JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

MINISTRY OF WATER RESOURCES, GOVERNMENT OF INDIA
PUBLIC WORKS DEPARTMENT, GOVERNMENT OF TAMIL NADU

THE STUDY
ON
THE REHABILITATION OF MINOR IRRIGATION TANKS
FOR RURAL DEVELOPMENT
IN
TAMIL NADU

FINAL REPORT

VOLUME I
EXECUTIVE SUMMARY

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Exchange Rate

(as of July 1997)

US$ 1.00	=	Rs.35.25
Rs.1.00	=	US$ 0.0284
US$ 1.00	=	Japanese Yen 117.5

Rs. : Indian Rupee

PREFACE

In response to a request from the Government of India, the Government of Japan decided to conduct a development study on the Rehabilitation of Minor Irrigation Tanks for Rural Development in Tamil Nadu and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent to India a study team headed by Dr. Shoji Kanatsu, Pacific Consultants International, Japan, three times between December 1996 and October 1997.

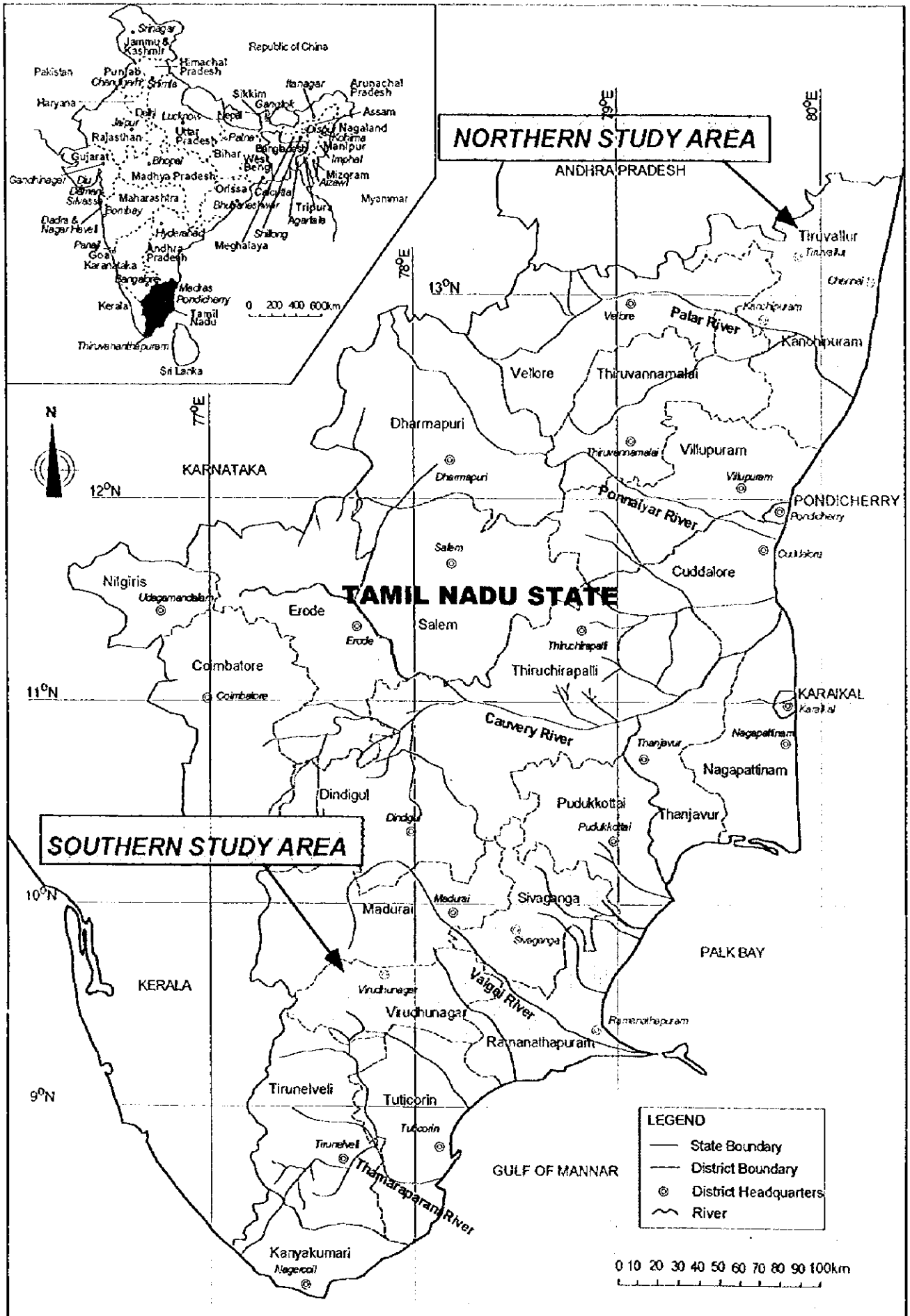
The team held discussions with the officials concerned of the Government of India, and conducted field surveys at the study area. After the study team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the promotion of the project and to the enhancement of friendly relations between two countries.

I wish to express my sincere appreciation to the officers concerned of the Government of India for their close cooperation extended to the study team.

January 1998

Kimio FUJITA
President,
Japan International Cooperation Agency



Location Map of the Study Area

THE STUDY ON THE REHABILITATION OF MINOR IRRIGATION TANKS FOR RURAL DEVELOPMENT IN TAMIL NADU

VOLUME I : EXECUTIVE SUMMARY

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SUMMARY

1. INTRODUCTION

In August 1995, the Government of India made a request to the Government of Japan to extend its technical cooperation for formulating a master plan for the rehabilitation of minor irrigation tanks in the Tamil Nadu State and to conduct feasibility studies for the selected irrigation tanks and their command areas.

In response to the request of the Government of India (GOI), the Government of Japan (GOJ) has decided to conduct the Study on the Rehabilitation of Minor Irrigation Tanks for Rural Development in Tamil Nadu (hereinafter referred to as "the Study") in accordance with relevant laws and regulations in force in Japan. Accordingly, Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of technical cooperation programs of GOJ, dispatched a preparatory study team to India on 29th July, 1996. The team agreed upon the scope of work of the Study (S/W) between GOI and the Government of Tamil Nadu (hereinafter referred to as "GOTN") on 9th August, 1996. Based on the S/W, the JICA organized and dispatched a team to conduct the Study (hereinafter referred to as the Study Team).

The Objectives of the Study are:

(1) To Formulate a Master plan on the Rehabilitation of Minor Irrigation Tanks for Rural Development in the State of Tamil Nadu.

(2) To conduct Feasibility Studies in the selected areas where tank irrigated agriculture is predominant in the rural society, and

(3) To carry out technology transfer to the Indian counterpart personnel through on the job training in the course of the Study.

Among the 29 districts in the Tamil Nadu State (hereinafter referred to as "the State"), 5 districts are selected as the Study Area as shown in the Study Location Map. They are divided into two regions; the Northern Study Area consisting of Tiruvallur and Kanchipuram districts (former Chengalpattu-MGR District), and the Southern Study Area consisting of Ramanathapuram, Sivaganga and Virudunagar districts. The total area of the five districts is 20,463 km^2 belonging to different agro-climatic zones. About 35 % of PWD rainfed tanks and 43 % of their command areas in the State are concentrated in the Study Area. The Study focuses on the PWD rainfed tanks of about 2,500 numbers in the Study Area.

2. BACKGROUND

2.1 Brief Description of India

(1) Land

India covers a total area of 3,287,590 km^2 and a population of 883 million inhabitants in 1991, presently estimated at more than 900 million accounting for one-sixth of the world population. The nation is located on a sub-continent formed as a peninsula of reverse triangular shape faced with Bay of Bengal on the East and Indian Ocean on the West, meanwhile its Northern hilly and Himalayan mountainous regions are bordered with Pakistan, China, Nepal, Bhutan, Bangladesh and Myanmar.

(2) People

Indian population is made of various ethnics. Combining a variety of ethnical cultures and languages, the Indian culture is a mixture of various ethnical cultures and civilizations along with the caste-system society. India has a labour force of 284.4 million, about one-third of its population, of which more than 65 % are considered being employed in the agriculture sector. The unemployment rate was high, 20 % in 1990. Its present literacy is approximately 50 % and life expectancy at birth is 62 years in average, 61 for male and 63 for female. The present population growth rate is about 2.0 %(1980-95).

(3) Administration

India has been formed as a federal republic nation since its independence in 1947. Being formed as a federal republic, the Republic of India is divided into 25 states and 7 union territories. India has a dual system of government, with division of powers between the Center and the States.

(4) State Economy

India's economy is a mixture of traditional farming practices with modern agriculture, old and new branches of industries as well as contemporary service practices carried out on the foundations of a strict caste system combined with the colonial environments made as the specific characteristics of its society.

The performance of national economy in India has not always been considered to be in a good trend in comparison with its neighboring countries. The GDP per capita is about US$ 350 (IBRD, 1995).

India launched a New Economic Policy (NEP) for fundamental economic reforms aiming at two objectives: the macro stabilization of Indian socio-economic conditions and the Structural Adjustment Program (SAP) in every important

economic sector in order to achieve a higher economic development to tackle sufficiently the national task of an affluent society at its basis. The 8th Five Year Plan insists a five-point strategy of 1) infrastructure development, 2) poverty alleviation, 3) employment generation, 4) population control and 5) safe, health and drinking water. However, a recent annual growth rate reaches 4.5 % in the last period of the Eighth Five Year Plan (1992 - 1997), slightly lower than the targeted rate of 5.5 - 6.0 %. The recent basic economic indicators of India are summarized below:

Item	Figures
GDP (1995-96) at current prices (provisional)	Rs. 9,822 billion
GDP per capita (1995-96, provisional)	Rs. 10,676
Share of Agriculture and Allied Sector	29.5 %
Share of Industrial Sector	29.0 %
Share of Services Sector	41.5 %
Annual GDP Growth Rate	6 %
Foodgrain Production	185 million ton
Foodgrain per capita	0.2 ton
Exports 1995-96 : tea, coffee, fish, chemicals, textiles, engineering goods, etc.	Rs. 1,064 billion
Imports 1994-96: Petroleum, capital goods, chemicals, iron, edible oils	Rs. 1,216 billion
Electricity Generation	414 billion kWh

Source: Statistical Outline of India 1996-97, Tata Service Limited

(5) Agriculture

The 8th and 9th Five Year Plan has identified financing, trade, industry and human resource development as the priority sectors. In the agricultural development, target was set not only for food self sufficiency but also for export of surplus agricultural production. High priority has been put on the improvement of agricultural productivity to satisfy the food demands of ever increasing population. It is also emphasized on the improvement and stabilization of agricultural production in semi-arid zone where rainfed cultivation is practiced.

The agricultural workers in 1991 is estimated at 185.3 millions including cultivators and agricultural labors, who correspond to 64.8 % of the total workers in India. The agricultural gross domestic product in India is estimated at Rs. 625,890 million at 1980-81 prices in 1992-93, which share 28.0 % of the total domestic product.

(6) Land Reform and Land Holding

India had continuously implemented a land reform program by abolishing the *Zamindari* system (landlord system) by the U.P. *Zamindari* Abolition and Land Reform Act in 1950. This had facilitated the distribution of about 5.8 million ha of land to landless farmers in the whole country. The average size of operational holdings in India is estimated as 1.57 ha in 1990-91. However, about 60 % of the operational holdings is marginal with an average operated area of 0.4 ha.

In 1990, out of 70 million holdings in the Country, 64 million are wholly owned and self-operated, 3 millions are partly owned and partly rented, and 3 millions are

wholly leased. With regard to the area of farmland, out of 162 million ha or 91 % is wholly owned and self-operated, 6 % is partly owned and partly rented, and the balance of 3 % is wholly leased.

(7) Crops and Production

The major crops cultivated in India are rice, wheat, jowar (Cholam or Great millet, *Sorghum bicolor*), bajra (Bulrush or spiked millet, *Pennisetum Typhoides*), groundnut, cotton, gram, rapeseed and mustard, maize, soybean, Tur (red gram or pigeon pea, *Cajanus cajan*) and sugarcane. Among these crops food grains occupied 66.5 % of the total cropped area followed by oil seeds (13.6 %) and fiber crops (4.6 %). Vegetable and fruit crops share only 2.2 % and 1.5 %, respectively.

The average yields in kg/ha in 1992-93 are 1,744 for rice, 2,327 for wheat, 982 for jowar, 1,676 for maize, 573 for pulses, 1,049 for groundnut, 797 for oil seeds, 257 for lint in cotton, 894 for soybean and 64, 000 for sugarcane.

At present, India has been producing enough amount of food grains for self sufficiency. The growth rate of rice production is higher than their population (1.9 %), and productivity is still more excepted for the states in northern zone. Since the introduction of high-yielding dwarf varieties in 1965, there has been a continuous increase in both production and productivity without any increase in area and mainly by breeding high yielding new genotypes.

(8) Agricultural Marketing and Agro-industries

In general, the dominant marketing practice for agricultural products in India is an old and complicated conservative system carried out by multi-level middle men.

Despite that agriculture is the traditional and major industry in the national economy, the situation of agro-industries is not developed so much due to the status-quo of present marketing system controlled by traders and regulated markets of the Government. In India, cottage and small scale agro-industries have been carried out mainly with handloom products and some simply processed agricultural products only e.g. drying chili, date, coffee etc.

(9) Irrigation

In 1991-92, 48.8 million ha of lands are irrigated by several water sources in India. The major irrigation water source was canal at 42.1 % in 1960s, but in 1970s groundwater replaced it. In 1991-92, the groundwater, canal and tank water irrigate 51.2 %, 35.4 % and 6.8 % of areas, respectively. The tank irrigation significantly reduced its command areas in these 30 years. The tank irrigation areas are concentrated in the southern part of the India, and 16 % of tank irrigation areas are in Tamil Nadu.

2.2 Brief Description of Tamil Nadu State

Tamil Nadu is situated on the southeast of the Indian peninsula bounded in the north by Karnataka and Andhra Pradesh, in the west by Kerala, in the east by Bay of Bengal and the south by Indian Ocean. It covers a total area of 130,069 km^2 extending from northern latitude of 8° 5' to 13° 35'N and eastern longitude from 76° 15' to 80° 20'E. Its climate is basically tropical exposing to both Southwest and Northeast monsoons.

The population of the State is 55.6 million (6.6 % of the total Indian population) with about 8 million of farm holdings and the agricultural population of about 72 % of its total population (1991 Census).

The State is plotted in tropical savanna so that vegetation is scanty. Rainfall in the State fluctuates from region to region and year by year. The State is divided into 7 agro-climatic zones as shown in Fig. S.1. The recorded annual average rainfall is about 900 mm of which 450 mm and 300 mm occur in Northeast and Southwest Monsoon periods, respectively. Due to Northeast monsoon, there is more than 1,000 mm of annual rainfall in the northeast part of the State, while it is only 600 to 700 mm in the southwest area.

(1) State Socio-economy

The Net State Domestic Product (SDP, Rs. 252 billion) shared 7.5 % of the Net National Product (NNP, Rs. 3,435 billion) in 1992-93, proportionally with the population figures with recent improvements in the last decade. The State Domestic Products per capita at Rs. 6,205 in 1992-93 is recently improved comparing with the National Domestic Products per capita (Rs. 6,234).

Major socio-economic indicators of the State are shown below:

Major Socio-economic Indicators in Tamil Nadu

	Item	Tamil Nadu	All India	Share in %	Year
1.	Area (km^2)	130,000	3,287,000	About 4%	1991
2.	Population (Million)	55.6	843.9	7%	1991
3.	Density (Persons/km^2)	428	267		1991
4.	Sex Ratio (Female/Male)	0.97	0.93		1991
5.	Urban Population Percent	34.8	25.7		1991
6.	Rural Population Percent	65.2	74.3		1991
7.	Population in Poverty (%)	32.8	29.9		1991
8	Percentage of Agr. Workers	59.1	64.9		1991
9.	Female Workers Rate	30.9	22.7		1991
10.	Literacy Rate	84	52		1991
11.	Infant Mortality Rate	5.6	7.4		1991
12.	Population Growth (%)	2.0	2.2		1991
13.	GDP (Crore Rs)	35,225	543,566	About 7%	1992-93
14.	GDP per capita (Rs)	6,205	6,234	98%	1992-93
15.	Share of Primary Sector (%)	20.5			1992-93
16.	Share of Secondary S. (%)	30.9			1992-93
17.	Share of Tertiary S. (%)	48.6			1992-93
15.	Foodgrain Production (t)	7,747,000	167,064,000	4.8%	1991-92

ource: Indian Economy, Sultan Chand & Sons

(2) Agriculture in the State

1) Policy and Characteristics

In the 8th Five Year Plan of the State, the agriculture is focused as the main sector with the following targets:

i) To bring the fallow lands under the cultivation in about 10,000 ha every year.
ii) To promote less water consuming horticulture crops through special schemes for production and distribution of quality seeds and seedlings of fruit trees, flowers and vegetables and also establishing horticulture estates
iii) To give impetus to training the farmers in modern technology
iv) To encourage self-employment especially in seed production and agro-based industries
v) To increase the forest coverage of the State through conservation, community and commercial forestry with special emphasis on fuel and fodder plantations under Sustainable District Forestry Program (SDFP)
vi) To emphasize the coastal aquaculture by establishing Brackish Water Fish Farmers' Development Agencies

The State is basically deficient in water resources, and most of the available water resources has been exploited as described in the next section. Special attention is paid to the conservation, management and optimization of utilization of such resources.

The situation of the State agriculture is characterized below.

i) Small size of operational holdings: The average size of operational holdings in the State is as small as 0.93 ha, which corresponds to 59 % of the national average (1.57 ha). 73.1 % of the holdings are marginal ones with an average size of 0.36 ha.
ii) High irrigation rate: The State ranks the 3rd among the most advanced states in percentage of irrigated area to the total area under principal crops (47.9 %)
iii) High agricultural input: The consumption of fertilizer in the State is 136.64 kg/ha on average in 1994 - 95, which is 81 %, higher than the national level (75.68 kg/ha).
iv) Yield per unit area: The average yields of rice, bajra, groundnut, sugarcane and cotton in the State are 3,116 kg/ha, 1,144 kg/ha, 1,486 kg/ha, 107 ton/ha and 289 kg/ha in 1992-93, respectively.
v) Share of agricultural production in the State: The share of total food grains of the State to the national production is 4.7 % only.

2) Land Use and Land Tenure

Out of the total area of 13.0 million ha in the State, 16 % is occupied by forest, 14 % by non-agricultural use, 11 % by current fallow and 44 % by net area sown. 20 % of the net area sown (1.1 million ha) was sown more than once, and then, the cropping intensity is 120 %. The major sources of irrigation are wells (45%), canals (32%)

and tanks (23%) in 1991-93. The share of area irrigated by well increased during the last 20 years from 31% in the early 1970s to 45% in the early 1990s. On the contrary the share of area irrigated by tank decreased from 34% to 23%.

The predominant system of land tenure in the State is the *ryotwari* system, under which a land owner is free to alienate his right over the land by sale or gift. The GOTN has imposed a ceiling of 6.07 ha on land holding. About 83 % of the holdings are small and below 2 ha. Further, 64.7 % of the holdings which cover an operational area of 21.1 % of the land area are less than 1.0 ha.

3) Crop Production

The principal crops in terms of cultivated area in the State are paddy, groundnut, pulses, cholam (*Sorghum Vulgare*), sugarcane and cotton, which occupy 32.2 %, 16.2 %, 9.6 %, 7.1 %, 3.5 % and 3.2 % of the total cultivated area of 7,158,000 ha in 1993-94, respectively. The average yield of these crops is estimated to be 2,927 kg/ha for paddy, 1,611 kg/ha for groundnut with shell, 400 kg/ha for pulses, 960 kg/ha for cholam, 104,386 kg/ha for cane of sugarcane and 316 kg/ha for lint of cotton.

4) Cropping System

The main cropping sequences and systems in the State are summarized below.

Rainfed Single crop (Kharif)

Groundnut, cumbu, ragi, cholam, kodo millet (*Paspalum scrobiculatum L.*), redgram and cotton are cultivated in Kharif in rainfed area. Often lab lab, redgram, dewgram, castor, cowpea etc. are grown as intercrops with millets or groundnut as main crop. Tapioca is grown in rainfed area through out the year.

Rainfed Double crop (Kharif/Rabi)

Groundnut, cumbu, ragi are cultivated as 1st crop in Kharif and horsegram, gingelly, bengalgram, coriander and cotton are cultivated as 2nd crop in Rabi. In the cases of gingelly/castor (Kharif) - horsegram (Rabi) and cotton/groundnut (Kharif) - bengalgram/sorghum (Rabi) are also found out.

Irrigated

- Rice - rice
- Rice - rice - rice/vegetables/ragi/cumbu
- Rice - pulses/groundnut/gingelly/maize/cotton
- Rice - tapioca
- Cotton - sorghum/millets
- Cumbu/ragi - vegetables - summer groundnut
- Ragi/sorghum - cotton
- Redgram - maize - groundnut
- Sugarcane/banana/betel vine/ornamentals (2 - 3 years)

5) Livestock

Cattle is the major livestock bred and ranked first among all the livestock bred in the State, which shares 35.5 % of the total number of livestock of about 26 million heads in 1989. The number of poultry in the State in 1989 is 21,450,638 of which 98% is occupied by fowls and the rest are ducks and drakes. The milk and egg productions rose to 3,483,400 t and 2,812 million pieces per year on the average of the 5 years from 1990-91 to 1994-95, respectively.

6) Farm Holding Economy

The basic aspects of farm holding economy are characterized by two major issues: 1) the limited agricultural land for a large agricultural population, and 2) the low agricultural revenues to farmers, especially marginal and small farmers.

Basically, the surplus of farmers' farm produces will be sold for family expenditure and operation capital for the next crops. On this basis, marginal farmers of less than 1 ha are found without considerable surplus, particularly in case of only one crop is available, for having some revenue for even family expenditure. Most marginal farmers, therefore, have to carry out salary-works like coolies outside their farm works for supporting their family expenditure.

As agricultural labor or landless farmers possess no farmland and carry out farming activities on seasonal basis of hiring, their farming income are very unstable, depending on seasons and employers. As they are classified as unskilled workers, their daily salaries are Rs. 30 - 50 for men and Rs. 15 - 30 for women upon work-type, region and season.

7) Agricultural Marketing

In order to facilitate the agricultural marketing in the State, Agricultural Marketing Department was formed, and 14 Market Committees at district level with 270 regulated markets, 15 sub-regulated markets and 44 check posts have been set up. 96 of the 270 Regulated Markets have been installed with commercial grading facilities and godowns of 1,000 units were constructed in 98 regulated markets.

In order to help farmers to avoid distress sales during harvest times and inferior pricing periods, the GOTN offers pledge loan facilities in 98 Rural Godowns and 39 Regulated Markets having godown facilities with maximum ceiling limit of Rs. 10,000-25,000 per farmer with nominal interest of 15 %. Besides, to attract the farmers for selling their produces through Regulated Markets and to get better prices, the Tamil Nadu Farmers Development and Welfare Fund was established in 1995.

8) Agro-industry

The cottage and small scaled industries in the State have a rich heritage of hand-looms mainly in the south of the State. The GOTN has implemented various schemes for its promotion including the cooperative program for modernization of handlooms and conversion to power-looms to deal with the situation of inferior working conditions and higher wages. Important items are rice mills, oil mills and

sugar factories which are performed in cottage and small industries types.

9) Agricultural Supporting System

Agricultural research and technology development in the State are carried out by TNAU at 37 agricultural research stations. There are 7,696 personnel in Agricultural Department of GOTN for the agricultural extension activities.

In order to help marginal and small farmers in their agricultural production a short term loan scheme for cultivation purposes (Crop Loan Scheme) has been carried out by NABARD for offering the crop loan to individual farmers. In general the loan amount for paddy is about Rs.3,000 per acre (about $210/ha) made in about Rs. 1,000 by cash and the rest by materials. The annual interest is from 12 to 18 % depending on season and region.

(3) Water Resources and Irrigation

1) Available Water Resources and Water Policy

The State is deficient in water resources. Per capita water availability in the State is only 600 m^3 against the national average of 4,000 m^3. The State has surface flow potential of 340 million m^3 of which about 333 million m^3 has been utilized already. This requires a conscious attention to rehabilitate the existing irrigation projects, canal systems, *anicuts* and tanks to make them functionally most effective in quick and optimal delivery of inflows received without allowing them to go waste, and economizing on the delivery and use of water utilized.

One-third of the irrigated areas are those by tanks. Next to the tank irrigation is lift irrigation through wells individually owned. These are simple sources that beneficiaries bring sustainable benefits to the agricultural sector. The tank irrigation system has a special significance to the marginal and small scale farmers who make a very large number essentially depending on irrigation. The State Water Policy in 1994 stresses to ensure equitable use of the scarce water resources, and, in the planning and operation systems, water allocation priorities should be broadly applied for 1) drinking water, 2) irrigation, 3) hydropower, 4) industrial and other uses.

2) Tank Irrigation System

According to the Minor Irrigation Census in 1987, the total number of tanks in India was counted for about 510,000, and they are concentrated in the southern states of India. The State shares 7.8% of total tanks in the Nation. But the share of tank irrigation at 31% for 1983-84 was the largest among other states in the Nation.

There are more than 39,000 tanks in the State, and they are classified into system and rainfed tanks based on the water supply system, and Panchayat Union, PWD and Ex-Zamin tanks upon the maintenance agencies. About 9% of total tanks are system tanks; mostly PWD tanks are getting their water from semi-perennial rivers through a system of canals in to a series of tanks situated as a chain along the river. Rainfed tanks of PWD, Panchayat Union and Ex-Zamin tanks occupy the 13 %,

52 % and 25 %, respectively.

Panchayat Union tanks have command area of less than 40 ha, and under the control of village union (Panchayat union). PWD tanks are those having a command area of more than 40 ha maintained by the PWD. Ex-Zamin tanks were constructed by Zamindars (landlords) during the British administration. After abolishment of zamindari system by GOTN in 1957, they were transferred to Panchayat Union and PWD upon the sizes of command areas. There are about 8,000 Ex-Zamin tanks, of which more than 60 % are concentrated in the undivided Ramanathapuram district.

3) Tank Modernization

The minor irrigation schemes are considered as those which benefit an *ayacut* (command area) of below 2,000 ha. In the State, 67 % of net irrigation area comes under minor irrigation schemes. The major components of minor irrigation schemes relate to construction and maintenance of tanks, open wells and tubewells besides small irrigation works under streams. Apart from this, Special Minor Irrigation Programme (SMIP) contemplates formation of tanks, construction of anicuts, excavation of link channels, restoration of abandoned tanks, formation of percolation ponds, river pumping schemes, etc. Another Minor irrigation scheme viz., Desilting cum Reclamation (DCR) which include desilting of tanks to restore the capacity abandoned due to siltation by reclamation of foreshore lands is also undertaken regularly.

In 1981, a pilot study of modernization of tank irrigation was commenced to investigate the present status of tank irrigation systems, in Padinalur Tank, Chengalpattu district by the Center for Water Resources, Anna University, Madras, with financial assistance from the Ford Foundation. Tank modernization of Periyar-Vaigai systems and water management projects under Sathanur, Thambaraparani, Kodayar systems etc. are implemented to improve canal system efficiencies, taken up with the World Bank assistance. Through improving the operational and field application efficiency, 1,890 million m^3 of water is estimated to be saved and this may extend the irrigation area additionally for about 60,987 ha.

EEC (presently European Union) Tank Modernization Project (hereinafter referred to as the "EC Project") has been started since 1983. The aim of the project is to increase agricultural production and income of farmers through extended irrigation and better water management of system based on rainfed tank irrigation thus leading to a higher cropping intensity. EC Project was implemented in 2 phases, Phase I covered modernization of 150 tanks with financial assistance amounting ECU 25 million by 1989, and Phase II covered 346 tanks under EC financial assistance amounting ECU 8.7 million. Due to the appreciation of ECU, the Phase II Extension was started utilizing the balance of Phase II assistance in 1994. Under the Phase II Extension, 50 rainfed tanks are under modernization and 50 tanks are under preparation stages. More efforts were taken for the farmers' participation and institutional strengthening.

3. THE STUDY AREA

3.1 General Features

(1) Location

The Study area consisting of the Northern and the Southern Study Areas is located in the State as shown in Location Map. The areas are measured to be about 7,857 km^2 and 12,606 km^2 for the Northern and the Southern Study Areas, respectively. About 2,600 units of minor irrigation tanks area requested for the Study are scattered in these areas.

Tiruvallur and the Kanchipuram districts area in the Northern Study Area and Virudunagar, Sivagangai, Ramanathapuram districts are in the Southern Study Area. At present, there are 16 and 18 taluks in the Northern and the Southern Study Areas, respectively.

(2) People

The population of Study Areas is about 4.65 million and about 3.8 million for the Northern and the Southern Study Areas, respectively (Population Census 1991). The rural populations are also calculated at 55.1% for the Northern Study Area and 70.3% in the Southern Study Area.

The share population of scheduled castes and tribes in the Northern Study Area is considered remarkably high (36.7%) taking into account of the average in the State (24.3 %) and the Southern Study Area (21.6%). The literacy rate of the Study Area indicates rather low values between 47.2 to 49.0 % comparing with the State's average of 62.66 % including the urban areas. The total worker population is 1.12 million and 1.4 million for the Northern and the Southern Study Areas, respectively, including the marginal workers. The workers of the industrial categories related to agricultural activities are predominant, sharing about 60 % to the whole workers in the Study Area.

(3) Social Infrastructure

In general, the conditions of social infrastructures in the Study Area are observed in a rather good conditions, especially on the aspects of communications, water supply, electrification and education. This situation implies the recent efforts for social development in rural areas of the State. The aspects of housing and sewerage, however, are considered still inferior, particularly in areas for agricultural labourers. Health care system also requires some improvements on nutrition and health-check for landless marginal and small farmers in order to improve their living conditions.

3.2 Natural Features

(1) Topography

Most of the Northern Study Area is located in the coastal alluvium extending along the Coromandel coast except the western and the southern ends of the Study Area. The area is generally considered to be flat with little undulations of which elevation varies less than 100 m above sea level except some hilly areas in western end of the area. In the flat plain areas, vast paddy fields extends and thousands of large and small irrigation tanks are scattered. The Palar river is the largest river in the Northern Study Area and flows eastward into Bay of Bengal.

In the Southern Study Area, Sivagangai and the Ramanathapuram districts are located in the coastal alluvium, while Virudunagar District is in the hard rock area. The elevations vary less than 100 m in Sivagangai and the Ramanathapuram Districts, those in the Kamarajar district exceed 100 m at the western end of the district. The Vaigai river is the largest river in the Southern Study Area. It forms an alluvial plain and vast agricultural land is created. The land surface is flat along the river with mild slopes toward Bay of Bengal.

(2) Meteorology and Hydrology

As shown in Fig. S.1, the Northern Study Area of Tiruvallur and Kanchipuram districts have an annual rainfall more than 1,000 mm. Part of Ramanathapuram and Sivagangai districts of the Southern Study Area have an annual rainfall of between 800 and 1,000 mm. Part of Ramanathapuram and Virudunagar districts of the Southern Study Area have an annual rainfall of 600 to 800 mm.

In the Northern Study Area, the rainfall is observed to be generally more than 1,000 mm with the variation from 1,000 mm to 1,200 mm, while it decreases below 1,000 mm in the Southern Study Area. In the Southern Study Area, the rainfall varies from 700 mm to 900 mm. It decreases from north to south in the Southern Study Area, while it increases west to east. 7 development blocks in the Southern Study Area are declared as drought prone area by the Department of Rural Development of the GOTN.

About 55 % of rainfall occurs during the NE Monsoon in general. The average temperature reaches a maximum of about 33 °C in May and a minimum of about 24 °C in January in both Study Areas. According to the long term annual rainfall data in the Study Area, serious drought has been occurred with an interval of about five (5) years.

Based on the drainage pattern of the rivers, Araniar, Koratalaiyar, Palar flow in the Northern Study Area and Pambar, Kottakaraiyar, Vaigai, Gundar, Vaippar flow in the Southern Study Area.

(3) Geology and Hydrogeology

The Northern Study Area is principally made up of archean, upper Gondwana and Tertiary formation. These are overlaid by laterite and alluvium. The geological formations met within the Southern Study Area, comprises Archean Metamorphic complex represented by granites, granitic gneiss, felspalthic gneiss and charnockites. These are overlaid by tertiaries, granites and clays. In some places these are overlaid by river alluvium and coastal alluvium of quaternary period comprising of sand, sandy clay and clay.

Out of the total groundwater recharge about 15 % is kept reserved to meet the domestic and industrial uses. The balance 85 % is taken as utilisable groundwater recharge for irrigation purposes. The total dynamic groundwater resource was estimated at 26,395 million m^3 in the State, and the ultimate irrigation potential from groundwater was estimated at 3.144 million ha. as on January, 1992.

Groundwater development in the Northern Study Area has been on moderate scale with some scope for further development. In the coastal area, due to extensive pumping of groundwater, sea water interface moved more than 10 km. Hard rock areas have saturated thickness of 6 to 8 m in monsoon and 1 to 2 m in summer. In Minjur area there is water quality problem. Minjur, Tiruvallur and Madhavaram are over developed areas.

Groundwater quality has some problem in Ramanathapuram taluk, R.S. Magnalam, Kadaladi and Mudukulathur Unions. Presently, parts of dune aquifers of Mandapam area, Vaigai river bed, Tiruvadanai aquifer in southern and western sides are judged over development.

(4) Soils and Vegetation

Soils in the Study Areas are divided into five (5) orders; Entisol (Redloam), Inceptisols (Lateritic), Vertisols (Black), Alfisols (Sandy Coastal Alluvium) and Ultisols (Red Sandy). The Study belongs to tropical savanna climate. The natural vegetation is somewhat differed by the northern part and the southern part of the Study Area. In the northern part, the vegetation consists of teak, sal, rosewood, pine, bamboo, redwood, anjan, garjan, paduk, mulberry, sisu, myrabolans and a large number of valuable trees. In the southern part, the vegetation becomes sparse and consists of shorea robusta, acacia, catechu kikar, acacia arabica, prosopis, tamarix albizzias, date palm, ber, pipal and other bushes.

(5) Environmental Conservation

The Ministry of Environment and Forests have passed an Act "The Environmental Protection Act, 1986" to protect the environment and has also issued a hand book on environmental procedure and guidelines. The Red Data Book on plants brought out by the BSI has identified 3 plants related to the Study Area. two plants, *Cupparis*

Shevaroyensis and *Cleoxme burmanni* are in the Southern Study Area and one plant *Decaschistiarufa* is in the Northern Study Area. Based on the recommendations of the National Committee on wetlands, mangroves and coral reefs, 15 mangrove areas have been identified for intensive conservation and management purposes, but no protected mangrove area falls in the Study Area.

Totally 7 sanctuaries lie in the Study Area. 4 sanctuaries namely Srivilliputhur Grizzled Giant Squirrel wild life sanctuary, Ultangudi Birds Sanctuary, Kanjiramkulam Birds Sanctuary and Chitragudi Birds Sanctuary are in the Southern Study Area and 3 sanctuaries, Vedanthangal Birds Sanctuary, Karikili Birds Sanctuary and Pulicat Lake Bird Sanctuary lie in the Northern Study Area. No National Park fall in the Study Area.

3.3 Agriculture

(1) Land Tenure and Holding

About 41 % of the Study Area are cultivated and more than 55 % cultivated area are irrigated. The number of operational holders in the Study Area is 1,476,507 in 1990-91 which occupies 18.5 % of the total operational holders in the State. The area operated is 1,150,246 hectares which shares 15.4 % of the total operated area in the State. The average size of operational holdings in the Study Area is 0.78 ha in 1990-91 ranging from 0.69 ha in Tiruvallur, Kanchipuram and Sivagangai districts to 0.99 ha in Virudunagar District. The average size is smaller than that of the State (0.93 ha) and about 78 % of the operational holdings are below 1.0 ha .

(2) Agricultural Production

The major crops cultivated in the Study Area are largely differed by the location of the area. In the districts of Tiruvallur, Kanchipuram and Sivagangai where the percentage of irrigated area to the total cropped area is above 60 %, the major crops cultivated are paddy, groundnut and sugarcane. In these areas paddy, groundnut and sugarcane share more than 60%, 10 to 20 % and 3 to 4 % to the total cropped area, respectively. On the other hand in the Ramanathapuram and Virudunagar districts where the percentage of irrigated area to the total cropped area is 32 % and 33 %, the major crops are diversified as paddy, chili, groundnut and ragi in the Ramanathapuram District, and Cotton, paddy, cumbu (*Pennisetm typhoideum*), groundnut, blackgram, Cholam, greengram, gingelly, chili, sugarcane, ragi (*Eleusine cora cana*), varagu (*Paspalum Scrobiculatum*) and redgram in Virudunagar District.

The crop production in the State varies widely from district to district as shown in the table.

The maximum gross income is obtained by banana with the average gross income of Rs.158,267 in the Study Area followed by mango (Rs.157,432), turmeric (Rs.101,097), sugarcane (Rs.78,175), tamarind (Rs.41,659), tapioca (Rs.31,674), onion (Rs.18,183), chilies (Rs.16,727), paddy (Rs.13,673) and groundnut (Rs.8,999).

Variation of Crop Production in Tamil Nadu

Crops	From	To
Rice	1,537 kg/ha (Ramanathapuram)	3,172 kg/ha (Virudunagar)
Groundnut	973 kg/ha (Sivagangai)	1,786 kg/ha (Tiruvallur & Kanchipuram)
Sugarcane in cane	95 t/ha	107 t/ha
Ragi	929 kg/ha (Ramanathapuram)	2,495 kg/ha (Virudunagar
Cotton	1,014 kg/ha (Virudunagar)	2,279 kg/ha (Sivagangai)

(3) Farming Practice

In the southern part of the Study Area, the timely receipt of rain has a decided influence on the land use and cropping patterns. The farmers in the area adopt the required farming technology in order to meet the insecure rainfall as follows:

- Use of rice seedlings purchased from outside areas.
- Change over cultivation method from transplanting to direct sowing.
- Change over the cultivation crop from rice to cholam/groundnut/cotton.
- Introduction of mixed cultivation such as cholam, cumbu and cotton.

(4) Cropping Pattern

Generally, paddy is cultivated under irrigated condition in Rabi season. In Ramanathapuram District, rainfed paddy prevails in large areas in Summer season (January to June). Sugarcane is cultivated only under irrigated condition. The areas remains only 2 to 3% of the total planted areas due to the long growing duration extending nearly for one year. In some water available areas, paddy in kharif season and irrigated ragi, cotton, groundnut and chillies are also cultivated. For most of the crops, irrigated yields obtained are 2 to 2.5 times more than that of non-irrigated areas.

(5) Livestock

The main livestock in the Study Areas are Cattle (1.359 million heads), sheep (1.138 million heads), goats (0.787 million heads), buffaloes (0.479 million heads) and pigs (46,000 heads). Nearly half of livestock population in the Study Area has been spread in Tirvallur and Kanchipuram districts. Especially, buffaloes and cattle concentrate in the district. Poultry is raised in 12 % of the State in the Study Area, and 42.1 % of the total heads of ducks and drakes in the State is raised in the Study Area, almost concentrating in Tirvallur and Kanchipuram districts. Milk production in the Study Area amounted to 564,200 tones on average of the years from 1990 to 1995, which correspond to 16.2 % of those in the State. Egg production in the Study Area amounts to 149 million pieces per year, which is equivalent to 5.3 % of those

of the State.

(6) Farm Holding Economy

The following 4 categories of farmers are identified upon the sizes of their land holding.

1) Large scale farmers with a land holding more than 10 ha - their farm holding economy is considered very stable for making a good profit. Basically their crops are for economic purposes. Their cropping systems are based on the high profitable marketability with basic crops such as paddy, gingelli, cotton to high-valued cash crops such as sugarcane, vegetables and fruit trees.

2) Medium scale farmers with a land holding of more than 2 ha up to 10 ha - the characteristics of their farm holding economy have been observed similar to large scale farmers, based on high marketable produces, except for a lower annual financial surplus after family expenditure due to a rather smaller farm-size.

3) Small scale farmers with a land holding of 1 - 2 ha - their farm holding economy is basically based on family consumption at first with surplus to be sold in the market. Their cropping system, therefore, is mostly based on staple crops for self consumption, mainly paddy, with a minor part for other cash crops. The revenue from selling the surplus farm produces will be used for paying loans, family expenditure and inputs for the next cropping operations.

4) Marginal farmers with a land holding of less than 1 ha - their production is mainly for family consumption. Their farming is substantially based on traditional farming style to crop mainly paddy combined with millet for assuring their staple food in any cases of rainfall precipitation. They essentially need stable supplies of irrigation water, capital, inputs and knowledge for a stable farming operation, especially in the drought-prone region in the Southern Study Area. Generally, marginal farmers have to do other labour works for earning some revenue for supporting their family expenditure.

Farm holders in the Northern Study Area are basically gaining higher farm revenues than farmers in the Southern Study Area of a same farmland area due to better farming conditions, especially on irrigation water and soil, for assuring 2 crops in a year. Particularly, for marginal farmers of less than half ha their farm revenues could not support the whole family expenditure in a year. The situation of these farmers is more severe in the Southern Study Area.

(7) Agricultural Marketing

The marketing system of agricultural produces in the Project Area is basically similar to the whole marketing system in Tamil Nadu but mostly limited in 5 produces: 1) paddy and foodgrains, 2) sugarcane, 3) cotton, 4) groundnut and 5)

vegetables. In general the marketing system of agricultural produces in the Study Area is not well organized, especially for agricultural produces and the lack of related facilities for supporting marketing such as multipurpose storage, cold storage, transport means, central retailing markets of all goods to facilitate all kinds of marketing activities.

(8) Agro-Industry

In general, the situation of agro-industries in the Study Area is similar to its basic conditions in Tamil Nadu but handloom is basically not carried out in the Study Area. Meanwhile, rice mills and oil mills of cottage or home type are in operation in each village.

In the Study Area, village level agro-industries and even cottage industries are basically not existing. Farmers sell their produces in raw types. Some minor and simple activities like threshing paddy, drying chilli, collecting milk for sale etc., however. have been carried out on family or individual basis.

(9) Agricultural Supporting System

Four (4) research stations out of 37 under the TNAU are located in the Study Area. The research focuses on need-based field-oriented and location-specific research to develop the technology for the benefit of the farming community.

(10) Aquaculture

Tamil Nadu State has an inland waterspread area of about 371,000 ha with 28 reservoirs of 52,000 ha and about 5,400 major and 30,000 minor irrigation tanks offering a good scope for developing inland fisheries. Besides there are about 3,000 small ponds in villages.

In the Study Area, there are two (2) FFDAs, one at Kancheepuram with jurisdiction over Tiruvallur and Kanchipuram districts and another at Ramanathapuram. In the Southern Study Area, intensive activities are in progress only in 179 Panchayat Union tanks under 10 Panchayat Unions in the Virudunagar district at present.

Since the annual rainfall is limited in the Southern Study Area, it seems to be difficult to introduce such pisciculture that needs the water for feeding fish long period. On the contrary, the rainfed tanks in the Northern Study Area have water even during the dry season, therefore, it is considered possible to introduce pisciculture to the pilot tanks in the Northern Study Areas.

3.4 Tank Irrigation

Crop water requirement for paddy in the Southern Study Area is 550mm and amount of rainfall in NE monsoon season is 500mm. Considering the irrigation efficiency and

effective rainfall, it is apparent that for most crops especially paddy, it is not possible to carry out secure agricultural operation under rainfed conditions and the irrigation is inevitable in the area.

(1) PWD Rainfed Tanks in the Study Area

The Study focuses on the 2,093 of PWD tanks commanding areas more than 40 ha except for system tanks as tabulated below.

Districts	Tank Inventory List		Data Not Available	Number of EC Tanks	Study Tanks (estimated)	
	Number of Tanks	Average Command Area (ha)**			Number of Tanks	Command Area (ha)
Northern Study Area	1,214	116.36	85	107	1,022	127,488
Southern Study Area	1,214	97.85	12	131	1,071	86,258
Study Area Total	2,428	106.30	97	238	2,093	213,746

Source : * prepared by PWD in May 1997

Tank command area is reduced from 0.94 million ha in 1961 at peak to 0.63 million ha in 1993, while the groundwater command area increased from 0.5 million ha in 1951 to 1.2 million ha in 1993 in the State, because of deterioration of tanks including the non-reliability rainfall and drought. In the Study Area, irrigated area by canal, tank and groundwater are 1.4%, 62.0% and 36.6%, respectively. Agriculture in Virudunagar district which is the most drought prone area, mostly depends on groundwater at 54 %, and wet area of Tiruvallur & Kanchipuram districts also depend at 50.5 % to enable the second paddy crop after NE monsoon.

(2) Irrigation in Tank Command Area

Mostly basin/flood irrigation for paddy and sugarcane are applied through earth channels after taking off water by sluices from the tank pond. After receiving water from irrigation channel, water is taken by plot to plot method. There is neither diversion nor discharge measurement devices. Temporary earth banks are usually used for changing flow from the irrigation channel to other irrigation channel or to increase the water level in the channel.

Neerkattis are employed by the village under control of the headman, to manage water distribution and sluice operation maintaining flows in the distribution system. Water is supplied by rotation following a set pattern. The traditional leadership at local level declined as political interference in village life create groupism leading to difficulties in organizing collective efforts.

Most of tanks in the Study Area have formal or informal water users' association (WUA). The timing and water distribution of irrigation water is determined by the WUA under the advise of agricultural extension workers. Most cases, the large scale farmers have the priority to get water from tanks specially in drought year. Basically upstream farmers get high priority in the water distribution. Irrigation Management Training Institute (IMTI), PWD, provide water management training to the farmers organization especially for WUAs.

(3) Present Conditions of Irrigation Systems and Facilities

Various constraints such as deterioration, damage, siltation, lacking, etc. on the structures, facilities, command areas as well as catchment areas are identified as summarized in Table S.1, and these constraints have to be mitigated or removed to realize the adequate and optimum operation of the tank system.

(4) Necessity of Rehabilitation of Tank Irrigation System and Facilities

The maintenance and repairs of many of tanks are poor. Almost all tanks require repairs either in tank itself or in their components. Since the tank irrigation forms one third of total tank irrigated area, more attention should be paid for utilizing these storage structures for the benefit of country. To attain maximum productivity from a farm land, water must be supplied and regulated in such a way that maximum production could be obtained from the available water. In fact, the lowest yield per unit area in irrigated land is only from the tank irrigated lands.

Because of scarcity of water resources and limitation of development potential of surface water in the Study Area, the most effective work to maximize the available water resource for the irrigation is canal lining. According to the CWR-Anna University measurement, the irrigation efficiency can be improved by more than 25%. This means, by canal lining only, more than 25% of irrigable area can be extended.

(5) Categorization of PWD Rainfed Tanks

Since the Study for rehabilitation of PWD rainfed tank amounts over 2,300, it is necessary to categorize into several types, and to conduct the feasibility study for each representing category to facilitate the establishment of tank rehabilitation plans.

The following data are used as a data source of tank categorization:

1) Tank Long List: prepared by PWD and handed over to JICA Preparatory Study Team in August 1996.
2) Tank Inventory List : prepared by PWD in January and revised in May 1997.
3) Rainfed Tank Baseline Survey : prepared by Statistics Department in 1995.
4) Social Environmental Survey : conducted on 240 tank areas under supervision of the Study Team in 1996

The tanks are categorized based on 1) factor of water availability (hydrological feasibility) including the agro-climatic condition, which can identify the possibility and degree of difficulty of water storage or needs of groundwater development, 2) factor of cost for rehabilitation which can be determined by the physical dimensions of tanks, 3) factor of benefit which can be determined by the efficiency of O&M of rehabilitated tank facilities and increased agricultural production by tank

rehabilitation.

The following tank categorization is made by the 1) agro-climatic zones from the water availability factor, 2) cultivated area ratio in the command area from the project benefit factor, 3) ratio between free catchment area and command area from the water availability factor, and 4) scale of command area from the efficient O&M and social factors. Also the tank which are no more functioning and they need not to be rehabilitated are measured by cultivation ratio less than 10% even under surplus condition or no information on ayacut in the Tank Inventory List and tanks used by mostly medium to large scale farmers (marginal farmers' share less than 10%).

Category	Agro-climatic Zone	Ratio of Cultivated Area	Ratio of Free Catchment Area / Command Area	Scale of Command Area	Estimated Tank No.
NR-1	Northern	more than 75%	----	Small	262
NR-2				Medium	289
NR-3				Large	248
NR-4		less than 75%		---	223
SP-4	Southern	less than 75%	----	---	220
SR-1		more than 75%	more than 5	---	216
SP-1			less than 5	Small	240
SP-2				Medium	238
SP-3				Large	157
NR	Rehabilitation non-effective tanks : cultivation area less than 10% to registered command area or share of marginal farmer in command area less than 10% or tank data not available				97

3.5 Social Environment

(1) Present Sociological Condition

1) Religion, Caste and Culture

In India, religion can be changed but one's caste can not be changed. The caste in which one is born is immutable. The caste system is also called the '*Varna*' system. There are more than 3,000 castes as against the four (4) *Varnas* presented by the Hindu scriptures (*Vedas*). The traditional *Varna* system stratified society and determined status.

In 'the modernization of tanks' the material aspects can bring in improved storage of water, better techniques of management, etc. However, if the small and marginal farmers refuse to change their practices of cultivation, and stick to 'what was good for our forefathers is good for us' (reverence for the past) and refuse to break habits, then the whole project may not give the results that are expected. The non-material aspects must be taken care of and changed to keep up with the speed and rate of the material aspects in the 'modernization of tanks'. It is, therefore, necessary to educate, create awareness and make the users cooperate and be involved from the initial stages as copartners rather than so beneficiaries of a project.

2) Gender Issue

Since the Constitution of India not only affirms equality to women but urges and empowers the state to take various measures and efforts have been taken to achieve

as envisaged. However, the women in India are still discriminated, exploited and backward. The sex ratio, women's population to 1,000 males, indicates different values in the Northern and the Southern Study Areas. The ratio of the Northern Study Area is estimated at 960, while that of the Southern Study Area is 1,010.

In a hierarchical and patriarchal society, the women come lowest because of no access to land and no means of production. They are exploited also in wage discrimination. Thus, they are considered as cheap labour forces to work for a pittance.

It is significant that the women's share in the marginal workers are quite large followed by the agricultural labourers. The share of women in the marginal workers exceed 90 %, while that of agricultural labourers follows with a range from 45 % to 55 %. It means that the employment opportunity for women is quite less than that for men and only temporary opportunity is available for them. Furthermore, in agricultural activities, mainly the common works such as weeding, harvesting, etc. are carried out by women. The wages for women are within a range from Rs. 25 to 30/day, while those for men within a range from Rs. 40 to 50/day.

(2) Social Environment Survey

To grasp the present conditions of the marginal and small scale farmers whose intentions are often ignored during project implementation, a social environment survey was carried out during the field survey consisting of 1) rural community survey, and 2) farmers' organization survey. The survey was carried out for the pre-selected villages sampled at random for the categories. 240 villages consisting of 119 villages in the Northern Study Area and 121 villages in the Southern Study Area were selected in all so as to select 40 villages in each category.

Interview surveys were made with a village administrative officer (VAO) or a village or Panchayat president of each village. Furthermore, five marginal farmers (landholder less than one ha of farm land) were selected in each particular village, and interview surveys were carried out for them also to grasp their intentions, living conditions, etc.

(3) Farmers' Organization

According to the results of the social environment survey conducted during the field survey, none of the villages covered by the survey has formal organization but has informal ones. 65 %, 76 %, 79 % and 82 % of the villages have informal organizations in Tiruvallur, Kanchipuram, Ramanathapuram, Sivagangai and Virudunagar districts, respectively. Those organizations have been maintained as a part of the traditional village system for years, and are considered active only the period when the scarcity of tank water takes place or some conflict occurs in distribution of water among villagers.

3.6 Database and Geographical Information System (GIS)

Geographical Information System (GIS) was formulated using MapInfo (UK version) in

the Study provides tank information on the topographical map base, based on the desired criteria such as tank location, engineering and social aspects. Many irrigation tanks including other type of tanks, such as Panchayat and Ex-Zamin tanks, are distributed closely, and in some tanks, the tank rehabilitation was completed under EC program. So formulation of geophysical information becomes necessity considering other program.

GIS is corresponded with Tank Database System (by MS ACCESS) on the basis of inventory list and both systems can be offered such as 1) use the output as an location map of each tank for rehabilitation works, 2) identify the administrative information, such as district, taluk, and development block, of the targeted tanks, 3) easy access to the tank data on engineering and social aspects for selection of tanks, and 4) clarify the dependability of well and well irrigated area.

4. THE MASTER PLAN

4.1 Objectives of the Master Plan

The objectives of the Master Plan is to increase the agricultural production and to improve living standard of farmers, especially small holding farmers, through the rehabilitation of minor irrigation tanks. As shown in Fig. S.2, it can be achieved by the following activities:

1) Maximization of water utilization by rehabilitation of tank irrigation facilities and introduction of proper O&M system, and

2) Introduction of sustainable agricultural development by appropriate cultivation system, proper inputs for agricultural production including the irrigation, qualified seeds, fertilizer/chemicals, and supporting system.

4.2 Basic Strategy

(1) Present Constraints

Based on the results of field survey, the present conditions of the Study Area are grasped, and the development potential and constraints for rehabilitation of minor irrigation tanks are analyzed. The following characteristics and problems of natural, social and economical conditions were analyzed for the respective categories.

- Existing conditions of damages on tanks and related irrigation facilities
- Structure of poverty and regional difference (present situation of marginal and landless farmers)
- Needs of beneficial farmers
- Agricultural supporting services
- Farmers' organization and human resources
- Marketing and distribution systems

- Existing development projects and schemes

Then, the present constraints of tank irrigation are fund as follows;

1) Shortage of Stored Water in the Tank
2) Deterioration of Tank Irrigation Facilities
3) Poor Irrigation Management
4) Farmers' Strong Persistent Inclination toward Paddy Cultivation
5) Poor Coordination of Water Distribution among Chained Tanks
6) Lack of Ownership Awareness for Tank Irrigation Facilities
7) Poor Accessibility to Market

(2) Basic Concepts and Strategies for the Master Plan

Basic concepts of the Master Plan are proposed as follows (also ref. Fig. S.3):

1) Maximization of water resources for minor tank irrigation system including conjunctive use of surface water and groundwater, total management of chain tank basin, increasing the irrigation efficiency by proper water distribution, crop diversification for water saving and crop benefits.
2) Establishment of systematic method for rehabilitation of minor irrigation tanks in the State, the Project shall be a model of remaining tank rehabilitation in the State and expectable synergetic effects to rural development.
3) Formulate improvement plan of irrigation/drainage facilities include canal lining and on-farm development (OFD) for sustainable agricultural development in the command area.
4) Farmers' participation in efficient operation and maintenance
5) Establishment of sustainable agricultural production system
6) Improvement of rural infrastructure for agricultural development
7) Institutional development for the project implementation

4.3 The Master Plan for Rehabilitation of Minor Irrigation Tanks

(1) Component of the Master Plan

Based on the basic concepts of the Master Plan, the following components are considered to be included in the Project of Rehabilitation of Minor Irrigation Tank for Rural Development:

1) Watershed management and total hydrological and hydra-geological assessment of basin of tanks in chain,
2) Conjunctive use of surface and groundwater in the catchment and command area including the sinking community wells for irrigation in the water scarcity area,
3) Rehabilitation and improvement of tank facilities (ref. Table S.1),
4) Efficient irrigation operation and management through canal lining, on-farm

development and establishment of water users' association through the community organizer system,

5) Crop diversification for the improvement of marginal and small scale farmers through cultivation of water-saving and high beneficial crops instead of paddy in the water scarcity area including the demonstration farms,
6) Strengthening agricultural support and extension to achieve the sustainable agricultural development and crop diversification including agricultural input distribution improvement, agricultural credit and strengthening technical extension services,
7) Value-added agricultural products by crop producers association, village industries,
8) Improvement of rural infrastructures related to the agricultural development such as access roads to cultivation fields and markets, community centers, and
9) Institutional strengthening to support the early and easy achievement of the Project plan, including turnover the maintenance of irrigation system to the WUAs.

(2) Total Water Management in the Chain Tank Basin

More than 20% of land surface is covered by waterspread area of tanks in the Study Area. These high density tank installation cause the tight interaction of hydrological and social conditions of connected tanks. Social survey of EC project have shown that there is considerable interaction among tanks within a chain and that activities within one tank command area may provide cause for conflict with farmers of the next tank. In collaboration with organization, such as PRADAN, the Project shall be implemented based on hydrological and social studies for the sustainable water resources and agricultural development.

(3) Conjunctive Use of Water Sources

A simulation study on Srivilliputhur Big Tank in Ramanathapuram concluded that the investment strategy of sluice and rotation management, canal lining and well development is most recommendable.

The availability of groundwater in many tank command areas is limited due to geologic nature of underground formation (hard rock) which constitute the aquifer. The major sources of recharge for these aquifers are:

- downward or lateral seepage from tank, and
- downward percolation from the channels and irrigated paddy fields
- the yield of wells in command area is mainly dependent on the tank storage. The well facilitate to capture and re-use portion of irrigation water lost by deep percolation from the irrigated rice fields and from tanks.

Considering the potential of groundwater resources in the tank command area which receive good replenishment not only from rainfall and tank storage, but also from

the applied irrigation water, sinking community wells for irrigation, spaced appropriately in the middle and tail reaches will be quite helpful for the poor farmers to tide over the water scarcity experienced during certain periods of the year. This will also help in capturing and re-using a portion of irrigation water lost by deep percolation from the irrigated rice field and effective use of carry-over storage in good years during the second crop season.

The northern part of Northern Study Area, such as Poondi, Minjur, Thiruvallur and adjacent are over exploited area, and some areas in Virudunagar District is groundwater scarcity area, such as Rajapalayam, Vatrap and Srivilliputhur. Some of coastal area of both Study Areas are facing the sea water intrusion caused by over extraction of fresh aquifer. Groundwater in Ramanathapuram district was observed to be high salinity water (EC 0.75 - 2.25 dS/m) in December 1996. These area shall be carefully studied before installation of wells and to be properly managed during the well operation.

The community irrigation wells are necessary to be maintained by the farmers. Before going for implementation, modernization works are to be decided duly considering the following points:

- estimate groundwater development potential by water balance analysis within the total catchment area of tanks chained
- confirmation of groundwater quality for the agricultural purposes
- willingness of the farmers to use community irrigation wells and maintain them according to the norms to be prescribed by the PWD
- selection of sites for wells and type of well and norms for using the community well
- availability of power connection, etc.

(4) Farmer's Participation

As infrastructure improvement measures, lining of canals and on-farm development are proposed to achieve an efficient irrigation operation and management and to attain the sustainable agricultural development. To realize such sustainable agriculture under the rainfed tank irrigation, it is considered to be indispensable to involve the beneficial farmers in planning, implementation and operation and maintenance of those proposed measures.

The water users' (farmers') active participation is considered to be essential to make such farmers to be responsible for operation and maintenance of the facilities as well as to ensure equitable water sharing among the users. To facilitate these farmers' participation in the course of the implementation, the water users' association (WUA) is proposed to be established by-law to coordinate the member farmers. The functions and responsibilities of the association are proposed as summarized below.

- to decide whether to take up construction or not and to ensure the members

willingness to take up the construction
- to allocate and distribute irrigation water within the scheme on an equitable basis
- to operate and maintain lift pumps and ancillary equipment
- to maintain channels and water courses
- to prepare and agree cropping patterns and schedules for each season
- to resolve minor disagreements in water allocation
- to act on behalf of the members with respect to water use

The community organizers are proposed to play a vital role in building a situation ideal for the total involvement of the farmers. The following task accomplishments are proposed for the community organizers:

- Integration and social investigation
- Animation
- Formalization
- Mobilizing financial resources

The process to be taken, the factors to be considered in, and the outcome expected in each activity of the community organizer are summarized in the following table.

Matrix for Community Organization

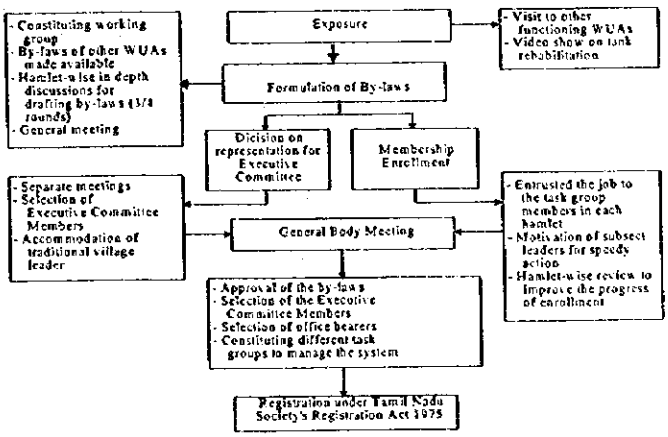
Activities	Process	Factors	Outcome
Integration and Social Investigation			
i) Integration and Familiarization ii) Creating Participatory Awareness	- Living with community - Familiarization of village and tank - Contacts with individuals, group and local officials - Meeting with community leaders - Street corner meetings - Field meetings with farmers	- Caste system - Village spread and hamlets - Literacy - Tradition and culture	- Social acceptance - Interest creation among community towards participatory concept and need for group action - Strategy design for motivation and development of WUA
iii) Social Investigation	- Collection and analysis of primary and secondary data - Studying the inherited social relationship between different caste, hamlets and village - Understanding farmers' problems and their response and behavior towards tank irrigation	- Data availability - Social equation betwee hamlets and village and between different caste groups - Leadership quality	- Emergence of a realistic social spectrum - Understanding of tank problems - Better understanding of the behavior of sharing common property resource and farmers' perception towards sharing of tank water - Scope to refine the strategy towards motivation
Animation			
i) Identification of a Leader	- Organizing group discussions - Skill testing among different potential farmers by assigning task accomplishments - Open discussions on common issues and developing skill on decisio making - Free interaction among farmers in task accomplishment and decision making results in emergence or potential leaders	- Existing social relationship between village and hamlets - Power polarization between different caste groups - Traditional leadership and its role	-Emergence of acceptable leadership
ii) Organizing Farmers through Meetings	- Motivate and facilitate better interaction among leaders and farmers - Organize discussions to elicit different views of approach among farmers - Initiate process to crystallize consensus on issues by entry program, exposure visits, etc.	- Prevalent social system - Tradition - economic benefits	- Awareness on the benefits of unified action - Realization of the need to organize - Designing the steps to organize
Formalization of Water Users' Associations (WUAs)	- Membership enrollment by task group members - Hamlet-wise to improve enrollment progress - Formalization of by-laws for the WUA by group discussions - Structuring of the association on the composition of the Executive body - Convening the general body meeting with 2/3 representatives to approve the by-law and to elect/select office bearers - General body also nominates different task groups for specific task accomplishment - Formal registration under the relevant State Government Act	- Eagerness to organize and act with a spirit of accommodation	- Formation of legally constituted Farmers Organization with its task groups

It is necessary to grasp and analyze the socio-economical characteristics and nature of each community in these aspects to organize such community in the most effective and suitable manners as well as to make the organized community

sustainable in all the aspects. It is, therefore, proposed to carry out the social investigation before commencing the implementation to find out the soci-economical constraints of each community.

The Participatory Rural Appraisal (PRA) is the method being applied for the Tank Modernization Project of EC to select the tanks suitable for introducing the tank modernization together with social scoring method. It is a means of collecting socio-economic and physical information through close interaction with local inhabitants using various techniques. It is also a systematic approach which helps resource poor communications to articulate their felt needs and prioritize effectively. It enables these communities to take an active role as equal partners in their own development. In addition, it can provide an improved sense of responsibility and ownership by the community in natural resource management and care for the local environment.

The formation of Water Users' Association (WUA) is one of the most important targets of the community organizers' tasks, and the work flow of WUA formulation is presented in the figure.



The WUA involves only the farmers who own some farm land irrigated by the respective tank system. The landless farmers usually consisting of scheduled castes and tribes. According to the results of the social environmental survey, about 20 - 30 % of the village community is composed of such population, and they are facing the various difficulties in living such as low diet, worse health and nutrition conditions, etc. Therefore, it is recommended to involve such groups of people and to make the organization to provide the job opportunities in the organization activities to improve their living conditions. In addition, women and children may also be involved by holding various classes and lectures to enlightening them.

(5) Rehabilitation and Improvement of Irrigation Tank Facilities

Irrigation tank facilities can not be functioning satisfactorily due to unsuited operation and inadequate maintenance and deterioration. Rehabilitation and improvement plan of the irrigation tank facilities are proposed as follows for maximized utilization of water resources.

1) Soil and water conservation in the catchment area
2) Rehabilitation and strengthening of tank bund

3) Repairs and reconstruction of sluices
4) Repairs and construction of surplus arrangement
5) Improvement of supply channel including desiltation

(6) Efficient Irrigation Operation and Maintenance

The canal lining is the most effective measure to maximize the existing water resources in the command area through the reduction of water losses. The canal lining can reduce the area for irrigation canal and reduce the maintenance requirements. And it contributes to the equity of water distribution from head farms to tail-end farms.

At the outlet of sluices, at the beginning point of the irrigation canal measurement devices shall be installed to confirm the accurate irrigation water distribution.

In order to achieve the efficient irrigation management, the on-farm development (OFD) is essential, because it is connected directly to actual water users. At present, the OFD works are planned and executed by the Agricultural Engineering Department under the overall control of PWD. Therefore, the OFD shall be planned based on the direct discussion with direct beneficiaries, farmers.

(7) Crop Diversification for Sustainable Agricultural Development

It seems that present agriculture in the State is biased to food crop production, especially rice production, in which high water consumption is required. However, considering the agricultural situations in the State such as the limited available water sources, the small size of operational holdings, the high irrigation rate in near limitation and the fortunate temperature, more sustainable and more high profitable farming should be introduced with crop diversification and improved cropping pattern.

(8) Strengthening of Agricultural Support and Extension

To attain success of the sustainable and profitable agriculture, strengthening the agricultural support and technology extension is indispensable. The outline will be planned as below.

An experimental demonstration farm (EDFs) each 5 districts of the Project Area will be established. The activities of the EDFs are verification and demonstration of new technology / new varieties / new crops and farmers' training. The verification experiments of improved farming method and new crop for diversification include not only evaluation of the crop production technology but also economic evaluation of the technology.

Timely supply system of new seeds and seedlings to the required farmers is important. Especially, on the special materials such as turmeric, grafted tamarind

and mango, propagation activities of the seedlings by the government agency will be needed.

The government agency concerned will support the growers on the development of markets for new agricultural products and the market price information. Keeping pace with introduction of cash crops, establishment of growers' association will become important. The government agency concerned needs to support the establishment of growers' association.

(9) Value-added Agricultural Products

In order to increase the value of the agricultural products for the farmers under the Project, the following activities will be proposed and installed as a value-adding agricultural products: 1) Processing of dried mango chips, 2) Canned/packed mango juice, 3) Tomato juice, 4) Bottled vegetable pickles, 5) Powdered turmeric, 6) Dried banana chips, 7) Roasted peanuts, 8) Bottled tamarind paste, 9) Prevention of grain loss by improved post harvest practices.

(10) Improvement of Rural Infrastructures

The most of the existing rural infrastructures are considered sufficient for the farmers' living in rural areas, but the community halls and agricultural feeder roads are proposed to be provided to facilitate the envisaged project effects.

A community hall is proposed to be provided for each village of the tank system. Various activities are envisaged for the institutional development. They will functions meeting space for operation of WUA, agricultural extension, cultural events and health-care, etc.

There exists no farm road in cultivated areas to approach the irrigated farm. It is proposed to provide farm roads with a width wide enough to enable the bullock cart to pass in order to facilitate carrying out the harvested crops. In addition, it is also proposed to improve the feeder road to main roads running near the village in order to facilitate the effective access to market places with coordination of other Government schemes.

(11) Institutional Development for the Project Implementation

In general, the programs of institutional development will be composed of 2 parts: 1) the organization on management and O&M for the core body of the Project, and 2) the organization and operation of related programs for farmers and local inhabitants to carry out smoothly and realize the Project components.

For the management and O&M of the Project aiming at the core personnel concerned, there are also 2 parts related to the 2 phases of project implementation: 1) the management and O&M in the construction phase mainly concerned PWD

officials, and 2) the management and O&M in the project-operation phase mainly for the concerned local body to be involved in the Project management.

For the management and O&M in the phase of construction, the formation of related committees, e.g. from ventral level with the central steering committee for directives and controlling works to local bodies at each construction site with site office for implementation and field supervision of works related to construction of project structures and facilities.

For the management and O&M in the phase of project-operation, the formation of the farmers' organizations with each core competent personnel for each site and their union-organization in each region will be carried out simultaneously so that the management for project operation can be properly handled by farmers themselves when the Project is handed over to them.

For the realization of project-components related to these programs, local farmers and inhabitants will be sufficiently trained for clearly grasping the details of operation works and sufficiently supplied with inputs for their fruitful application on fields.

4.4 Project Implementation

(1) Objectives

The final objective of the Project is to improve the farmers' living standards in rural areas through the rehabilitation and improvement of minor irrigation tanks. And the development plans of each sector have to be established so as to improve agricultural productivity by supporting and reinforcing the present organizations for better farming practices, operation and maintenance, water management, etc. Basically, whole of PWD rainfed tanks, except modernized EC tanks, in the Study Area is expected to be rehabilitated/improved under the Project. Based on the tank categories, tanks having urgency of rehabilitation will be taken up on priority basis.

(2) Component of the Project

1) Civil works will be included for the Project:
   a. Rehabilitation of supply channel
   b. Rehabilitation and improvement of tank bund
   c. Rehabilitation or reinstallation of head sluices
   d. Rehabilitation or extension of surplus arrangement
   e. Improvement of distribution system (field channel lining and on-farm development)
   f. Community wells for supplemental during marginal stage of cultivation
   g. Improvement of rural infrastructures (inspection roads, community halls, etc.)
   h. Building of Project office

2) Agricultural development
As a part of the technical agricultural extension, experimental demonstration farms will be established for the verification of appropriate crop production, crop diversification, and economical evaluation.

3) Institutional Strengthening
a. Farmers participation and community organizer system
b. Farmers and government field staff training
c. Monitoring & evaluation

4) Procurement of office equipment and inspection vehicles

(3) Implementation Method

The executing agency will be Water Resources Organization (WRO) of the Public Works Department of GOTN. The Project will be executed under a Steering Committee; its primary task will be reviewing the Project's progress and discussing long-term strategic and policy issues. It would consist of representatives from the Directorate of Agriculture, the Department of Agricultural Engineering, the Department of Environment and Forestry and the Department of Rural Development of the State Government and Ministry of Water Resources and the Department of Economic Affairs of Government of India. The chairman of the Steering Committee would be the Secretary for PWD.

The Project Management Unit (PMU) under the Chief Engineer, DRCS in the PWD-WRO, will be responsible for overall coordination and monitoring the Project implementation.

The consultant shall be employed by the Executing Agency selected under an international competitive bidding (ICB) based on the guidelines of the lending agency for the Project. The consulting services to be provided would consist of: 1) providing assistance to PWD staff in the preparation of guidelines together with PWD for feasibility studies and detailed design, preparation of tender documents, evaluation of tenders, supervision of the construction works by suggesting appropriate methodology and training; and 2) assisting PWD for monitoring of the Project progress, etc.

After completion of the tank rehabilitation/improvement, the operation of irrigation and tank will be handed over to WUA legally established. On the other hand, the major maintenance works will be under the responsibility of the PWD-WRO until the correspondent legislation is completed; after formalization of WUA, the responsibility will also be handed over to the WUA which will financed through the water fees collected from the beneficiaries (farmers).

(4) Implementation Procedure and Schedule

The implementation procedure of each tank rehabilitation works is considered as follows:

a) public announcement of proposal of tank rehabilitation to the farmers;
b) selection of tank by the district level committee;
c) determination of hydrological characteristics and approximation of irrigable area by the PWD's field office staff based on the guidelines;
d) preliminary estimation of construction costs by the PWD's field office staff;
e) social screening and determination of requirement of community organizer and dispatching of community organizer by the PWD;
f) provision of feasibility study including topographic mapping based on the existing village maps by the PWD field offices;
g) detailed design and preparation of tender document by the PWD field office staff based on the guidelines;
h) tendering civil works under a national/local competitive bidding (NCB/LCB) carried out by the PWD based on the guidelines;
i) construction by contractor under the supervision of the PWD field engineers based on the guidelines;
j) preparation of operation and maintenance manual;
k) final inspection by the PWD and the consultant and hand-over to farmers

(5) Phasing and Prioritization

Considering the previous experiences of PWD under the EC Project, the rehabilitation of 2,097 tanks in the Project will be implemented about 13 years. Therefore financial arrangement, the Project shall be implemented with 3 phases. For selection of tanks for rehabilitation, criteria for the prioritization shall be established.

Based on the feasibility study results on the pilot tank representing tank category, prioritization is studied. The results of the feasibility study on 10 pilot tanks are summarized as follows:

Tank Category	Name of Tank	Ayacut (ha)	No. of Farm	Average Farm Holding (ha)	Present Cultivation Ratio (%)	Rehabilitation Cost Financial (Rs/ha)	Economic Incremental Benefit (Rs/ha)	EIRR Basic Condition
NR-1	Echur	58.68	166	0.35	80%	42,996	12,407	22.80%
NR-2	Cherukkanur	91.26	268	0.34	91%	45,803	9,661	15.90%
NR-2	Polambakkam	94.59	139	0.68	84%	38,683	14,516	29.60%
NR-3	Vadakkupattu	417.21	355	1.18	89%	42,312	5,507	7.40%
NR-4	Enadur	574.67	448	1.28	56%	29,244	4,793	11.70%
SR-1	A. Ramalingapura	76.53	49	1.56	86%	72,128	14,288	14.70%
SP-1	Pandikanmoi	41.88	140	0.38	97%	62,989	11,027	12.30%
SP-1	Siruvalai	49.25	106	0.46	100%	55,350	7,901	8.70%
SP-2	Kurumbi	52.67	112	0.47	99%	40,877	21,386	40.10%
SP-4	Sengangulam	99.23	313	0.32	50%	31,906	8,029	19.70%
Average(Total)		(1,555.97)	(2,066)	0.75		46,229	10,952	18.30%

From the above table, it is possible to identify the following tendencies:

In the Northern Study Area:

- the smaller scale of tanks have the higher economic priority,
- tanks having a present cultivation ratio of less than 75% show smaller economic priority, and
- tanks having small average farm holding area in their ayacut show higher economic priority.

In Southern Study Area:

- larger-scale tanks have the higher economic priority,
- tanks having a present cultivation ratio of less than 75% show a higher economic priority, and
- tanks having small average farm holding area in their ayacut show a higher economic priority.

Considering the above results and regional distribution in the Project Area, and efficiency of financial usage, etc. the tank category to be implemented in each phase are as shown in the table:

The Project implementation schedule, assuming the introduction of foreign financial assistance, is shown in Fig. S.4 including the schedule of application of foreign assistance.

Number of Tanks and Command Area by Phases

Phase	Category	No. of Tanks	Average Area(ha)	Total Area(ha)
Phase-1	NR-1	262	49.41	12,945
	50% of NR-2	145	80.77	11,712
	SP-4	220	82.32	18,110
	SP-3	157	171.58	26,938
	Subtotal	784	88.91	69,706
Phase-2	50% of NR-2	144	80.77	11,631
	NR-3	248	255.68	63,409
	SP-2	238	69.73	16,596
	50% of SP-1	120	46.68	5,602
	Subtotal	750	129.65	97,237
Phase-3	NR-4	223	124.62	27,790
	SR-1	216	62.09	13,411
	50% of SP-1	120	46.68	5,602
	Subtotal	559	83.73	46,803
Total	Total	2,093	102.1	213,746

4.5 Project Justification

(1) Basic Justification on Project Framework

Basically, the Project is formulated to support and enhance agricultural production in Tamil Nadu. The agricultural sector is the predominant economic sector in this state, employing about 60% of its labour-force and using 45 % of its total land area. Taking into account the present basic conditions for agricultural production activities, irrigation water has been considered as the most basic factor determining the development of this sector. According to some estimations, the area presently

subjected to irrigation in the State ranges from 2.3 to 2.8 million ha. However, in fact, the more accurate estimated irrigated area is far below from this figure. On the ratio of irrigation sources, wells represent 40%; surface irrigation, 33%; and tanks, 27%. Recently, the ratio for tanks has been gradually decreasing due to a decrease in total storage capacity mainly as a result of the deterioration of the rain-fed tanks.

As aforementioned, the total surface water resources available in the State are estimated at 34,000 million m^3(MCM) at present of which 97 % are already developed for an annual water resource per capita of 600 m^3, which is considered to be very low in comparison with the national average of 4,000 m^3 per capita. In this section, the efficient storage and use of the presently available water sources is essential for the State agriculture.

The Project Area includes almost 49 % of total rainfed tanks in the whole State. Since the average command area for a rainfed tank is 103 ha. According to the data of DOA, the average shares of net irrigated areas by sources showed that 62 % of the sources is represented by tanks, 36.5 % by groundwater sources and 1.5 % by canals. This shows a basic insufficiency of irrigation by tanks due to lack of water.

Besides, the Project aims at additional benefits coming from new cropping patterns introducing more cash-crops in the Project and value-added programmes to be intensively carried out along with other basic programmes for improving rural life.

With the totally combined application of all mentioned Project, the Project could prove its vitality in terms of becoming a basic national project for India itself and a basic human needs (BHN) project in reference to the issue of poverty alleviation in the State

(2) Evaluation Methodology

The Project implies the basic characteristics of a national project for solving the crucial problem of rural poverty in India. As a matter of fact, the economic analysis with economic prices based on national point of view will be basically carried out at first , after the general justification of the Project framework. Besides, the sensitivity analysis based on 3 cases: 1) increase of Project cost at 10 %, 2) decrease of Project benefit at 10 % and 3) three-year delay of Project benefit will be made to cope with these possible risks. Apart from these analyses, the financial analysis on farm budget of typical marginal and small farmers will be performed as well.

The framework of evaluation for the Project implementation will be carried out in an order 1) General justification, 2) Economic analysis, 3) Sensitivity analysis, 4) Financial analysis, 5)Environmental assessment, 6) Gender, and 7) Overall evaluation.

(3) Project Costs

Project costs for each pilot tank are estimated as shown below:

(Unit : Rs.X 1,000)

Tank Category	Name of Tank	Ayacut (ha)	Tank Rehabilitation Civil Works	GOTN & Other Expenses	Contin-gencies	Total Cost	Average Cost (Rs/ha)
NR-1	Echur	58.68	1,717	582	224	2,523	42,996
NR-2	Cherukkanur	91.26	2,848	962	370	4,180	45,803
NR-2	Polambakkam	94.59	2,493	852	324	3,669	38,788
NR-3	Vadakkupattu	417.21	12,023	4,067	1,563	17,653	42,312
NR-4	Enadur	574.67	11,449	3,869	1,488	16,806	29,245
SR-1	A. Ramalingapuram	76.53	3,759	1,272	489	5,520	72,129
SP-1	Pandikanmoi	41.88	1,797	607	234	2,638	62,989
SP-1	Siruvalai	49.25	1,857	627	242	2,726	55,350
SP-2	Kurumbi	52.67	1,466	496	191	2,153	40,877
SP-4	Sengangulam	99.23	2,156	729	281	3,166	31,906
Average (Total)		(1,555.97)				(61,034)	39,226

Based on the average unit cost of construction of 10 pilot tanks, the total Project cost is estimated as follows:

Item	Cost	
Tank Rehabilitation Costs	5,436	million Rs.
Community Well Construction Costs	275	million Rs
5 Demo. Farms & Community Centers	354	million Rs
Construction of Project Office	57	million Rs
Total Initial Cost for Civil Works	6,127	million Rs
Procurement of Inspection Vehicles and Motor Cycle	153	million Rs
GOTN Establishment & Other Administrative Cost	1,931	million Rs
Training & Study Visits for Farmers and Project Staff	214	million Rs
Engineering Service-Fees	100	million Rs
Total Initial Investment Cost	8,519	million Rs

(Note : cost escalation, contingencies and compensations are not included)

This initial investment cost will be evenly allocated for the first 5 years of each phase of implementation. An annual cost for O&M. of Rs.445 million (5 % of the investment cost) will be applied through the project life (30 years). For the replacement cost to be applied for civil works related to tanks and well only, 60 % of their initial investment costs are evenly applied in the 15th and 16th years of the Project life in each phase. For the economic analysis with economic prices, a Standard Conversion Factor (SCF) of 0.80 generally applied in India is applied to the corresponding market prices in this analysis.

(4) Project Benefits

For the incremental crop benefits, the total command area of 10 pilot tanks are summarized as follows:

Incremental Economic Benefits

Tank Category	Name of Tank	Ayacut (ha)	NPV without Project (Rs.X1000)	NPV with Project (Rs.X1000)	Incremental Benefit (Rs.X1000)	Value Added (Rs.X1000)	Total Incremental Benefit (Rs.X1000)	Average Total Incremental Benefit (Rs./ha)
NR-1	Echur	58.68	961.6	1,609.2	647.6	80.5	728.1	12,408
NR-2	Cherukkanur	91.26	2,734.3	3,443.8	709.5	172.2	881.7	9,661
NR-2	Polambakkam	94.59	1,030.4	2,289.0	1,258.6	114.5	1,373.1	14,516
NR-3	Vadakkupattu	417.21	9,420.8	11,158.9	1,738.1	557.9	2,296.0	5,503
NR-1	Enadur	574.67	5,008.0	7,392.8	2,384.8	369.6	2,754.4	4,793
SR-1	A. Ramalingapuram	76.53	770.5	1,775.2	1,004.7	88.8	1,093.5	14,288
SP-1	Pandikanmoi	41.88	172.9	604.5	431.6	30.2	461.8	11,027
SP-1	Siruvalai	49.25	663.7	1,002.7	339.0	50.1	389.1	7,901
SP-2	Kurumbi	52.67	1,041.0	2,064.2	1,023.2	103.2	1,126.4	21,386
SP-4	Sengangulam	99.23	1,032.4	1,742.0	709.6	87.1	796.7	8,029
Average					1,024.7	165.4	1,190.1	10,951

Note : For the annual value-added benefits from post-harvest treatments, 5 % of the net annual production value would be considered to be the result of treatments such as storage for off-season prices, primary processing etc. from related institutional programmes.

Based on the average incremental benefits (Rs.10,951/ha), the Project Benefit is estimated.

(5) Economic Analysis of the Project

The economic analysis judges the project viability in terms of direct contribution to the national economy. For this economic analysis, the EIRR is estimated.

From the annual disbursement of project costs and benefits, the basic economic internal rate of return (EIRR) was estimated to be 18.8 %.

(6) Sensitivity Analysis of the Project

For the sensitivity analysis in the aforementioned 3 cases, the EIRRs are estimated as follows:

1) Increase of Project cost at 10 % EIRR: 17.0 %.
2) Reduction of Project benefit at 10% EIRR: 16.8 %
3) Delay of Project benefit (3 years) EIRR: 12.3 %

In the sensitivity analysis of these 3 cases, the EIRRs show a decrease compared with the basic case, in which the lowest (12.3 %) is for the risk case of benefit-delay for a period of 3 years.

(7) Financial Analysis of Average Farm Budgets

In the financial evaluation, mainly analyzing the farm budgets for the categories of small and marginal farms in both cases of "without project" and "with project" as shown in Table S.4, the farm budgets of these farm categories are proved to be largely improved with an remarkable increase of the original incomes (1.3 times to

4.1 times or Rs. 3,367 to Rs.27,561), as shown below.

Tank Category	Name of Tank	Ayacut (ha)	No. of Farm	Average Farm Holding (ha)	NPV without Project (Rs.)	NPV with Project (Rs.)	Value Added (Rs.)	Incremental Benefit (Rs.)
NR-1	Echur	58.68	166	0.35	4,798	9,875	494	5,571
NR-2	Cherukkanur	91.26	268	0.34	10,260	13,812	691	4,242
NR-2	Polambakkam	94.59	139	0.68	6,553	19,727	986	14,160
NR-3	Vadakkupattu	417.21	355	1.18	26,404	34,415	1,721	9,732
NR-4	Enadur	574.67	448	1.28	10,278	19,621	981	10,324
SR-1	A. Ramalingapuram	76.53	49	1.56	8,951	34,773	1,739	27,561
SP-1	Pandikanmoi	41.88	110	0.38	-677	4,391	220	5,288
SP-1	Siruvalai	49.25	106	0.46	3,627	8,187	409	4,969
SP-2	Kurumbi	52.67	112	0.47	8,004	19,608	980	12,585
SP-4	Senganguiam	99.23	313	0.32	2,479	5,568	278	3,367
Average(Total)		(1,555.97)	(2,066)	0.75	(80,678)	(169,977)	8,499	9,780

The living conditions of the landless farmers also would be improved to some extent as more job opportunities would be obtained from the medium and big farms who are also beneficiaries of the Project.

(8) Environmental Assessment

From the results of the environmental impact assessment for the Pilot Tank Areas, it can be said that basically the Project will not induce any significant direct negative environmental impacts excepting groundwater component at some areas. A summary of likely environmental impact in 10 Pilot Tank Areas is presented in Table S.2.

The groundwater development in the areas where high saline groundwater and/or likely sea water intrusion are observed may induce significant impacts on soils. In such areas groundwater development is not recommended. Thus, the groundwater development needs careful planning regarding water quality, water table, scale of development and selection of crops.

In addition to the above, some minor impacts may be induced such as increase of conflict/friction on water sharing, increase of agrochemical use, outbreak of mosquito-related diseases and destroying peacocks nests in the southern area. However, these minor impacts can be avoided through appropriate development procedures and countermeasures.

Post-project monitoring and supporting services are required for groundwater development, agrochemical use, water-users association (WUA) and outbreak of mosquito-related diseases. Such monitoring and support services shall be conducted by relevant government agencies utilizing existing organizational structures and staff.

As for the environmental policies and ordinances in India, the Government of India

enacted the Environment (Protection) Act of 1986 under the Constitution and the Environment (Protection) Rules of 1986. According to the Notification on Environmental Impact Assessment of Development Projects of 1994, all the projects listed under Schedule-I are required to obtain environmental clearance from the Central Government. For the irrigation sector, among the projects under Schedule-I, all river valley projects including hydropower, major irrigation and their combination including flood control, where the investment is Rs. 500 million or above, only need environmental clearance from the Central Government.

According to the Environment and Forests Department (EFD) and the Tamil Nadu Pollution Control Board (TNPCB), the Project does not require environmental clearance from the Central Government, as far as the Project is going to be implemented in the existing minor irrigation tanks.

(9) Women in Development (WID)

The following effects are expected to be induced to the women of marginal farm families in the villages by modernizing the tank irrigation system.

- Women in the Study Area are mainly employed in hard works of agricultural practices such as sowing/planting, weeding and harvesting, and their wage rates are set rather low. If marginal farmers' income is improved, they will be able to buy draught animals such as cows, etc. As a result, some of the women's work load in agricultural works will be done using those animals; in the case for some farmers, improvement of income may allow women to be free from such hard farm labor. Women will be able to have opportunity to get employed in the other works where salary may be higher.

- Women will be able to become more educated in the aspects of family planning, literacy, health and nutrition, etc. through the various activities carried out by the women and youth clubs under farmers' organization.

- Women and youth in the villages of the modernized tank will get in better diet and improved nutrition conditions, if their income is improved due to the modernization of irrigation tanks.

- The traditional discrimination of women may be mitigated and their social position may be improved in the future, if they are able to be much more educated due to improvement of their families' income.

(10) Overall Evaluation of the Project

The Project shows a basic EIRR of.18.8.%, proving the economic and financial feasibility through the viability of this Project. The sensitivity analysis proved also that the Project is economically feasible with corresponding EIRRs of 17.0% (increase of Project cost at 10 %), 16.8 % (reduction of Project benefit at 10 % and

12.3 % (delay of Project benefit for 3 years).

About 280 thousand farm households with population 1.3 million can be receive the Project benefits and totally Rs.280 million of annual incremental agricultural income is expected through the implementation of the Project.

For small and marginal farmers, the financial analysis proved that their farm budgets will be largely improved by the Project implementation. This will result in a substantial raise of their rural living conditions. Landless farmers also will be benefited by the Project as a result of raising of labor-hiring capacities for medium and big farmers.

The "soft" part including institutional components which is an important part for functioning of the Project, however, should be carefully applied in an intensive but flexible way according to local specific conditions to implement the Project procedures smoothly and successfully. The proper supply of necessary inputs including farm materials and crop loans should be applied accordingly for their successful farming.

Apart from the environmental impacts to be separately evaluated, the basic technical and financial aspects of the Project proved possible basic lines for implementing the Project. Further planning in details of these aspects should be elaborated accordingly. .

In the short term, the balance and combination of both "hard" and "soft" parts in the implementation of all project components will be very important for a successful achievement of the Project's objectives.

5 PILOT TANK FEASIBILITY STUDIES

5.1 The Pilot Tank Feasibility Study

The Project is expected to rehabilitate/improve the all PWD rainfed tanks for the rural development in the Study Area. In order to confirm the Project feasibility, the feasibility study of about 10 pilot tank areas were conducted in the next stage. At first, based on the tank category of the Study tanks, the typical tanks representing each category were examined for their feasibility. Then the total feasibility of the Project was assessed including prioritization of tank categories in the project implementation. The feasibility results were used for the prioritization of rehabilitation implementation.

5.2 Selection of Pilot Tanks

The 10 pilot tank areas were selected for the feasibility studies so that the selected tanks represent each category considering the geographical distribution, etc. Consequently, the 10 tank areas were selected as the pilot tank areas for the feasibility study as shown in the table. The locations of these tanks are plotted in Fig. S.5.

Selected 10 Pilot Tank Areas

Northern Study Area			
Category	Name of Tank	District	Taluk
NR-1	Echur	Kanchipuram	Chengalpattu
NR-2	Cherukkanur Big	Tiruvallur	Tiruthan
NR-2	Polampakkam	Kanchipuram	Madurantakam
NR-3	Vadakkapattu	Kanchipuram	Sriperumbudur
NR-4	Unadur Big	Kanchipuram	Kanchipuram
Southern Study Area			
Category	Name of Tank	District	Taluk
SR-1	A.Ramalingapuram	Virudunagar	Sattur
SP-1	Pandikanmoi	Ramanathapuram	Paramakudi
SR-1	Siruvalai	Sivaganga	Sivaganga
SP-2	Kurumbi	Sivaganga	Karaikudi
SP-4	Sengangulam	Sivaganga	Manamadurai

5.3 Methodology of Pilot Tank Feasibility Study

The following surveys and analysis were conducted in the feasibility study of pilot tank areas:

(1) Field Survey/Investigation

1) Topographic Survey (for all pilot tank area)
   - Survey of the waterspread areas of tanks to grasp storage capacity and to observe variation of capacity even after the study
   - Longitudinal profile surveys along bunds and irrigation canals
   - Elevation survey at the sill of sluices and spillways, top of dikes, field plots to be irrigated, farm inlet etc.

2) Hydro-geological Survey (Cherukkanur Big and Vadakkupattu tanks in the Northern Study Area, Sengangulam and Pandikanmoi tanks in the Southern Study Area)
   - test drilling at the sites in waterspread and command areas, and on bund of the tanks,
   - core samplings and laboratory testing, and
   - pumping-up tests.

The agricultural and institutional study including the following items for all pilot tank area:

1) Agriculture and farming practices including crop diversification
2) Farm household economy survey at 10 pilot tank area totaling 200 farms households. This survey was conducted hiring the local surveyors under the supervision of the study team.
3) Operation and maintenance of tank and irrigation facilities by farmer's organization
4) Value adding agricultural products
5) Agricultural support and extension

6) Institutional strengthening

(2) Formulation of Rehabilitation Plan

The rehabilitation planning includes the following items.

1) Rehabilitation plan of minor irrigation tanks
2) Operation and maintenance plan of the tank irrigation facilities
3) Farming practice and cropping pattern
4) Farmers' organization and water management
5) Agricultural extension services
6) Farmers' supporting services
7) Environmental protection
8) Preliminary design of major irrigation facilities
9) Cost estimate and benefit calculation including project evaluation
10) Implementation schedule

(3) The project justification include the following items:

1) Project costs not only civil works but also related costs for implementation
2) Project benefits
3) Economic and financial justification
4) Environmental and WID
5) Overall justification

5.4 Meteo-hydrological Survey and Analysis

(1) Rainfall and Runoff

10 years rainfall data from 1986 to 1995 at adjacent rain gauge station of each pilot tank were collected on daily basis from Statistic Department of GOTN and monthly data was obtained from the groundwater section of PWD.
Based on the daily and monthly rainfall data, the monsoon runoff were estimated applying Strange formula.

(2) Crop Water Requirement

Crop water requirement in NE monsoon season paddy, as a representing the major water consumption in the Study Area, were estimated. It is estimated at present condition with irrigation efficiency 0.4 and with channel lining under the Project (Ei=0.8) with consideration of effective rainfall.

(3) Catchment Hydrological Survey

Based on the topographical survey of waterspread area, effective storage capacity at each pilot tank area is estimated. Comparing with tank capacity in the Inventory List

and survey results, the sedimentation in the waterspread are is no significant. Therefore desilting effects are no fund. Hydrological characteristic in each pilot tank area is shown in Table S.3.

(4) Water Balance Study

Based on the daily rainfall, estimated crop water requirement and waterspread area characteristics, the water balance study was made using wet damp and dry method. These results show very low irrigable area by tank. Comparing with cultivation area data obtained in the field survey, it might be possible to say the crop cultivation in pilot tank area depend upon the groundwater.

Tank Category	Name of Tank	Farm Survey Monsoon Paddy only				Water Balance Study	
		Ayacut (ha)	Present Average Cultivation (ha)	Planned Cultivation (ha)	Present Cultivation Ratio	Present Cultivation (%)	Cultivation aft. Canal Lining(%)
NR-1	Echur	58.68	47.00	47.00	80%	32%	46%
NR-2	Cherukkanur	91.26	83.00	83.00	91%	36%	53%
NR-2	Polambakkam	94.59	79.70	79.70	84%	56%	78%
NR-3	Vadakkupattu	417.21	370.00	370.00	89%	20%	30%
NR-4	Enadur	574.67	322.00	317.00	56%	80%	97%
SR-1	A. Ramalingapuram	76.53	66.00	66.00	86%	64%	70%
SP-1	Pandikanmoi	41.88	40.60	40.60	97%	40%	58%
SP-1	Siruvalai	49.25	49.30	42.40	100%	74%	86%
SP-2	Kurumbi	52.67	52.00	52.00	99%	68%	81%
SP-4	Sengangulam	99.23	50.00	50.00	50%	29%	45%

(5) Development Strategies for chain tank basin management

In chain tank basin management, the important aspect is the participatory and chain basin approach to the tank rehabilitation. Moreover, a comprehensive and systematic program for the repair and maintenance of chain of tanks is necessary. This can be achieved by formation of multi-tier farmers association

By this approach, all farmers from catchment to farm level in the chain will form one single association of their own with specific responsibilities as shown below.

Tier	Association	Level	Responsibilities
I	Tank WUA	Tank/village	To identify and suggest need based tank management program
II	Chain Basin Farmers Council	Minor/chain basin	To resolve conflicts arising among the chain of tanks
III	District Tank Farmers Federation	District	To identify the opportunities available for inter and intra-chain basin water transfer

Eventually the WUA need to be made as a multipurpose organization with the responsibilities of equitable water sharing, financial contribution to the tank

rehabilitation and maintenance. The techno-managerial quality control guidance will be provided by PWD. Later training need to provided to farmers on scientific water management and improved agricultural practices.

5.5 Social Conditions

(1) Field survey

Field survey conducted at the availability of social infrastructure in the pilot tank area, social setting such as land holding and land tenure, water distribution, O&M of the tank, social conflicts and problems, and parameter for the sociological evaluation in each pilot tank area.

(2) Sociological evaluation

Finally, the sociological evaluation were made applying the participatory rural appraisal (PRA) and social scoring used by the EC tank modernization program. Results are summarized in the table.

According to the table, most pilot tank area shows good scoring except Polambakkam which is recently transferred to PWD from Ex-zamin tank. Based on the criteria of EC Project, the community organizer placement will be at the time of estimate preparation for all tanks except Polambakkam Tank, that is required 6 months prior to estimate preparation.

Summary of Social Scoring

Name of Tank	Number of Hamlets	Farm Size	Conflicts	Association	Leadership	Resource Mobilization	Water Dist. & Maint. of Stru.	Overall
Northern Study Area								
Echur	5	1	15	8	35	20	5	89
Cherukkanur Big	5	5	15	8	35	20	5	93
Polambakkam	5	5	10	4	10	10	5	49
Enadur Big	3	5	10	8	30	20	5	81
Vadakkupattu	5	5	15	0	30	20	5	80
Southern Study Area								
Siruvalai	5	5	15	8	35	20	5	93
A. Ramalingapuram	4	5	15	8	35	20	5	92
Pandikanmoi	5	5	15	8	30	20	5	93
Sengangulam	5	5	15	8	35	20	8	96
Kurumbi	4	5	15	8	35	20	8	95

(3) Proposed Farmers' Organization

Based on the present social and agricultural condition in each pilot tank, the WUA requirement is studied.

5.6 Agricultural Development

(1) Present conditions

From the farmers, village officer ,and extension officer the following details of the present agriculture were collected and the cultivation conditions are inspected in each pilot tank area:

- land use
- crop production by crop and variety
- irrigation condition (tank water availability and groundwater usage)
- fertilizer application
- labour input, cost and availability
- livestock
- farm size and land tenure

(2) Agricultural Development Plan

Based on the field survey and interviews on the present conditions, the agricultural development potentials are identified for the development planning. Then the target of agricultural development plan is set as "***rice based profitable and sustainable agriculture***".

Agricultural development plan includes the followings:

- cropping plan suitable natural conditions in the pilot tank areas
- labour requirement
- crop budget
- marketing
- farm household economy
- Agricultural supporting services available
- plan of technology demonstration center/ experimental farms

The present and proposed agricultural development in each pilot tank area are shown in Table S.4.

5.7 Rehabilitation of Tank Irrigation System and Facilities

(1) Present Conditions

On the field inspection of tank irrigation facilities such as tank bund, surplus arrangement, sluices, groundwater irrigation and operation and management of existing facilities were clarified. The result of field inspection is summarized in Table S.6. Most of the pilot tank are deteriorated on this structures, and some of them are abandoned. Then the urgency of the rehabilitation works also evaluated.

(2) Irrigation System and Facilities Rehabilitation Plan

Based on the assessment of irrigation facilities, the rehabilitation works requirement are estimated based on the topographical survey results in each pilot tank area. They are summarized in Table S.5.

Based on the hydra-geological and groundwater investigation shown in Fig. S.6, the

groundwater development in the Northern Study Area has little potential resulted by the groundwater development by individual farmers in command area. On the other hand, the Southern Study Area has rather high groundwater development potential caused by the water quality problems. Therefore, no further groundwater development shall be proposed in the Northern Study Area. In the Southern Study Area, installation of two community wells for emergency and supplemental irrigation in each tank area are planned.

Based on the PWD format, the cost of the rehabilitation was estimated as shown in Table S.6. Component of cost for rehabilitation is summarized as follows:

(Unit : Rs.X 1,000)

Tank Category	Name of Tank	Tank Bund Improvement	Sluice Improvement	Surplus & Supply Channel Improvement	Channel Lining and On-farm Development	Community Wells & Others	Total Construction Cost
NR-1	Echur	13	196	113	1,265	130	1,717
NR-2	Cherukkanur	4	212	1,229	1,273	130	2,848
NR-2	Polambakkam	232	220	36	1,875	130	2,493
NR-3	Vadakkupattu	149	327	552	10,865	130	12,023
NR-4	Enadur	620	374	0	10,325	130	11,449
SR-1	Ramalingapura	1,869	126	0	1,234	530	3,759
SP-1	Pandikanmoi	131	145	0	991	530	1,797
SP-1	Siruvalai	144	565	133	485	530	1,857
SP-2	Kurumbi	52	144	0	740	530	1,466
SP-4	Sengangulam	378	398	0	850	530	2,156
Average	Rs. X 1,000	359	271	206	2,990	330	4,157
Average	(Rs./ha)	2,309	1,740	1,326	19,218	2,121	26,713

5.8 Project Justification

(1) Project Costs and Benefits

Based on the cost estimate of tank rehabilitation including the institutional costs which can be obtained by financial cost, the economic costs for the economic evaluation is estimated applying the standard conversion factor 0.8. the investment cost will be disbursed equally in the period of two year for tanks having less than 100 ha of registered ayacut, but disbursed in three years for tanks having more than 100 ha ayacut. O&M costs are estimated at 5% of investment costs. Also replacement costs of facilities are estimated total 60% of investment cost after 15 and 16th year of the Project commencement.

Benefits of the Project are estimated applying the incremental benefits with and without Project. Economic price of the rice is estimated based on the World Bank's projection and others are estimated by the market prices in the Study Area. Five years to reach the 100% of incremental benefit is applied.

(2) Economic Evaluation

Based on the costs and benefits mentioned above, economic evaluation is made and estimated economic internal rate of return (EIRR). Also sensitivity analysis on the variation of cost and benefit are estimated as shown as follows:

Tank Category	Name of Tank	Ayacut (ha)	No. of Farm	Average Farm Holding (ha)	EIRR Basic Condition	EIRR Cost+10 %	EIRR Benefit-10%	EIRR Benefit Delay 3 Yr.
NR-1	Echur	58.68	166	0.35	22.8%	20.6%	18.9%	14.1%
NR-2	Cherukkanur	91.26	268	0.34	15.9%	14.1%	12.9%	10.0%
NR-2	Polambakkam	94.59	139	0.68	29.6%	27.0%	24.6%	17.6%
NR-3	Vadakkupattu	417.21	355	1.18	7.4%	5.7%	5.1%	4.1%
NR-4	Enadur	574.67	448	1.28	11.7%	9.9%	9.0%	7.1%
SR-1	A. Ramalingapuram	76.53	49	1.56	14.7%	12.9%	12.6%	9.2%
SP-1	Pandikanmoi	41.88	110	0.38	12.3%	10.6%	9.7%	7.7%
SP-1	Siruvalai	49.25	106	0.46	8.7%	4.8%	6.4%	2.4%
SP-2	Kurumbi	52.67	112	0.47	40.1%	36.8%	33.3%	22.4%
SP-4	Sengangulam	99.23	313	0.32	19.7%	17.6%	16.2%	12.3%
Average					18.3%	15.8%	14.7%	10.5%

(3) Environmental Impact Assessment

Based on the tank rehabilitation plan of each pilot tank and present social and natural conditions, the possible impact of the Project to the environment were examined. These results are summarized in Table S.2.

6. Conclusion and Recommendations

6.1 Conclusions

The Project should be implemented as soon as possible in consideration of the following matters:

- The Project is judged feasible from both of technical, economical and financial view points. And the implementation of the Project will contribute very mush to improvement of living standards of the farmers in the Project Area and also to development of the State.
- The Project is very important as the pilot rehabilitation and agricultural/rural development in PWD rainfed tank areas. This pilot project will be applied to the rehabilitation of PWD rainfed tank area out of the Project Area

6.2 Recommendations

The following actions will be recommended for the smooth implementation and realization of the target of the Project:

- Early implementation of the Project because phasing required
- Involvement of community organizer system as a staff of PWD
- Coordination and collaboration works with other government agencies concerned
- Early implementation of demonstration farms in the Project Area
- Provision of Opportunity of Suitable Training by establishing new training organization
- Finalization of tank inventory applying database system for the Study
- Selection of contractors for smooth implementation
- Introduction of new technology for the construction of the Project

Table S.1 Constraints and Proposed Countermeasures for Rehabilitation Minor Irrigation Tanks

Component		Category	Constraints	Countermeasures
Tank System Facilities	Tank	Catchment Area	• Soil erosion induced reduction in tank storage and tendency for silting up at intake points.	• Desilting of storage area and at intake points • Conservation of catchment through soil erosion control measures such as afforestation and terracing
		Tank Bund	• Insufficient top width and freeboard due to soil erosion of top level. • leakage	• Restoration of top width and free board. • Reinforcement of bund top and slopes with lining.
	Intake and outlet Structures	Intake Works	• Water leakage due to damaged shutters • Broken water control facilities such as Plugs and Barrels • Broken and damaged front and rear inlets and outlets	• Provision of new slide gates and shutters • Provision of new plugs, plug rods and barrels • Reconstruction of inlets and outlets.
		Surplus Arrangement	• Insufficient length • Damaged leaky body wall and eroded rear protective works.	• Increase of length and modifications of crest shape to increase discharges. • Reconstruction and reinforcement of damaged works.
	Supply Works	Supply Channel	• Reduction of design discharge as a result of silting of channel. • Deterioration of stone masonry channel. • Insufficient flow velocity due to weed growth.	• Periodical desilting of supply channel. • Reconstruction of damaged portion and strengthening at vulnerable sites. • Cleaning of vegetation in the channel.
Irrigation System	Distribution Network		• Slow movement due to obstruction by vegetation growth. • Heavy seepage loss • Salt injury in inundated command areas due to channel leakage.	• Periodical repair of channel by WUA. • Lining of main distribution channel • Proper maintenance of drainage channel
	Operation and Management		• Occurrence of non irrigated area due to insufficient water control structures.	• Lined channel with proper regulating and diversion structures at off-take points.
	Irrigation management		• Continuous over drawl without relevance to actual need, unofficial restoring subordinating equity to vested interests.	• Irrigation scheduling based on crop water requirements, cropping pattern and effective rainfall etc.
Farm Management	Agricultural Practices		• Reduction in farm profit due to non-proper cropping pattern, cropping schedule. • Crop injury due to continuous cropping and insufficient use of treated seeds, fertilizers, pesticides.	• Proper selection of cropping pattern and crop calendar to match with land use pattern. • Extension of new agricultural technology through Farmers' organization, , optimum use of fertilizers and proper plant protection measures and provision of agricultural credits

Table S.2 Possible Environmental Impacts of Tank Rehabilitation Works

Environmental Impact	Northern Area					Southern Area				
	Echur	Cherukkanur	Polambakkam	Enadur Big	Vadakkupattu	Sirvalai	Ramalinguram	Pandikanmoi	Sengangulam	Kurumbi
1. Social Environment										
1) Socio-economic Issues	O	O	O	O	O	O	O	O	O	O
- Conflict/friction on water sharing (By establishment of WUA)										
2) Health and Sanitary Issues	O	O	O	O	O	O	O	O	O	O
- Increase of agrochemical use (By expansion of irrigated agriculture)	---	O	O	---	---	---	---	O	---	---
- Spreading of filariasis/malaria (By expansion of irrigation)	---	---	---	---	---	---	---	---	---	---
3) Cultural Asset Issues	---	---	---	---	---	---	---	---	---	---
2. Natural Environment										
1) Biological and Ecological Issues										
- Negative impact on wildlife (peacocks) (During rehabilitation works of tank)	---	---	---	---	---	O	O	O	O	O
2) Soil and Land Resources										
- Soil contamination (By increase of agrochemical use)	O	O	O	O	O	O	O	O	O	O
- Soil salinization & deterioration of soil fertility (By saline groundwater utilization)	---	O	---	O	---	*	*	*	*	---
3) Hydrology and Water Quality										
- Water contamination (By increase of agrochemical use)	O	O	O	O	O	O	O	O	O	O
- Lowering the water table (By large scale groundwater extraction)	*	*	*	*	*	*	*	*	*	*
- Sea water intrusion (By large scale groundwater extraction)	*	---	---	---	---	---	---	O	---	---

Note: ▲ : Significant impact, * : Medium impact, O : Small impact or likely no impact, ---: No impact

Table S.3 Hydrological Characteristics of Pilot Tank Area

Pilot Tank	Echur	Cherukkanur	Polambakkam	Enadur	Vadakkupattu	Siruvalai	A. Ramalingapuram	Pandikanmoi	Sengangulam	Kurumbi
Rainfall Station	Chengalpattu	Tiruthani	Madurantagam	Kanchipuram	Sriperumpudur	Sivaganga	Sattur	Paramakudi	Manamadurai	Karaikudi
Basin	Palar	Nandiyar	Kiliyar	Kanchipuram	Adayar	Vaigai	Vaippar	Vaigai	Lower Gundar	Manimuthar
Annual Rainfall (mm)	1,151.1	1,036.9	1,111.5	1,155.8	1,234.9	851.5	719.3	721.4	977.4	1,019.2
South West Monsoon (June-Sep)	454.6	459.4	426.8	515.3	435.6	298.0	159.1	180.9	301.0	404.2
North East Monsoon (Oct-Dec)	603.6	471.4	627.0	535.2	716.6	390.2	370.4	381.9	488.7	458.4
Winter (Jan-Feb)	29.9	27.0	29.3	23.2	30.1	32.2	43.0	43.1	43.7	47.7
Summer (Mar-May)	63.0	79.1	28.4	82.1	52.6	131.1	146.8	115.5	144.0	108.9
Catchement Area										
Free Catchment (Km^2)	1.57	1.9606	2.276	14.6	6.32	1.415	6.34	2.6	2.49	2.459
Intercepted Catchment (Km^2)	0	0	3.693	13.08	4.66	12.772	146.34	0	0	4.336
Equivalent Catchment (Km^2)	1.57	1.9606	3.0146	17.216	7.252	3.9694	20.974	2.6	2.49	3.3262
Combined Catchment (Km^2)	1.57	1.9606	5.969	27.68	10.98	14.187	152.68	2.6	2.49	6.795
Tank										
Water Spread Area [WSA] (Km^2)	0.42	0.703	0.887	1.958	1.43	0.357	0.772	0.411	2.075	0.169
Registered Ayacut (ha)	58.68	91.26	94.59	574.67	417.24	49.25	76.55	41.88	99.23	52.67
Capacity (Mm^3)	0.464	1.5226	1.507	3.205	2.538	0.374	0.639	0.382	2.124	0.151
Ratios										
Free Catchment/Regd Ayacut	2.68	2.15	2.41	2.54	1.51	2.87	8.28	6.21	2.51	4.67
WSA/Regd. Ayacut	0.72	0.77	0.94	0.34	0.34	0.72	1.01	0.98	2.09	0.32
Capacity/Reg. Ayacut	0.008	0.017	0.016	0.006	0.006	0.008	0.008	0.009	0.021	0.003
WSA/Capacity	0.905	0.462	0.589	0.611	0.563	0.955	1.208	1.076	0.977	1.119

Table S.4 Present and Proposed Crop Production in Pilot Tank Area (1/2)

Code No.	Study Area	Present					Plan					Increased Production (%)
		Crop	Cropping Time	Area Sown(ha)	Yield (kg/ha)	Production (tons)	Crop	Cropping Time	Area to be Sown (ha)	Yield (kg/ha)	Production (tons)	
N-1	Echur (58.6 ha)	Paddy	Sep-Dec	47.0	4,650	218.6	Paddy	Sep-Jan	47.0	5,000	235.0	98
		Paddy	Jan-May	10.0	4,650	46.5	Paddy	Jan-May	5.0	5,000	25.0	
		Groundnut	Jan-Apr	2.0	1,500	3.0	L. Finger	Jan-Apr	7.0	15,000	105.0	-
							L. Finger	May-Aug	12.6	15,000	189.0	-
		Total		59.0		268.1	Total		71.6		554.0	207
N-2	Chenukkanur Big (91.3 ha)	Paddy	Jul-Oct	83.0	4,000	332.0	Paddy	Jun-Oct	83.0	4,800	398.4	120
		Paddy	Dec-Mar	50.0	4,000	200.0	Paddy	Nov-Apr	50.0	4,800	240.0	
		Sugarcane	Jun-Jun	20.0	100,000	2,000.0	Sugarcane	Jun-Jun	20.0	125,000	2,500.0	125
		Casuarina	Per Years	12.0	22,500	270.0	Banana	May-May	4.0	27,965	111.9	-
		Total		165.0		2,802.0	Total		157.0		3,250.3	116
N-3	Polambakkam (94.6 ha)	Paddy	Jul-Nov	12.3	3,800	46.7	Paddy	Sep-Jan	29.7	5,000	398.5	114
		Paddy	Oct-Feb	79.7	3,800	302.9	L. Finger	Feb-May	4.3	15,000	64.5	-
		Groundnut	Jan-Apr	2.0	1,250	2.5	Black gram	Jun-Aug	4.3	1,200	5.2	-
							Egg plant	Feb-Jul	4.3	20,000	86.0	-
							Turmeric	Jun-Mar	5.0	25,000	125.0	-
						-	Banana	May-May	5.0	27,965	139.8	-
		Total		94.0		352.1	Total		102.6		819.0	233
N-4	Enadur Big (574.7 ha)	Paddy	Jul-Jan	322.0	4,000	1,288.0	Paddy	Jul-Nov	102.0	4,750	484.5	119
							Paddy	Aug-Dec	220.0	4,750	1,045.0	
							Groundnut	Jan-Apr	10.0	1,900	19.0	-
							L. Finger	Jan-Apr	5.0	15,000	75.0	-
							Chili(Green	Jan-Aug	50.0	2,500	125.0	-
							Banana	May-May	5.0	27,965	139.8	-
		Total		322.0		1,288.0	Total		392.0		1,888.3	147
N-5	Vadakkupattu (471.3 ha)	Paddy	Aug-Dec	370.0	4,500	1,665.0	Paddy	Aug-Dec	370.0	5,000	1,850.0	109
		Paddy	Jan-Apr	225.0	4,700	1,057.5	Paddy	Jan-Apr	225.0	5,000	1,125.0	
							Banana	May-May	5.0	27,965	139.8	-
							Turmeric	Jun-Mar	5.0	25,000	125.0	-
							Tomato	Mar-Jul	4.0	15,000	60.0	-
							L. Finger	Feb-May	4.0	15,000	60.0	-
							Tomato	Mat-Oct	4.0	15,000	60.0	-
							L. Finger	Aug-Nov	4.0	15,000	60.0	-
		Total		595.0		2,722.5	Total		621.0		3,479.8	128
S-1	Siruvalai (49.3 ha)	Paddy	Aug-Dec	49.3	3,900	192.3	Paddy	Aug-Dec	42.4	5,000	212.0	110
							L. Finger	Sep-Dec	6.9	15,000	103.5	-
		Total		49.3		192.3	Total		49.3		315.5	164
S-2	A.Rama-lingapuram (76.5 ha)	Paddy	Sep-Jan	66.0	3,500	231.0	Paddy	Sep-Jan	66.0	5,000	330.0	143
		Cotton	Feb-Jun	1.2	980	1.2	L. Finger	Feb-May	14.0	15,000	210.0	-
		Greengram	Feb-May	3.5	450	1.6	Greengram	May-Aug	14.0	1,200	16.8	1,050
		Total		70.7		233.8	Total		94.0		556.8	238
S-3	Pandikanmoi (41.9 ha)	Paddy	Oct-Feb	40.6	2,000	81.2	Paddy	Oct-Feb	40.6	4,000	162.4	200
		Cotton	Jan-Apr	2.5	560	1.4	Cotton	Feb-Jun	10.0	725	7.3	518
		Chili(Dry)	Dec-Apr	2.0	635	1.3	Blackgram	Feb-May	10.0	700	7.0	-
							Greengram	Feb-May	10.0	800	8.0	-
		Total		45.1		83.9	Total		70.6		184.7	220
S-4	Senganguiam (99.2 ha)	Paddy	Aug-Dec	50.0	4,750	237.5	Paddy	Aug-Dec	50.0	5,000	250.0	105
		Cotton	Jan-May	10.0	1,000	10.0	L. Finger	Feb-May	5.0	15,000	75.0	-
		Ragi	Jan-Apr	40.0	2,000	80.0	L. Finger	May-Aug	5.0	15,000	75.0	-
					-	0.0	Chili(Green	Jan-Aug	5.0	10,000	50.0	-
					-	0.0	Ragi	Jan-Apr	40.0	2,750	110.0	-
		Total		100.0		327.5	Total		105.0		560.0	171
S-5	Krumbi (52.7 ha)	Paddy	Jun-Sep	16.0	4,200	67.2	Paddy	Aug-Dec	52.0	4,500	234.0	78
		Paddy	Oct-Feb	52.0	4,500	234.0	Chili(Green	Jan-Aug	5.0	10,000	50.0	-
		Groundnut	Feb-May	10.0	1,400	14.0	Turmeric	Jun-Mar	5.0	25,000	125.0	-
		Blackgram	Feb-Apr	6.0	500	3.0	L. Finger	Feb-May	5.0	15,000	75.0	-
						0.0	L. Finger	May-Aug	5.0	15,000	75.0	-
						0.0	Egg plant	Jan-Jun	5.0	20,000	100.0	-
						0.0	Tomato	Jan-Jun	5.0	15,000	75.0	-
		Total		84.0		318.2	Total		82.0		734.0	231
Whole	Paddy(Rainy season)		-	1,188(75%)	4,121	4,896(57%)	Paddy(Rainy season)		1,203(69%)	4,855	5,840(47%)	-
	Paddy(Dry season)		-	285(18%)	4,575	1,304(15%)	Paddy(Dry season)		230(13%)	5,000	1,150(9%)	-
	Others		-	111(7%)	-	2,388(28%)	Others		312(18)	-	5,353(43%)	-
	Total		-	1,584(100%)	-	8,588(100%)	Total		1,745(100%)	-	12,342(100%)	-

Table S.4 Present and Proposed Crop Production in Pilot Tank Area (2/2)

Code No.	Study Area	Present							Plan						
		Crop	Productn (tons)	Unit Price (Rs/kg)	Gross Income (1,000 Rs)	Productn Cost (Rs/ha)	Productn Cost (1,000 Rs)	Net Income (1,000 Rs)	Crop	Productn (tons)	Unit Price (Rs/kg)	Gross Income (1,000 Rs)	Productn Cost (Rs/ha)	Productn Cost (1,000 Rs)	Net Income (1,000 Rs)
N-1	Echur (58.6 ha)	Paddy	218.6	5.20	1,136.7	11,700	549.9	586.8	Paddy	235.0	5.20	1,222.0	11,700	549.9	672.1
		Paddy	46.5	6.50	302.3	11,700	117.0	185.3	Paddy	25.0	6.50	162.5	11,700	58.5	104.0
		Groundnut	3.0	13.00	39.0	7,340	14.7	24.3	L. Finger	105.0	4.50	472.5	23,463	164.2	308.3
									L. Finger	189.0	4.50	850.5	23,463	296.0	554.9
		Total	268.1	-	1,478.0	-	-	796.4	Total	554.0	-	2,707.5	-	1,068.6	1,639.3
N-2	Cherukkanur Big (91.3 ha)	Paddy	332.0	5.20	1,726.4	11,700	971.1	755.3	Paddy	398.4	5.20	2,071.7	11,700	971.1	1,100.6
		Paddy	200.0	6.50	1,300.0	11,700	585.0	715.0	Paddy	240.0	6.50	1,560.0	11,700	585.0	975.0
		Sugarcane	2,000.0	0.75	1,500.0	24,215	484.3	1,015.7	Sugarcane	2,500.0	0.75	1,875.0	24,215	484.3	1,390.7
		Casuarina	270.0	1.40	378.0	9,513	114.2	263.8	Banana	111.9	3.00	335.6	25,100	100.4	235.2
		Total	2,802.0	-	4,904.4	-	-	2,749.8	Total	3,250.3	-	5,842.3	72,715.0	2,140.8	3,701.5
N-3	Polambakkam (94.6 ha)	Paddy	46.7	6.50	303.6	11,700	143.9	159.6	Paddy	398.5	6.50	2,590.3	11,700	932.5	1,657.8
		Paddy	302.9	5.50	1,666.0	11,700	932.5	733.5	L. Finger	64.5	4.50	290.3	23,463	100.9	189.4
		Groundnut	2.5	13.00	32.5	7,340	14.7	17.8	Black gram	5.2	14.00	72.2	4,144	17.8	54.4
		-	-	-	-	-	-	-	Egg plant	86.0	3.00	258.0	20,000	86.0	172.0
		-	-	-	-	-	-	-	Turmeric	125.0	4.00	500.0	25,100	125.5	374.5
		-	-	-	-	-	-	-	Banana	139.8	3.00	419.5	25,100	125.5	294.0
		Total	352.1	-	2,002.0	-	-	910.9	Total	819.0	-	4,130.2	109,507.0	1,388.2	2,742.0
N-4	Enadur Big (574.7 ha)	Paddy	1,288.0	6.50	8,372.0	11,700	3,767.4	4,604.6	Paddy	484.5	6.50	3,149.3	11,700	1,193.4	1,955.9
		-	-	-	-	-	-	-	Paddy	1,045.0	6.50	6,792.5	11,700	2,574.0	4,218.5
		-	-	-	-	-	-	-	Groundnut	19.0	13.00	247.0	7,340	73.4	173.6
		-	-	-	-	-	-	-	L. Finger	75.0	4.50	337.5	23,463	117.3	220.2
		-	-	-	-	-	-	-	Chili	125.0	25.00	3,125.0	23,938	3,196.9	1,928.1
		-	-	-	-	-	-	-	Banana	139.8	3.00	419.5	25,100	125.5	294.0
		Total	1,288.0	-	8,372.0	-	-	4,604.6	Total	1,888.3	-	14,070.7	103,241.0	5,280.5	8,790.2
N-5	Vadakkupattu (471.3 ha)	Paddy	1,665.0	6.00	9,990.0	11,700	4,329.0	5,661.0	Paddy	1,850.0	6.00	11,100.0	11,700	4,329.0	6,771.0
		Paddy	1,057.5	6.00	6,345.0	11,700	2,632.5	3,712.5	Paddy	1,125.0	6.00	6,750.0	11,700	2,632.5	4,117.5
		-	-	-	-	-	-	-	Banana	139.8	3.00	419.5	25,100	125.5	294.0
		-	-	-	-	-	-	-	Turmeric	125.0	4.00	500.0	25,100	125.5	374.5
		-	-	-	-	-	-	-	Tomato	60.0	4.00	240.0	21,488	85.0	154.0
		-	-	-	-	-	-	-	L. Finger	60.0	4.50	270.0	23,463	93.9	176.1
		-	-	-	-	-	-	-	Tomato	60.0	4.00	240.0	21,488	86.0	154.0
		-	-	-	-	-	-	-	L. Finger	60.0	4.50	270.0	23,463	93.9	176.1
		Total	2,722.5	-	16,335.0	-	-	9,373.5	Total	3,479.8	-	19,789.5	163,502.0	7,572.1	12,217.4
S-1	Siruvalai (49.3 ha)	Paddy	192.3	5.00	961.4	11,700	576.8	384.5	Paddy	212.0	5.00	1,060.0	11,700	496.1	563.9
		-	-	-	-	-	-	-	L. Finger	103.5	4.50	465.8	23,463	161.9	303.9
		Total	192.3	-	961.4	-	-	384.5	Total	315.5	-	1,525.8	35,163.0	658.0	867.8
S-2	A.Rama-lingapuram (76.5 ha)	Paddy	231.0	5.20	1,201.2	11,700	772.2	429.0	Paddy	330.0	5.20	1,716.0	11,700	772.2	943.8
		Cotton	1.2	15.00	17.6	10,630	12.8	4.9	L. Finger	210.0	4.50	945.0	23,463	328.5	616.5
		Greengram	1.6	12.00	19.2	4,144	14.5	4.7	Greengram	16.8	12.00	201.6	4,144	58.0	143.6
		Total	233.8	-	1,238.0	-	-	438.6	Total	556.8	-	2,862.6	39,307.0	1,158.7	1,703.9
S-3	Pandikammoi (41.9 ha)	Paddy	81.2	5.20	422.2	11,700	475.0	-52.8	Paddy	162.4	5.20	844.5	11,700	475.0	369.5
		Cotton	1.4	15.00	21.0	10,630	26.6	-5.6	Cotton	7.3	15.00	108.8	10,630	106.3	2.5
		Chili(Dry)	1.3	25.00	31.8	23,938	47.9	-16.1	Blackgram	7.0	14.00	98.0	4,144	41.4	56.6
		-	-	-	-	-	-	-	Greengram	8.0	12.00	96.0	4,144	41.4	54.6
		Total	83.9	-	475.0	-	-	-74.5	Total	184.7	-	1,147.2	30,618.0	664.2	483.0
S-4	Sengangulam (99.2 ha)	Paddy	237.5	5.10	1,211.3	11,700	585.0	626.3	Paddy	250.0	5.10	1,275.0	11,700	585.0	690.0
		Cotton	10.0	15.00	150.0	10,630	106.3	43.7	L. Finger	75.0	4.50	337.5	23,463	117.3	220.2
		Ragi	80.0	4.20	336.0	5,750	230.0	106.0	L. Finger	75.0	4.50	337.5	23,463	117.3	220.2
		-	-	-	-	-	-	-	Chili(Gree	50.0	10.00	500.0	23,938	119.7	380.3
		-	-	-	-	-	-	-	Ragi	110.0	4.20	462.0	5,750	230.0	232.0
		Total	327.5	-	1,697.3	-	-	776.0	Total	560.0	-	2,912.0	88,314.0	1,169.3	1,742.7
S-5	Krumbi (52.7 ha)	Paddy	67.2	5.20	349.4	11,700	187.2	162.2	Paddy	234.0	5.20	1,216.8	11,700	608.4	608.4
		Paddy	234.0	5.20	1,216.8	11,700	608.4	608.4	Chili	50.0	10.00	500.0	23,938	119.7	380.3
		Groundnut	14.0	13.00	182.0	7,340	73.4	108.6	Turmeric	125.0	4.00	500.0	25,100	125.5	374.5
		Blackgram	3.0	14.00	42.0	4,144	24.9	17.1	L. Finger	75.0	4.50	337.5	23,463	117.3	220.2
		-	-	-	-	-	-	-	L. Finger	75.0	4.50	337.5	23,463	117.3	220.2
		-	-	-	-	-	-	-	Egg plant	100.0	3.00	300.0	20,000	100.0	200.0
		-	-	-	-	-	-	-	Tomato	75.0	4.00	300.0	21,488	107.4	192.6
		Total	318.2	-	1,790.2	-	-	896.4	Total	733.0	-	3,491.8	149,152.0	1,295.7	2,196.1
Whole		Paddy	6,200	5.89	36,504	11,700	17,233	19,271		6,989.8	5.9	41,510.5	11,700.0	16,762.6	24,747.9
		Others	2,388	1.15	2,749	10,467	1,164	1,585		5,352.5	3.2	16,969.1	18,032.0	5,633.5	11,335.6
		Total	8,588	4.57	39,253	11,614	18,397	20,856		12,342.3	4.7	58,479.6	12,834.0	22,396.1	36,083.8

Table S.5 Countermeasures for Rehabilitation of Pilot Tanks

Pilot Tanks in Northern Study Area

Component	Rehabilitation works	Echur Tank		Cherukkanur Big Tank		Polambakkam Tank		Enadur Big Tank		Vadakupattu Tank	
Tank Bund Improvement (Total Bund Length)	• Strengthening of the bund for reshaping to standard size.	298m (1218m)		183m (1605m)		1275m (1310m)		2512m (2665m)		1343m (1483m)	
Intake works (Sluice)	• Modification for intake system using gearing shutter • Protection of back-fill for side slope.	Wing wall type Tower head type	2 units	Wing wall type Tower head type	2 units	Tower head type	2 units	Tower head type	2 units	Tower head type	2 units
Surplus arrangement	• Widening as 16.5m of width of Bye-wash type weir. • Provision of rough stone for revetment	Bye-wash type weir	1 units	B.C. type weir	1 units	B.C. type weir	1 units	-	-	B.C. weir	2 units
Tank supply channel	• Reshaping of cross section			2,006m							
Selective Lining for Field Channel including On-farm development	• Installation of lining canal up to 10ha • Provision of diversion boxes with paddle shutter for equal distribution. • Reshaping of existing canal. • Provision of incidental device such as cart, cattle, and canal/crossing.	600m as main 1,350m as branch	2 units 3 units	830m as main 930m as branch	2 units 1 units	1610m as main 890m as branch	2 units 2 units	Concrete lining 4920m as main Earthen lining 1100m as main 7370m as branch	1 unit 1 unit 9 units	7480m as main 4570m as branch	1 unit 7 units
Building for Farmers' Association	• Provision of community hall for WUA, local farmers and inhabitation.	50m²	1 Nos.	50m²	1 Nos.	50m²	1 Nos.	50m²	1 Nos.	50m²	1 Nos.

Pilot Tanks in Southern Study Area

Component	Rehabilitation works	Siruvalai Tank		A. Ramalingapuram Tank		Pandikanmoi Tank		Sengangulam Tank		Kurumbi Tank	
Tank Bund Improvement (Total Bund Length)	• Strengthening of the bund for reshaping to standard size.	2010m (2010m)		1940m (2016m) Protection of bund using rough stone..		2855m (2855m)		4230m (4230m) Protection of bund using rough stone for preventing irrigation canal along the tank bund.		1120m (1120m)	
Intake works (Sluice)	• Modification for intake system using gearing shutter • Protection of back-fill for side slope.	Tower head type Wing wall type	3 units 3 units	Wing wall type	3 units	Wing wall type	3 units	Tower head type Wing wall type	2 units 3 units	Head tower type	1 unit
Surplus arrangement	• Repairing of water cushion by clogging wet masonry	B.C. weir	1 unit	-	-	-	-	-	-	-	-
Selective Lining for Field Channel including On-farm development	• Installation of lining canal • Provision of diversion boxes with paddle shutter for equal distribution. • Reshaping of existing canal. • Provision of incidental device such as cart, cattle, and canal/crossing.	930m as main 840m as branch	1 unit 5 units	1930m as main	3 units	1550m as main	3 units	1220m as main	3 units	670m as main 470m as branch	1 unit 3 units
Building for Farmers' Association	• Provision of community hall for WUA, local farmers and inhabitation.	50m²	1 Nos.	50m²	1 Nos.	50m²	1 Nos.	50m²	1 Nos.	50m²	1 Nos.
Community well	• Provision for irrigation as supplemental use		2 Nos		2 Nos		2 Nos		2 Nos		2 Nos

Table S.6 Tank Rehabilitation Costs for Pilot Tanks

Name of Tank Ayacut (ha)	Echur 58.68	Cherukkanur Big 91.26	Polambakkam 94.59	Enadur Big 574.67	Vadakupattu 417.21	Siruvalai 49.25	Kurumbi 52.67	A. Ramalingapuram 76.53	Senganguiam 99.23	Pandikanmoi 41.88	Average of Pilot Tank	
Description	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost Rs.	Total Cost	Average Cost Rs./ha
1 Tank Bund Improvements	13,000	4,000	232,000	620,000	149,000	144,000	52,000	1,869,000	378,000	131,000	3,592,000	2,309
2 Sluices Improvement	196,000	212,000	220,000	374,000	327,000	565,000	144,000	126,000	398,000	145,000	2,707,000	1,740
3 Surplus Improvement	113,000	1,194,000	36,000	0	552,000	133,000	0	0	0	0	2,028,000	1,303
4 Tank Supply Channel Improvement	0	35,000	0	0	0	0	0	0	0	0	35,000	22
5 Field Channel Lining & On-farm Development	1,265,000	1,273,000	1,875,000	10,325,000	10,865,000	485,000	740,000	1,234,000	850,000	991,000	29,903,000	19,218
6 Building for Farmers' Association	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	130,000	1,300,000	835
7 Community Well	0	0	0	0	0	400,000	400,000	400,000	400,000	400,000	2,000,000	1,285
Direct Construcion Cost	1,717,000	2,848,000	2,493,000	11,449,000	12,023,000	1,857,000	1,466,000	3,759,000	2,156,000	1,797,000	41,565,000	26,713
8 Petty Supervision Charges	52,000	85,000	75,000	343,000	361,000	56,000	44,000	113,000	65,000	54,000	1,248,000	802
9 Physical Contingencies	52,000	85,000	75,000	343,000	361,000	56,000	44,000	113,000	65,000	54,000	1,248,000	802
10 Price Contingencies	172,000	285,000	249,000	1,145,000	1,202,000	186,000	147,000	376,000	216,000	180,000	4,158,000	2,672
Total work cost	1,993,000	3,303,000	2,892,000	13,280,000	13,947,000	2,155,000	1,701,000	4,361,000	2,502,000	2,085,000	48,219,000	30,990
11 Preparation Works	5,000	8,000	7,000	33,000	35,000	5,000	4,000	11,000	6,000	5,000	119,000	76
12 Advertisments, Photos, etc.	5,000	8,000	7,000	33,000	35,000	5,000	4,000	11,000	6,000	5,000	119,000	76
13 Documentation Charges	10,000	17,000	14,000	66,000	70,000	11,000	9,000	22,000	13,000	10,000	242,000	156
14 Codification of Hydraulic Particulars	5,000	8,000	7,000	33,000	35,000	5,000	4,000	11,000	6,000	5,000	119,000	76
15 Preparation Cost (Govt. Share)	25,000	41,000	35,000	165,000	175,000	26,000	21,000	55,000	31,000	25,000	599,000	385
Total Project Cost	2,018,000	3,344,000	2,927,000	13,445,000	14,122,000	2,181,000	1,722,000	4,416,000	2,533,000	2,110,000	48,818,000	31,375
16 Overhead Charges Estt., T&P, Etc., @ 25% of Total Project Cost	505,000	836,000	732,000	3,361,000	3,531,000	545,000	431,000	1,104,000	633,000	528,000	12,206,000	7,845
17 Total Administration Charges (11 to 14, 15)	550,000	877,000	767,000	3,526,000	3,706,000	571,000	452,000	1,159,000	664,000	553,000	12,805,000	8,230
18 Total Project Cost with Overhead Charges (Work Cost + Govt. Share)	2,523,000	4,180,000	3,659,000	16,806,000	17,653,000	2,726,000	2,153,000	5,520,000	3,166,000	2,638,000	61,024,000	39,219
Rs./ha	43,000	46,000	39,000	29,000	42,000	55,000	41,000	72,000	32,000	63,000		
$ /ha	1,200	1,300	1,100	800	1,200	1,600	1,200	2,000	900	1,800		

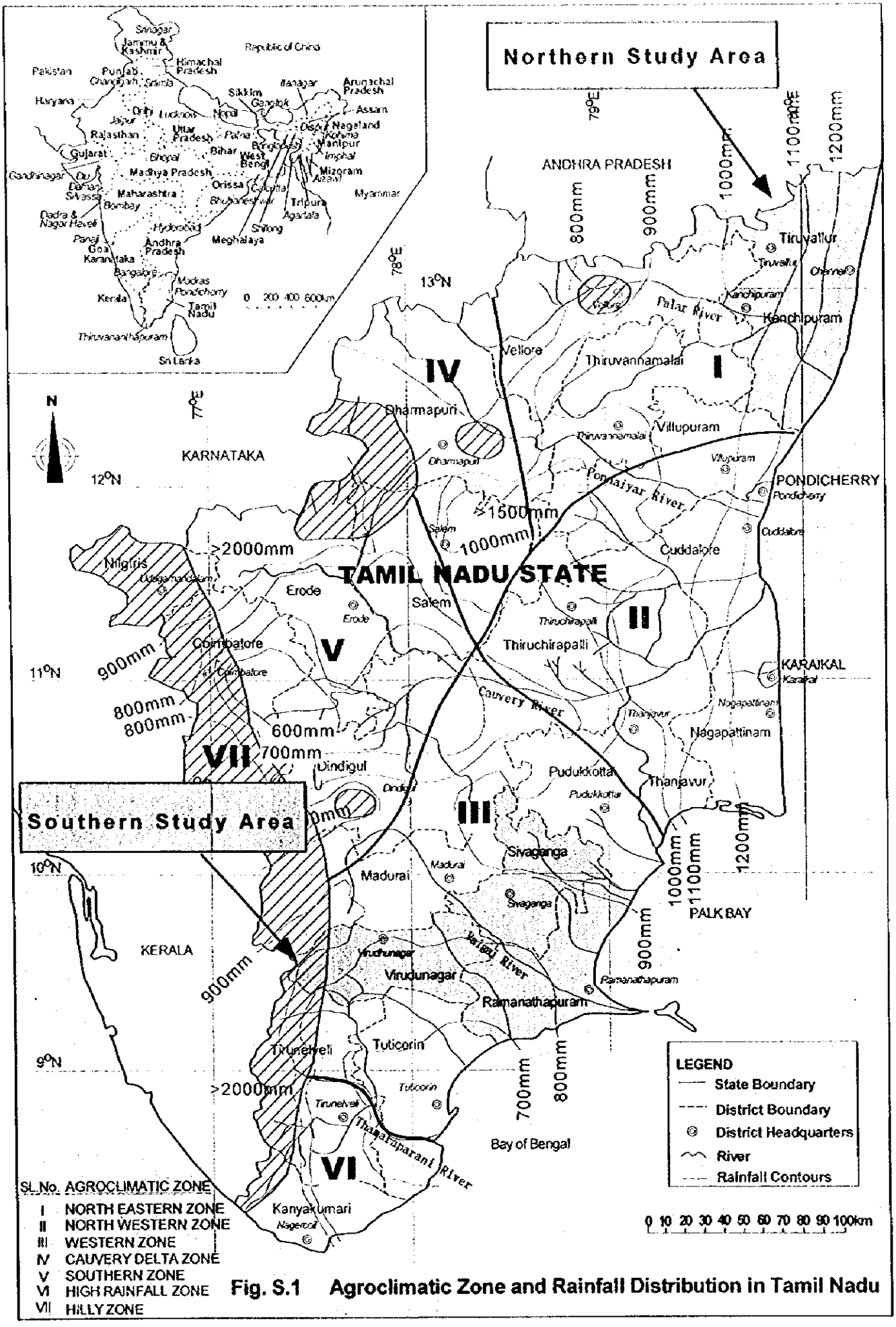


Fig. S.1 Agroclimatic Zone and Rainfall Distribution in Tamil Nadu

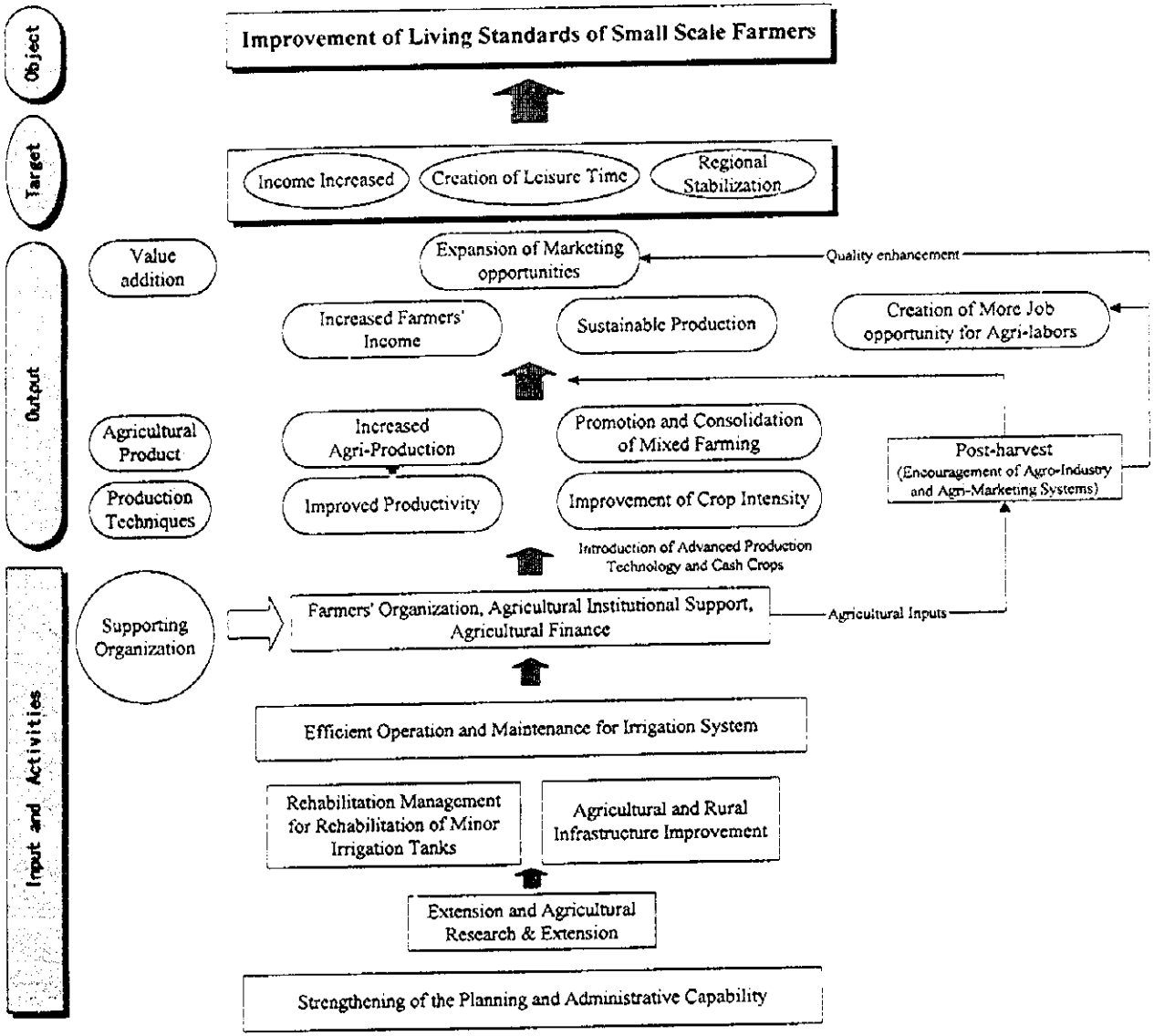


Fig. S.2 Skeleton Rehabilitation of Minor Irrigation Tank

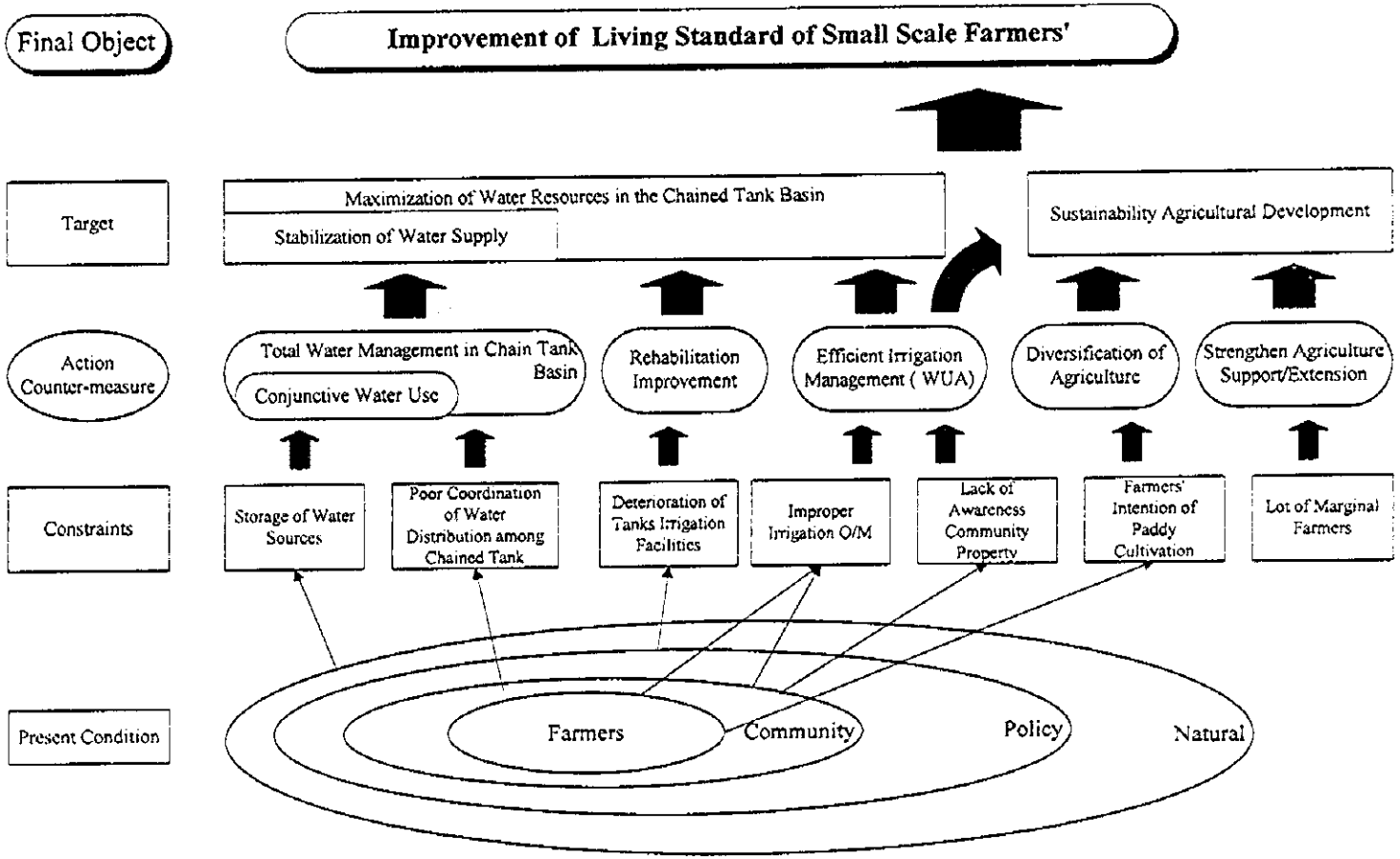
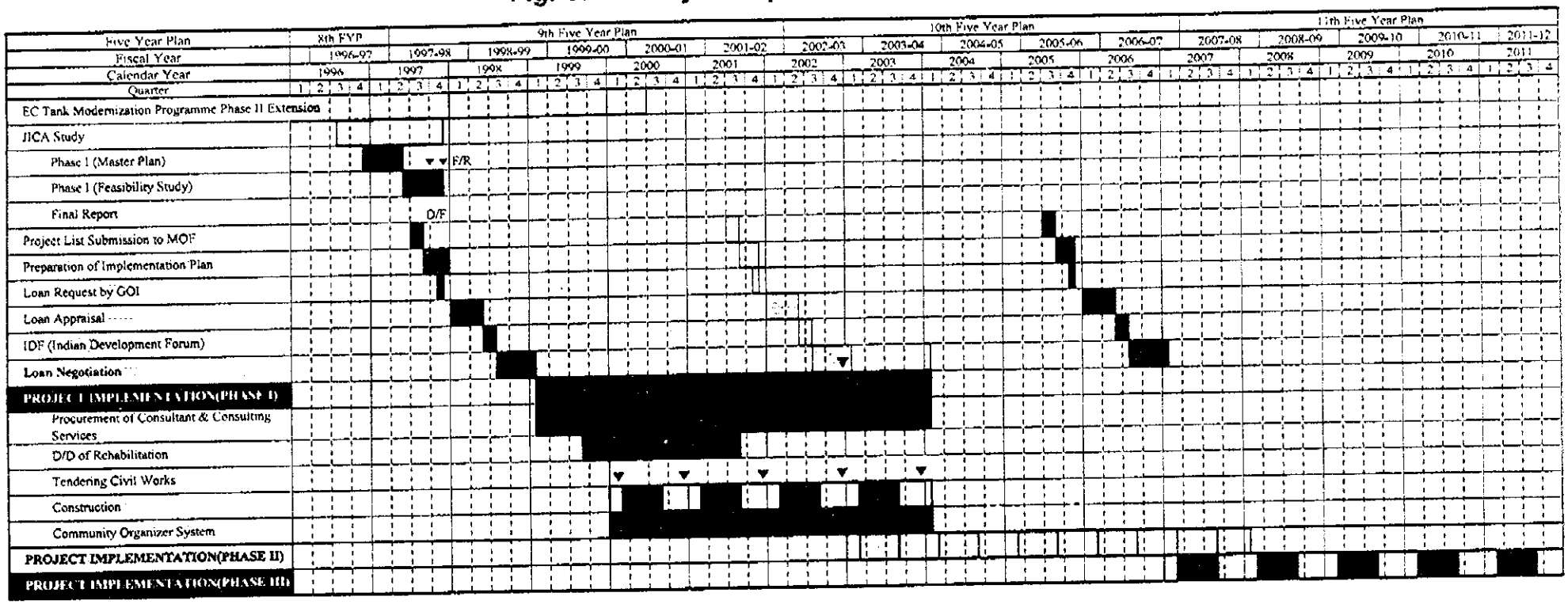


Fig. S.3 Basic Concept of the Master Plan for Rehabilitation of Minor Irrigation Tanks

Fig. S.4 Project Implementation Schedule



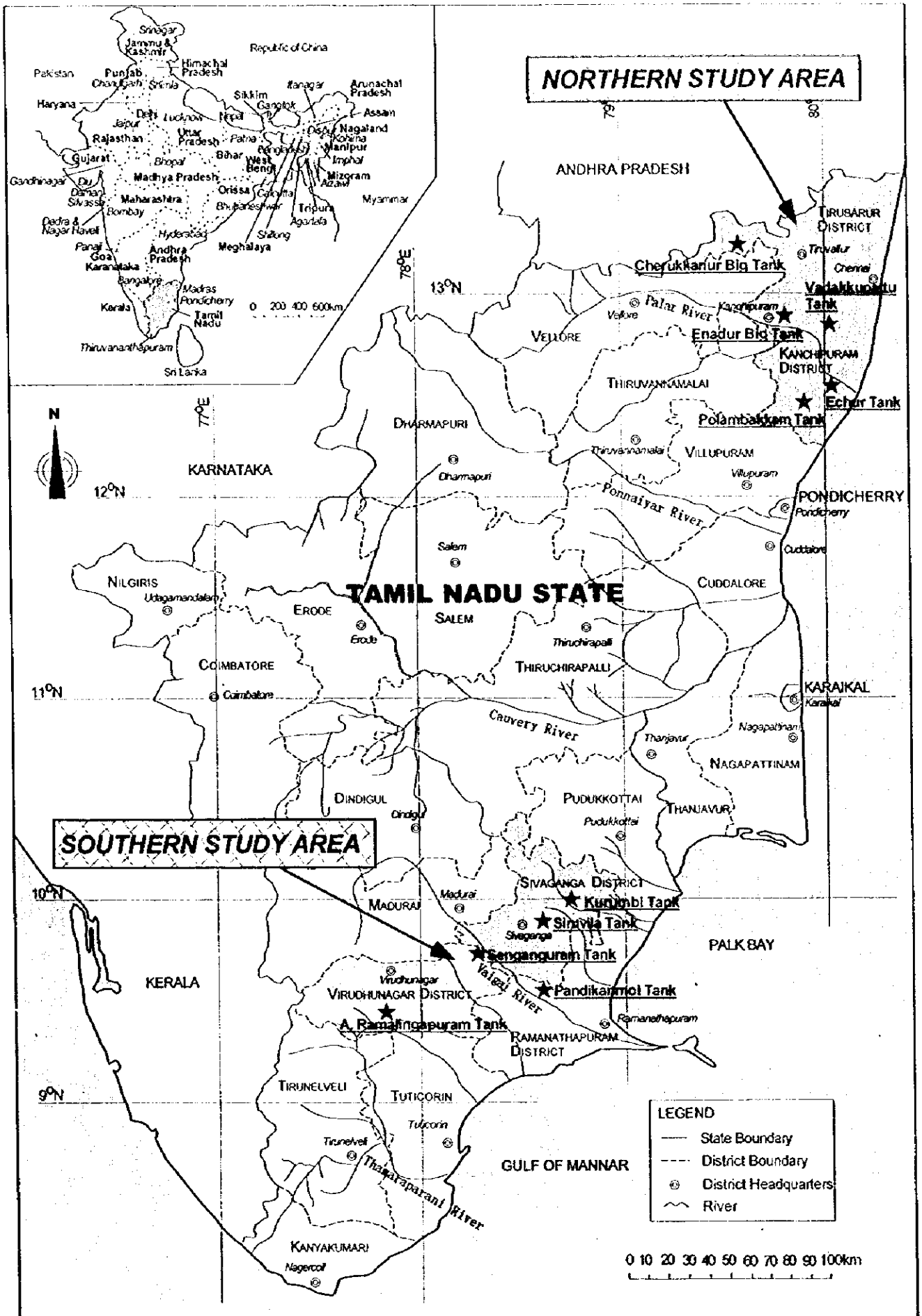


Fig.S.5 Location of Pilot Tanks Feasibility Study

Hydrogeological Features of Pilot Tank Areas

Name of the Tank	Ground-water Potential in Ayacut (10^3m^3)	Draft in the Ayacut (10^3m^3)	Exploitable Volume of Groundwater in the Ayacut (10^3m^3)	Depth to Water Table During the Study	pH	Electric Conductivity (μS/cm)	Unit Potential (10^3m^3/ha)
Echur Tank	6,750	1,350 (20%)	5,400	1.5 - 4.2	7.1 - 8.5	400 - 575	115
Cherukkanur Big	4,920	3,197 (65%)	1,723	1.0 - 4.5	6.5 - 8.0	400 - 850	54
Polambakkam Tank	3,396	2,343 (69%)	1,053	2.0 - 3.0	6.8 - 7.9	300 - 500	36
Enadur Big Tank	9,375	4,957 (53%)	4,418	3.0 - 7.0	7.0 - 7.8	270 - 520	16
Vadakkupattu Tank	8,340	1,668 (20%)	6,672	2.0 - 6.0	6.5 - 7.5	475 - 845	20
Siruvalai Tank	2,825	424 (15%)	2,401	3.6 - 14.0	6.9 - 8.1	540 - 3,000	53
Kurumbi Tank	3,156	227 (7%)	2,929	4.5 - 8.0	6.0 - 7.8	320 - 1,200	42
A. Ramalingapuram	3,217	123 (4%)	3,094	3.0 - 4.0	7.4 - 8.2	4,000 - 6,700	77
Sengangulam Tank	8,712	510 (6%)	8,202	13.0 -	6.8 - 8.1	1,050 - 2,500	88
Pandikanmoi Tank	3,520	87 (2%)	3,433	19.0 -	7.0 - 7.5	2,800 - 5,000	67

Note: The groundwater potential in tank areas is estimated using the total command area, average thickness of the saturated zone and their hydrological properties. The present groundwater usage is estimated from the block-wise data available in PWD.

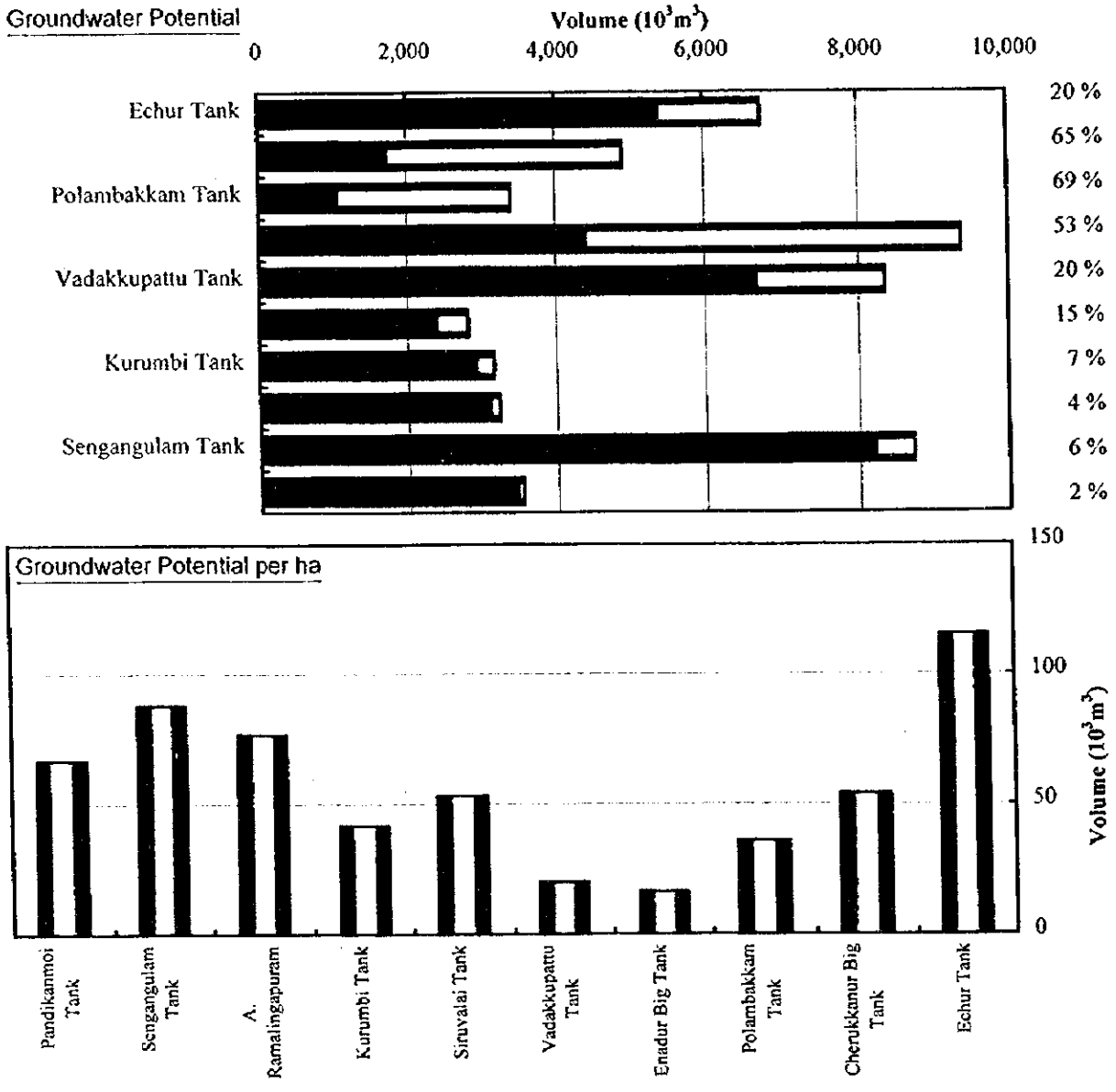


Fig. S.6 Results of Hydro-geological Analysis of Pilot Tank Areas