigated area and 6.2 lakh hectares of gross area accounting for 22 per cent of net area irrigated and 25 per cent of gross irrigated area. The storage capacities of the tanks are about 128 million cubic meters⁷, spread out in about 3.6 lakh hectares of water spread area. Each million cubic meter is assumed to irrigate about 85 hectares of rice in the command area⁸.

The Problem

During the five year plans, the government has focussed attention on major and medium surface irrigation projects and ground water development. The availability of favourable sites for reservoir construction and institutional finance accelerated the growth of major and medium projects. Energization, rural electrification and institutionalization of credit gave a boom to ground water development and tank irrigation has been considered as a neglected opportunity both by the government and the local community⁹.

⁷Total tank storage = Actual Storage Capacity x Number of Fillings in the Season.

⁸S.Ramachandran, "New Approach on Tank Irrigation". National Bank Review, 4(3): 24-27, May, 1988.

⁹P.T.Umashankar, Performance Analysis of Tank Irrigation Systems in Tamil Nadu, Unpublished M.Sc.(Ag.) Thesis, 1992,

Reduction in tank storage capacity, erratic and uncertain rainfall has reduced the tank water availability resulting in reduction of irrigation area, increased water stress and crop yield reductions. In several cases, farmers have started supplementing the inadequate tank water with ground water particularly at the later stage of the rice crop¹⁰.

In the mean while, expansion of major irrigation projects is subjected to cost escalation, availability of potential sites and environmental implications¹¹. Ground water exploitation has a limited future as in several places over exploitation had taken place and timely availability of electrical energy is also a problem. So continued progress in water resources development in the future will depend upon the utilization of the existing irrigation potential particularly in tanks where the performance of the tanks measured in terms of actual area irrigated to the target area has been about 65 per cent¹².

¹⁰K.Palanisami, and William K.Easter. "The Tanks of South India (A Potential for Future Expansions in Irrigation)". Economic Report No. ER. 83-4 University of Minnesota, St. Paul, Minnesoka, 1983.

¹¹K.S.Satyajit, "Evaluating Large Dams in India", Econ. and Pol. Weekly. 25(11): 12, March, 17, 1990.

¹²P.T.Umashankar, Performance Analysis of Tank Irrigation Systems in Tamil Nadu, Unpublished M.Sc.(Ag.) Thesis, 1992.

Currently, several international as well as national agencies are focussing their attention on the ways and means of improving the existing tank performance. The results of several studies on tank irrigation are being examined for large scale application. However, earlier studies in tank irrigation were conducted with individual tanks as the basis and not their occurrence in chains as the basis. Every tank in a chain depends on other tanks in the same chain and performance is a function of their location in the chain, i.e., whether in the upper or lower reach. So studies of individual tanks independent of their location in a chain, might be misleading. Hence, it is in order to study the performance of tank chain as a whole. This study is a modest attempt focusing on issues relating to tank chains and compares four chains in Karumaniyar basin in Tirunelveli and Chidambaranar districts. Various aspects of the chains such as hydrology, resource mobilisation and utilisation, water users organisation, cropping pattern and tank performance have been covered.

Hypotheses

The hypotheses forming the basis of this study are:

- (1) There is difference in hydrology of the tanks within the chain and between the chains which influence the water availability from the tank.

- (2) There is difference in pattern of resource mobilisation and utilisation in tank commands within and between the chains.
- (3) There is difference in the performance of the tanks within and between the chains.

Objectives

The objective is to compare the performance of tanks in the chain with respect to lower and upper reaches of chain. The specific objectives are :

- (1) to study the hydrology and tank water availability to the farm in the chains,
- (2) to study the pattern of resource mobilisation and utilisation, and
- (3) to analyse the performance of tanks in the chain.

Limitations of the study

This study is confined to four chains of the total 16 chains in the Karumaniyar basin. The field data were collected covering five years from 1991 to 1996. Further the study is confined to a single river basin and may not give a clear picture at the macro level. Thus, for policy at macro level, studies be conducted involving many other river basins to verify the results of this study.

Organization of the thesis

The thesis is organised in the following chapters :

- Chapter I - Introduction, objectives and limitations of the study are given.
- Chapter II - Review of the past work on the subject
- Chapter III - Methodology used and tools of analysis.
- Chapter IV - General description of study area.
- Chapter V - Presentation and discussion of Results of the study.
- Chapter VI - Summary of study results and conclusion.

CONCEPTS AND REVIEW

CHAPTER II

REVIEW OF LITERATURE

Review of the past work done is essential for formulating and understanding a research problem. This chapter briefly reviews the concepts and literature related to tank irrigation systems and their performance.

Irrigation tank is a small reservoir constructed across the slope of a gentle valley to catch and store runoff water. Generally the tanks have a maximum depth of not more than five meters, although some are as deep as eight to ten meters. Medium sized tanks have a capacity upto 50 million cubic meters with an average depth of 2.0 to 3.0 meters¹.

Von Oppen and Rao defined a tank as a small reservoir behind earthen dams².

¹K.Palanisami, and William K. Easter, "The Tanks of South India (a potential for future expansions in irrigation)". Economic report No. ER.83-4 University of Minnesota, St. Paul, Minnesota

²M.Von Oppen, and K.V.Subba Rao, "Tank Irrigation in Semi Arid Tropical India. Past and Present Performance - Future Development". ICRISAT Res. Bulletin, 1980.

Sharma defined tank as a small water reservoir created by throwing an embankment of earth across the flow of water³.

Sakthivadivel et al. defined a tank as small storage reservoir used to impound the runoff from the monsoon rains which occur during a few months of the year and to regulate the supply of water mainly for agricultural use⁴.

Sengupta defined tank as three sided reservoir with onside (the high side) open for run off water to enter which are retained for future use⁵.

Reddy defined a tank as a technology for the conservation and utilization of runoff water for percolation and irrigation purpose⁶.

³P.N.Sharma, "Optimization of small reservoir irrigation systems for semi-arid tropics", (Ph.D. Thesis Univ. of California at Davis), 1981. In: Somasekhara Reddy "Declining Ground Water levels in India", Int. J. of Water Resources Development. 5(3): 187, 1989.

⁴R.Sakthivadivel, "A pilot study of modernization of Tank Irrigation in Tamil Nadu", Paper Presented at Modernization of Tank Irrigation : Problems and issues. Centre for Water Resources, Anna University, Madras, 1982.

⁵Nirmal Sengupta, "Irrigation : Tradition Vs Modern". Econ. and Pol. Weekly. 20(45, 46, 47): 1920, Nov. 1985.

⁶Somashekara Reddy "Declining ground water levels in India", Int. J. Water Resource Development, 5(3): 187, 1989.

Factors associated with tank irrigation systems

Von Oppen and Rao have shown that enough funds are not allotted by public works department for repair and maintenance of tanks and the funds allotted amounted to one third of the one per cent of capital values⁷.

Jayabalan identified the major constraints in tank irrigation. They are inadequate maintenance of tanks, technically deficient sluices and surplus weirs, siltation of supply channels, tank beds and irrigation water courses, seepage losses in the delivery system etc. These inadequacies resulted in a permanent gap between the registered command area and the area actually irrigated by the tank⁸.

Wells in the command area of a tank may be an indicator of the performance of the tank irrigation systems. Earlier studies had concluded that more the tank is undependable, the greater is the number of wells in its command area⁹.

⁷M.Von Oppen, and K.V.Subba Rao, *Op.cit.*, p.4.

⁸B.A.Jayabalan, "Modernisation of Tank Irrigation in Tamil Nadu", Paper Presented at **Workshop on Modernisation of Tank Irrigation : Problems and Issues**, Centre for Water Resources, Anna University, Madras, 1982.

⁹K.Palanisami and William K.Easter, "Irrigation Tanks of South India", *Management Strategies and Investment Alternatives*", *Ind. J. of Agrl. Econ.*, 39(2): 214-223, 1984.

Sakthivadivel observed that water use efficiency in South Indian tanks has declined to as low as 25 to 35 per cent in many cases. The reasons for the low water use efficiency were inadequate maintenance, lack of control over water releases and excessive losses of water at the farm level. These inadequacies resulted in a permanent gap between the registered command area and the area actually irrigated by the tank¹⁰.

✓ Elumalai found that the presence of wells in the tank command area hinders the co-operation between the farmers in maintaining the system. Often conflicts arise between different villages benefited by single tank as well as between political, communal or social groups within a village. Problems like the inability of state irrigation engineers to control water releases, inadequate maintenance of supply channel and field to field irrigation were also identified¹¹.

¹⁰R.Sakthivadivel, "A Pilot Study on Modernization of Tank Irrigation in Tamil Nadu". **Modernization of Tank Irrigation : Problems and Issues** Centre for Water Resources, Anna University, Madras, 1982.

¹¹G.Elumalai, "Modernization of Tank Irrigation Systems - Farmers View", Paper presented at **Workshop on Modernization of Tank Irrigation Problems and Issues**. Centre for Water Resources, Anna University, Madras 1982.

✓ In almost, all tank irrigated areas, there are many socio-economic problems like unequal distribution of water resulting in frequent conflicts between head, middle and tailend farmers¹².

Chambers observed that in the absence of counter vailing custom, social sanction or physical force, the top enders satisfy their own needs before allowing water to flow down the channel to the farms below. However in certain villages priority was given to tail enders first¹³.

✓ The failure of tank system was probably due to result of inadequate system operation and maintenance practices, lack of commodity market and insufficient technical assistance¹⁴.

¹²"Fillip to integrated dryland development", **The Hindu**, dated 20-5-1996, p.12.

¹³Robert Chambers, "Men and Water : The organisation and operation", **In Green Revolution : Technology and Change in Rice Growing Areas of Tamil Nadu and Sri Lanka** (Boulder : West View Press Co., 1977), p.7.

¹⁴USAID, **Small Scale Irrigation (Tank irrigation)**, Project Paper (Thailand : United States Agency for International Development, 1980), p.2.

Resource mobilisation and utilisation

In 1981 Swedish International Development agency gave funds to the state Government to establish social forestry plantations in the foreshore area of tanks and tank bed. Main aim of the project is that the local community should get the entire benefit of the plantations¹⁵.

The resource obtained from the social forestry plantation was to be divided in the ratio of 60:40. 60 per cent for Village Panchayat and 40 per cent for Forest Department. Of the 60 per cent obtained by the Village Panchayat atleast 20 per cent should be used for regeneration planting¹⁶.

The resource obtained from the social forestry plantations of the Public Works Department tanks was Rs.12 per year per hectare of command area but the resource obtained from Panchayat Union tanks was Rs. four and thirty paise per year per hectare of command area¹⁷.

¹⁵K.Palanisami, R.Balasubramanian and A.Mohamed Ali, Final Draft Report (Tamil). "Ford Foundation Tank Project", Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, 1997,

¹⁶K.Palanisami, R.Balasubramanian and A.Mohamed Ali, Op.cit., p.45.

¹⁷K.Palanisami, R.Balasubramanian and A.Mohamed Ali, Op.cit., p.46.

Umashankar found that the tank bed plantations undertaken by social forestry Department though beneficial in various aspects, do not help in improving the tank performance¹⁸.

Pisciculture in tanks were based on the water availability in the tanks. In the earlier days, village community in the particular area enjoyed fishing rights in the tanks. But nowadays the government influence on this local resources has increased¹⁹.

Fishery resources obtained from the Public Works Department tanks is about Rs. two per hectare of command area per year, while the fishery resource obtained from Panchayat union tanks is about Rs. four and a half per hectare of command area per year²⁰.

¹⁸P.T.Umashankar, "Performance Analysis of Tank Irrigation Systems in Tamil Nadu". Unpublished M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 1992. p.77.

¹⁹K.Palanisami, R.Balasubramanian and A.Mohamed Ali, *Op.cit.*, p.46.

²⁰K.Palanisami, R.Balasubramanian and A.Mohamed Ali, *Op.cit.*, p.50.

Water users organisation

Palanisami and Easter opined that, where tanks have existed for long time, farmers have usually organised themselves to allocate water, but in many cases the results are still inefficient and inequitable. They also found that, where tanks are more recent as in North-East Thailand, farmer's organisational problems are sometimes more serious than physical problems. They observed the presence of water users organisation in some tanks being informal in most cases and they are an important factor in improving tank management and water distribution²¹.

^{sr} Jayaraman concluded that the irrigators are prepared to form an informal association at the outlet level, with minimum functions which include the maintenance of physical infrastructure below the outlet, solving disputes among farmers and the regulations of water distribution schedules²².

²¹K.Palanisami, and William K.Easter, "Tank Irrigation in India and Thailand : Problems and Prospects, "ODI Network Paper ID (Agricultural Administration Unit, overseas Development Institute, London, 1984). pp.1-12.

²²J.K.Jayaraman, "Irrigation's organisation for Better Water Management : A case study of Attitudes of Irrigators from Gujarat State, India, Agricultural Administration, 10(2): pp.189-212, 1982.

✓ Sundar and Rao stressed the need for farmers association for rotational distribution of water below outlet and also for onfarm development²³.

✓ The World Bank study in Periyar-Vaigai Irrigation project revealed that during periods of scarce water supply, rotation between branch channels and distributaries was followed²⁶.

²³A.Sunder and P.S.Rao, "Farmers organisation for efficient water use in irrigated agriculture", **WAMANA** 1(4): pp.1-13, 1981.24

²⁶World Bank, "India Periyar Vaigai : Irrigation Project (Tamil Nadu)", Report No.1519 9-1N (World Bank, Washington, D.C), 1977.

✓ Singh described about "Warabhandi" and explained that the water turn interval should be fixed taking into consideration the optimum irrigation intervals of the crop grown²⁷.

✓ Rajagopalan has stated that different approaches have grown out of need for effective group action of farmers in the tank command and they may be appropriate, with suitable modifications if needed, for improving tank irrigation in general. The group action also supports farmers' initiatives and creativity particularly in devising organizational solutions to basic irrigation roles like the water distribution, system maintenance, fund collection and conflict management²⁸.

✓ Palanisami has stated that the presence of farmers' group seems to be a strong predisposing factor for many a basic issues relating to improved system performance. The dependency on well water to supplement the insufficient

²⁷Mukthar Singh, "Irrigation and drainage systems and management" in **Proceedings of Symposium on Water Management**, (New Delhi : Indian Society of Agronomy, 1968), pp.197-202.

²⁸V.Rajagopalan, "Changing Roles of Rural Institutions for Management of Tank Irrigation Systems" in Anna University of Technology, **Workshop on Modernisation of Tank Irrigation : Problems and Issues** (Madras : Centre for Water Resources, Anna University of Technology, 1982). pp.1-19.

supplies from tanks implies the need for introduction of community wells in tank command area. Afforestation programmes can be implemented for discouraging the encroachment in the tank beds and this will give revenue after five to six years by auctioning the trees²⁹.

Doherty has made a cross cultural analysis of tank irrigation and revealed that for localised irrigation, system participation is more important than authoritarianism. He has mentioned about tanks which were built by colonizing group of households and water rights were shared along with land rights³⁰.

Performance of Tank Irrigation

Von oppen and Rao used actual area irrigated in their calculation of economic performance of tanks in semiarid tropical India³¹.

²⁹K.Palanisami, "Managing Tank Irrigation Systems : Basic Issues and Implications for Improvement", In Anna University of Technology, **Workshop on Modernisation of Tank Irrigation : Problems and Issues** (Madras : Centre for Water Resources, Anna University of Technology, 1982), p.7.

³⁰Victors Doherty, "A cross cultural analysis of tank irrigation", In Peraringar Anna University of Technology, **Workshop on Modernisation of Tank Irrigation : Problems and Issues** (Madras : Centre for Water Resources Peraringar Anna University of Technology, 1982), pp.1-52.

³¹M.Von Oppen, and K.V.Subba Rao, *Op.cit.*, p.9.

✓ Palanisami and Easter used ratio of actual area irrigated to the total command area as the measure of tank performance³².

Balraj et al., used comparative analysis between the irrigation requirements under the system and the actual utilization as per drawal details in the channel to compare the performance efficiency in the Thamirabarani river system³³.

✓ Ganapathisubramaniam estimated the overall system performance efficiency as the ratio of the actual irrigation quantity required to the total irrigated quantity³⁴.

Palanisami and Flinn developed a simulation model to evaluate the performance of tank irrigation under existing and alternate physical improvement (Sluice modification,

³²K.Palanisami, and William K.Easter, Op.cit., p.9.

³³Amelia Balraj, Ganesan,A. and Venkatraman,B. "Some case studies on the deficiencies and performance of the existing irrigation system", Paper presented at the Regional Seminar in Hydrological Problems Relating to Tanks held at Irrigation Management Institute, Taramani, Madras, Oct.1990.

³⁴G.Ganapathisubramaniam, S.Vasudevan and C.Sundararaman, "Performance efficiency in tank irrigation systems - A critical study" Paper presented at the Regional Seminar in Hydrological Problems Relating to Tanks held at Irrigation Management Problems Relating to Tanks Held at Irrigation Management Institute, Taramani, Madras, Oct. 1990.

sluice management canal lining and provision of additional wells). They used productivity ratio, equity ratio and financial measures to evaluate the system performance³⁵.

^{PK} Lenton formulated two systems of performance, viz., productivity and equity. He measured productivity by monitoring water delivery from tanks and with yield of crops (the ratio of farm yield under existing condition and farm yield with optimum irrigation and existing levels of input). Equity is measured as the variability of water delivery in head and tail reaches or variability on yields between individual farms located within the command³⁶.

³⁵K.Palanisami and J.C. Flinn, "Evaluating the Performance of Tank Irrigation System", *Agricultural Systems*, 28(3): 161-177, 1988.

³⁶Roberto L.Lenton, "A note on monitoring productivity and equity in irrigation systems" in Niranjana Pant ed., *Productivity and Equity in Irrigation Systems* (New Delhi : Asish Publishing House, 1984). pp.51-65.

DESIGN OF THE STUDY

CHAPTER III

DESIGN OF THE STUDY

In this chapter the ratiocination behind the choice of study area, sampling procedure, method of data collection, tools and methods of analysis are discussed in detail. Therefore, this chapter forms the prerequisite for any scientific and meaningful interpretation of field based research.

Selection of study area

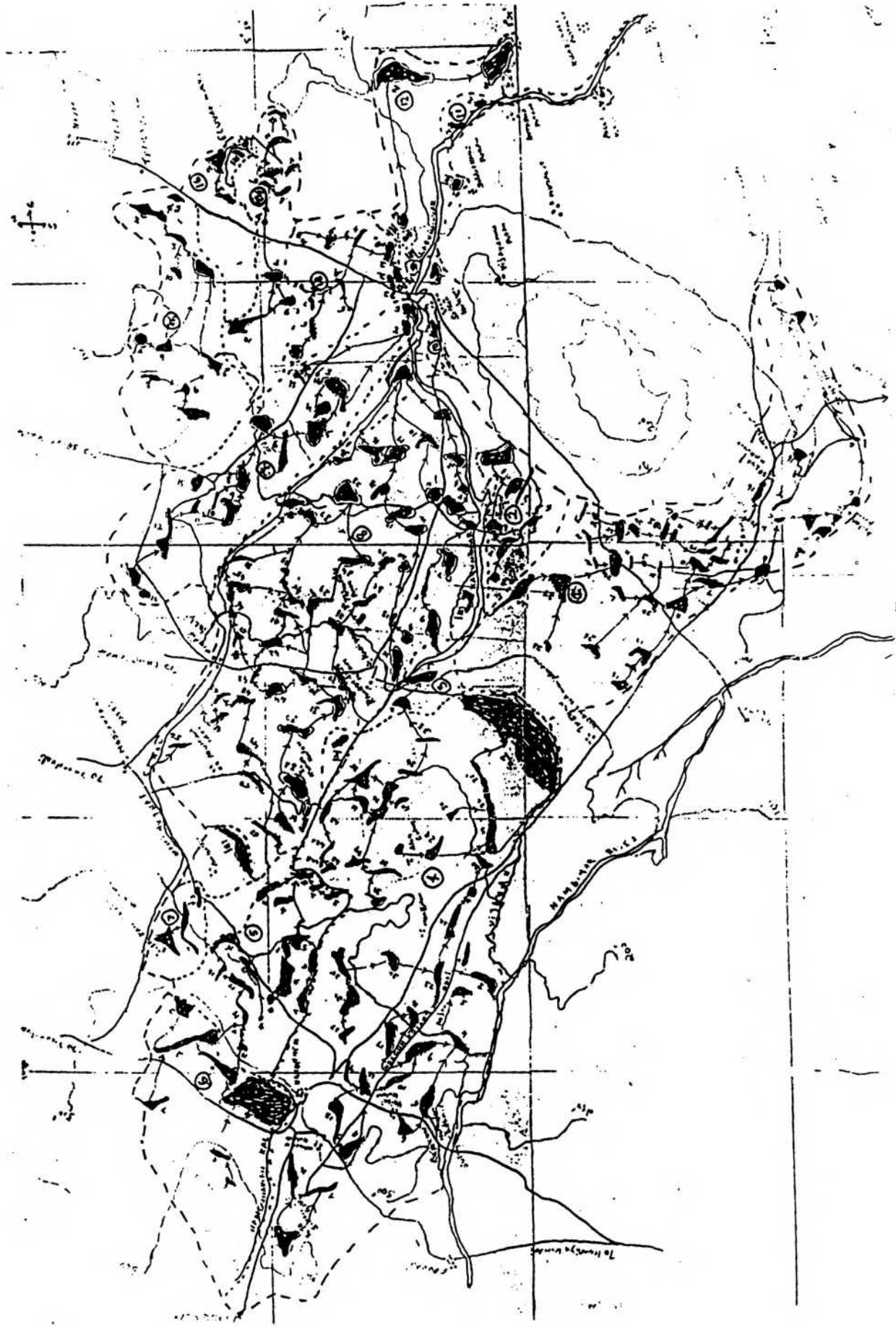
Tirunelveli-Kattabomman and Chidambaranar districts are predominantly tank irrigated districts with 43 per cent of gross irrigated area in both districts are irrigated by tanks. These districts are selected for this study. The tanks in these districts are age old and irrigation management in the tank bed areas are marred by limited availability of water from river systems and ill distributed rainfall. Furthur, these districts receive rainfall below the state average which necessitise the minor irrigation systems like tanks to be managed efficiently for wise water use.

Sampling Procedure

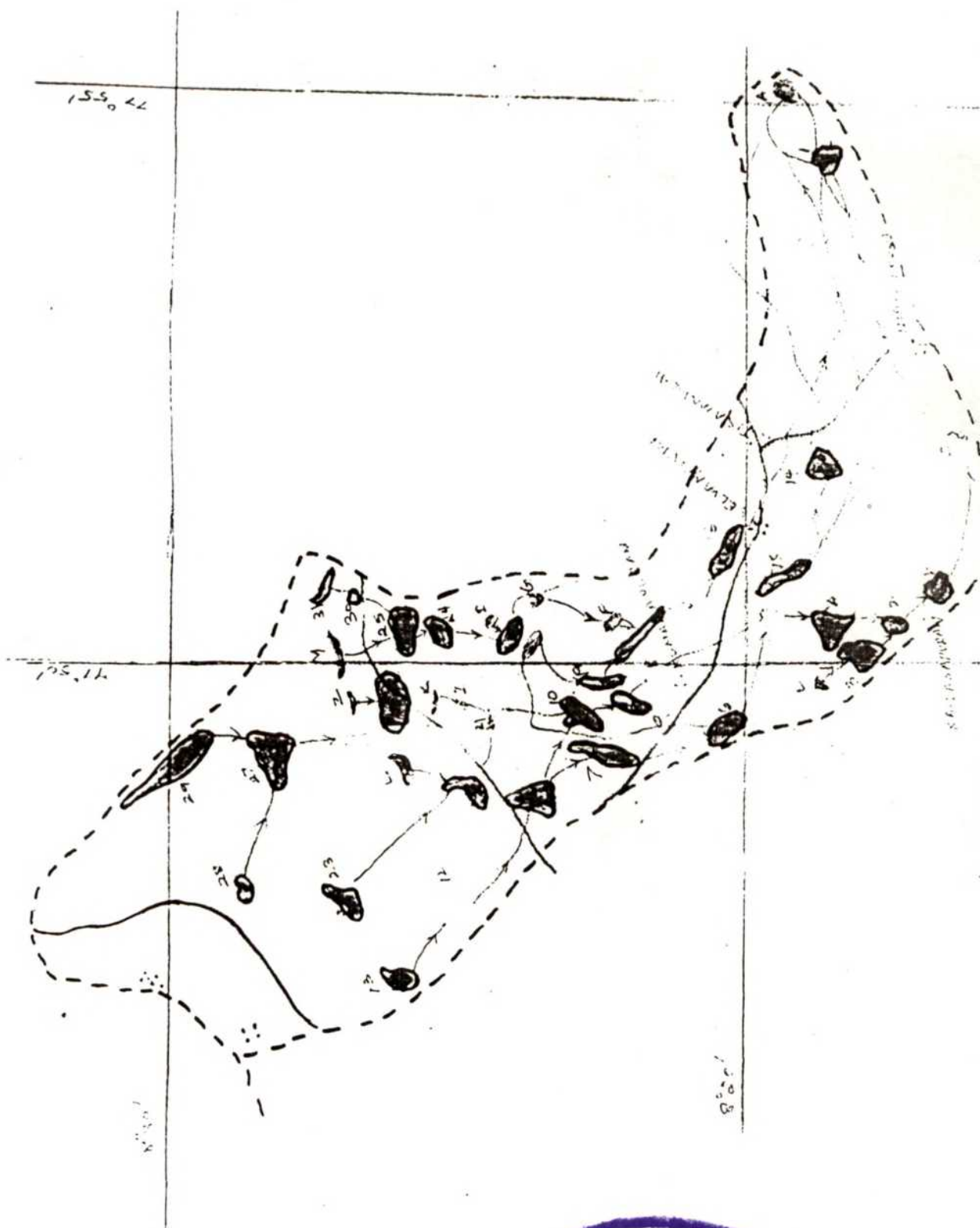
Earlier studies on tank irrigation systems considered made in individual tank and few attempts were made to study tank chains. The studies in individual tanks do not give an account of clear picture about factors related to tanks since each tank is dependent on other tanks in the chain. Because of the above said features, total Karumaniyar basin with its 256 tanks distributed in 16 chains was taken as universe for this study.

When the water level in Manimuthar dam reaches 25 meters, water is let out for Karumaniyar through Nangunarian Kal by its first, second, third and fourth reaches. The Nangunarian Kal is in the first and second reach and Karumaniyar river is in the third and fourth reaches. In order to include the locational aspects in the study, chains in all these reaches were considered and from these, four chains were selected at random.

Among the four chains, three were river fed and one was canal fed. The river fed chains selected were : (1) Udaiyar Kulam group, (2) Vavval Pettaikulam group and (3)



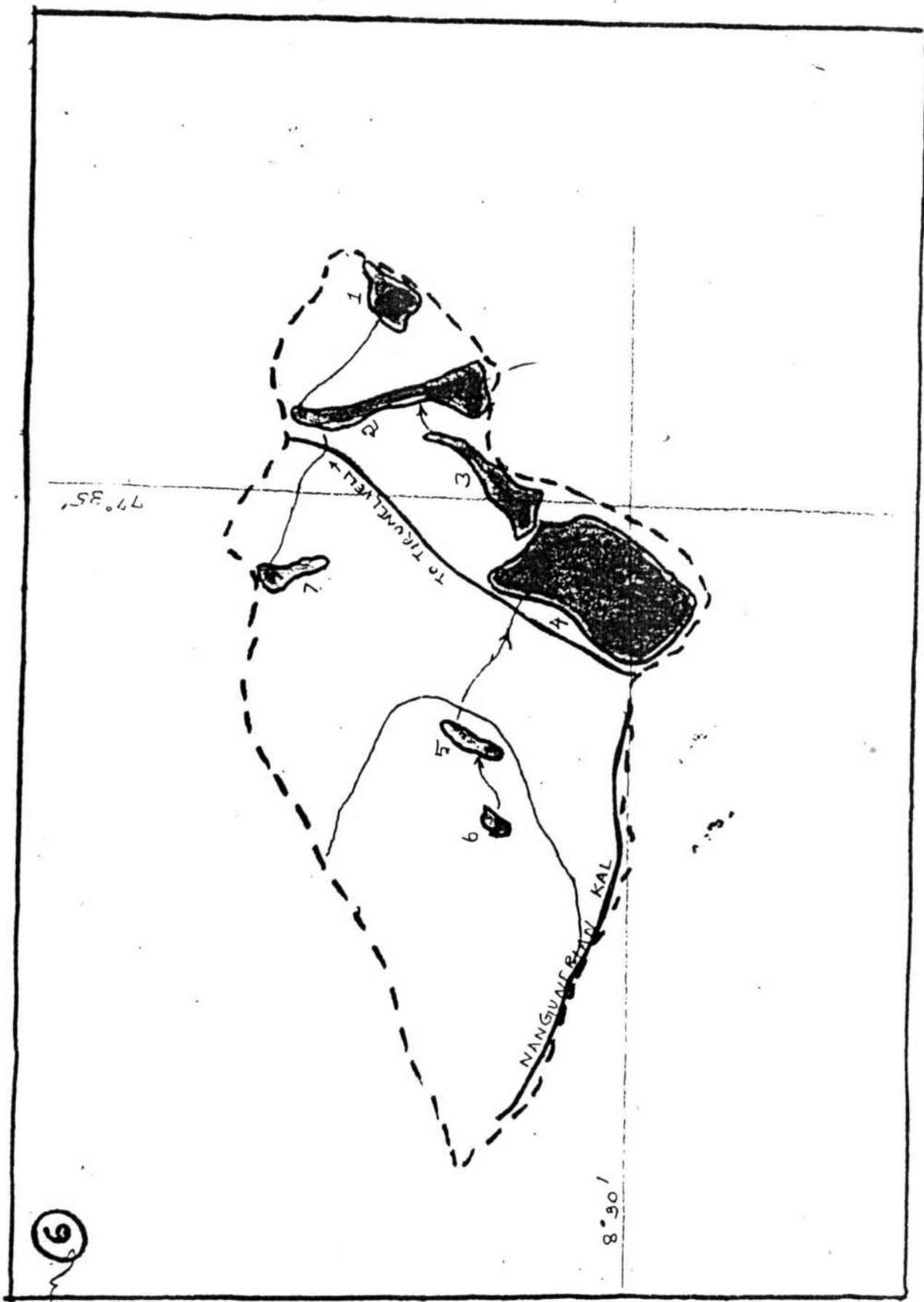
KARUMANIYAR RIVER BASIN MAP



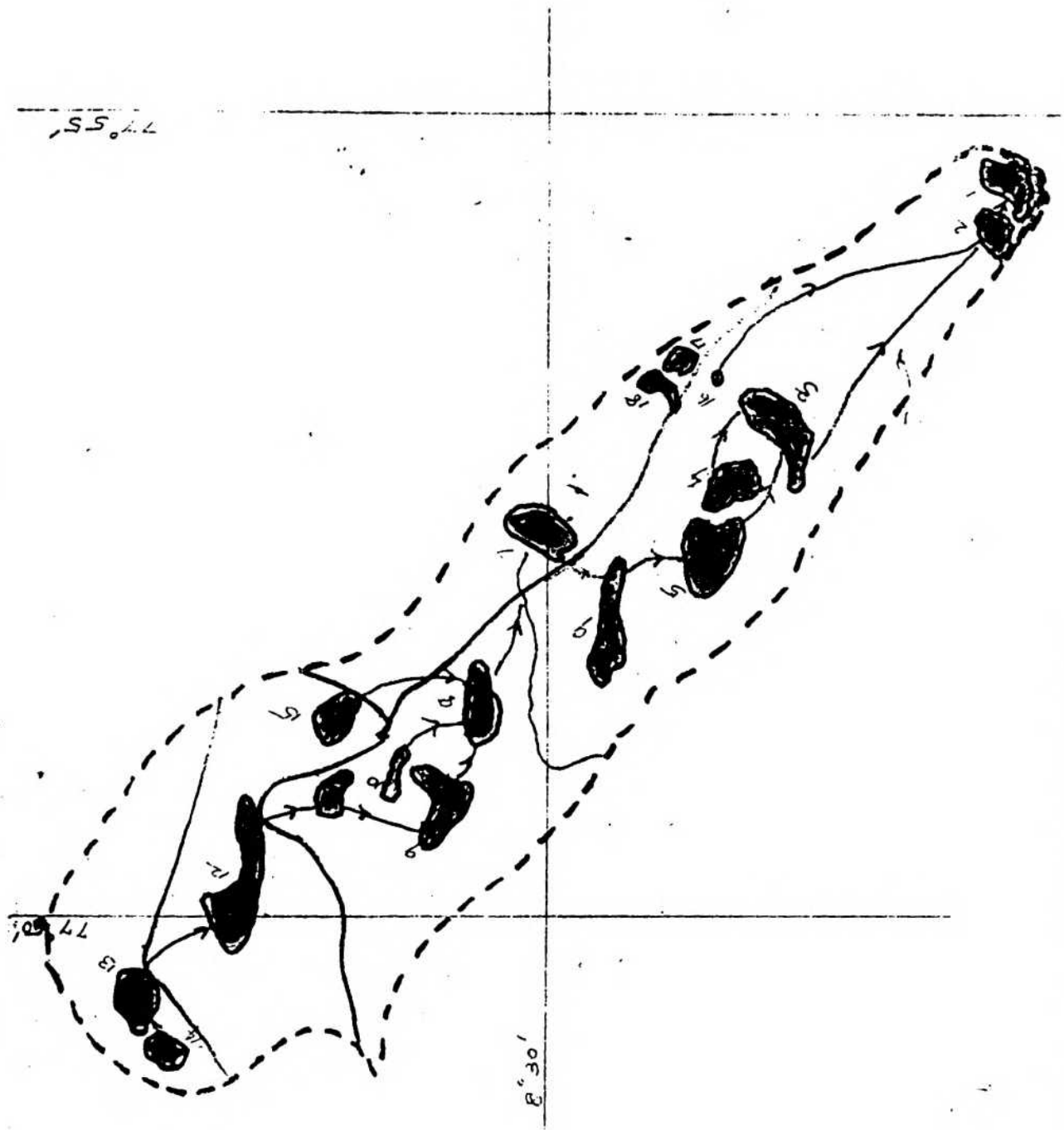
ILAKULAM GROUP MAP

(1)



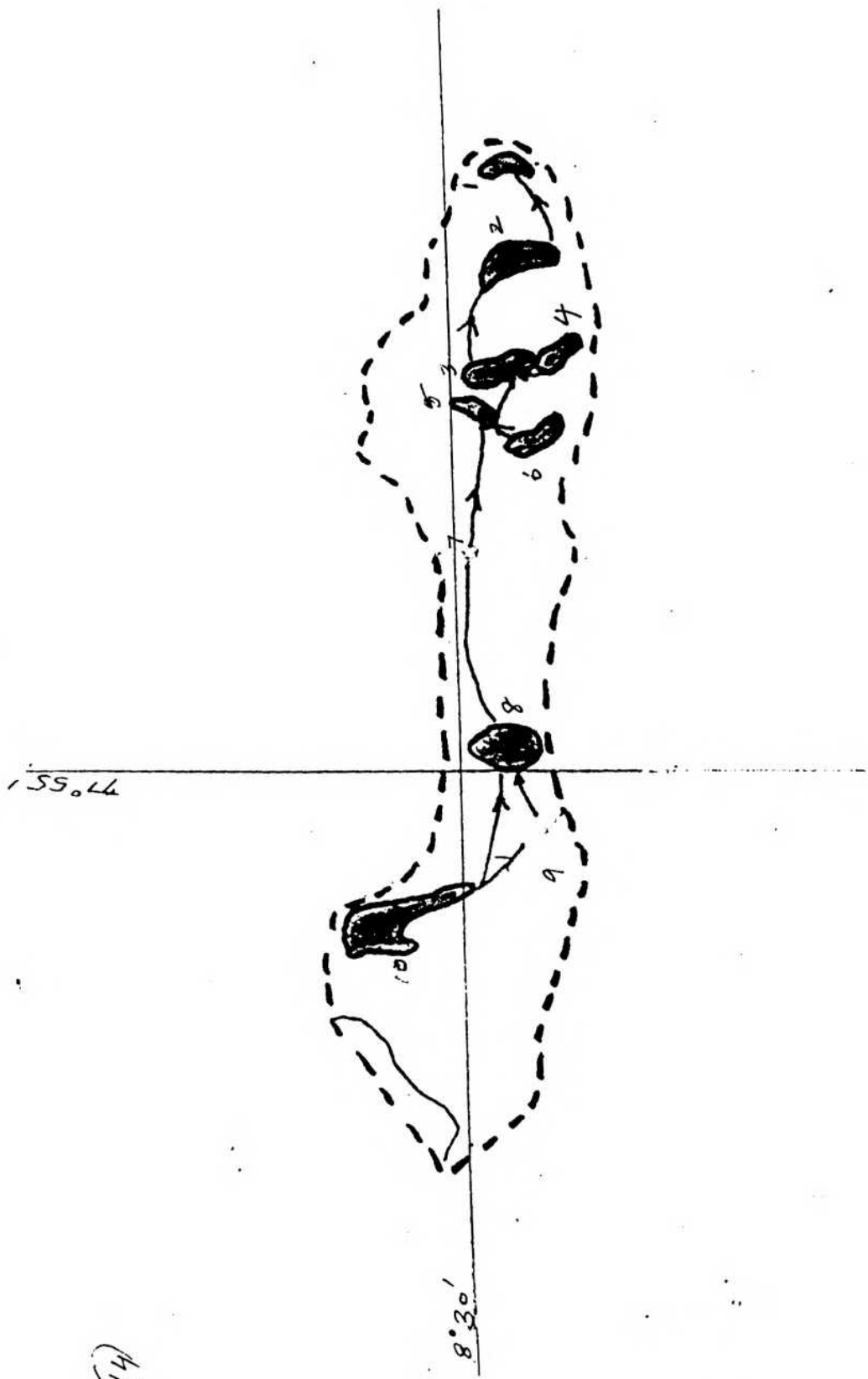


PILLAI KULAM GROUP MAP



UDAIYAR KULAM GROUP MAP

(2)



VAVVAL PETTAI KULAM MAP

Table 1. Name of chain and tank selected for study and its command area

Sl. No.	Name of chain	Name of tank	Command area
1	Ilakulam group Upper	Kada kulam	5.77
2		Pasuvai kulam	11.70
3		Erumai kulam	13.31
4		Tharuvai kulam	9.51
5		Boothaneri kulam	10.28
6		Kumarapuram kal kulam	4.94
7		Nalanthula kulam	13.04
8		Yerandai kulam	24.46
9		Sankanam kulam	16.41
10		Appuvilai kulam	5.04
11		Pillaiyar kulam	16.70
12		Sen kulam	5.44
13	Ilakulam group Lower	Mahadevan kulam	10.27
14		Suvisesha puram kal kulam	1.14
15		Urani kulam	17.44
16		Rajagopala puram kulam	12.11
17		Thiru ural neri kulam	16.01
18		Ayakaran kulam	21.44
19		Nainar kulam	21.44
20		Ilankaiyadi kulam	5.53
21		Vijaya achampadu kulam	4.01
22		Andan kulam	20.64
23		Nainaminden kodayan kulam	19.34
24		Urani kulam	4.70
25		Ayyanar kulam	8.24

Contd..

1	Pillai kulam Upper	Pillai kulam	22.97
2		Nedun kulam	15.86
3		Vilvarayan kulam	30.77
4		Nanguneri periakulam	663.90
5	Pillai kulam Lower	Suttiparai kulam	9.02
6		Rastha mela kulam	9.57
7		Nedun kulam	16.40
1	Vavval pettai kulam Upper	Ammachiar amman pettai kulam	30.74
2		Paramarthan kulam	6.77
3		Achampadu kulam	26.76
4		Therkku peria kulam	27.09
5		Alan kulam	2.18
6		Kattari mangalam periya kulam	47.74
7	Vavval pettai kulam Lower	Manikandapuram kulam	10.15
8		Vadaku vagai kulam	5.96
9		Keela pudukadu vetti kulam	6.56
1	Udaiyar kulam group Upper	Arumuganeri kulam	6.47
2		Chetti kulam	47.88
3		Narthan kurichikulam	6.31
4		Ilamal kulam	24.39
5		Karungadal	20.48
6		Pulian kulam	18.62
7	Udaiyar kulam group Lower	Therkku peikulam	27.06
8		Pettai kulam	5.13
9		Karungal peira kulam	12.31
10		Perumal kulam	17.88
11		Meerankulam keela kulam	18.61
12		Meerankulam mela kulam	10.08
13		Thirubarangaveri kulam	2.52
14		Nochi kulam	2.56

Ilakulam. The canal fed chain was represented by the Pillaikulam group. There were 31 tanks in Ilakulam group of which six were defunct, seven tanks in Pillaikulam group of which one was defunct, 18 tanks in Udaiyarkulam group of which four were defunct, and 10 tanks in Vavval Pettaikulam of which one tank was defunct. List of tanks is given in Table 1. All the needed particulars for the said tanks were collected.

Period of study

The field survey was conducted during November-December 1996. The data and information collected related to the agriculture year, 1991-92 to 1995-96.

Method of survey

All the data and information about the tanks were collected from Public Works Department records, village revenue records and forest department office records.

Similarly, the information for the study were collected from the farmer in person the pretested questionnaire. The purpose of study was explained to the farmers to seek their co-operation.

Data collection

The information technical features of the tank like hydrology, registered command area and number of defunct tanks were obtained from Public Works Department. Information about the tanks including the command area, full tank level, maximum water level, water spread area, number of fillings, sluice levels and surplus arrangements were also collected from the tank memoirs.

The number of wells in the tank command area, assessment, actual area of irrigation by each tank, cropping pattern in tank command area were collected from village administrative office.

The resource mobilisation from social forestry plantation was collected from social forestry department.

Farmers' survey had been conducted to collect data about fishery resources, resource utilisation, water users organisation, farmers participation in tank improvement and the problems faced by the tankfed farmers.

Methods and tools of analysis

The selected four chains were divided into lower and upper reaches based on the geographical location of the tank. This helped to compare the features of the tanks in terms of lower and upper reaches of the chain.

In order to bring uniformity in command area, the single and double crop area, were added to arrive at the actual command area. (Command area = Registered ayacut single crop + Registered ayacut double crop).

$$\text{Performance of tank} = \frac{\text{Average actual (irrigated) ayacut of tank}}{\text{Registered ayacut of tank}} \times 100$$

Adjusted tank performance analysis

It was observed in the field that well irrigation had a dent in several tanks. Recent studies also confirmed it. In order to remove the influence of wells in the command area on the performance of tanks, a adjusted performance was calculated. If the influence of the wells are not excluded then it will give a upward biased estimate of tank performance.

The number of wells in each chain was calculated. Then the number of wells above the chain average in each tank

command area was calculated. Based on the field data, area covered by each well was deduced. In Nanguneri block (1st and 2nd chain) each well has been irrigating about 0.5 ha and in Sathankulam block (3rd and 4th chain), each well has been irrigating about 0.4 ha. The number of wells below the chain average was multiplied by respective area it was irrigating, and this area was subtracted from actual irrigated area of the tank in order to isolate the pure effect of wells. Thus the influence of well, was removed from the tank. Adjusted tank performance was calculated by dividing the adjusted actual ayacut by the registered ayacut.

$$\text{Adjusted performance} = \frac{\text{Adjusted actual (irrigated) ayacut of tank}}{\text{Registered ayacut of tank}} \times 100$$

Regression Analysis

Multiple Linear regression was fitted with independent variables such as number of wells per hectare of command area, combined catchment area per hectare of command area, total yield per hectare of command area and number of fillings, dependent variable as performance of tank in order to find the degree of influence of the independent variable on dependent variable. The model used was.

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4$$

where

Y = Performance of tank

X₁ = Number of wells per hectare of command area
(well density).

X₂ = Combined catchment area per hectare of
command area.

X₃ = Total yield per hectare of command area

X₄ = Number of fillings

a = Constant

b₁, b₂, b₃, b₄ are the parameters to be estimated.

Since tank performance is expected to vary between chains, the model was run separately for all the chains.

(Identification of Different Water Users Organisation

Formal Water Users Organisations :

These are the water users organisation which have registered under societies act and having regularly elected office bearers.

Informal Water Users Organisations :

These are grouping of farmers under a village leader which is not registered and subtle at the village level.

Active Water Users Organisations :

These are those organisations which are actively participating the tank management activities such as collection of money, attending the repairs etc., through the year.

Inactive Water Users Organisations :

Those organisations which are not participating the tank related activities though they are formal or informal.

DESCRIPTION OF THE STUDY AREA

CHAPTER IV

DESCRIPTION OF THE STUDY AREA

This chapter describes the area selected for the study, viz., Tirunelveli Kattabomman and Chidambaranar districts. Though the tanks in Karumaniyar river basin with its 16 chains had extended over both the districts, the four chains selected for this study are found mainly in the Nanguneri taluk of Tirunelveli Kattabomman district and Sathankulam taluk of Chidambaranar district. This chapter throws light on the agro-climatic factors like soil, topography rainfall etc. and the other details like land use pattern, cropping pattern and sources of irrigation of both the districts.

Area

The total geographical area of Tirunelveli Kattabomman district is 682308 hectares. There are 9 taluks in Tirunelveli Kattabomman district namely (1) Tirunelveli (2) Palayamkottai (3) Tenkasi (4) Shenkottai (5) Nanguneri (6) Radhapuram (7) Sivagiri (8) Ambasamudrum (9) Sankarankoil. Tirunelveli Kattabomman district is divided into 27 blocks.

The total geographical area of Chidambaranar district is 459054 hectares. There are 7 taluks in Chidambaranar district namely (1) Srivaikuntam (2) Tuticorin (3) Tiruchendur (4) Sathankulam (5) Ottapidaram (6) Vilathikulam (7) Kovilpatti. There are 12 blocks in Chidambaranar district.

Soil

Tirunelveli district is having both red and black soil with predominance of red soil in majority of the taluks. Black soil is found in Sankaran Koil taluk and in certain pockets of Nanguneri and Radhapuram taluks. Alluvial soil is found predominantly in Ambasamudrum taluk and along the Thamirabarani river course.

Chidambaranar district is having both red and black soil in equal proportion. Red soil is found in Sathankulam, Tiruchendur, Tuticorin taluks and in certain pockets of Srivaikuntam taluk. Black soil is found in Ottapidaram, Vilathikulam and Kovilpatti taluks. Alluvial soil is found in the Srivaikuntam and Tiruchendur taluks along the Thamirabarani river course. Theri soil is found in small pocket of Tiruchendur taluk.

Table 2. Monthwise distribution of Rainfall in Tirunelveli district in (mm)

Sl.No	Month	1987	1988	1989	1990	1991	1992	1993	1994	Average
1	January	7.86	--	5.05	85.92	52.21	2.27	--	33.63	23.37
2	February	1.13	7.42	--	4.99	14.77	--	5.10	77.90	13.91
3	March	18.32	61.03	47.49	15.80	51.71	--	17.30	44.80	32.05
4	April	23.02	83.97	38.90	15.11	21.84	58.44	30.49	117.56	49.66
5	May	25.68	5.90	20.88	11.74	20.76	78.63	19.24	14.74	24.69
6	June	7.11	25.64	34.23	6.61	116.95	54.39	16.69	27.19	36.10
7	July	0.55	23.98	81.11	3.83	154.22	27.63	18.28	60.67	46.25
8	August	14.96	17.52	12.91	5.83	3.46	21.05	18.92	30.84	15.06
9	September	50.04	16.62	18.87	3.72	16.04	62.02	21.54	31.64	27.06
10	October	209.01	58.58	79.98	198.92	182.15	124.6	122.33	212.01	139.69
11	November	65.08	163.17	126.61	157.04	354.01	345.2	392.24	231.38	129.34
12	December	140.64	34.21	42.16	65.94	20.7	442.14	139.75	13.55	112.37

Source : Office of the Assistant Director of Statistics - Tirunelveli.

Table 3. Monthwise distribution of Rainfall in Chidambarnar district in (mm)

Sl.No.	Month	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	Average
1	January	--	--	2.72	138.93	37.72	15.99	0.50	--	34.39	21.54	25.17
2	February	--	14.68	26.05	--	3.05	--	4.63	--	16.93	9.47	7.47
3	March	--	76.48	41.26	--	24.12	--	--	--	55.57	--	19.75
4	April	--	97.13	5.11	--	10.96	15.54	10.16	--	59.86	75.27	27.37
5	May	27.89	--	6.59	--	10.00	52.40	0.91	--	58.03	17.57	12.13
6	June	8.69	3.00	12.09	--	33.61	2.38	4.16	--	13.64	16.87	9.44
7	July	--	16.09	5.08	--	11.70	7.9	0.16	--	4.25	7.25	4.33
8	August	3.2	39.83	44.84	3.5	2.54	7.65	6.5	--	19.06	26.4	15.35
9	September	49.10	23.57	199.28	14.63	55.51	59.15	3.57	34.05	29.9	2.4	33.16
10	October	265.2	80.68	173.48	--	239.90	96.02	--	213.25	34.50	--	110.30
11	November	132.31	125.20	43.11	--	143.07	315.56	--	162.98	100.62	--	102.17
12	December	71.08	56.45	138.62	--	13.34	96.07	--	0.25	2.41	--	37.5
												404.43

Source : Office of the Assistant Director of Statistics - Tuticorin.

Climate and Rainfall

Both Tirunelveli Kattabomman and Chidambaranar districts are dry districts with ill distributed rainfall. Both the districts are benefited by South-west as well as North east monsoon rain. The monthwise distribution of rainfall for Tirunelveli and Chidambaranar district is given in Table 2 and Table 3 respectively. It could be observed from the tables that both districts got their maximum rainfall in the months of October, November and December which is the Northeast monsoon season. Further it could be observed from the tables, that annual average rainfall for Tirunelveli district from 1987 to 1994 was 748.55 mm and for Chidambaranar district it was 404.43 mm. The annual average rainfall for both the districts was below the state annual average. Since the rainfall was ill distributed, both the districts remain dry in major part of the year.

Land use pattern

The total geographical area of Tirunelveli district is 682308 hectares of which only 25.24 per cent of the land is put into agricultural use and rest of the area is covered by forest, fallow land, pastures etc. The land utilisation pattern of Tirunelveli district is given in Table 4.

Table 4. Land use pattern (1993-94) : Tirunelveli district

Sl.No.	Particulars	Area in ha	Percentage
1	Forests	122055	17.88
2	Barren and uncultivable land	27191	3.98
3	Land put to non-agricultural use	99086	14.52
4	Cultivable waste	72197	10.58
5	Permanent pastures and other grazing lands	9807	1.43
6	Land under miscellaneous tree crops and groves not included in net area sown	9284	1.36
7	Current fallow	18582	2.72
8	Other fallow	151845	22.25
9	Net area sown	172261	25.24
10	Total geographical area	682308	100.00

Source : Office of the Assistant Director of Statistics,
Tirunelveli

Table 5. Land use pattern (1994-95) : Chidambarnar district

Sl.No.	Particulars	Area in ha	Percentage
1	Forests	11002	2.39
2	Barren and uncultivable land	19669	4.28
3	Land put to non-agricultural use	70685	15.39
4	Cultivable waste	19174	4.17
5	Permanent pastures and other grazing lands	5001	1.08
6	Land under miscellaneous tree crops and groves not included in net area sown	36088	7.86
7	Current fallow	75930	16.54
8	Other fallow	42787	9.32
9	Net area sown	178718	38.93
10	Total geographical area	459054	100.00

Source : Office of the Assistant Director of Statistics,
Tuticorin

The total geographical area of Chidambaranar district is 459054 hectares of which nearly 38.93 per cent of land is put to agricultural use and rest of the area is covered by forest, fallow land, pastures etc. The land utilisation pattern of Chidambaranar district is given in Table 5.

Area under various crops

The major crops grown in Tirunelveli districts are generally paddy, cholam, pulses, cotton and fruit crops like banana, in addition to it cumbu, maize, ragi, spices and senna are also grown. But major area is occupied by paddy, banana and cotton. Area under different crops in Tirunelveli district is given in Table 6.

It could be seen from the table that paddy crop occupied more than 55 per cent of the net area sown. Pulses, oilseeds and cotton are the other major crops accounting for 41.92 per cent.

Major crops in Chidambaranar district include Paddy, pulses, cotton, oilseeds, chillies and there are certain pockets in which betelvine and senna are grown. Area under various crop in Chidambaranar district are given in Table 7.

Table 6. Area under various crops in Tirunelveli district (1995-96)

Crops	Area in ha	Percentage
Paddy	79504	55.89
Cholam	2428	1.70
Cumbu	1903	1.33
Maize	1392	0.97
Ragi	810	0.56
Pulses	19084	13.41
Spices	5636	3.96
Fruits	12151	8.54
Vegetables	3207	2.25
Cotton	18668	13.12
Edible oil seeds	21894	15.39
Non-edible oil seeds	98	0.06
Senna	212	0.14
Fodder	3830	2.69
Green manure	64	0.04
Miscellaneous crops	628	0.44
Net area sown	171509	100.00

Source : Office of the Assistant Director of Statistics, Tirunelveli

Table 7. Area under various crops in Chidambaranar district (1995-96)

Crops	Area in ha	Percentage
Paddy	22635	12.66
Cholam	7254	4.05
Cumbu	19036	10.65
Maize	1266	0.007
Ragi	513	0.002
Other millets	577	0.002
Pulses	27116	15.17
Chillies	18602	10.40
Coriander	9116	5.10
Tamarind	314	0.001
Palm tree	4863	2.72
Banana	9468	5.29
Mango	225	0.001
Cuava	340	0.001
Vegetables	3205	1.79
Cotton	24833	13.89
Oil seeds	12057	6.74
Senna	1452	0.008
Petel leaf	185	0.001
Fodder	17227	9.63
Net area sown	178718	100.00

Source : Office of the Assistant Director of Statistics,
Tuticorin

Table 8. Sources of irrigation and area irrigated in 1994-95
in Tirunelveli Kattabomman district

Source of irrigation	Gross irrigated area (ha)	Net irrigated area (ha)	% of Gross irrigated area (ha)	% of net irrigated area (ha)
Canal	30724	17804	18.34	14.30
Tanks	73316	57580	43.77	44.04
Wells	56105	47401	33.50	36.25
Wells supplementing other sources of irrigation	7323	7043	4.37	5.38
Total	167468	129828	100.00	100.00

Source : Office of the Assitant Director of Statisitics,
Tirunelveli.

Table 9. Sources and area irrigated by different irrigation
sources in 1994-95 in Chidambaranar district

Source of irrigation	Gross irrigated area (ha)	Net irrigated area (ha)	% of Gross irrigated area (ha)	% of net irrigated area (ha)
Canals	6708	4346	13.60	10.58
Tanks	21611	16471	43.81	40.12
Wells	21001	20221	42.57	49.28
Others	3	3	0.0006	0.0009
Total	49323	41041	100.00	100.00

Source : Office of the Assitant Director of Statisitics,
Tuticorin

It could be seen from the table that paddy occupied just 12 per cent of the net sown area. Pulses occupied nearly 15 per cent, cotton 13 per cent and chillies 10 per cent. Because of little rain and lack of proper irrigation facilities area under paddy is highly fluctuating over years.

Irrigation

The main sources of irrigation in Tirunelveli Kattabomman district is tanks. The other source of irrigation are canals and wells. The gross and net area irrigated by these different sources are given in Table 8.

It could be seen from the table that 43 per cent of gross irrigated area and 44 per cent of net irrigated area were irrigated by tanks during 1994-95. Next came the wells which irrigated nearly 33 per cent of gross irrigated area and 36 per cent of net irrigated area during 94-95. Canal is another important source of irrigation in Tirunelveli Kattabomman district.

The main sources of irrigation in Chidambaranar district are canals, tanks and wells. The gross and net area irrigated by different sources are given in Table 9.

It could be seen from the table that tanks irrigated nearly 43 per cent of gross irrigated area and 40 per cent of net irrigated area during 1994-95. Wells irrigate nearly 42 per cent of gross irrigated area and 49 per cent of net irrigated area. Canal irrigation accounted for about 10 per cent of the total irrigated area.

RESULTS AND DISCUSSION

CHAPTER V

RESULTS AND DISCUSSION

The collected data were analysed and the results are given in the chapter and discussed.

Comparison of Hydrology of the Tank Chains

Full tank level per hectare of command area

Comparison of one of the major hydrological factors viz., full tank level per hectare of command area had indicated that the full tank level per hectare of command area was comparatively higher for the upper tanks than the lower tanks in the chains except for the first chain for which full tank level per hectare of command area was

Table 10. Comparison of full tank level (meters)

Chains	No. of tanks		Average full tank level		t value (intra chain)
	Upper	Lower	Upper	Lower	
Chain 1	13	12	2.57	4.24	1.012 ^{NS}
Chain 2	4	3	11.84	5.82	0.160 ^{NS}
Chain 3	6	8	3.12	2.32	0.714 ^{NS}
Chain 4	6	3	3.28	2.25	0.908 ^{NS}

NS Non Significant

FTL expressed as height above the benchmark

4.25 meters for lower tanks and 2.57 meters for the upper tanks. However, the difference between the upper and lower reaches was not significant as indicated by the 't' value. Between the chains, except for the second chain all the other chains were having uniform full tank level per hectare of command area (Table 10).

Maximum Water Level per hectare of Command Area

Comparison of average maximum water level per hectare of command area is given in Table 11.

Table 11. Comparison of maximum water level (meters)

Chains	Average maximum water level		t value (intra chain)
	Upper	Lower	
Chain 1	2.60	4.23	1.020 ^{NS}
Chain 2	11.89	5.85	0.159 ^{NS}
Chain 3	3.15	2.39	1.191 ^{NS}
Chain 4	3.31	2.32	0.583 ^{NS}

NS Non Significant

MWL expressed as height above the benchmark

It could be inferred from the table that tanks in the upper part of the chains are having more average maximum water level per hectare of command area than that of lower chains except for the first chain in which average maximum



water level per hectare of command area for the upper tanks is 2.61 meters and that of lower tanks is 4.23 meters and the t values show that mean variation between the lower and upper tanks in the chain is non-significant for all the chains. Between the chains, except for the chain 2 which is having higher average maximum water level per hectare of command area of 11.89 and 5.85 meters in the upper and lower reaches of chain respectively, all the other 3 chains have more or less uniform average maximum water level per hectare of command area.

Full tank level Vs Maximum water level

Maximum water level per hectare of command area is following the trend of full tank level per hectare of command area for all the four chains. Chain 2 is having higher full tank level and maximum water level compared to all the other 3 chains and this is because this chain is located in the first reach of Manimuthar dam which is fed through Nangunerian kal and there is assured supply of water for this chain. Other 3 chains are found in the 3rd and 4th reaches and probability of getting more water is comparatively lesser.

In both the cases of full tank level (FTL) and maximum water level (MWL), chains 2, 3, 4 are following the same trend where the upper reaches of chain were having comparatively higher F.T.L and M.W.L per hectare of command area whereas chain 1 was having higher F.T.L and M.W.L per hectare of command area at its lower reach and this might be due to the fact that this chain is found in black soil and all the other 3 chains are found in red soil.

Comparison of average catchment area

It could be observed that average intercepted catchment area per hectare of command area was comparatively higher for the lower reaches for all the four chains (Table 12). However the t values showed that these intra chain variations are insignificant in all the four chains.

The average area of free catchment per hectare of command area also followed the line of intercepted catchment area and was comparatively higher for the lower reaches of chain than the upper reaches for all the four chains and the t values showed that intra chain variation ~~however~~ is insignificant for all the four chains.

Table 12. Comparison of average catchment area per command area
(in square kilometer/hectare of command area)

Chains	Average intercepted catchment area		Average area of free basin		Average Combined catchment area							
	Upper	Lower	Upper	Lower	Upper	Lower						
Chain 1	0.26	2.93	0.87	NS	0.18	0.20	0.28	NS	0.45	3.13	0.80	NS
Chain 2	0.01	0.41	0.97	NS	0.14	0.48	0.35	NS	0.15	0.89	0.81	NS
Chain 3	0.29	0.72	---		0.09	0.18	1.01	NS	0.38	0.91	0.79	NS
Chain 4	0.14	0.33	2.11	NS	0.11	0.16	1.23	NS	0.26	0.50	1.33	NS

NS - Non significant

The average combined catchment area per hectare of command area also showed the same trend where the tanks in the lower reaches of chain were comparatively higher combined catchment area than that of upper reaches. Here also the t value showed that intra chain variation is non-significant.

The reason attributed for comparatively higher values of intercepted catchment area, free basin area and combined catchment area per hectare of command area for the tanks in the lower reaches of chain is that the tanks in the upper reaches of chain were having more number of supply channels than that of lower reaches and water supply is mainly through the supply channels. But the tanks in lower reaches didn't have the supply channels as its main source and it necessarily should have more catchment area than the tanks in the upper reaches. However there was inter chain variation in the catchment area per hectare of command area in all the four chains. This is due to the fact that there is difference in the water harvesting capacity of the catchment area in all the four chains since it depends upon the reach in Manimuthar dam in which the chain is located as well as the rain fall of the catchment area.

Tanks in the upper reaches of the chain were having comparatively higher number of fillings than that of the lower reaches of chain but the t value show that the intra chain variation interms of average number of fillings is non significant (Table 13).

Table 13. Comparison of average number of fillings (Numbers)

Chains	Average number of fillings		t value (intra chain)
	Upper	Lower	
Chain 1	2.48	1.49	1.151 ^{NS}
Chain 2	2.00	1.44	1.109 ^{NS}
Chain 3	1.53	1.44	0.791 ^{NS}
Chain 4	1.25	1.05	1.1889 ^{NS}

NS Non Significant

The tanks in the lower reaches of the chain for all the four chains didn't show any variation but the tanks in the upper reaches of chain 1 and 2 did show variation with that of the chains 3 and 4 and this is because the upper reaches of chains 1 and 2 are having more number of supply channels and chain 2 is in the first reach of the

Manimuthar dam which is having more dependable water supply. Tanks in the upper reaches of chains 3 and 4 were having comparatively lesser number of fillings. Tanks in the lower reaches of all the four chains showed more or less uniform number of fillings since they depended mostly on the catchment area for water supply. It could be seen that combined catchment area per hectare of command area of the tanks in lower reaches of chain 1 is higher than the other 3 chains which are uniform (Table 12). From this it could be understood that water harvesting capacity of the catchment area of tanks in the lower reaches of chain 1 was comparatively lower. This chain 1 was the only chain in the black soil area, which has poor permeability due to poor porosity.

It could be observed from the Table 14 that tanks in the lower reaches of the chain were having comparatively higher average total yield per hectare of command area but the t values showed that intra chain variation is non significant. However there is inter chain variation in both upper and lower reaches of the chain for all the four chains. Chain 1 in the black soil region was having comparatively higher average total yield per hectare of command area in both upper and lower reach when compared with the other 3 chains found in the red soil region.

Table 14. Comparison of total yield of water

(million cubic meter/hectare)			
Chains	Total yield		t value (intra chain)
	Upper	Lower	
Chain 1	0.02	0.05	1.199 ^{NS}
Chain 2	0.01	0.16	0.078 ^{NS}
Chain 3	0.01	0.01	1.498 ^{NS}
Chain 4	0.01	0.03	0.944 ^{NS}

NS Non Significant

It could be observed from the Table 15 that average number of supply channels per hectare of command area was higher for the tanks in the upper reaches of the chain in all

Table 15. Comparison of average number of supply channels

(Numbers)		
Chains	Average number of supply channels	
	Upper	Lower
Chain 1	0.75	0.15
Chain 2	0.50	0.20
Chain 3	0.12	0.00
Chain 4	1.00	0.33

the four chains and it could be inferred that all the tanks in the upper reaches of the chain were fed mainly by the supply channels than the tanks in the lower reaches of the chains which had lower number of supply channels. Further, even in the upper and lower reaches, there were few tanks with no supply channels.

It could be observed from the Table 16 that average number of upper tanks (i.e. number of tanks above each tank) were comparatively higher for the tanks in the lower reaches of the chain for all the four chains and it could indicate that tanks in the lower reaches of the chain are fed mainly by the upper tanks than the supply channels.

Table 16. Comparison of average number of upper tanks above each tank

Chains	(Numbers)	
	Average number of upper tanks above each tank	
	Upper	Lower
Chain 1	1.6667	1.4615
Chain 2	0.5000	1.2000
Chain 3	1.7500	2.8333
Chain 4	0.0000	4.3333

Table 17. Comparison of water users organisation

Type of water users organisation	(Per cent)							
	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Formal	00.00	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Informal	50.00	92.30	50.00	80.00	100.0	66.60	33.30	83.30
Active	33.30	76.90	00.00	80.00	100.0	66.60	00.00	83.30
Nonactive	16.70	15.30	00.00	00.00	00.00	00.00	33.30	00.00

Comparison of Water Users Organisation

Earlier studies have clearly indicated that the presence of water users organisation could highly enhance the farmers participation in tank management. So it has become necessary to study the water users organisations in the study area. Comparison of water users organisations that are present and active in the study area is given in the Table 17.

It could be observed from the table that as such there is no formal water users organisation in the study area. Informal water users organisation have been widely prevalent even though some tanks didn't have informal organisation. The average level of presence of informal water users organisation had ranged from 33 to 100 per cent. This indicates that water users organisation was present in as low as 33 percent in upper reach of chain 4 to 100 per cent in upper reach of chain 3.

It could be observed from the table that presence of informal water users organisation was more prevalent in the lower reaches of the chains than the upper reaches except for chain 3 in which tanks in upper reach was having 100 per cent informal water users organisation.

The informal water users organisations were mostly associated with other crop growers association like banana growers association, betel vine growers association or cotton growers association.

Further it is found that water users organisation was more active in lower reaches of the chain except for a single chain in which water users organisation was active in all the tanks in the upper reach also. It is found that water users organisation was active at the time of water scarcity, as they strongly influence officials of Public Works Department mainly to get adequate supplies.

It could be further observed from the table that non-active form of water users organisation was comparatively more in upper reaches of the chain which strengthens the argument that when the probability of getting water is more water users organisation is not active.

Wells in the tank command area

Wells that are present in the tank command area had a significant influence on the tank performance. Earlier studies had concluded that more the tank is undependable, the greater is the number of wells in its command¹ so

it becomes necessary to study the wells in the tank command area. Average number of dug wells, bore wells and dug cum bore wells present in the tank command area is given in the Table 18.

Table 18. Average number of wells in the tank command area

Type of well	(Number/tank)							
	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Dugwells	5.3	4.8	4.0	8.6	3.1	2.1	7.0	5.3
Borewells	2.3	1.2	1.5	5.0	1.0	0.3	1.3	2.8
Dugcum Borewells	0.6	0.1	1.0	1.8	0.2	0.0	0.0	1.0
Total	8.3	6.2	6.5	15.4	4.3	2.4	8.3	9.1

It could be observed from the table that average number of dug wells, bore wells and dug cum bore wells is comparatively higher in the upper reaches of the chain 1 and 3 compared to chains 2 and 4, where lower reaches have more wells.

¹K.Palanisami and William K.Easter, "Irrigation Tanks of South India : Management Strategies and Investment Alternatives". Ind. J. of Agrl. Econ. 39(2): 214-223, 1984.

Table 19. Comparison of factors related to wells

Factors	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Average cost of digging wells (Rs./ well)	33333.33	33846.15	45000.00	39000.00	36250.00	28333.33	53333.33	25000.00
Average cost of water (Rs./hr)	29.17	28.46	30.00	30.00	26.25	20.83	45.00	22.50
Average depth of wells (meters)	13.00	11.53	13.33	12.33	12.50	10.00	20.00	10.00

The difference between the average number of wells between lower and upper reaches of chain 2 is significantly higher than the difference between the average number of wells between the upper and lower reaches of other chains.

Analysis of well density showed that number of wells per hectare of command area (well density) was higher in the tanks in the upper reaches of the chains 1,3 and 4. But in chain two well density was higher in the lower reach of the chain.

When compared with the number of wells per tank, in chain 4 number of wells per tank is higher in the lower reach of the chain but well density was higher in the upper reach of the chain.

Average cost of digging was comparatively lower in the lower reaches of the chain for all the chains except chain 1, where average cost of digging was more or less equal in the lower and upper reaches of the chain. The average cost of water per hour was comparatively lower in the lower reaches of the chain. Further it could be observed that average depth of wells was also comparatively lower in the

lower reaches of the chain which supported the argument that cost of water per hour was lower in the lower reaches since there is a direct relationship between cost of water and depth of wells.

Table 20. Comparison of average number of times tank failed in the last five year

Chains	Average number of times tanks failed in last five year	
	Upper	Lower
Chain 1	0	0
Chain 2	0	0.4
Chain 3	2.0	2.0
Chain 4	2.0	2.0

From the Table 20 it could be observed that all the tanks in the chains 3 and 4 in both upper and lower reaches failed 2 times in the last five years. Also 0.4 times the tanks in the lower reach of chain 2 has failed. This indicates that in terms of water availability chains 1 and 2 are comparatively better and these two chains are found in Nanguneri block. Chains 3 and 4 are found in Sathankulam taluk.

Table 21. Comparison of soil type

Chains	Soil type	
	Upper	Lower
Chain 1	1.0	1.0
Chain 2	2.0	2.0
Chain 3	2.0	2.0
Chain 4	2.0	2.0

1 = Black soil, 2 = Red soil

It could be observed from the Table 21 that chain 1 with its both upper and lower reaches were in black soil region and chains 2, 3 and 4 with its both upper and lower reaches were in red soil region.

Cropping pattern in tank irrigated crops

Average area under various crops in the tank irrigated area of the selected chains for the year 1991-92 are given in the Table 22. From the table it could be observed that I season paddy occupied major area, as this season starts in October and ends in February which coincides with the north-east monsoon. More than 70 per cent of the

Table 22. Comparison of Average Area Under Various Crops in the year 1991 - 1992

Crop	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Iseason								
Paddy	2.1250 (72.85)	3.8846 (73.61)	2.0000 (72.72)	20.1000 (44.66)	6.5500 (71.78)	5.2333 (59.92)	2.6667 (100.00)	5.9167 (78.83)
Banana	0.5833 (19.99)	1.2000 (22.74)	0.7500 (27.27)	24.9000 (55.33)	1.1375 (12.46)	3.0833 (35.30)	0.0000	1.5833 (21.11)
Others	0.1250 (4.28)	0.0385 (0.72)	0.0000	0.0000	1.4375 (15.75)	0.0000	0.0000	0.0000
IIseason								
Paddy	0.0833 (2.85)	0.1538 (2.90)	0.0000	0.0000	0.0000	0.4167 (4.77)	0.0000	0.0000
Others	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total area	2.9166	5.2769	2.7500	45.0000	9.1250	8.7333	2.6667	7.5000

(Figures in parantheses indicate percentage of area to the total area)

area in the upper and lower reaches of chain 1 were under I season paddy crop. In all the other 3 chains area under I season paddy crop was higher in the upper reaches of the chain than the lower reaches. This clearly indicates that tanks in the upper reaches of chain had higher probability of getting adequate tank water for the I season paddy.

Next major crop is banana. Dry banana is grown in all these tanks under rainfed conditions. It could be observed from the table that area under dry banana was more in the lower reaches of the chain for all the four chains than the upper. Hence, when probability of getting water is low, people used to go for dry banana.

The other crops grown in the I season included mostly cotton and it was grown in certain pockets only, that too only in the upper reaches of the chains. The II season paddy crop was also grown only in certain pockets and percentage of area under second season paddy was far lower than the first season crop.

Comparison of average area under various crops in the year 1992-93 is given in Table 23. The I season paddy crop had occupied major area. ~~Except~~ for the first chain, the percentage of area

Table 23. Comparison of Average Area Under Various Crops in the Year 1992- 1993

Crop	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
(ha/tank)								
Iseason								
Paddy	2.0833 (71.42)	4.2308 (76.32)	1.7500 (70.00)	17.2000 (40.95)	6.0375 (69.49)	5.7667 (60.38)	2.3333 (100.00)	5.8333 (65.72)
Banana	0.4583 (15.71)	1.0769 (19.42)	0.7500 (30.00)	24.8000 (59.04)	1.0250 (11.74)	3.4500 (36.12)	0.0000	3.0333 (34.21)
Others	0.2917 (10.00)	0.1538 (2.77)	0.0000	0.0000	1.6250 (18.64)	0.0000	0.0000	0.0000
IIseason								
Paddy	0.0833 (2.85)	0.0769 (1.38)	0.0000	0.0000	0.0000	0.3333 (3.49)	0.0000	0.0000
Others	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total area	2.9166	5.5429	2.5000	42.0000	8.6875	9.5497	2.3333	8.8333

(Figures in parantheses indicate percentage of area to the total area)

under I season paddy crop was higher in the upper reaches of the chain than that of the lower reaches. Next to paddy crop dry banana was the major crop and percentage of area under banana crop was higher in the lower reaches of the chain than that of the upper reaches of the chain for all the four chains.

Here also other crops in the I season included mainly cotton and it was grown only in certain pockets. The area under second season paddy crop (mostly semi dry paddy) was very small and it was grown in certain pockets and there was no other crop in the second season.

Comparison of average area under various crops in the year 1993-94 is given in Table 24. It could be observed from the table that the tanks in the chains 3 and 4 had completely failed in the year 1993-94. These two chains are found in 3rd and 4th reach of the Manimuthar dam. In the area irrigated by other two chains, first season paddy occupied major area, for the chain 1 percentage of paddy area irrigated by lower reaches of chain was higher than that of upper reaches of chain.

The other major crop was dry banana. It could be noted that percentage of banana area irrigated by lower

Table 24. Comparison of Average Area Under Various Crops in the Year 1993 - 1994

Crop	. (ha/tank)							
	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Iseason								
Paddy	1.8750 (69.23)	3.6923 (72.18)	1.7500 (77.77)	17.7000 (40.97)	0.0000	0.0000	0.0000	0.0000
Banana	0.4583 (16.92)	1.1538 (22.55)	0.5000 (22.22)	25.5000 (59.02)	0.0000	0.0000	0.0000	0.0000
Others	0.2500 (9.23)	0.1923 (3.75)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
IIseason								
Paddy	0.0833 (3.07)	0.0769 (1.50)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Others	0.0417 (1.53)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total area	2.7083	5.1153	2.2500	43.2000	0.0000	0.0000	0.0000	0.0000

(Figures in parantheses indicate percentage of area to the total area)

reaches of chain was higher than that of upper reaches of the chain. Major crop which comes under other crops category was cotton and it was grown in certain pockets only. The second paddy crop occupied only small percentage of area and this was also semi dry paddy type.

Comparison of average area under various crops in the year 1994-95 is given in Table 25. It could be observed from the table that, chains 3 and 4 had failed for the second consecutive year. I season paddy crops had occupied major area irrigated in the chains 1 and 2. Here also percentage of I season paddy area irrigated by lower reaches of chain 1 was higher than that of upper reaches of chain. On the contrary percentage of I season paddy area irrigated in chain 2 was higher in the upper reaches of the chain.

Dry banana was the next major crop. In the chain 1 the percentage of banana area was higher in the upper reaches of the chain which was in contrary to the existing pattern over the past 3 years. In the chain 2 the percentage of banana area was higher. In the lower reach in the case of other crops cotton was the major crop. Second season paddy was grown only in small pockets.

Table 25. Comparison of Average Area Under Various Crops in the year 1994 - 1995

Crop	(ha/tank)							
	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Iseason								
Paddy	1.4750 (56.75)	3.1538 (84.53)	1.5000 (100.00)	14.6000 (39.84)	0.0000	0.0000	0.0000	0.0000
Banana	0.7917 (30.44)	0.4615 (12.37)	0.0000	22.0400 (60.15)	0.0000	0.0000	0.0000	0.0000
Others	0.2917 (11.21)	0.0385 (1.03)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
IIseason								
Paddy	0.0417 (1.60)	0.0769 (2.06)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Others	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total area	2.6001	3.7307	1.5000	36.6400	0.0000	0.0000	0.0000	0.0000

(Figures in parantheses indicate percentage of area to the total area)

Comparison of average area under various crops in the year 1995-96 is given in Table 26. It could be observed from the table that I season paddy was occupying major area in the tank irrigated areas. The percentage of I season paddy area was higher in the lower reaches of the chain and it was in line with the existing trend. The percentage of area under I season paddy crop following the already existing trend where upper reach of the chains were having more percentage of area than the lower reach.

As far as the first season paddy crop area is concerned, the chains 3 and 4 were showing exactly opposite trend when compared to the existing pattern. Here the percentage of area was higher in the lower reaches of chains for both the chains. Percentage of area under other crops such as cotton and chillies in the I season had significantly increased in the upper reaches of both the chains.

Dry banana was another major crop grown. Trend in percentage of area under banana crop was completely erratic and it is contrary to the existing trend for the chains 1 and 3. In all these chains the percentage of area under banana crop was higher in the upper reaches of the chains. The



Table 26. Comparison of Average Area Under Various Crops in the year 1995 - 1996

Crop	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Iseason								
Paddy	2.2917 (64.70)	3.0077 (75.77)	3.7500 (100.00)	20.8000 (44.01)	3.5625 (63.10)	4.4167 (67.94)	1.0000 (38.70)	4.0000 (73.84)
Banana	0.9583 (27.05)	0.9231 (23.25)	0.0000	26.4600 (55.98)	0.5000 (8.85)	1.5833 (24.35)	0.1667 (6.45)	1.4167 (26.15)
Others	0.2083 (5.88)	0.0385 (0.96)	0.0000	0.0000	1.5833 (28.04)	0.5000 (7.69)	1.4167 (54.83)	0.0000
IIseason								
Paddy	0.0833 (2.35)	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Others	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Total area	3.5416	3.9693	3.7500	47.2600	5.6458	6.5000	2.5834	5.4161

(Figures in parantheses indicate percentage of area to the total area)

percentage of area under second season paddy crop was very small that too it is found only in the upper reaches of chains.

In summary, the I season paddy crop had occupied more area in the tank ranging from 40 to 100 per cent. In the chain 1 which is found in the black soil area, the lower reaches devoted higher percentage of area under I season paddy crop than that of upper reaches. In all the other 3 chains which are found in the red soil area, the upper reaches of chain was having higher area under I season paddy crop than that of the lower reaches of chain though this trend was not seen in the last year.

Dry banana was the next major crop in all the tank irrigated area and the general trend found was that lower reaches of chain were having higher percentage of area under banana cultivation than that of the upper reaches for all the four chains irrespective of the soil type with the exception of 1994-95. The reason for this change could not be found out since one year data is found to be inadequate.

Cotton was the major crop which comes under other crop category and it was grown only in certain pockets which were found mainly in the upper reaches of the chain. The percentage of area under cotton crop had increased significantly in the last year in the upper reaches of the chains 3 and 4 which was found in Sathankulam taluk of Chidambaranar district.

The second season paddy which is a semi dry paddy was grown in certain pockets of upper and lower reaches of chain 1, but the area under second season paddy crop was very small.

Resource Mobilisation

Forestry Resources

Comparison of average forestry resources obtained per hectare of command area in the last five year by the forest department is given in the Table 27.

The social forestry division of forest department plants babul trees (Acacia nilotica) in the tank beds. The babul trees take nearly 10 years to attain the cutting stage.

Table 27. Average Forestry resources obtained in the
last five years

(Rs/ha/5 year)		
Chain	Upper chain	Lower chain
Chain 1	2949.91	2753.11
Chain 2	0000	382.67
Chain 3	1384	946.29
Chain 4	0000	354.72

Source : District Forest Officer, Department of Forestry,
Tirunelveli and Tiruchendur.

When it reaches the cutting stage the social Forestry Department auctions the trees by open auction system. Those who wants to take auction should become a contractor. With the government by paying Rs.1050 towards the Forest Department, Government of Tamil Nadu. Now they get the power of attorney to be a party in the auction. Notifications relating to the auction which contains the list of tank plantations, area of the plantation and procedure of auction will be sent to all the contractors. The auction will be carried out in the presence of District Forest Officer.

The mean value of the sale proceeds per hectare of command area for the last five years is given in Table 27. Sales proceed obtain from the tanks in the upper reaches of the chain was higher than that of the lower reaches. No sale proceeds had been obtained from the tanks in the upper reaches of chain 2 and 4 in the last five years. Though there are plantations in these tanks they have not attained the cutting stage.

The average sale proceeds from the chain 1 in the upper and lower reaches were higher than that of the average sale proceeds obtained from other 3 chains. Hence, black soil might be suited well for this plantation since chain 1 is found in the black soil region.

Problems associated with social forestry plantation

The major problem with this plantation is that it raises the bed level of the tanks and resulting in lesser storage capacity. Further the local community was not allowed to collect fuel wood so people lost interest in maintaining these plantations.

Fishery Resources

Pisiculture in the tanks is an ancient practice in Tamil Nadu. This used to meet out the fish requirement of local community. Now Fish Farmers Development Agency (FFDA) is looking into the aspect of Pisiculture in the tanks. For FFDA to operate in a particular tank, the tank should have water for atleast ten months in a year. Further FFDA will give training for 15 days for those who are interested in Pisiculture from the local community.

After training, they supply the trained people with fingerlings from the fishery department. Every month, officials visit the tanks and give technical advice to the fish growers. Since no tank in the selected study area was having water for 10 months and since Sathankulam and Nanguneri taluk are declared as drought affected blocks in 1983 itself, FFDA is not operating in any of the study tanks.

The local community itself takes care of the fishing activities in the tanks. The fishing right in the village community is having a traditional base and its origin is not clearly known. In every village there are one or two families who are owning the fishing right. They have to pay certain royalty to the village common fund. This amount varies from tank to tank. But this practice is not followed

varies from tank to tank. But this practice is not followed strictly now a days due to social conflicts and frequent droughts. The average value of fishery resources obtained per hectare of command area in the last five years by the farming community given in Table 28.

Table 28. Comparison of average fishery resource mobilised in the last five years by the farming community

Chains	(Rs/ha/5 years)	
	Upper	Lower
Chain 1	377.32	1022.45
Chain 2	1748.34	3649.52
Chain 3	213.91	94.42
Chain 4	9.85	102.90

Source : Field data

It could be observed from the table that the average fishery resources per hectare of command area obtained by the local community was higher in the lower reaches of the chain than that of the upper reaches except for a single chain. In terms of fishery resources, the chain 2 is performing well when compared to other 3 chains. Chain 2 is found in the first reach of the Manimuthar dam. It is the

only chain which is having the irrigation status III while all other chains are having the irrigation status IV. This implies that as the irrigation level of the tanks in the chain increases the fishery resources obtained from that tank could also increase.

Farmers participation in tank management

Farmers participation in tank management is an important aspect in resource mobilisation, as farmers participation reflects directly on the tank performance. It could be observed from the Table 29 that farmers were involving themselves in cleaning the supply channels in the last 5 years which ranged from 0.33 to 1.2 times. In the chain number 1 and 2, farmers in the lower reaches of the chains were involving themselves more in cleaning supply channels than that of farmers in the upper reaches. In chains 3 and 4 farmers, in the upper reaches of chain, farmers were involving themselves more when compared to lower reaches so no clear trend was emerging out.

 Status III - Irrigation water available upto five months in a year from the tank.

Status IV - Irrigation water available upto three months in a year from the tank.

Table 29. Comparison of farmers participation in tank management in the last five years
(No. of times/5 yrs)

Activities	Chain 1		Chain 2		Chain 3		Chain 4	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
Cleaning supply channel	0.33	0.69	0.50	1.20	0.75	0.33	0.66	0.50
Cleaning main channel	0.08	0.00	0.00	0.00	0.00	0.00	0.00	0.16
Removing encroachment	0.00	0.00	0.50	0.80	0.37	0.50	0.00	0.00
Other activities	0.75	1.38	1.00	1.60	1.25	1.66	1.00	1.16

Farmers were occasionally involved themselves in cleaning the main channel in the study area (Table 27). Removing encroachment was another important activity in tank management which could minimise the water loss during transportation and storage. In chains 2 and 3, farmers have involved themselves in removing encroachment, and that too farmers in the lower reaches of chain have involved themselves more when compared to farmers in the upper reaches of chain. Since water availability for irrigation from the tanks was not assured. The PWD which is managing the tanks is not giving any responsibility to farmers in tank maintenance thus farmers lost interest in the tanks.

But the farmers have been involving themselves in the other activities which mainly includes the cleaning of field channels. Here farmers participation was ranging from 0.75 times to 1.66 times in the last five years. Here too, farmers in the lower reaches of chain participated more when compared to the farmers in the upper reaches. This indicates that farmers in the lower reaches of the chain were having more interest in efficient utilisation of the tank water

since they are more frequently facing scarcity of water than the farmers in the upper reach.

Resource utilisation

The resource that are mobilised through social forestry plantations and fishery resources were utilised mainly by Village panchayats, Panchayat Union and local farming community. The resource that are obtained from the social forestry plantations are normally divided in the ratio as given below.

Sixty per cent of the total outlay goes to Panchayats and forty per cent is retained by the Forest Department. Of the sixty per cent which goes to Panchayats, ten per cent is retained by the Panchayat Union. So, of the total outlay, six per cent is retained by Panchayat Union and forty per cent by Forest Department and remaining goes to village Panchayat.

Since Fish Farmers Development Agency is not operating in the selected study area village Panchayat or Panchayat Union was not getting any benefit from fishery resources of the tanks. The amount of money given to village Panchayats, Panchayat Union and utilised by local community, per hectare of the command area of the tank is given in Table 30.

Table 30. Average amount of money given to Village Panchayat, Panchayat Union and to Local community in the last Five Years (Rs. / ha / 5 years)

Chains	Average amount given to Village Panchayat		Average amount given to Panchayat Union		Average amount used by Local community	
	Upper	Lower	Upper	Lower	Upper	Lower
Chain 1	1460.20	492.01	162.45	67.45	349.02	1022.45
Chain 2	0.00	607.01	0.00	22.96	1748.34	4391.47
Chain 3	747.41	206.64	83.04	56.77	212.75	93.96
Chain 4	0.00	510.99	0.00	51.38	9.85	102.90

Village Panchayats and Panchayat Unions which are getting their revenue through the social forestry plantation got comparatively higher amount from the tanks in the upper reaches of the chains and the local community which is getting the revenue from the fishery resources got comparatively higher amount from the tanks in the lower reaches of the chain than that from the upper reaches.

Revenue that is obtained by the village Panchayat was utilised for the payment of Waterman (Neerkatti) and also for the maintenance of Panchayat wells, road, street and street lamp maintenance. Amount obtained by local community was not used for tank maintenance but it indirectly reflected on the farmers participation in tank management activities. Usual practice of paying certain percentage of resource obtained by the village community to the village common fund is also not found in the villages of the study area since the amount obtained was found to be very small.

Performance of tanks

Tank irrigated area in Tamil Nadu had decreased from 38 per cent in 1950 to 23 per cent in 1988. Over the past 26 years (1961 through 1986) there existed a wide year

to year variation in the gross tank irrigated area². In order to check the validity of the statement, performance of the selected tank chain was studied.

Average performance of each chain was calculated and presented in Table 31. Performance was calculated as a ratio of actual area irrigated to the registered ayacut and expressed as percentage.

Table 31. Average performance of tank chains

(Per cent)		
Average performance of tank chains		
Chains	Upper	Lower
Chain 1	25.69	69.45
Chain 2	19.95	11.99
Chain 3	39.55	20.67
Chain 4	28.05	31.07

The average performance of tanks present a dismal situation where the tank performance have vastly reduced ranging from thirty to eighty percent.

²P.T.Umashankar, Performance Analysis of Tank Irrigation Systems in Tamil Nadu.Unpublished M.Sc.(Ag) Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore. 1992.

Adjusted tank performance

Adjusted tank performance was calculated as adjusted actual area irrigated by the tank to the registered ayacut area of the tank result is given in Table 32.

Adjusted performance results have shown that tanks in the upper reach of the chain have been performing better than the tanks in the lower reaches of the chain but for chain 1 the tanks in the lower reaches have been performing better than the upper reaches.

Table 32. Comparison of adjusted performance of tanks

Chains	Adjusted performance (%)	
	Upper	Lower
Chain 1	18.78	52.79
Chain 2	19.95	-0.1457
Chain 3	30.75	13.01
Chain 4	20.01	6.23

³The lower reach of chain 2 had a negative performance. There are four tanks in the lower reach. Among that four tank one tank is having command area of 663 hectares. there are 50 wells in the command area of that tank. The actual average area irrigated by that tank in the last five year was less than 20 hectare. Because of the influence of this tank the performance of the entire chain may be negative.

Thus it could be concluded that in black soils, tanks in the lower reaches had better performance. In the red soil location, tanks in the upper reaches have been performing better than the lower reaches. This result could be summarized below (Table 33).

Table 33. General conclusion about tank performance and soil type

Location of tank	Soil type	
	Red	Black
Upper	High	Medium
Lower	Medium	High

Note : The high and medium level performance is based on the relative level of one tank over the other.

Above table gives a picture about the performance of tanks in upper and lower reaches of the chains with respect to the soil type and the location of the tank in chain.

Tank Irrigation Performance - Regression Analysis

To study the factors responsible for tank irrigation performance actual utilization (measured as the ratio of actual command area) irrigated to the registered

command area as the dependent variable and well density, combined catchment area, total yield per hectare of command area and number of fillings as independent variable, a regression model was constructed and the results are given in Table 35.

Equation for the chain 1 shows, that combined catchment area and total yield per hectare are significant at one per cent level. Well density and number of fillings are nonsignificant.

Negative sign for total yield per hectare of command area which is significant at one per cent level shows that as total yield increase tank performance has decreased. Reason attributed for this is as total yield increases area of water spread also increases since number of fillings remains constant over years, this resulted in more social forestry plantation and finally results in decreased storage as tank bed level increases thus water gets wasted out to the surrounding areas of the tanks.

The positive sign for combined catchment area was as expected. This shows that as combined catchment increases performance increases.

Table 34. Levels of Factors Influencing Tank Performance

Chain	Catchment area		Total yield		Upper tanks		Supply channels		No. of fillings		Fishery resource		Forestry resource		WUO (informal)		Well density		Performance		
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	
Chain 1	Low	High	Low	High	High	Low	High	Low	High	Low	Low	High	High	Low	Low	High	High	Low	Low	Low	High
	High	Low	High	Low	Low	High	Low	High	Low	High	Low	Low	High	No	High	Low	High	Low	High	High	Low
Chain 2	Low	High	Low	High	Low	High	High	Low	High	Low	Low	High	High	No	High	Low	High	Low	High	High	Low
	High	Low	High	Low	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Chain 3	Low	High	Low	High	Low	High	High	Low	High	Low	High	Low	High	High	Low	High	Low	High	High	Low	Low
	High	Low	High	Low	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low
Chain 4	Low	High	Low	High	No	High	High	Low	High	Low	Low	High	No	High	Low	High	High	Low	Low	High	Low
	High	Low	High	Low	High	Low	Low	High	Low	High	Low	High	High	Low	High	Low	High	Low	High	Low	High

Upper = Upper reaches of the chain ; Lower = Lower reaches of the chain

The levels (low/high) is based on the relative level of one tank over the other.

Catchment area is given as intercepted catchment area + Area of free basin expressed as sq.km. per hectare of command area

Total yield is mm³ per hectare of command area

Fishery resource and Forestry resource are given as resources obtained as rupees per hectare of command area.

WUO - Water Users Organisation

Upper tank is the average number of upper tank in the reaches

Total wells expressed as No. of wells per hectare of command area

Table 35. Tank irrigation performance - Results of Regression analysis

Chain	Coefficient of variables				Number of tanks	
	Well density	Combined catchment area	Total yield	Number of fillings		
			Constant	R ²		
Chain 1	33.20NS (49.74)	23.72** (8.62)	2242.22** (645.18)	-5.49NS (8.28)	0.52	25
Chain 3	-168.51NS (144.74)	159.76NS (102.72)	-- 14938.22	63.38NS (70.30)	0.48	14
Chain 4	22.92* (10.99)	13.18** (3.78)	-248.83NS (153.74)	38.50NS (42.87)	0.86	9

Figures in the parentheses are the standard errors.

- ** - Significant 1 per cent level
- * - Significant at 5 per cent level
- NS - Nonsignificant

Well density = Number of wells per hectare of command area
 Combined catchment area = Area of free basin + Intercepted catchment area
 Total yield = mm³ per hectare of command area.

4. Regression analysis is not done for chain 2 since there were only 7 tanks

In the equation for chain 4, well density was significant at one per cent level and combined catchment area at five per cent level. Number of fillings and total yield were non-significant. Earlier studies have shown that (Particularly in non system tank) as the number of wells in the tank command area increases, it has a negative influence on the performance of tanks. But in the case of study positive sign of the well density showed that wells in the study area has a positive influence on the tank performance due to greater recharge.

The positive sign of combined catchment area is on expected line. This shows that as combined catchment area increases, performance of tank could also increase.

SUMMARY AND CONCLUSION

CHAPTER VI

SUMMARY AND CONCLUSION

This study is one of the pioneering studies in tank chains since earlier studies were mostly confined to individual tanks.

Study results have shown that tanks in the first and second reach of Manimuthar dam (Chain 2) had higher full tank level and maximum water level per hectare of command area in both upper and lower reaches when compared with the other three chains which were in third and fourth reach of the Manimuthar dam. Further tanks located in the black soil area are having comparatively higher full tank level and maximum water level per hectare of command area in the lower reaches of the chain whereas for tanks located in red soil area this trend was reversed due to drainage and seepage properties.

Analysis of combined catchment area showed (combined catchment area = Intercepted catchment area + Area of free basin expressed as per hectare of command area) that combined catchment area is comparatively higher for tanks in the lower reaches of all the four chains. Since the number

of supply channels were comparatively lower for tanks in the lower chains, it has to have higher combined catchment area.

Number of fillings was comparatively higher for tanks in the upper reaches of all the four chains. Tanks found in the black soil location (Chain 1) was having comparatively higher number of fillings in both upper and lower reaches when compared to all other chains which were found in the red soil location. Since total yield for all the four chains didn't show significant difference, comparatively higher number of fillings in the black soil region shows that size of the tanks in the black soil region was comparatively smaller.

Study on water users organisation showed that informal water users organisations were present in most of the tanks in the study area. These water users organisation were mostly associated with crop growers association. The presence of water users organisation is comparatively lower in tanks in upper reaches of the chain. This implied that, when probability of getting tank water is higher, presence of water users organisation is comparatively lower. Further water users organisations are active at the time of water stress, which strongly influence the farmers in the upper reaches of chain and PWD Officers to get adequate water.

Study on wells showed that average number of wells per tank was higher in the upper reaches of chain except for the second chain in which number of well per tank is higher in the lower reaches of the chain. This second chain is found in the first reach of the Manimuthar dam.

Study on cropping pattern was done using the five years data collected from the farmers. Study shows that I season paddy crop occupied major irrigated area. Percentage of area occupied by I season paddy ranges from 40 to 100 per cent. Upper reaches of the chain were having comparatively higher area under I season paddy crop. Banana was the next major crop grown in tank irrigated area. Area under banana was comparatively higher in the lower reaches of the chain. Cotton and chillies are other crops that were grown in the tank irrigated area. II season paddy crop was grown in certain pockets of upper reaches of the chain.

Resource Mobilisation

Social Forestry and Fishery were two main sources income in tanks Social Forestry resources obtained from tanks measured interms of Rupees per hectare of command per 5 years had indicated that tanks in upper reaches of the chain were getting comparatively higher amount than the tanks in the lower reaches of the chain.

Though tanks in the upper reaches of chain 2 and 4 are having social forestry plantations no auction has been done in the 5 years taken for study.

Since Fish Farmers Development Agency was not acting in the tanks of study area, local community itself takes care of fishing activities in the tanks. It was found that tanks in the lower reaches of the chain were more suited for pisciculture.

Farmers participation of tank management is very important aspect in improving the performance of the tanks. Farmers participation in tank management is generally poor. Occasionally farmers were involving themselves in cleaning main channel and removing encroachment. Farmers were more frequently involving themselves in cleaning field channels irrespective of upper or lower reaches of the chain.

Resource Utilisation

Resource obtained from social forestry plantations were divided in the ratio of 60 per cent for village Panchayats and 40 per cent for Forest Department. Since FFDA or any other government agency is not acting in the study area, the fishery resources obtained were not given to Panchayats. Entire amount is given to local community which

owns the fishing rights.

Average amount given to village Panchayat was higher from the upper reaches of chain but no revenue is obtained from upper reaches of chain 2 and 4. But the average resource obtained by local community was higher from the tanks in lower reaches of the chain. Resource obtained were mostly not used for tank management except for the payment to Neerkatti (Waterman). Resource obtained from tanks were kept in the panchayat's general account only.

Performance of Tanks

Performance of tanks which was measured as the percentage of actual area irrigated by tank to the registered ayacut, shows that tanks in the upper reaches of chains in the red soil location (Chain 2,3,4) have been performing better than that of the lower reaches. But in black soil locations tanks in the lower reaches of the chain have been performing better.

Adjusted performance was calculated in order to remove the influence of wells on the tanks. Adjusted performance shows that wells have had influence on the tank performance. Further it shows that tanks in upper reaches performed better in the red soil location but in black soil

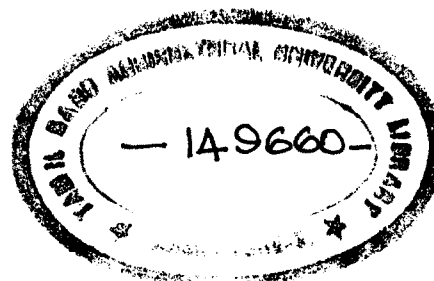
location tanks in the lower reaches of chain were performing better.

Results of regression analysis done to find the influence of selected variables on the performance of tanks showing that combined catchment area was having positive influence on the performance of tanks. But the total yield has a negative influence on tanks. For the chain 3 all the selected variables (well density, combined catchment area, total yield and number of fillings) are non-significant. So there were some other factors which influence the tanks performance.

Equation for chain 4 showed that well density was significant at one per cent level and combined catchment area was significant at 5 per cent level. The positive sign of combined catchment area was on expected line. The positive sign of well density showed that presence of wells to a certain level could enhance the performance of tanks.

Policy Implications

Future research on tanks can be done in relation to chains instead on individual tank. This would give a clear idea about the tanks than the individual attempts.



Social forestry plantations can be oriented to the tanks in the upper reaches of chain since study shows that tanks in the upper reaches are more suitable for plantations. Since local community is not given any chance of participation in social forestry activities they lost their interest. So local community should be given a chance to use the products of social forestry plantation for the better performance of social Forestry Plantations.

Results on resource mobilisation have shown that fishery revenue from the tanks for the last five years was very small (Table 28). One of the important reasons for this is traditional method of fishing in these regions. So Fish Farmers Development Agency (FFDA) should be encouraged to participate in the fishing activities of the tank wherever the potential exists.

Farmers participation is comparatively higher in the tanks in the lower reaches of chain I where the performance of tanks is also comparatively higher. Further, the study has shown that farmers participation is comparatively higher where the Water Users Organisation is having a direct influence on the performance of tanks, it is suggested that tank management activities can be handed over

to the Water Users Organisation (WUO). Local community should be encouraged to form or strengthen the water users organisation in those tanks where WUO are either absent or inactive.

Regression analysis showed that influence of wells in the tank command area of fourth chain on the performance of tanks was positive. So digging of wells can be encouraged to a certain level.

BIBLIOGRAPHY

BOOKS

- Robert Chambers, "Men and Water : The organisation and operation", In **Green Revolution : Technology and Change in Rice Growing Areas of Tamil Nadu and Sri Lanka**, (Boulders : West View Press Co., 1977). p.7.
- Roberto L. Lenton, "A note on monitoring productivity and equity in irrigation system" in Niranjan Pant ed., **Productivity and Equity in Irrigation Systems** (New Delhi : Asish Publishing House, 1984), pp.51-65.
- Ruddar Dutt and K.P.M.Sundharam, **Indian Economy**, (Chand and Company Pvt. Ltd., New Delhi), Edition, 1996, 36: p.437.

JOURNALS

- Anonymous, 77.5% of surface water wasted Everyyear "Far and Nearin Irrigation and Tower, 12(5): 89, Sep-Oct. 1987.
- Dhawan, B.D., "The case of Irrigation". **Monthly commentry**, 29(9): 50-51 Mar-April, 1988.
- Jayaraman. J.K. "Irrigations organisation for Better WaterManagement: A case study of Attitudes of Irrigation from Gujarat state India, **Agricultural Administration** 10(2): 189-212, 1982.
- IndianInstituteof Management , Bangalore and Ford Foundation New Delhi, " Workshop on Farmers organisation", **WAMANA**, 1(1): p.13, 1981.
- Palanisami, K. "Hydro-Economic Interaction Between Tank Storage and Groundwater Recharge". **Ind. J. of Agri. Econ.**, Vol.46, No.2, April-June, 1991.

Palanisami, K. and J.C. Flinn. "Evaluating the Performance of Tank Irrigation System". **Agricultural Systems**. 28(3): 161-177,1988.

Palanisami, K. and William K. Easter. "Irrigation Tanks of South India". Management Strategies and Investment Alternatives", **Ind. J. of Agrl. Econ.**, 39(2): 214-223,1984.

Ramachandran, S. "New Approach on Tank Irrigation". **National Bank Review**. 4(3): 24-27,May,1988.

Sengupta, N. "Irrigation:Tradition Vs Modern". **Econ. and Pol., Weekly**. 20(45,46,47): 1920, Nov.1985.

Sharma, P.N. "Optimization of small reservoir irrigation systems for semi-arid tropics", (Ph.D.,Thesis Univ. of California at Davis), 1981. In: Somasekhara Reddy "Declining Ground Water levels in India", **Int. J. of Water Resources Development**., 5(3):187,1989.

Somasekhara Reddy. "Declining ground water levels in India", **Int. J. of Water Resources Development**. 5(3): 187,1989.

Sunder, A. and P.S.Rao, "Farmers organisation for efficient water use in irrigated agriculture", **WAMANA**, 1(4): pp.1-13,1981.

Timothy Randir,O. and S. Krishnamoorthy. "Optimal Crop Planning Under Production Risk in Tank of South Indian Farms". **Ind. J. Agrl. Econ.**, Vol.48. No.4, Oct-Dec.1993,pp.678-685.

Von Oppen, M. and K.V. Subba Rao. "Tank irrigation in semiarid tropical India. Past and Prsent Performance - Future Development". **ICRISAT Res. Bulletin**, 1980.

PERIODICALS AND REPORTS

- Amelia Balraj, A.Ganesan and Venkataraman,B. "Some case studies on the deficiencies and performance of the existing irrigation system", Paper Presented at the **Regional Seminar in Hydrological Problems Relating to Tanks** held at Irrigation Management Intstitute, Taramani, Madras, Oct., 1990.
- Elumalai,G. "Modernization of Tank Irrigation Systems - Farmers View", Paper Presented at **Workshop on Modernisation of Tank Irrigation : Problems and Issues**. Centre for Water Resources, Anna University, Madras. 1982.
- Ganapathi Subramaniam,G., S.Vasudevan and C.Sundaraman, "Performance efficiency in tank irrigation systems - A critical study", Paper Presented at the **Regional Seminar in Hydrological Problems Relating to Tanks** held at irrigation management problems Relating to Tanks held at Irrigation Management Institue, Taramani, Madras, Oct, 1990.
- Jayabalan,B.A. "Modernisation of Tank Irrigation in Tamil Nadu", Paper presented at **Workshop on Modernisation of Tank Irrigation : Problems and Issues**, Centre for Water Resources, Anna University, Madras, 1982.
- Mukthar Singh, "Irrigation and drainage systems and management", In **Proceedings of Symposium on Water Management**, (New Delhi : Indian Society of Agronomy, 1968), pp. 197-202.
- Palanisami,K. and William K. Easter, "The Tanks of South India (a potential for future expansion in irrigation)", **Economic Report No.ER 83-4 University of Minnesota, St. Paul, Minnesota, 1983**
- Palanisami,K. "Managing Tank Irrigation Systems : Basic Issues and Implications for Improvement", In Anna University of Technology, **Workshop on Modernisation of Tank Irrigation : Problems and Issues** (Madras : Centre for Water Resources Anna University of Technology, 1982), pp. 1-52.

- Palanisami, K. and William K. Easter, "Tank Irrigation in India and Thailand : Problems and Prospects, "ODI Network Paper IOE (Agricultural Administration Unit, Overseas Development Institute, London, 1984), pp. 1-12.
- Palanisami, K., A. Balasubramanian and A. Mohamed Ali, Final draft report (Tamil), "Ford Foundation Tank Project", Water Technology Centre, Tamil Nadu Agricultural University, Coimbatore, 1997.
- Rajagopalan, V., "Changing Roles of Rural Institutions for Management of Tank Irrigation Systems", Anna University of Technology, Workshop on Modernisation of Tank Irrigation : Problems and Issues (Madras : Centre for Water Resources, Anna University of Technology, 1982), pp. 1-19.
- Sakthivadivel, R. "A Pilot Study of Modernization of Tank Irrigation in Tamil Nadu", Paper Presented at Modernization of Tank Irrigation : Problems and Issues. Centre for Water Resources, Anna University, Madras, 1982.
- Sivanappan, R.K. "Water Management in Tank Irrigation in Tamil Nadu", Pre-workshop Papers on Modernisation of Tank Irrigation : Problems and Issues, Section B, Irrigation : Problems and Issues, Section B, pp. 1-9, 1982.
- USAID. Small Scale Irrigation (Tank Irrigation), Project Paper (Thailand : United States Agency for International Development), 1980, p.2.
- Victors Doherty. "A cross cultural analysis of tank irrigation", In Anna University of Technology, Workshop on Modernisation of Tank Irrigation : Problems and Issues (Madras : Centre for Water Resources, 1982), pp. 1-52.

World Bank, "India Periyar Vaigai : Irrigation Project (Tamil Nadu)", Report No.15199-1N, World Bank, Washington, D.C.), 1977.

"Fillip to Integrated Dryland Development", **The Hindu**, dated 20.5.1996, p.12.

THESIS

Umashankar, P.T. "Performance Analysis of Tank Irrigation Systems in Tamil Nadu" Unpublished M.Sc.(Ag.) Thesis, Tamil Nadu Agricultural University, Coimbatore, 1992, p.77.

GLOSSARY

- Command area : Total area irrigated by a tank
- Catchment area : Area from which rain water is collected and supplied to the tank
- Free Catchment : Area from which water is collected and supplied to a single tank
- Intercepted Catchment area : Catchment area for morethan one tank
- Combined Catchment area : Intercepted catchment area + free catchement
- Total yield : Yield of free catchment + one fifth of the yield of intercepted catchment
- Number of fillings : Total yield / Capacity of tank
- Full tank : Level corresponding to the design storage capacity of tank
- Maximum water level : Level corresponding to the peak flood discharge

