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Farm Level Land and Water Productivity in Tank Irrigation: Some Methodological Issues

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Abstract

Agriculture consumes a lion share of available water which is becoming increasingly scarce day-by-day. For proper management of agricultural water it is essential to understand how much water is currently used for crop production and other uses; how much is needed in the coming decades; and to what extent and in what ways they can be met with. In the process of agricultural water management, efficiency of water use -in terms of the quantum of water released at the source to the fraction of water actually required for crop growth- is considered important to understand the current levels of water use in the surface and groundwater irrigation. Apart from water use efficiency, the water productivity is also an important parameter to reckon with. Obviously, the volume of water used for irrigation through surface as well as groundwater is the basis to measure water productivity. In order to estimate the efficiency of agricultural water use as well as its productivity a small river basin, namely the Cheyyar sub-basin of the Palar basin, in Tamil Nadu is taken up for investigation under the IWMI-TATA Policy Research Programme.

The main objective of this research is to compute farm level land and water productivity under tank irrigation. This paper presents the findings of the study based on the fieldwork carried out in seven tanks in Tiruvannamalai district. The findings indicate that the land and water productivity differ considerably with its location from the source of supply and access to well water. Either the tank supply alone or the well water alone does not help the farmer to get more returns. Both these sources should be used conjunctively to get maximum returns in tank irrigation. It is also suggested that "community wells" developed within tank ayacuts will serve the purpose of maintaining equity among farmers especially among the marginal, small and farmers who do not get adequate supply from both the tanks and wells.

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Section I

Introduction

Population explosion is the major concern of all nations of the world, especially the underdeveloped and developing nations. In India, a baby has born every 1.4 seconds adding about 16 to 17 million every year to the population. The net result of population explosion is decreased per capita water availability but increased demand for food and fibre to sustain the growing population. Presently we are facing a lot of water deficiency in many of our river basins thereby restricting our efforts to bring more area under irrigation. Also, the present efficiency of surface irrigation systems is considerably low, which is estimated around 35 %. Unless, we increase this efficiency at least from 35 % to 60 % in future, bringing more area under irrigation will not be feasible.

In this context it is worthwhile to point out the observations made in the X FYP document on the efficiency of water use in agriculture:

"The water use efficiency (WUE) in most Indian irrigation systems is low in the range of 30 to 40 % against an ideal value of 60 %. Low WUE leads to lower productivity, inequity in supplies to tail-enders and water logging and salinity. Major reasons attributed for this low WUE are basically due to low water rates, poor O&M, dilapidated conditions of infrastructure in the system and poor participatory irrigation management. All these are inter-related and need to be tackled as a package of measures to improve the WUE. The package should include: modernisation, conjunctive use of water, provision of tamper-proof outlets, promotion of water saving devices and back-ended subsidy-cum-loan schemes. A Task Force on WUE would be set up to coordinate all these measures." (GOI, X FYP 2002-7. p.879).

In India, utilisation of water in agriculture varies considerably across states and between seasons depending upon the availability of supply. The availability of water from various sources also makes differences in its utilisation. For instance, when water is provided through canals, and it is not measured by volumetric basis, it is likely that more water is used for specified crops than it is provided through pumping source say, well irrigation. This difference is mainly due to cost factor in availing of water from the specified source. However, it should be noted that even though water is used from different sources with specified quantity (according to farmers' perception) there has been wide variations in the productivity of same crop. Although several factors are responsible for productivity variations, if other things remain constant, water and its proper application is considered to be the prime factor for major productivity variations. A simple example is useful to understand this aspect. When water is provided through drip or sprinkler irrigation, productivity of certain crops increases considerably apart from a considerable quantum of water saving (this practice of **timely, adequate and assured supply of water** is otherwise called **quality of irrigation**). If this practice is adopted for all regions then it would be possible to reduce a large quantum of water, which is currently applied for many crops. But we do not know actually what happens at field level when water is applied from different sources. Hence, a better understanding of the agri-business with multiple sources of supply helps one to provide an optimum quantity of water required for crop production, which in turn reduces the over use of water and its savings help to bring in more area under irrigation.

The earlier study carried out by Vaidyanathan and Sivasubramaniyan (2004)[2] pointed out the gaps in our understanding of the consumptive use of water and also its efficient utilisation by crops in India. The study has also suggested exploring possibilities of filling the gap with available data. In a micro-level study, it is possible to find out the water use efficiency not only in the aggregate but also by crop, crop groups and seasons in a normal rainfall year and a dry year. For this purpose, a field survey in seven tanks in the Cheyyar sub-basin of the Palar basin was undertaken to observe and compute farm level land and water productivity. This report is based on the findings of that field study.

Objectives: The objectives of this study are to:

(i) estimate the water used for irrigation (by both surface and groundwater) in crop production;

(ii) find out the ratio of consumptive use to gross water diverted; and

(iii) find out the gross land and water productivity per unit of diverted water.

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[2] The pioneering basin level study involving all major river basins in all the states of India is brought out at the Madras Institute of Development Studies (Working Paper No. 183) in January 2004. The text version of this Working Paper is also published in the Economic and Political Weekly (3-9. Vol. XXXIX. No. 27) in July 2004. Based on that macro level work this micro level field study was undertaken.

Concepts, Assumptions and Definitions

For the purpose of this study, 8 crops are taken into account and they are grouped under three heads: (1) Paddy (long duration and short duration), (2) Sugarcane and (3) Other (seasonal) crops. (other crops include all seasonal crops other than paddy and sugarcane). Those crops specifically cultivated in the survey area are Cholam, Cumbu, Ragi (cereals); Blackgram, (pulses); Groundnut (oilseeds) and Brinjal (vegetables).

For paddy cultivation, water requirement for land preparation is a must. For this an allowance of 150 millimeter (mm) is taken as evaporation and percolation losses during land preparation in addition to the consumptive use requirements for season 1. For seasons 2 and 3 the required quantum for land preparation being taken as 100 mm. The quantum of supply required per hectare of paddy (which includes the quantum for land preparation) as per the **consumptive use norm** (which is used in this study) is given below:

Season I: August-November: (150+107) 257 mm = 2570 Cubic meter / Ha
Season II: December-March : (100+378) 478 mm = 4780 Cubic meter / Ha
Season III: April-July : (100+523) 623 mm = 6230 Cubic meter / Ha

To compute the volume of water used for crops from either tank source or well source, the following procedure is used. The number of watering provided and approximate depth that a farmer applies at each watering for each crop is taken as the basis to estimate the volume of water used from the tank source. For well irrigation, the horsepower of the motor and the number of hours pumped was observed. With this observed field data, the following guidelines were developed to compute the quantity of water used for each crop:

Method of Computing Irrigation Water Supplied at Field Level under Tanks and Wells:

Computation for Tank Irrigation: In each irrigation, normally, the depth of water provided is the basic information used to find out the quantity of water supplied. This depth varies from crop to crop. For instance, paddy requires frequent watering compared to any other crop. As a result, when number of watering increases automatically the depth of irrigation goes down. For paddy the total number of watering provided, as reported by farmers, varies between less than 20 to over 100 in a given season (depending upon the variety grown and field to field irrigation). Hence, in order to get an approximate quantum of supply provided for each watering the following computation is adopted.

If a farmer reported to have provided more than 80 watering in a season then it is accounted as 1 cm depth per watering. This is roughly equal to 100 cubic meters per hectare per watering (that is, 10000 X 0.01 = 100 cum). In this example, if the farmer provides 80 watering it is equal to (80X100) 8000 cum. Likewise it is accounted 2 cm depth for 61 to 80 watering; 3 cm depth for 41 to 60 watering; 4 cm depth for 21 to 40 watering and 5 cm depth for < 20 watering.

For crops other than paddy, irrigation is provided intermittently rather than continuously. For these crops water may be supplied once in a week or once in 10 days. Here, when the number of days of irrigation interval increases the depth of irrigation is also increasing to a considerable level. As a result, the depth of irrigation is normally higher than paddy crop for each watering. As noted, in this study, sugarcane and all "other crops" are taken into account. For sugarcane a nominal depth of 6 cm per watering is considered. Whereas for "other crops" it is 5 cm depth per watering. This is roughly, 600 cubic meters and 500 cubic meters per hectare per watering for sugarcane and "other crops" respectively. The consumptive use of sugarcane is 1008 mm (107+ 378 + 523) and for seasonal crops, it is Season 1 = 86 mm; season 2 = 302 mm and season 3 = 418 mm. The "other crops" as reported in this study normally takes a growing period between 80 and 100 days and these are the crops most stress period. Hence for these crops 80 per cent of potential evapo-transpiration in each season is taken into account for productivity computation.

Computation of Well Irrigation: In the case of well irrigation, well supply is individually controlled and it is not continuously available to all farmers. Hence the appropriate method as required for computing the quantum of water supplied from wells is the number of hour's water provided per watering for each crop. The quantity of water pumped for irrigation from the wells is calculated by using the following method. From the field observations, as reported by farmers, it is taken **5 hours, 30 hours and 20 hours to irrigate** one hectare each per watering for **paddy, sugarcane and "other crops"** respectively.

The other important measure is the quantum of water pumped per second from the wells by a pump. As it is generally assessed from the manufacturer's (pumping capacity) table that **one horsepower** (1 hp) **pump** usually **discharges one litre per second**. In our survey a large majority of respondents reported having 5 hp electric pump to lift water from their wells. Hence it is assumed at that one **5 hp pump discharges 18,000 litres per hour** (60X60X5). Since the entire sample wells are located in and around the survey fields wastage of water through conveyance is very minimal. Hence **no allowance** is given for conveyance losses through pumping water from the wells for irrigation. The computation of gross water used by each respondent in each season is given in appendix 2 (normal year) and appendix 3 (dry year).

Potential Evapo-Transpiration (PET) and Rainfall in Tiruvannamalai District: This district comes under Agro-Climatic Region no. 11.4 under coastal zone in Tamil Nadu (see MIDS. Working Paper No. 183. Pp.24-30). The relevant data as used in our analysis pertaining to PET, rainfall and effective rainfall for this district is given in **table 1.1**.

From the field survey data, the actual gross value of crops cultivated in the plots were calculated as reported by the farmers in terms of rupees per hectare. For paddy and sugarcane this output value is calculated into kilogram per hectare, whereas for "other crops" only actual reported value in rupees per hectare is used.

Table 1.1 Month wise Potential Evapo-transpiration, Rainfall and Effective rainfall in Tiruvannamalai District (values in mm)

Month	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	Annual
1. PET	113	123	163	171	185	170.0	155	153.0	142	120	105.0	105	1705.0
2. Rainfall	29	8	9	21	47	48.0	82	117.0	117	257	331.0	112	1178.0
3. 80 % RF	23	6	7	17	38	38.4	66	93.6	94	206	264.8	90	942.4
4. **(1-3)**	90	117	156	154	147	131.6	89	59.8	48	-86	-160	15	1008.0

Note: When (**PET - 80% of rainfall**) value is negative, those values are taken as "0", because the excess rainfall over and above the PET goes as runoff (unutilized).

Source: Vaidyanathan and Sivasubramaniyan, Working Paper No. 183. MIDS. P.27.

Based on the gross values of production, the gross water productivity per cubic metre of water is estimated. This is arrived at dividing the gross value by gross consumptive use of water as well as by diverted water. Computation of land and water productivity for each respondent in each season is given in appendix 4 (normal year) and appendix 5 (dry year).

Assumptions:

a. In this study, the consumptive use of crops is assumed to be equal for all selected tanks.

b. It is generally known that consumptive use of crops in the dry year is more than that of the normal year. However, in this study the consumptive use is assumed to be the same in both for the normal and dry years. Therefore, output per unit of consumptive use in the dry year is overstated.

Limitation of the study:

The operational holdings used in this study is fully related to the data (extent of cultivation) that are given by the sample respondents rather than the specific data as available from the Adangal registers maintained by the Village Administrative Officers of the respective tanks / villages.

Definition: In this survey, data for two years were collected from the sample respondents. One is a normal year and the other one a dry year.

Normal Year (NY): 1998-99

The normal year represents a year in which the local annual rainfall is equal to the long-term annual rainfall of that district. This normal year was 1998-99 as most of the tanks got filled during this year.

Dry Year (DY): 2003-04
Contrary to the normal year, the dry year represents apart from scanty rainfall, the selected tanks did not get adequate water from either rainfall or diversion from the anicut to supply water to the ayacut at least for one crop season. In other words, the dry year is the one, which does not provide any water to the tanks, and the tanks are reported to be empty. Hence the cropping is possible only through well irrigation. This dry year for this study was 2003-04.

Methodology: Selection of Tanks for the Study

The Palar basin (includes the tributary of Cheyyar basin) is broadly divided into six agro-climatic sub-zones and the selected seven tanks are located in four zones (which excludes tanks in the upper Palar and lower Palar) as shown in **table 1.2**. "Except for parts of upper Palar, the Kamandalanadhi and Upper Cheyyar zones, which are hilly, the others are made up of more or less well-drained plain lands with moderate slope and generally with good potential for groundwater" (Vaidyanathan 2001: 77). Irrigation under Palar basin is mainly through tanks and wells. There are 604 system (Base Line Survey: Anna University: 46-68) and 538 non-system tanks (Vaidyanathan: 2001: 79) in the Palar basin. For the purpose of this study, five system tanks and two rainfed (non-system) tanks in the Cheyyar River basin are selected representing the head, middle and tail reaches of the basin. The system tanks are selected at random and the non-system tanks are selected purposively. The latter are included mainly to observe the differences between the two types of tank categories. All selected tanks are located in Tiruvannamalai district. The locations of selected tanks are shown in **figure 1.1.**

Selection of Sample Farmers

This study has used primary and secondary data sources. As a first step, in each selected tank, the command area of each sluice is demarcated in the village map and the sluices are divided into three segments as head, middle and tail reaches according to their distance from the tank sluice along the main supply channel. From the village map, in each segment two sample survey numbers are randomly selected. While selecting survey numbers if at least one of the selected survey numbers did not have wells, then one survey number was replaced with an adjacent one with wells. All the owners *(Pattadars)* of the plots within the selected sample survey numbers are the sample farmers for the survey. If the land has been leased in, the tenant is interviewed. Altogether, there are 99 sample farmers selected for the survey. They are distributed as head 29,

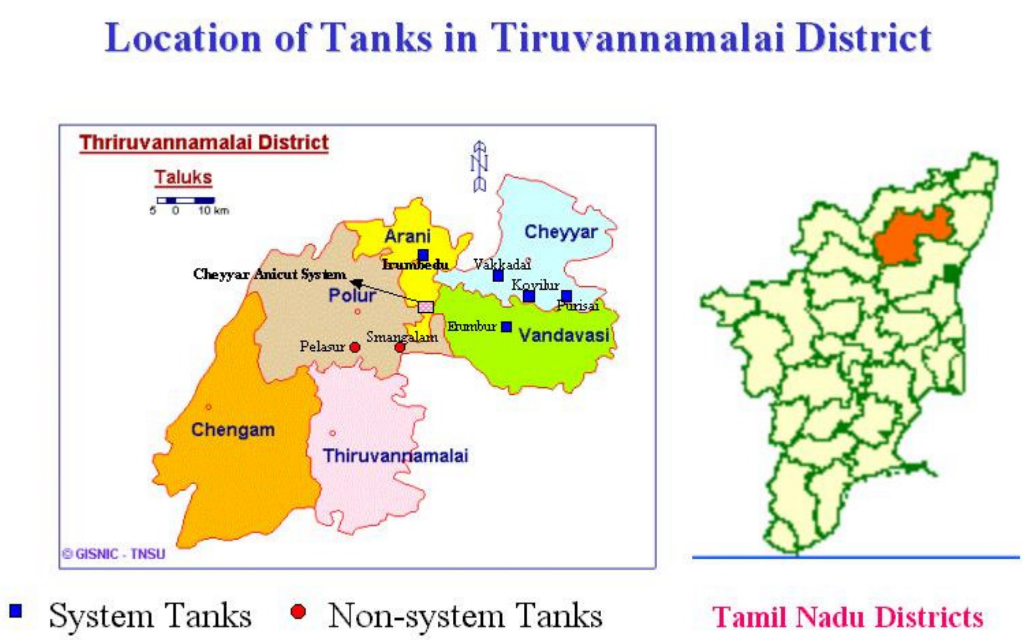
Table 1.2 Salient Features of Selected Tanks under Cheyyar Basin

Sl. No.	Name of Village	Tank (S / NS)	Taluk	Capacity (MCM)	Regis-tered Ayacut Hectares	Water Spread Area Sq.Km.	Catch-ment Area Sq.Km.	Zone
1	Vakkadai	Tank (S)	**Cheyyar**	3.96	471.40.0	0.813	2.80	LC
2	Kovilur	Tank (S)	**Cheyyar**	0.82	133.15.5	1.953	3.24	LC
3	Erumbur	Peria Eri (S)	**Vandavasi**	0.48	352.42.0	0.470	2.40	KR
4	Purisai	Peria Eri (S)	**Cheyyar**	2.66	184.49.0	3.375	4.53	KR
5	Irumbedu	Tank (S)	**Arni**	1.69	180.57.5	1.175	3.97	KN
6	Pelasur	Peria Eri (NS)	**Polur**	2.59	166.09.0	1.265	7.45	UC
7	Semmia-mangalam	Tank (NS)	**Polur**	1.15	72.09.0	0.581	2.91	UC

Source: PWD Memoirs of Respective Tanks.
Anna University, Base Line Survey of Irrigation Commands, CWR, Chennai. 2000.
Vaidyanathan, A. Tanks of South India, CSE. 2001.

Note: S = System Tank. NS = Non-System Tank. Zonewise Classification of Tanks: LC = Lower Cheyyar. KR = Kiliyar. KN = Kamandalanadhi. UC = Upper Cheyyar.

Figure 1.1



middle 22 and tail 48. Among the sample farmers 50 of them owned wells and 49 non-well farmers (see **table 1.3**). A questionnaire (**given in appendix 1**) is used to collect information from the sample farmers. The area held, operated, season wise and crop wise cultivation, source of irrigation supply from tank / well and both are collected. This is done separately for paddy, sugarcane and all "other crops" for three agricultural seasons in a normal tank supply year (1998-99) and a dry year (2003-04) in the seven study tanks.

Table 1.3 Distribution of Sample Farmers and Wells Across Reaches in the Selected Tanks

Reach of Tank	NAME, TYPE and REACH of Tank	Total Sample Farmers	No.of Well Farmers	Number of Non-Well Farmers	% of Well Farmers
HR	Vakkadai (System) HR (CAS2)	3	1	2	33
MR		3	3	0	100
TR		9	6	3	67
Tank_total		15	10	5	67
HR	Kovilur (System) HR (CAS4)	3	1	2	33
MR		4	1	3	25
TR		10	4	6	40
Tank_total		17	6	11	35
HR	Erumbur (System) MR (CAS33)	4	3	1	75
MR		3	0	3	0
TR		7	1	6	14
Tank_total		14	4	10	29
HR	Purisai (System) MR (CAS62)	8	6	2	75
MR		2	0	2	0
TR		7	0	7	0
Tank_total		17	6	11	35
HR	Irumbedu (System) TR (CAS138)	4	4	0	100
MR		5	5	0	100
TR		2	1	1	50
Tank_total		11	10	1	91
HR	Pelasur (Non-System) HR	4	2	2	50
MR		2	1	1	50
TR		7	6	1	86
Tank_total		13	9	4	69
HR	Semmia Mangalam (Non-System) HR	3	2	1	67
MR		3	1	2	33
TR		6	2	4	33
Tank_total		12	5	7	42
ALL 7 TANKS		**99**	**50**	**49**	**51**

Note: HR=Head Reach. MR=Middle Reach. TR=Tail Reach. CAS=Cheyyar Anicut System.

Source: Survey, December 2004.

Land Use Pattern in the Villages under Selected Tanks

Among the 5 system tanks, area wise, Kovilur is the smallest one but it is thickly populated. In the case of Semmiamangalam –a non-system tank- both the area as well as population are the lowest in the three census periods compared to all the seven tanks. Even though the Census data as given in **table 1.4** is far from perfect still one may make some inferences. Regarding land use pattern, none of the selected tanks has any forest area. All selected tanks (villages) have got either tank supply or well supply or both for irrigation purpose. It may be noted that in the selected tanks irrigated land is relatively more in system tanks compared to non-system tanks.

Table 1.4 Village-wise Land Use Pattern under Selected Tanks: 1971, 1981 and 1991

Village/ CDB/ Taluk		Geo. Area Hecs)	Popu- lation	No. of HHs	**Land Use in Hectares** Forest	Source irrigated	Un- irrigated	Cultu- rable Waste	Area not available for cultivation
Vakkadai/ Cheyyar/	a	552.8	1293	293	0	TK- 81.0 W- 28.0	258.0	0.0	185.0
Cheyyar	b	552.8	1248	280	0	TK- 62.9 W – 63.5	155.0	51.2	220.2
	c	552.8	1461	347	0	W-126.4	155.0	51.2	220.2
Kovilur/	a	500.7	2083	469	0	TK-128.0	165.0	0.0	146.0
Anakavur/ Cheyyar	b	500.7	2115	525	0	TK-162.1 W- 24.0	80.1	52.6	181.8
	c	500.7	2104	530	0	TK-202.5	120.8	0.10	177.3
Erumbur/	a	816.1	1322	320	0	TK-270.0	483.0	45.0	18.0
Perna-	b	816.1	1312	322	0	TK-133.0	238.2	139.7	305.3
Mallur/ Vandavasi	c	820.1	1447	360	0	TK-170.4	383.0	19.7	247.0
Purisai/	a	989.1	1961	501	0	W-225.0	511.0	46.0	207.0
Anakavur/ Cheyyar	b	983.1	2349	555	0	TK-172.6 W- 60.1	165.3	317.3	267.8
	c	989.1	2263	555	0	W-385.3	247.7	0.79	355.4
Irumbedu/	a	856.4	3447	729	0	W-254.0	355.0	24.0	223.0
Arani/	b	856.4	4203	888	0	W-254.0	355.0	24.0	223.4
Arnai	c	856.4	5051	1067	0	W-515.0	96.0	24.0	221.4
Pelasur	a	633.8	1431	321	0	TK-166.0	359.0	22.0	7.0
Chetpet/ Polur	b	633.8	1619	354	0	TK- 57.0 W -113.0	239.0	18.0	206.8
	c	633.8	1948	449	0	TK-174.0	245.8	16.0	198.0
Semmiya- Mangalam/	a	454.5	1217	248	0	TK- 71.0 W – 11.0	333.0	34.0	5.0
Chetpet/ Polur	b	454.5	1341	306	0	TK- 73.0 W- 29.0	168.0	61.0	123.5
	c	454.5	1358	334	0	TK-107.5	173.0	50.0	124.0

Note: CDB = Community Development Block. TK = Tank. W = Well.

Source: Census of India (a) 1971, (b) 1981, and (c) 1991. Tamil Nadu. District Census Handbook. North Arcot and Tiruvannamalai-Sambuvarayar. Village and Town Directory.

The report consists of five sections. Following the **introductory Section**, an overview of the selected tanks is given in **Section 2**, which deals with characteristics of sample farmers, cropping pattern, characteristics and accessibility of well irrigation, well water use, source of water for different stages of crop growth and seasonwise groundwater level in the sample tanks. All these aspects are discussed for both normal and dry years. In **Section 3,** the core aspect of tank wise farm level land and water productivity is discussed. This analysis pertains to productivity of all selected tanks in the normal and dry years, tank wise and crop wise water use efficiency, reach wise land and water productivity, comparison between well intensive and less well intensive tanks, and comparison of well and non-well farmers. In **Section 4**, system wise land and water productivity is discussed. This analysis is based on four typologies, which are derived from clubbing all the sample farmers into one category and dividing them into well and non-well farmers and system and non-system farmers to arrive at the typologies. **Section 5** summarizes the main points emerging from the earlier chapters and conclusions are derived.

Section II

An Overview of the Selected Tanks

Characteristics of Sample Farmers

Operational Holdings: Of the seven selected tanks (5 system and 2 non-system), two of the system tanks are reported to have more number of sample wells (10 each). The highest and lowest percentage of area owned by well farmers to total operational holdings is 95 percent in Irumbedu and 32 per cent in Purisai, both are system tanks. Taking all tanks together the percentage of area owned by well farmers is nearly two-thirds of the total operational holdings. However, the number of well and non-well farmers is equally distributed (**table 2.1).** The average extent of operational holding owned by a sample farmer is 0.54 hectare.

Table 2.1 Distribution of Well and Non-Well Farmers in the Selected Tanks

Sl. No.	NAME and Type of Tank	No.of Well Farmers	No.of Non-well Farmers	Total Sample Farmers	Operational Holdings Hectares	TOTAL Area Owned by Farmers (Hectares)		% of Area Owned by well farmers	% of (no. of) well farmers
					Well + Non-well	Well	Non-well		
1	2	3	4	5	6	7	8	9	10
1	Vakkadai **S**	10	5	15	6.65	4.58	2.07	69	67
2	Kovilur **S**	6	11	17	5.51	3.16	2.35	57	35
3	Erumbur **S**	4	10	14	4.90	2.22	2.68	45	29
4	Purisai **S**	6	11	17	8.58	2.77	5.81	32	35
5	Irumbedu **S**	10	1	11	6.92	6.60	0.32	95	91
6	Pelasur **NS**	9	4	13	12.40	10.25	2.15	83	69
7	Semmiaman-galam **NS**	5	7	12	8.06	3.10	4.96	38	42
All 7 Tanks		**50**	**49**	**99**	53.02	32.68	20.34	**62**	**51**

Note: S=System tank. NS=Non-system tank.
Source: Survey, December 2004.

Gross Irrigated Area: In the normal year 86 per cent of the operational holdings of all the sampled tanks have received water supply, whereas in the dry year only 32 per cent of operational holdings received irrigation. During the dry year even system tanks did not perform better. This is because no tank had got any supply and hence whatever area reported under irrigation is purely irrigated by wells. Across tanks only two system tanks are reported to get irrigation around 100 per cent of the operational holdings in the normal year and the remaining three is between 60 and 90 per cent. Interestingly, the non-system tanks also performed better in the normal year. This is evident from Pelasur tank where the gross irrigated area is 95 per cent. However, in the other non-system tank only 62 per cent of GIA is irrigated. The non-system tanks' main source of supply is only from rainfall and even wells that serve in these tanks fully depend upon the rainfall for recharge. As a result, in the dry year, the GIA in the non-system tanks had dropped heavily and the lowest percentage is only 5 per cent in Semmiamangalm tank (**table 2.2**). The season wise area under irrigation compared to operational holdings reveals that in the normal year the maximum extent of irrigated area in season 2 is only 38 per cent and the minimum being 16 per cent in season 3. This reinforces a point, that there is a lot of scope to bring in more area under irrigation across seasons within the wetland (ayacut) in the normal year if irrigation is properly managed.

Table 2.2 Tank wise Gross Irrigated Area by Sample Farmers in Normal and Dry Years

Sl. No.	NAME of Tank	Opera-tional Holdings Hectares	Normal Year (NY)				Dry Year (DY)				GIA as % of Operational Holdings	
			Seasonwise Area (Hectares) under Irrigation								NY	DY
			S1	S2	S3	Gross	S1	S2	S3	Gross		
1	2	4	5	6	7	8	5	6	7	8	9	10
1	Vakkadai	6.65	2.89	2.68	1.24	6.81	2.04	1.20	0.82	4.06	**102**	**61**
2	Kovilur	5.51	0.00	2.35	0.96	3.31	0.31	0.23	0.23	0.77	**60**	**14**
3	Erumbur	4.90	1.50	2.56	0.79	4.85	0.98	0.35	0.40	1.73	**99**	**35**
4	Purisai	8.58	2.83	3.57	1.21	7.62	0.94	1.45	0.81	3.19	**89**	**37**
5	Irumbedu	6.92	2.38	2.45	1.35	6.18	2.08	0.83	0.08	2.99	**89**	**43**
6	Pelasur	12.40	4.81	4.80	2.15	11.76	2.25	1.18	0.59	4.02	**95**	**32**
7	Semmia-mangalam	8.06	2.47	1.94	0.54	4.96	0.38	0.00	0.00	0.38	**62**	**5**
ALL 7 TANKS		53.02	16.89	20.35	8.25	45.49	8.98	5.24	2.92	17.15	**86**	**32**

Source: Survey, December 2004.

Cropping Pattern in the Normal Year: 1998-99

Taking into account of the soil conditions prevailing in the tank command under study, farmers are raising mostly paddy as a main crop in all the three seasons although the extent of cultivated area varies across seasons. Within paddy, farmers grow both long and short duration varieties. Ponni, I.R. 20 and some traditional varieties like Ambasamudram are considered long duration varieties, which normally takes between 120 and 150 days for harvest. The short duration (between 90 and 120 days) varieties include short ponni, I.R. 50, ADT-36, and 43, TKM-9, IET-27, Co-29 and 39, Kullakar, Gundu and Vaigai. The respondents raise all these long and short duration varieties. The well farmers and farmers located in the head reach of the tanks are normally cultivating long-duration paddy. Most of the non-well farmers cultivate only the short-duration paddy. During the normal year, one may observe from **table 2.3** that paddy occupies nearly 90 per cent of total area of cultivation. **Since the southwest monsoon helps the farmers** to receive some rains during the first season, this season is considered favourable for the cultivation of paddy in most of the surveyed tanks. It should be important to note that farmers, in the non-system tanks had grown only a very limited extent of long duration paddy mainly due to uncertainty in availability of water supply not only from the tanks but also from wells even in the normal year. Next to paddy, sugarcane is considered important. However, only the well farmers are able to raise this crop in two tanks (one each in system and non-system) with a limited extent. The less extent devoted for sugarcane implies that this crop does not fetch good income and it also requires assured water supply throughout the year. Apart from paddy and sugarcane, a limited number of farmers had grown oilseeds; small millets and vegetables were grown to a very limited extent. In our analysis, these crops are grouped under 'other seasonal crops' category.

Table 2.3 Cropping Pattern in the Normal Year: 1998-99 (Area in Hectares)

Tanks	Detail	Ponni	IR50	ADT	Sugarcane	B.gram	Groundnut	Cumbu	Ragi	Total
Vakkadai	Extent	1.46	2.30	3.06						6.81
	Farmers	7	9	16						32
Kovilur	Extent	0.13	2.23	0.94						3.31
	Farmers	1	15	6						22
Erumbur	Extent	2.70	0.88	1.04		0.23				4.85
	Farmers	7	2	7		1				17
Purisai	Extent	2.50	0.00	3.79	1.32					7.62
	Farmers	7	0	12	9					28
Irumbedu	Extent	2.06	1.23	2.34			0.55			6.18
	Farmers	7	5	11			2			25
Pelasur	Extent	0.38	5.27	3.30	1.71		0.38	0.30	0.40	11.76
	Farmers	1	16	7	6		1	1	1	33
Semmia-mangalam	Extent	0.25	2.26	2.45						4.96
	Farmers	1	9	8						18
Total	Extent	9.49	14.17	16.93	3.04	0.23	0.93	0.30	0.40	45.48
	Farmers	31	56	67	15	1	3	1	1	175

Note: Blank entries denote nil. Number of farmers represents, the sample farmer is also counted more than once according to the crops raised by him in the sample plots. Sugarcane is counted as season acres

Source: Survey, December 2004.

Cropping Pattern in the Dry Year: 2003-04

As indicated earlier even in the dry year the cultivation of paddy is dominating in all the three seasons and in all the tanks. However, the area under paddy is comparatively less during the dry year. Compared to system tanks the performance of the non-system tanks is very poor. Of the two non-system tanks selected, Semmiamangalam tank did not crop anything at all except a very little extent with cholam/cumbu (see **table 2.4**). There is no change in the extent of area under sugarcane between the reference years. However, it should be mentioned that in Kovilur system tank one farmer tried for sugarcane cultivation with a limited extent but the crop withered due to lack of well water in the final stages of the crop growth. 'Other seasonal crops' such as blackgram, groundnut, brinjal and small millets occupied a limited extent. It may be clear from the table that cultivation of crops requires good water supply either from the tank source or from the wells or both. **Reduced supply from any source leads to gross reduction in the area under cultivation in all the seasons, which is clearly observed from the study.**

Table 2.4 Cropping Pattern in the Dry Year: 2003-04 (Area in Hectares)

Tanks	Detail	Ponni	IR50	ADT/ O13	Sugarcane	Black gram	Groundnut	Brinjal	Cholam	Total
Vakkadai	Extent	0.20	0.26	3.13			0.09	0.38		4.06
	Farmers	1	1	12			1	1		16
Kovilur	Extent	0.27		0.36	0.13					0.77
	Farmers	2		2	3					7
Erumbur	Extent	0.75	0.35	0.40		0.23				1.73
	Farmers	2	1	1		1				5
Purisai	Extent	1.38	0.00	0.44	1.11	0.07	0.20			3.19
	Farmers	4	0	3	6	1	1			15
Irumbedu	Extent	0.91	0.40	1.44					0.23	2.99
	Farmers	6	1	6					1	14
Pelasur	Extent	0.94			1.76		0.94		0.38	4.02
	Farmers	2			3		3		1	9
Semmia-mangalam	Extent								0.38	0.38
	Farmers								2	2
Total	Extent	4.45	1.01	5.77	3.00	0.30	1.23	0.38	1.00	17.14
	Farmers	17	3	24	12	2	5	1	4	68

Note: Blank entries denote nil. Number of farmers represents the sample farmer is also counted more than once according to the crops raised by him in the sample plots. Sugarcane is counted as season acres

Source: Survey, December 2004.

Characteristics of Well Irrigation under Selected Tanks:

As indicated in the sampling procedure care was taken to include plots that have wells. Apart from the ayacut wells located in the tank command, information was also collected to get the total number of wells owned by the respondents in their dry lands also. In the seven tanks selected, total number of wells reported is 131. Of these, the total ayacut wells are 58 and wells in use are 50 (**table 2.5**). Since the analysis of land holdings (operational and irrigated) in this study is mainly concentrated on the wet holdings under tanks the discussion is mainly for the wells in the ayacut only. From the point of well density, the system tanks are much better than non-system tanks. In three of the system tanks, the well density (number of wells per hectare) is more than one and in the remaining two it is less than the overall tank average of 0.94. The non-system tanks well density is also below the tank average. Taking all tanks together, the percentage of wells not in use is 14. Among the five tanks reported having wells not in use, the maximum number of wells not in use in a tank is two and the minimum is one.

Table 2.5 Classification of Wells Owned by Sample Farmers and Year of Construction

Tanks	No. of Sample Farmers	Opera-tional Holdings: (wet) (Ha)	Total Wells in Wet & Dry Lands	Well Water Use in the Ayacut			Total wells in the Ayacut	Well Density Well/Ha	Year of Construction			
				No Well	Wells in use	Wells not in use			Before 1970	1971-90	After 1990	Total
Vakkadai	15	6.65	19	4	10	1	11	1.50	7	4	0	11
Kovilur	17	5.51	29	9	6	2	8	1.09	6	1	1	8
Erumbur	14	4.90	21	8	4	2	6	0.81	5	1	0	6
Purisai	17	8.58	12	10	6	1	7	0.70	6	0	1	7
Irumbedu	11	6.92	14	1	10	0	10	1.45	9	0	1	10
Pelasur	13	12.40	17	4	9	0	9	0.73	7	1	1	9
Semmia-mangalam	12	8.06	19	5	5	2	7	0.62	7	0	0	7
Overall Total	99	53.02	131	41	50	8	58	0.94	47	7	4	58

Source: Survey, December 2004.

Digging new wells in recent years is a rare phenomenon. Most of the wells were very old and they had been constructed before 1970. More than three-fourths of total wells are old wells. Between 1971 and 1990 only 7 wells are added into the stock and in the later period (after 1990) well digging was much slowed. This is mainly due to poor availability of groundwater supply to cope with the requirements. Especially in one of the non-system tanks no additional well is added after 1970. This clearly indicates that groundwater recharge and its availability are not conducive for further well construction in this tank.

Tank wise frequency distribution of wells by original and current depth is given in **table 2.6**. At the time of initial construction nearly half of the total wells was less than 6 metres, over a third of wells was between 6 and 12 metres depth and only 9 per cent of wells was over a depth of 12 metres. The deepest wells are reported only in Irumbedu tank where half of the wells are more than 12 meters depth. At the time of this survey, all wells in Irumbedu tank and a majority in Pelasur non-system tank have a depth of over 12 metres. Depth of wells depends on a variety of factors including volume and seasonal distribution of local rainfall, subsurface geology, well owner's economic viability and also the supply in the tanks that recharges them. The current depths of wells show that even in many tanks the present depth is only shallow and in many cases the geo-physical factors do not allow farmers to dig up more depths than what they are currently available now.

Table 2.6 Classification by Original and Current Depth of Wells

Tanks	Original Depth of Wells (Meter)				Total	Current Depth of Wells (Meter)				Total	Dug Before 1970	% to total
	Up to 6	6-12	12+	Not Known		Up to 6	6-12	12+	Not Known			
Vakkadai	6	5	0	0	11	2	6	3	0	11	7	64
Kovilur	3	4	0	1	8	0	8	0	0	8	6	75
Erumbur	4	0	0	2	6	2	4	0	0	6	5	83
Purisai	3	2	0	2	7	2	4	1	0	7	6	86
Irumbedu	3	3	4	0	10	0	0	10	0	10	9	90
Pelasur	3	4	1	1	9	0	3	6	0	9	7	78
Semmia-mangalam	4	3	0	0	7	1	5	1	0	7	7	100
Total	26	21	5	6	58	7	30	21	0	58	47	81

Source: Survey, December 2004.

Energisation: A large majority of wells (50 out of 58) were fitted with either electric motors of 3 to 5 horsepower or oil engines with 5 to 10 hp (**table 2.7**). Wells, which used the oil engines initially, were mostly fitted with 8 HP. Currently, this situation has changed considerably and a large majority of wells in use have energised lifts mostly using 5 hp electric motors. It should be pointed out that almost in all tanks (except Irumbedu and Pelasur); a couple of wells each fitted with energised lifts were out of use. This is mainly due to non-availability of water and also due to poor recharge in those wells. This succinctly tells us that mere ownership of wells does not make a farmer to prosper but a higher quantum of pumped water is the main criteria for farmer's prosperity by owning wells in agriculture.

Table 2.7 Original and Current Horse Power with Wells in Use and Wells Not in Use

Tanks	Wells in Original Condition							
	No. of Wells with				Wells Not in Use with			
	<---- Horse Power ---->			Total	<---- Horse Power ---->			Total
	3-5	6-10	NK		3-5	6-10	NK	
Vakkadai	1	4	5	10	0	0	1	1
Kovilur	0	2	4	6	0	0	2	2
Erumbur	3	0	1	4	0	1	1	2
Purisai	2	1	3	6	0	1	0	1
Irumbedu	5	0	5	10	0	0	0	0
Pelasur	4	1	4	9	0	0	0	0
Semmia-mangalam	3	1	1	5	0	0	2	2
Total	18	9	23	50	0	2	6	8
	Wells in Current Position							
Vakkadai	10	0	0	10	1	0	0	1
Kovilur	4	2	0	6	1	1	0	2
Erumbur	3	1	0	4	0	1	1	2
Purisai	5	1	0	6	0	1	0	1
Irumbedu	10	0	0	10	0	0	0	0
Pelasur	9	0	0	9	0	0	0	0
Semmia-mangalam	4	1	0	5	2	0	0	2
Total	45	5	0	50	4	3	1	8

Note: NK = Not known.
Source: Survey, December 2004.

Accessibility of Watering to the Sample Plots in the Normal Year:

To achieve higher yields adequate water at proper intervals need to be supplied. The water supply may be either from tank or well or both. Since in a normal year tanks receive adequate storage, it is possible to provide more number of irrigation from tanks than wells. However, one does not know how the farmer takes a decision. In order to see what actually happens in the field, data were collected for a normal tank supply year and the results are presented in **table 2.8**. Contrary to general expectations, it is found that overall watering in all tanks taking all three seasons together indicate that there has not been any difference between the number of watering provided by a farmer either from tank source or from the wells. Both sources have equally contributed which is on the average 56 watering in the whole year. However, the picture varies between seasons. In season I, average tank watering is more (60) than the well watering (49), whereas in season II, tank watering is less (53) than well watering (58) and in season III, there has not been much difference between the two (T-57, W-60).

Table 2.8 No. of Watering From Tanks and Wells by Seasons: All Crops: Normal Year: 1998-99

Tanks	**Watering / Farmers**	**Season 1**		**Season 2**		**Season 3**		**Total**		Average / tank	
		Tank	Well	Tank	Well	Tank	Well	Tank	Well	Tank	Well
Vakkadai	Total Watering	960	0	765	50	0	365	1725	415	64	59
	No of Farmers	14	0	13	2	0	5	27	7		
Kovilur	Total Watering	0	0	1185	0	0	400	1185	400	74	80
	No of Farmers	0	0	16	0	0	5	16	5		
Erumbur	Total Watering	220	70	393	40	0	70	613	180	41	30
	No of Farmers	4	2	11	3	0	1	15	6		
Purisai	Total Watering	329	36	250	100	170	158	749	294	39	33
	No of Farmers	8	3	8	3	3	3	19	9		
Irumbedu	Total Watering	0	710	0	830	0	421	0	1961	0	78
	No of Farmers	0	9	0	10	0	6	0	25		
Pelasur	Total Watering	733	130	403	180	0	250	1136	560	54	37
	No of Farmers	12	5	9	3	0	7	21	15		
Semmia-mangalam	Total Watering	500	140	280	180	0	75	780	395	60	49
	No of Farmers	8	3	5	3	0	2	13	8		
Total	Total Watering	2742	1086	3276	1380	170	1739	6188	4205	56	56
	No of Farmers	46	22	62	24	3	29	111	75		
Average / Tank		60	49	53	58	57	60	56	56		

Note: No.of farmers in some cases are double counted since both types of supply are used for the same crop.
Source: Survey, December 2004.

All these variations indicate that in season 1, full tank supply has helped farmers to provide more number of tank irrigation. In season 2, receding tank supply led to less number of tank watering. However, crop water requirement should be met to get more yields; at this stage well irrigation comes under rescue. Wherever tank supply is insufficient well water is provided; consequently this source dominates in season 2. It should be pointed out that in season 3 mostly tank water is not available in many tanks. However, in a few tanks where the residual tank supply available after season 2 is not probably used for irrigation and the sluices are kept closed. Even then water is leaking through sluices which are mostly utilised by farmers located in the head reach of the tank or even at the tail end of the main sluice which gets more leakage and this has been utilised along with well supply. Exactly this is the situation happening in one of the tanks namely Purisai in the study. As one could observe from the table that tank irrigation is very little compared to well irrigation in season 3.

Apart from this, across tanks one may also observe several patterns of water use. In Kovilur tank no irrigation was done in Season 1 by using any of the sources. But only tank supply was used in season 2 and also only well supply was used in Season 3. In Irumbedu tank, only well irrigation was provided in all the seasons since tank sluices were closed for irrigation for a long period. In

Purisai tank, in all the seasons, more of tank supply and less of well supply was used. All these point out, irrespective of the source of irrigation, farmers' decision making vary over a wide range depending on the local situation of hydrogeology, availability of tank water and extraction devices available to pump water from the wells.

Well Water Use in Dry Year:

In recent decades irrigation by wells has been tremendously increasing all over the country. Importance of well irrigation increases considerably when it is used as a conjunctive source rather than as a sole source. Because, after raising a crop by using surface supply the well irrigation comes for rescue when water supply in the surface source is inadequate / depleted at the final stages of the crop growth. Apart from studying the supplementary nature of well water in the tank commands, an attempt was made to understand what the situation under well irrigation was when tank water was not totally available in a dry year. Relevant information of the area irrigated in each season is provided in **table 2.9**.

Table 2.9 Well Water Used by Sample Farmers, 2003-04 (Extent in Hectares)

Tanks	Extent / Farmers	OH (wet) (Ha)	SEASON			Total	% to OHs	Wells in Use	Well water use / Well	Well Density Well/Ha
			1	2	3					
Vakkadai	Total Extent	6.65	2.04	1.20	0.82	4.06	61	10	0.41	1.50
	No of Farmers	15	8	4	3	15				
Kovilur	Total Extent	5.51	0.31	0.23	0.23	0.77	14	6	0.13	1.09
	No of Farmers	17	3	2	2	7				
Erumbur	Total Extent	4.90	0.98	0.35	0.40	1.73	35	4	0.43	0.81
	No of Farmers	14	1	2	1	4				
Purisai	Total Extent	8.58	0.94	1.45	0.81	3.19	37	6	0.53	0.70
	No of Farmers	17	4	5	5	14				
Irumbedu	Total Extent	6.92	2.08	0.83	0.08	2.99	43	10	0.30	1.45
	No of Farmers	11	8	4	1	13				
Pelasur	Total Extent	12.40	2.25	1.18	0.59	4.02	32	9	0.45	0.73
	No of Farmers	13	9	3	3	15				
Semmia-mangalam	Total Extent	8.06	0.38	0.0	0.0	0.38	5	5	0.08	0.62
	No of Farmers	12	1	0	0	1				
Total	Total Extent	53.02	8.98	5.24	2.92	17.15	32	50	0.34	0.94
	No of Farmers	99	34	20	15	69				

Note: Crops that did not get well supply are excluded.
Sugarcane farmers are counted as 3 seasonal crops. Rainfed crops are excluded.

Source: Survey, December 2004.

The area that can be irrigated in different seasons obviously depends on water availability. This is easily observed from our survey. In the normal tank supply year, including well supplementation, the area under irrigation was 45 hectares (as observed from table 7), which is

86 per cent of the operational holdings. However, in the dry year only well irrigation was feasible since the tank supply was not available; therefore, the area under irrigation is only 17.15 hectares (see table 15), which is 32 per cent of the total holdings held by all the respondents. This 17.15 hectares represents the actual capacity of sample wells that can be irrigated without having any supplementation. The table indicates that taking all the three seasons together one may observe that two-thirds of the respondents are cultivating by using well water (this also includes farmers who cultivated annual crops which is counted as 3 seasonal crops) in the dry year.

It is also interesting to note that in all the tanks **in a normal year**, the irrigated area is moderate in season 1. During this season rainfall is also moderate, as is the moisture deficit, and dependence of irrigation on wells is high. In season 2, when rainfall is more and some tank supply is possible, the need for well irrigation for seasonal crops is generally limited. However, water intensive crop such as paddy needs irrigation in this season. Consequently, extent of paddy cultivation (especially in a rainfall deficient dry year) is mostly determined by the availability of groundwater supply. In the season 3, since there is not much tank supply, there is little recharge and the area irrigated by wells also becomes less. Further in this season, only those wells, which have some water, go for raising a crop. There is also a progressive decrease in number of farmers taking up irrigated cultivation in this season.

In the dry year across tanks, one can observe that well density does not make much difference in area under irrigation. Even in the high well density tank such as Vakkadai, Kovilur and Irumbedu area under well irrigation is reported 61 %, 14 % and 43 % respectively of the total holdings operated in that village. Further, the low well density villages such as Erumbur and Purisai had reported a moderate percentage of well-irrigated area (35 % and 37 % respectively). Also in one of the two non-system tanks, 32 per cent of area is well irrigated while in the other tank barely 5 per cent of well supply was possible in the dry year. The overall percentage of area getting well water, in all tanks in all seasons, compared to operational holdings is 32. Hence there is a mixed pattern of well water use in the dry year.

Number of Watering and Average Number of Hours Required:

The average number of watering and the number of hours for which well water is supplied in the dry year for paddy crop is given in **table 2.10**. Since paddy is the only dominant crop grown in

Table 2.10 No. of Watering and Average No. of Hours Required to Irrigate One Hectare of Paddy per Well, 2003-04

Tanks	Watering / Farmers	SEASON 1	SEASON 2	SEASON 3	Total	Avg. Watering / Farmer	Hours / Farmers	SEASON 1	SEASON 2	SEASON 3	Total	Avg. \hrs/ Ha
Vakkadai	Total Watering	585	160	205	950	**68**	Total Hours	41	34	24	99	**7**
	No of Farmers	8	3	3	14		No of Farmers	8	3	3	14	
Kovilur	Total Watering	200	95	160	455	**114**	Total Hours	21	19	15	56	**14**
	No of Farmers	2	1	1	4		No of Farmers	2	1	1	4	
Erumbur	Total Watering	130	115	70	315	**79**	Total Hours	21	18	9	49	**12**
	No of Farmers	2	1	1	4		No of Farmers	2	1	1	4	
Purisai	Total Watering	90	115	310	515	**74**	Total Hours	12	15	21	49	**7**
	No of Farmers	2	2	3	7		No of Farmers	2	2	3	7	
Irumbedu	Total Watering	434	305	80	819	**63**	Total Hours	165	67	18	250	**19**
	No of Farmers	8	4	1	13		No of Farmers	8	4	1	13	
Pelasur	Total Watering	207	0	0	207	**104**	Total Hours	38	0	0	38	**19**
	No of Farmers	2	0	0	2		No of Farmers	2	0	0	2	
Semmia-mangalam	Total Watering	0	0	0	0	**0**	Total Hours	0	0	0	0	**0**
	No of Farmers	0	0	0	0		No of Farmers	0	0	0	0	
Total	Total Watering	1646	790	825	3261	**75**	Total Hours	299	153	88	541	**12**
	No of Farmers	24	11	9	44		No of Farmers	24	11	9	44	

Note: Total hours represents, no. of hours required to irrigate one hectare of paddy crop per farmer and it is added to the no. of farmers reported..

Source: Survey, December 2004.

all the tanks surveyed, this crop is taken for analysis. By taking all the three seasons and all the tanks together, the average number of watering provided by a farmer works out to 75. Across tanks, the highest number of watering provided is reported in the system tank of Kovilur (114) followed by Pelasur (104), a non-system tank. The lowest number of watering, 63 is reported in Irumbedu. This is almost a half that of the highest watering tank. The more number of watering as reported is mainly due to adoption of field-to-field irrigation and also cultivation of long duration paddy that requires more watering during the growing period. One may also infer from the table that majority of farmers are growing only short duration paddy since average number of watering required is around 75. Across seasons, the first and second season report more or less equal number of watering (around 70) compared to the third season (92 watering). This shows that both the southwest and northeast monsoons in seasons 1 and 2 help to retain a good amount of soil moisture compared to the scanty rainfall during dry period, which prevails in season 3. Dry periods normally require more number of watering.

Apart from the average number of watering, the average number of hours of water supplied per hectare provides an interesting picture. Overall, one hectare of paddy land required 12 hours of pumping per watering. However, across tanks this varies widely ranging between 7 and 19 hours. The large difference between these two is mainly due to two factors: (i) the pump discharge rate may be very low; it may also due to the prevailing soil type of the tank ayacut and (ii) this may be due to over supply (irrigation) than what it is required for the crop water requirement. Across seasons, the average number of hours per watering per hectare is 12, 14 and 10 respectively for seasons 1, 2 and 3. It should be noted that the monsoon rains might have helped farmers to pump more number of hours during the first two seasons and the deficit rainfall / dry situation limited the wells to be operated only for a less number of hours as it may be the case for the third season. Due to this fact, third season cropping certainly receives inadequate water supply, especially in the dry year, leading to a deficit soil moisture resulting in poor yield and returns compared to the other two seasons. However, these are general observations as inferred from the table, and the exact picture requires a rigorous sampling and deeper investigation through farmer's field observations, which were not possible in this study.

Water Sale / Purchase

Respondents were also asked to state whether they purchased / sold water in the two reference years. Water sale / purchase was not reported in the normal tank supply year by any of the farmers; on the other hand purchase of water to a limited extent by the well farmers themselves was reported in the dry year. The responses for sufficiency of well water in the dry year indicates that only two-fifths of the total well owners satisfied with the availability of water from their wells and a majority reported insufficiency in water supply (**table 2.11**). Regarding purchase of well water no farmer was reported purchasing for the entire crop period. Only four farmers

Table 2.11: Sufficiency and Purchase of Well Water by Sample Farmers, 2003-04

Tanks	Well Water Sufficient			Purchase of Water		
	Yes	No	Total	Yes	No	Total
Vakkadai	7	3	10	1	14	15
Kovilur	2	4	6	0	17	17
Erumbur	2	2	4	2	12	14
Purisai	4	2	6	0	17	17
Irumbedu	4	6	10	1	10	11
Pelasur	2	7	9	0	13	13
Semmiamangalam	0	5	5	0	12	12
Total	21	29	50	4	95	99

Source: Survey, December 2004.

received water during the maturity period of their crop growth from the adjacent well owners, when their own well supply was inadequate to irrigate their cropped land. Even for these purchases no rigorous payments were made but these water purchasers and sellers adopted a "give and take" policy in many matters including well water transactions.

Source of Water for Different Stages of Crop Growth: **Normal Year**

The basis for providing adequate and timely irrigation supply during different stages of crop growth is to maximize yield. This is termed herein as quality of irrigation. Since water supply is not fully reliable from any one-source farmers mix different sources for supplementation. Water intensive crops such as paddy require more number of watering especially during its final stage of growth period. Our survey has documented information on how respondents applied water in each stage of its growth. Relevant information is given in **table 2.12** through 22 for the normal tank supply year.

Table: 2.12 Source of Water for Nursery Preparation, 1998-99

Tanks	<----------------- Source of Water Used by Sample Farmers in ----------------->												Adequacy of Supply Reported in		
	Season 1						Season 2			Season 3					
	Tank	Well	T + W	W + T	No Nur-sery *	Total	Tank	Well	Total	Tank	Well	Total	S 1	S 2	S 3
Vakkadai	14	0	0	0	0	14	11	2	13	0	5	5	14	13	5
Kovilur	0	0	0	0	0	0	15	1	16	0	5	5	0	16	5
Erumbur	3	1	0	0	0	4	8	3	11	0	1	1	4	11	1
Purisai	5	1	0	1	2	9	5	1	6	3	1	4	7	6	4
Irumbedu	0	8	0	0	0	8	0	10	10	0	6	6	8	10	6
Pelasur	6	5	1	0	0	12	8	2	10	0	2	2	12	10	2
Semmia-mangalam	6	3	0	0	0	9	5	2	7	0	2	2	9	7	2
Total	34	18	1	1	2	56	52	21	73	3	22	25	54	73	25

Note: In Irumbedu, tank water has not been available for the past 10 years due to lowering of the Kamandalanadhi river bed (due to sand removal) where from the inlet channel of the tank takes off. As a result, most of the tail end farmers of this tank did not get adequate recharge from their wells and some abandoned their wells even available with power connections. The tank occasionally filled up by local rainfall and local catchment supply.
In Kovilur no crop was raised in season 1. In season 2 all farmers (except 1) used the tank supply.
* In Purisai tank a couple of farmers solely raised paddy by direct sowing method and hence no nursery.

Source: Survey, December 2004.

Nursery Preparation: For raising nursery, a majority of farmers in seasons 1 and 2 used primarily the tank source and reported that available supply was adequate. In season 3, as noted earlier only in Purisai, tank water was adequately used. In season 1, farmers have used combinations of supply such as tank plus well and well plus tank in limited cases. This indicates that the main source of supply used for nursery preparation is tank water followed by the other sources. However, in season 2 and 3 this was not reported. Since nursery preparation requires very little water almost all respondents reported positively about raising nursery. The table indicates that almost half of the respondents had grown nursery for paddy in season 1, in season 2 three-fourths and in season 3 only 25 per cent.

Land Preparation: Farmers are primarily using tank source in the first two seasons and in the third season supply was mainly given from wells. The dependence on tanks in seasons 1 and 2 each is 73 per cent. In season 3, the dependence on wells is 90 per cent (see **table 2.13**). Regarding continuity of supply, over 80 percent of farmers in all three seasons reported that they are satisfied with the available water, even though variations exist across tanks and seasons. More or less the same responses were received for the adequacy of supply from the tank and well sources. Only, in season 3, where mostly well water was used only 70 per cent of the respondents reported that the supply was adequate. On the whole it may be observed that during normal year tank supply has helped much to prepare the land satisfactorily.

Crop Growth: It should be noted that for any type of crop, higher productivity might be achieved only if the crop gets its maximum water requirement especially in its maturity stage. Either water deficiency or improper water supply in this stage of crop growth certainly impedes the productivity levels. In our survey, even in the normal year, farmers reported widely untimely supply as well as its inadequacy at this stage of crop growth. **Table 2.14** amply demonstrates this fact. In the first two seasons around 70 per cent of respondents only reported that they got timely supply of water and one third receives only untimely supply. In season 3, only a third of the respondents reported that they got timely supply. In the case of adequacy of supply more or less equal responses (around 70 per cent) were received in all the three seasons.

It is well understood that better water supply contributes to good yields. But this situation is not always prevailing where water supply is a constraint. Especially in tropical countries better irrigation supply to meet the entire cropped land is always a problem. Under these circumstances it is necessary to manage the available deficit water supply according to the crop water requirements. Individual farmers who possess ownership of land and water can easily manage the supply by way of independent decision-making process. Since the entire control and

Table: 2.13 Source of Water for Land Preparation, 1998-99

Tanks	<---------------- Source of Water Used by Sample Farmers in ----------------->												Water Supply (Continuous / Intermittent)						Adequacy of Supply (Adequate / Inasequate)					
	Season 1				Season 2					Season 3			Season 1		Season 2		Season 3		Season 1		Season 2		Season 3	
	Tank	Well	T + W	Total	Tank	Well	T + W	W + T	Total	Tank	Well	Total	C	I	C	I	C	I	A	IA	A	IA	A	IA
Vakkadai	14	0	0	14	13	0	0	0	13	0	5	5	14	0	13	0	5	0	14	0	11	2	3	2
Kovilur	0	0	0	0	15	2	0	0	17	0	5	5	0	0	17	0	5	0	0	0	17	0	5	0
Erumbur	2	0	2	4	9	1	1	0	11	0	1	1	0	4	9	2	1	0	1	3	8	3	0	1
Purisai	9	2	0	11	8	3	0	0	11	3	3	6	11	0	10	1	5	1	9	2	10	1	4	2
Irumbedu	0	8	0	8	0	7	1	1	9	0	6	6	5	3	5	4	4	2	5	3	6	3	4	2
Pelasur	11	1	1	13	8	2	0	0	10	0	2	2	11	2	8	2	2	0	13	0	6	4	2	0
Semmia-mangalam	7	2	0	9	5	2	0	0	7	0	2	2	7	2	5	2	2	0	8	1	4	3	1	1
Total	43	13	3	59	58	17	2	1	78	3	24	27	48	11	67	11	24	3	50	9	62	16	19	8

Source: Survey, December 2004.

Note: In Irrumbedu, tank water was not used in all the three seasons since the tank did not get the river supply for many years. However, tank seepage through wells was supplemented by a couple of head reach farmers. In Kovilur, no crop was raised in season 1. In season 2 all farmers (except 2) used the tank supply.

Table: 2.14 Source of Water for Crop Growth, 1998-99

Tanks	<------------- Source of Water Used by Sample Farmers in ----------->											Water Supply (Continuous / Intermittent)						Adequacy of Supply (Adequate / Inasequate)					
	Season 1				Season 2				Season 3			Season 1		Season 2		Season 3		Season 1		Season 2		Season 3	
	Tank	Well	T + W	Total	Tank	Well	T + W	Total	Tank	Well	Total	C	I	C	I	C	I	A	IA	A	IA	A	IA
Vakkadai	14	0	0	14	11		2	13	0	5	5	14	0	11	2	0	5	10	4	11	2	3	2
Kovilur	0	0	0	0	15	2	0	17	0	5	5	0	0	17	0	0	5	0	0	17	0	5	0
Erumbur	2	0	2	4	9	1	1	11	0	1	1	0	4	9	2	1	0	1	3	8	3	0	1
Purisai	9	2	0	11	8	3	0	11	3	3	6	9	2	7	4	3	3	9	2	10	1	4	2
Irumbedu	0	8	0	8	0	7	2	9	0	6	6	4	4	4	6	3	3	5	3	6	3	4	2
Pelasur	11	1	1	13	7	1	2	10	0	2	2	10	3	6	3	2	0	10	3	6	4	2	0
Semmia-mangalam	7	1	1	9	3	2	2	7	1	1	2	6	3	3	4	1	1	6	3	5	2	1	1
Total	43	12	4	59	53	16	9	78	4	23	27	43	16	57	21	10	17	41	18	63	15	19	8

Source: Survey, December 2004.

management vest with individuals they can plan accordingly to maximize returns by using the scarce resources in a most beneficial manner. However, in the case of common resources such as tanks this independent decision-making will not work satisfactorily unless a preset rules and regulations are followed efficiently. Especially, in the southern states of India, irrigation tanks are more common and they have been under use over thousands of years. Even then one could come across a lot of irrigation problems in many of the tanks, especially during water scarcity periods. Most of these problems arise basically due to non-adherence of rules and regulations to manage the common source of tank supply. In the tanks selected for the study, the respondents have also reported severe water deficit problems during every supply season even in the normal year. The details of deficiency as reported are given in **table 2.15**.

Table: 2.15 Conditions of Water Supply for Crop Growth, 1998-99

Tanks	**<---- Inadequacy of Water Supply When ----->**								**Management of Inadequacy overcome by**					**Any Irrigation Management adopted**				**Did Tank Water affect yield**	
	Season 1		**Season 2**				**Season 3**		**Season 1**			**Season 2**		**Season 1**		**Season 2**			
	Early stage	F & H stage	Early stage	F stage	E & F stage	F & H stage	Early stage	F stage	Well	Tank + Well	Tank *	Well	Tank + Well	**Yes**	**No**	**Yes**	**No**	**Yes**	**No**
Vakkadai	0	4	0	0	0	2	0	2	3	0	0	0	0	0	0	0	0	2	12
Kovilur	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	17
Erumbur	2	1	0	1	2	0	0	1	1	1	1	2	0	0	1	0	1	3	8
Purisai	0	2	0	0	0	1	0	2	0	2	0	0	0	0	0	0	0	2	9
Irumbedu	0	3	1	2	0	0	1	1	2	0	0	1	2	0	0	0	1	3	7
Pelasur	1	2	1	0	1	2	0	0	2	0	0	3	0	0	0	0	0	4	9
Semmia-mangalam	2	1	0	0	1	1	0	1	1			1	0	0	0	0	0	3	6
Total	5	13	2	3	4	6	1	7	9	3	1	7	2	0	1	0	3	17	68

Note: F = Final stage. H = Heading stage.

* Indicates a few farmers diverted tank supply during night since well farmers did not use the tank supply.

Source: Survey, December 2004.

During each season some farmers reported that they had faced untimely as well as inadequacy of tank supply. In response to this, a question was asked to understand how they tackled this situation. Their specific responses indicate that in each season a section of farmers faced inadequacy of supply mostly during final and heading stages of the crop growth. The responses follow a sequence of decrease in the number of reporting from season 1 to season 3. This is due to the availability of tank supply between seasons. While managing the inadequacy of supply; it is commonly reported that a majority of farmers supplemented well water to tide over the situation. It should be noted that the water deficiency problems are reported more only in the first two seasons when tank supply was available while in season 3 this problem solely rests with the individual farmers who control their own source.

Importantly, irrigation management, especially under common source such as tanks, is a sine-qua-non for equitable sharing of deficit supply. Everyone also knows this. Even then in the current situation that prevails under tanks indicate that 'no irrigation management' procedures were adopted in most of the tanks to tide over the deficit supply. Also during normal supply period, over irrigation is a problem in the head reaches when irrigation management is not effective. This is also reported in a few tanks especially in Purisai. In our tanks under study, not even a single tank has reported any effective irrigation management practice currently during scarcity period. The consequence of deficit supply is certainly the loss of yield. Twenty per cent of respondents reported that they have lost potential yield even during the normal supply year.

Source of Water for Different Stages of Crop Growth: **Dry Year**

In the earlier discussion on source of supply for normal year, tanks and wells are the major sources. However, in the dry year only a single source supply, namely wells, was possible. This apparently tells us that only well farmers can get access to irrigation and non-well farmers cannot grow crops unless otherwise rains favour them during the monsoon to go for rainfed crops. It may be noted that even in the dry year when water supply was so scarce farmers tend to raise water intensive paddy in all the tanks although the number of persons raised the crop vary across seasons (see **table 2.16**). In season 1, although 36 per cent of farmers raised nursery eight per cent of them depended upon rains for their primary source of water. In seasons 2 and 3 only well water was used for nursery preparation. It may be observed that nursery preparation decreased considerably from season 1 to 3. This indicates the poor recharging capacity of wells during the dry year even in the monsoon season 2. Further, in each season, around 70 per cent of farmers only reported that their well supply was adequate for nursery preparation. It is mysterious to note that even under water deficiency situation it is not clear why farmers were preferred to grow mainly paddy when other dry irrigated crops are possible and remunerative at least for well farmers in the dry years. Actually, a few respondents reported that the paddy crop had withered due to paucity of water in a couple of tanks.

Table: 2.16 Source of Water for Nursery Preparation, 2003-04

Tanks	<---------- Source of Water for Cultivation in ----------->										Adequacy of Supply Reported in		
	Season 1				Season 2			Season 3					
	Well	Rain	No Cultivation	Total	Well	No Cultivation	Total	Well	Not Cultivated	Total	S 1	S 2	S 3
Vakkadai	7	1	7	15	4	11	15	3	12	15	7	4	4
Kovilur	3	0	14	17	2	15	17	2	15	17	2	1	1
Erumbur	2	1	11	14	1	13	14	1	13	14	2	1	1
Purisai	4	1	12	17	5	12	17	5	12	17	4	1	1
Irumbedu	9	0	2	11	4	7	11	1	10	11	4	4	1
Pelasur	3	3	7	13	1	12	13	1	12	13	2	1	1
Semmia-mangalam	0	2	10	12	0	12	12	0	12	12	0	0	0
Total	28	8	63	99	17	82	99	13	86	99	21	12	9

Source: Survey, December 2004.

As in the case of nursery preparation, well water use for land preparation also decreased from season 1 to 3. Further all those farmers who raised nursery in each season were not equally interested to transplant paddy. This is clear from the responses as shown in **table 2.17** compared to the previous table. There are 36, 17 and 13 farmers in seasons 1, 2 and 3 respectively raised nurseries. However, land preparation was done only 26, 14 and 11 farmers respectively in seasons 1, 2 and 3. This indicates that farmers might have believed that well water alone would not be feasible for growing paddy since monsoon would fail in due course (as per their usual climatic judgment). Even in this situation the remaining farmers prepared land for transplantation. To what extent their well water supply was feasible to serve adequately may be observed from the table. Among farmers who made land preparation reported that their well

Table: 2.17 Source of Water for Land Preparation, 2003-04

Tanks	Well Water Used by Sample Farmers in			Water Supply (Continuous / Intermittent)						Adequacy of Supply (Adequate / IA)					
				C	I	C	I	C	I	A	IA	A	IA	A	IA
	S1	S2	S3	Season 1		Season 2		Season 3		Season 1		Season 2		Season 3	
Vakkadai	7	4	4	7	0	4	0	4	0	7	0	4	0	4	0
Kovilur	2	1	1	0	2	0	1	0	1	0	2	0	1	0	1
Erumbur	2	1	1	0	2	0	1	0	1	0	2	0	1	0	1
Purisai	6	3	3	5	1	1	2	1	2	4	2	1	2	0	3
Irumbedu	7	4	1	2	5	1	3	1	0	6	1	2	2	1	0
Pelasur	2	1	1	2	0	1	0	1	0	2	0	1	0	1	0
Semmia-mangalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	26	14	11	16	10	7	7	7	4	19	7	8	6	6	5

Note: C = Continuous. I = Intermittent. A = Adequate. IA = Inadequate.

Source: Survey, December 2004.

supply was adequate for 70 per cent farmers in season 1 and about 55 percent farmers in seasons 2 and 3.

Apart from this, the most important part of paddy cultivation is providing sustained water supply during the crop growth period after transplantation. This situation also varies compared to nursery sowing and land preparation. Those farmers who raised nursery were not in a position to take up land preparation (some of them were dropped) and all farmers who prepared land for transplantation were not in a position to grow the crop sustainably. This is evident from **table 2.18**. The number of farmers who made land preparation was 51. However, only 47 farmers were able to cultivate paddy in the third stage. Between system and non-system tanks there exists a clear-cut difference. In Semmiamangalam tank not even a single farmer had grown paddy by using well supply. This indicates the vulnerable position of wells under the non-system tanks. The percentage of respondents reported adequacy of supply for crop growth decreases from seasons 1 to 3, which is nearly 75 % in seasons, 1 & 2 and only half in season 3.

Table: 2.18 Supply of (Well) Water for Crop Growth, 2003-04

Tanks	**Well Water Used by Sample Farmers in**			Water Supply (Continuous / Intermittent)						Adequacy of Supply (Adequate / **IA**)					
				Season 1		**Season 2**		**Season 3**		**Season 1**		**Season 2**		**Season 3**	
	S1	**S2**	**S3**	**C**	**I**	**C**	**I**	**C**	**I**	**A**	**IA**	**A**	**IA**	**A**	**IA**
Vakkadai	7	4	3	4	1	2	2	1	2	5	2	3	1	2	1
Kovilur	2	1	1	2	0	1	0	0	1	2	0	1	0	1	0
Erumbur	2	1	1	2	0	1	0	1	0	2	0	1	0	1	0
Purisai	6	2	1	3	3	2	0	0	1	4	2	2	0	0	1
Irumbedu	7	4	1	6	1	2	2	0	1	4	3	2	2	0	1
Pelasur	2	1	1	1	1	1	0	0	1	2	0	1	0	0	1
Semmia-mangalam	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	26	13	8	18	6	9	4	2	6	19	7	10	3	4	4

Note: C = Continuous. I = Intermittent. A = Adequate. IA = Inadequate.
Source: Survey, December 2004.

So far we have discussed cultivation practices adopted by farmers in the two reference years. During the dry year, the extent of inadequacy of well supply in each stage of paddy cropping was observed. Under these conditions; it is worthwhile to delineate the characteristics of well water supply in the normal and dry years during different seasons. **Table 2.19** is constructed to serve this purpose. Between the normal and dry years one could observe that during the later year a

Table: 2.19 Groundwater Level by Seasons in Normal and Dry Years **(Figures in meters)**

Tanks	Water Level in Normal Year - Season 1						Water Level in Dry Year - Season 1					
	Up to 3	3 - 6	6 - 8	8 - 10	10+	Total	Up to 3	3 - 6	6 - 8	8 - 10	10+	Total
Vakkadai	1	3		1	5	10			2	1	7	10
Kovilur		2	1	2	1	6				1	5	6
Erumbur	1	3				4				1	3	4
Purisai												
Irumbedu			1	2	7	10				2	8	10
Pelasur		4	1		4	9				1	8	9
Semmia-mangalam	1	2		1	1	5					5	5
Total	3	14	3	6	18	44			2	6	36	44
	Water Level in Normal Year - Season 2						Water Level in Dry Year - Season 2					
Vakkadai	3	4	1	1	1	10			1	1	8	10
Kovilur	3	2	1			6				2	4	6
Erumbur	2	2				4				1	3	4
Purisai												
Irumbedu		1	4	3	2	10				2	8	10
Pelasur	2	1		3	3	9				2	7	9
Semmia-mangalam	3	1	1			5					5	5
Total	13	11	7	7	6	44			1	8	35	44
	Water Level in Normal Year - Season 3						Water Level in Dry Year - Season 3					
Vakkadai	5	5				10			1		9	10
Kovilur	4	1	1			6					6	6
Erumbur	2	2				4					4	4
Purisai												
Irumbedu		5	2		3	10				2	8	10
Pelasur	2	5		2		9					9	9
Semmia-mangalam	3	2				5					5	5
Total	16	20	3	2	3	44			1	2	41	44

Note: Blank entries denote nil. For Purisai tank relevant particulars are not available. Figures indicate the depth of water from the ground level.

Source: Survey, December 2004.

majority of wells had a supply only below ten metres depth and wells with water level between 8-10 meters is considerably less in all the seasons. This indicates that shallow depth of wells does not provide adequate supply. Only in Irumbedu tank respondents reported that a couple of farmers got access to supply with less than 10 metres below ground level even in dry years. In the dry year, a large majority of wells in the non-system tanks do not supply water for cultivation and the available scanty supply is used merely for other than cultivation purposes.

During the normal year most wells at shallow depth get recharge in all seasons and a few well farmers in each tank also reported extracting supply even at a higher depth up to 10 metres. This is mainly possible due to seepage effect from the tank. Apparently this is not possible in the dry year. From this table one could observe only variation in the depth of water level in the wells in each season and it is not possible to find out how much water it could be pumped by every day. This type of data was collected by a different method from the well farmers to judge the quantum of supply used for crop production. Details of this will be presented in the following section. On the whole it may be observed that the depth of wells in the selected tanks was very shallow; consequently limited quantum of water is possible for extraction even in the normal year. Shallow depth of wells makes difficult to crop all the land by using well water especially by the farmers under non-system tanks. Deepening of the wells is also not fruitful since the sub-surface geology in this region is not conducive to yield more water.

Section III

Farm Level Land and Water Productivity: Tank Level Analysis

In the previous section taking all tanks together, inferences were drawn on the general characteristics of system and non-system tank farmers. The analysis pertains to operational holdings by well and non-well farmers, cropping pattern, characteristics of well irrigation and sources and conditions of water supply for different stages of crop growth. The differences between normal tank supply year and the dry year, especially on cropping and water supply conditions, were also found out. In this section, in order to find out the productivity details, taking the sample farmers into five specific categories, an analysis is carried out in the following order: a) tank wise; b) reach wise c) system and non-system wise; d) well intensive and less well intensive tank farmers and e) well and non-well individual farmers in a system and non-system tanks.

Methodology: As noted in the methodology part, there are 99 respondents selected from seven tanks (5 system and 2 non-system). All these farmers are grouped into well and non-well farmers. The basic details of each respondent related to operational holdings, season wise area under cultivation, number of watering provided from tank and well, total quantum of supply provided for each crop in each season; the details are provided in **appendix 2** (normal year) and **appendix 3** (dry year). Along with these basic details, the crop wise seasonal and annual land and water productivity for each respondent is presented in **appendix 4** (normal year) and **appendix 5** (dry year). Based on these appendices, an analysis of the five specific categories mentioned above is carried out and the results of this exercise are given below:

Findings of the Study

Operational Holdings: Table 3.1 presents the tank wise operational holdings and gross irrigated area of all the sample farmers in the selected tanks. It is evident that in a normal year, gross irrigated area over the year (three seasons put together) is 86 per cent of the operational holdings while that figure for dry year is only 32 per cent.

Table 3.1 Operational Holdings and % of Gross Irrigated Area of Sample Farmers in the Normal and Dry Years

NAME, TYPE and REACH of Tank	Total Sample Farmers	Operational Holdings (Ha)	No.of Well Farmers	No.of Non-Well Farmers	GIA Normal Year (Ha)	GIA Dry Year (Ha)	GIA Dry / GIA Normal
Vakkadai-S-HR (CAS 2)	15	6.65	10	5	6.81	4.06	0.60
Kovilur-S-HR (CAS 4)	17	5.51	6	11	3.31	0.77	0.23
Erumbur-S-MR (CAS 33)	14	4.90	4	10	4.85	1.73	0.36
Purisai-S-MR (CAS 62)	17	8.58	6	11	7.62	3.19	0.42
Irumbedu-S-TR (CAS 138)	11	6.92	10	1	6.18	2.99	0.48
Pelasur-NS-HR	13	12.40	9	4	11.76	4.02	0.34
Semmiamangalam-NS-HR	12	8.06	5	7	4.96	0.38	0.08
ALL 7 TANKS	**99**	53.02	**50**	49	45.49	17.15	0.38

Note: HR=Head Reach. MR=Middle Reach. TR=Tail Reach. CAS=Cheyyar Anicut System. S=System. NS = Non-System.

Source: Derived from Appendix 4 and 5.

Taking all sample tanks together, the ratio of gross irrigated area between normal and dry years indicates that in the dry year only 38 % of the normal year area is cultivated. Across tanks, the highest ratio of GIAdry / GIAnormal is in Vakkadai system tank (60 %) followed by Irumbedu system tank (48%). The table indicates that supplementation of well irrigation in the tanks surveyed is widely reported and over half of the total sample farmers owned wells.

Analysis of Productivity of All Tanks

Gross Irrigated Area (GIA): The average percentage of farmers having wells is 51 (**table 3.2**).

Table 3.2 Gross Irrigated Area during normal and dry year: System level

Name of tank	% of well farmers	% of GIA	
		Normal	Dry
Vakkadai (S)	67	102	61
Kovilur (S)	35	60	14
Erumbur (S)	29	99	35
Purisai (S)	35	89	37
Irumbedu (S)	91	89	43
Pelasur (NS)	69	95	32
Semmiamangalam (NS)	42	62	5
Average %	**51**	86	32

Source: Derived from Appendix 4 and 5.

It may be seen that the average percentage of gross irrigated area (88 %) in the system tanks in the normal tank supply year is relatively more compared to the non-system tank (78 %). However, in dry year one could not find any clear pattern but the area irrigated is grossly reduced both in system and non-system tanks due to paucity of well supply and also no tank supply was possible. **Figure 3.1** gives a graphical form of tank-wise percentage of gross area under

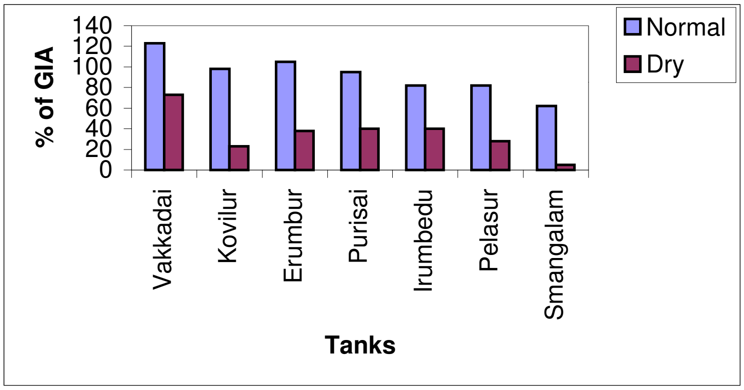


Figure 3.1 Gross area irrigated Across Tanks

irrigation. In the Semmiamangalam tank, in the dry year, cultivation is possible only to a limited extent; hence the percentage of GIA is negligible

Gross Land Productivity: Table 3.3 gives the gross land productivity in the selected tanks. In the normal year, the gross paddy productivity (output (Rs) per hectare) is the highest in the Irumbedu system tank (21344 Rs/ha) which is nearly two times that of the lowest gross output reported in Semmiamangalam non-system tank. However, in the dry year this output differs. The productivity in three tanks is lower than all tanks average (19661 Rs/ha). The overall tank average productivity is three-fifths of the highest output attained in Kovilur tank (33836 Rs/ha). Again one may note in Semmiamangalam due to non-availability of water, farmers incurred loss due to withering of crops. The figure 3.2 shows the productivity levels of paddy crop.

Table 3.3 Crop wise Gross Land Productivity of Sample Tanks in Normal and Dry Years

Tank	Gross Land Productivity per Hectare (Season Ha)					
	Normal Year			**Dry Year**		
	Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
	Rs / Ha			Rs / Ha		
1	2	3	4	5	6	7
Vakkadai	19152			24299		5200
Kovilur	20396			**33836**	**0**	
Erumbur	19346		5293	**8731**		
Purisai	13505	30441		12350	24067	**24700**
Irumbedu	**21344**		**10868**	20896		18261
Pelasur	13057	28379	5161	17853	6625	
Smangalam	**11263**					
Average	**16866**	29410	7107	**19661**	15346	16054

Note: In the dry year sugarcane crop withered in Kovilur tank. Blank entries denote nil
Sugarcane value is converted into seasonal average (Gross / 3 seasons).
Source: Survey, December 2004.

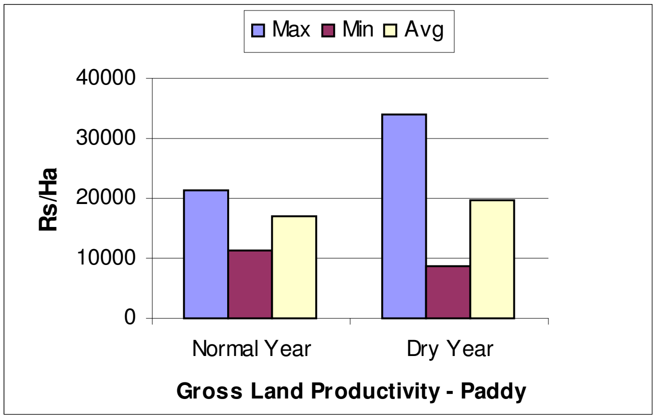


Figure 3.2 Maximum, minimum and average land productivity

Gross Water Productivity: Water productivity is measured in terms of Rupees per cubic metre of water diverted / supplied for each crop. Since sugarcane is an annual crop its seasonal water productivity is converted by dividing the annual value by three for comparable purpose. The diverted water productivity in two system tanks is higher than that of the overall tank average of Rs. 1.59 per cubic metre (**table 3.4).** The highest output (2.66 Rs/cum) is reported in Irumbedu and the lowest is in Purisai tank where it is 0.98 Rs/cum. It should be noted that the contribution of wells is the prime reason to the hike in values in the Irumbedu tank. Actually, this tank has 10 farmers who have wells out of 11 sample farmers. In the dry year one may observe wide variations in gross water productivity, which ranges from 0 to 3.93 Rs/cum and the overall tank average being 2.24 Rs/cum. Overall sugarcane output in terms of season hectare is 1.45 Rs/cum

Table 3.4 Crop wise Gross Water Productivity per Cubic Metre of Diverted Water in Normal and Dry Years: System Level

Tank	Gross Diverted Water Productivity per Cubic Metre (per Season)					
	Normal Year			**Dry Year**		
	Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
	(Rs / CuM)			(Rs / CuM)		
1	2	3	4	5	6	7
Vakkadai	1.83			3.27		0.58
Kovilur	1.95			**3.93**	**0**	
Erumbur	1.45		2.65	1.36		
Purisai	0.98	1.70		1.22	1.06	4.57
Irumbedu	**2.66**		6.04	2.95		1.01
Pelasur	1.18	1.19	2.04	0.72	0.40	
Smangalam	1.08			**0**		
Average	**1.59**	**1.45**	**3.57**	**2.24**	0.73	**2.06**

Note: In the dry year sugarcane crop withered in Kovilur tank. Blank entries denote nil.
Sugarcane value is converted into seasonal average (Gross / 3 seasons).
Source: Survey, December 2004.

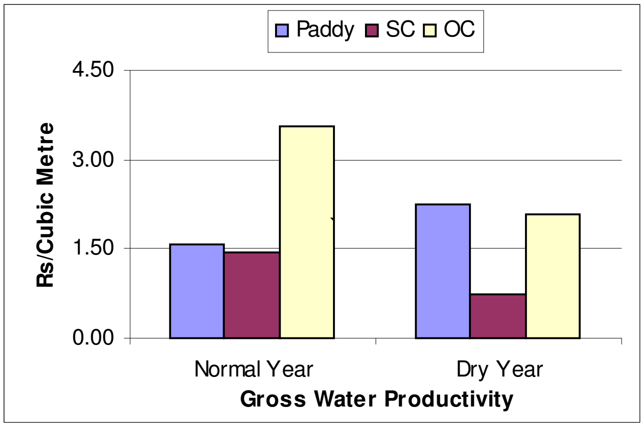


Figure 3.3 Gross water productivity of crops

in the normal year and it is less than half that level (0.73 Rs/cum) in the dry year. The importance of adequate water supply throughout the year for the annual crops is realised in this analysis. Due to severe water shortage the output values of sugarcane are drastically cut down. In the case of other crops, compared to normal year, the water productivity in the dry year is marginally lower. This tells us that water productivity of these crops is not affected during the normal as well as drought year. Figure 3.3 gives the detail in a graphical form.

Water Use Efficiency: The importance of any irrigation management lies with achieving higher water use efficiency. It is generally known that Indian canal irrigation systems are functioning with very low (30 to 40 %) efficiency depending upon the on-farm development works undertaken in that particular system. Since the command area of tank irrigation system spreads over a limited extent compared to canal irrigation, the efficiency of water use under tanks is higher (around 50 %) than the canal system. Our survey shows that at field level, the water use efficiency in the normal year is considerably higher with a percentage ranging from 57 to 98 for paddy in system tanks and in the non-system tanks it is around 70. In the dry year, only well irrigation is possible and due to water shortage the efficiency goes up to 122 % (under well irrigation) in Erumbur (**Table 3.5**).

The volume of water used per hectare of paddy shows that in the normal year all the tanks had used more than 1 ham (except one) with little variation across tanks. However, in the dry year, due to paucity of supply from the wells the volume of water used is below 1 ham and only in one tank it is more than this level. Further in Semmiamangalam, a non-system tank, in the dry year no water was used by any of the sample farmers (Figures 3.4, 3.5 and 3.6).

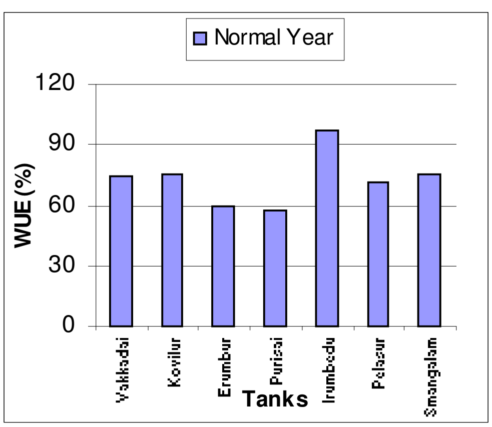
Table 3.5 Water Use Efficiency in the Sample Tanks

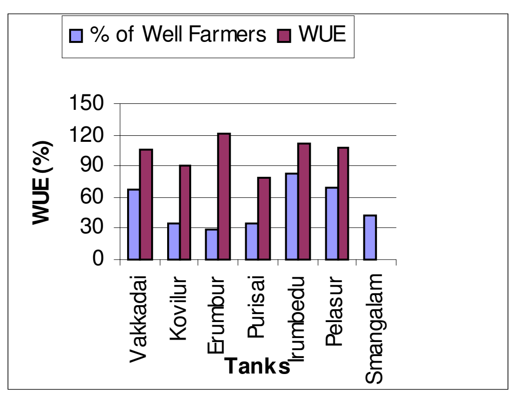
NAME of Tank	Gross Water Use (Hectare Meter)						% of Well Farmers	Consumptive Use Rate WUR in Meter/Ha			Water Use Efficiency (%)					
	Normal Year			Dry Year							Normal Year			Dry Year		
	Paddy	Sugar-cane	Other Crops	Paddy	Sugar-cane	Other Crops		Paddy	Sugar-cane	Other Crops	Paddy	Sugar-cane	Other Crops	Paddy	Sugar-cane	Other Crops
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Vakkadai	1.049			0.743		0.900	67	0.785	1.008	0.403	75			106		45
Kovilur	1.046			0.860	0.594		35	0.785	1.008	0.403	75			91	170	
Erumbur	1.310		0.200	0.644			29	0.785	1.008	0.403	60		202	122		
Purisai	1.376	1.794		1.013	2.279	0.540	35	0.785	1.008	0.403	57	56		78	44	75
Irumbedu	0.804		0.180	0.709		1.800	83	0.785	1.008	0.403	98		224	111		22
Pelasur	1.106	2.375	0.796	0.726	2.484		69	0.785	1.008	0.403	71	42	51	108	41	
Smangalam	1.044						42	0.785	1.008	0.403	75					
Average	1.106	2.122	0.643	0.773	2.324	1.163	51	0.785	1.008	0.403	71	48	63	102	43	35

Note: For Other Crops consumptive use rate is based on two seasons crop area in both the reference years. Blank entries denote nil.
CUR: Paddy (157+378+523+LP350 mm=1.358 Meter/Ha); Other crops (S1=86, S2=302 and S3=418 mm)

Source: Survey, December 2004.

Efficiency of water use for sugarcane is relatively more (48%) in the normal year compared to the dry year (43%). In Kovilur tank, one of the sample farmers raised sugarcane but was unable to get enough supply of water in the third season. As a result the crop withered. Due to this effect the water use efficiency shot to 170 %. Regarding the efficiency of water used for other crops, it should be noted that in the normal year farmers used less quantum of supply. This might be due to the nature of crop raised, which basically required a less amount of supply. Also the seepage effect of the tank supply might prevent the farmers to supply water. Due to these effects, in a couple of tanks the efficiency goes over 200%.





Figures 3.4 and 3.5 Water use efficiency (%) of paddy in normal and dry years

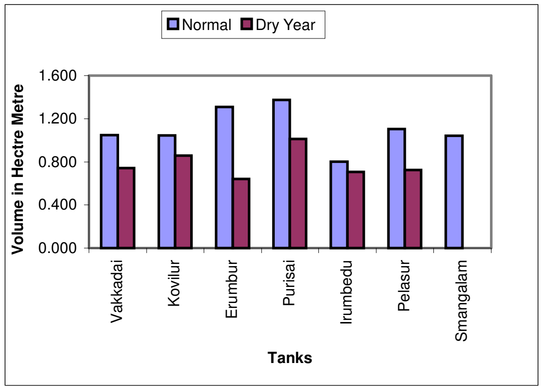


Figure 3.6 Volume of water used per hectare (ham) of paddy in normal and dry years

Reach wise Analysis of Land and Water Productivity

Percentage of GIA: Table 3.6 and figure 3.7 shows that since 50 per cent of sample farmers have wells, the percentage of GIA for the three seasons is more than 100 in the head reach and around 80 Per cent in the middle and tail reaches in a normal year. In the dry year, the percentage of GIA is less than a fourth in the middle and tail reaches, and around 50 per cent in the head reach. This implies that **although there are wells, they are ineffective unless tank water recharges them**. One could also find a declining trend in the GIA from head to tail in both the reference years.

Table 3.6 Percentage of gross irrigated area to operational holdings: Across reaches

Reach	Normal	Dry
Head	105	53
Middle	84	18
Tail	73	18

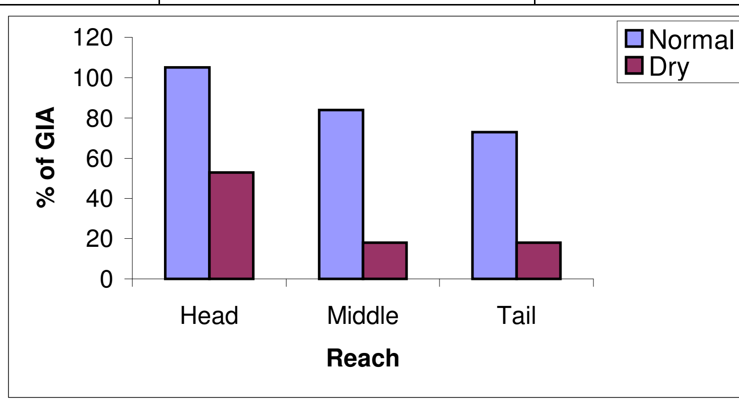


Figure 3.7 Percentage of gross irrigated area across reaches

Volume of Water Used per Hectare: In the tanks under study, a majority of farmers cultivate paddy as the main crop. The values (**Table 3.7**) of water use indicate that in the normal tank supply year only the head reach farmers use a higher quantum of supply (with 10 % of more water) compared to the middle and tail reachers. However, in the dry year the pattern differs and the middle reachers are the least users (0.7625 ham) and the tail reachers use more water. This again tells us that mere well irrigation alone does not improve the quality of irrigation, due to poor recharge in the wells. A good recharge potential requires for the supplementation of tank supply.

Table 3.7 Volume of water used per hectare (Hectare Metre): Across reaches

Reach	Normal Year			Dry Year		
	Paddy	Sugarcane	Other crops	Paddy	Sugarcane	Other crops
Head	1.1694	1.8141	1.4617	0.7857	2.2680	0.5400
Middle	1.0455	0.0	0.3045	0.7625	0.0	1.3500
Tail	1.1547	2.3160	0.5616	0.8029	1.5390	0.0

Gross Land Productivity Across Reaches: **Table 3.8** provides details of land productivity across reaches. In the normal year, productivity of paddy is around 16000 Rs/ha and it did not vary much. However, in the dry year in all reaches the productivity is higher than that of normal year. The difference is considerably more in the middle and tail reaches. In the case of sugarcane, productivity during dry year is considerably lower than the normal year. Especially in the tail reach the productivity is only Rs. 6067 per ha. This decrease is mainly due to deficiency in the supply of water. It is interesting to note that productivity values of other crops in the dry year are more than twice that of the normal year. This increase may be due to the type of crops grown and the soil and drainage conditions of the plot in which the crops are grown and the climatic conditions prevailing during the season, especially during high temperature.

Table 3.8 Gross land productivity across reaches

Reach	Normal Year			Dry Year		
	Paddy (Rs/ha)	Sugarcane (Rs/ha)	Other crops (Rs/ha)	Paddy (Rs/ha)	Sugarcane (Rs/ha)	Other crops (Rs/ha)
Head	16533	30333	6767	16874	24050	24700
Middle	16594	0	6130	24816	0	10088
Tail	16264	28383	4160	25845	6067	0

Note: Sugarcane productivity is in terms of season hectare (i.e. the gross productivity / 3).

Gross Water Productivity across Reaches: **Table 3.9** shows that water productivity of paddy in the dry year is relatively higher than that of in the normal year. This is primarily due to higher land productivity and less water use per hectare. For sugarcane the normal year productivity is greater than that of the dry year. In dry year, other crops productivity in the head reach is considerably higher than that of the productivity during the normal year.

Table 3.9 Gross diverted water productivity per cubic metre: Across reaches

Reach	Normal Year			Dry Year		
	Paddy (Rs/cum)	Sugarcane (Rs/cum)	Other crops (Rs/cum)	Paddy (Rs/cum)	Sugarcane (Rs/cum)	Other crops (Rs/cum)
Head	1.43	1.68	0.46	2.48	1.01	4.57
Middle	1.60	0.0	3.20	3.36	0.0	0.75
Tail	1.43	1.28	0.74	3.69	0.27	0.0

Note: Sugarcane productivity is converted into season hectare (i.e. the gross productivity / 3).

Comparison of Productivity between System and Non-System Tanks

Gross and Net Land Productivity: It is generally known that system tanks are endowed with better water supply compared to non-system tanks. **Table 3.10** confirms this view. The land productivity in all the system tanks is much higher than that of the non-system tanks in the normal year. However, in the dry year the gross land productivity in a couple of system tanks is lower than the non-system tanks average of 17853 Rs/ha. Also, in the dry year one of the non-system tanks reported the loss of crop value. This shows the vulnerability of non-system tanks in getting adequate supply. Figure 3.8 gives the land productivity of paddy.

Table 3.10 Crop wise Gross Land Productivity of Sample Tanks in Normal and Dry Years System and Non-system tanks

Tank	Gross Land Productivity per Hectare (Season Ha)					
	Normal Year			**Dry Year**		
	Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
	Rs / Ha			Rs / Ha		
1	2	3	4	5	6	7
Vakkadai	19152			24299		5200
Kovilur	20396			**33836**	**0**	
Erumbur	19346		5293	**8731**		
Purisai	13505	30441		12350	24067	**24700**
Irumbedu	**21344**		**10868**	20896		18261
System	**18749**	**30441**	**8080**	**20022**	**24067**	**16054**
Pelasur	13057	28379	5161	17853	6625	
Smangalam	**11263**					
Non-system	**12160**	**28379**	**5161**	**17853**	**6625**	**0**

Note: In the dry year sugarcane crop withered in Kovilur tank. Blank entries denote nil.
Sugarcane value is converted into seasonal average (Gross / 3 seasons).
Source: Survey, December 2004.

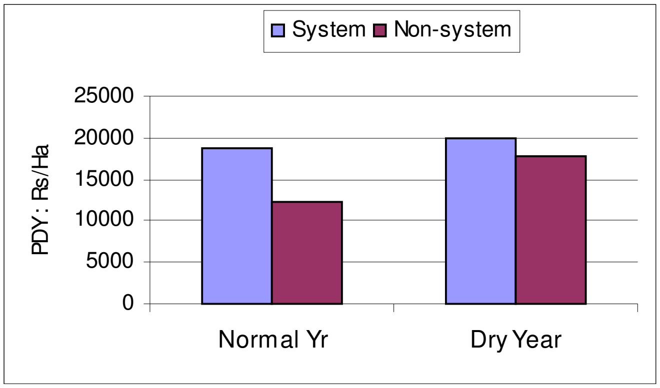


Figure 3.8 Gross land productivity of paddy in system and non-system tanks

Gross Water Productivity: The productivity differences are better noticed if one separates the tanks into system and non-system categories. The analysis (**Table 3.11** and Figure 3.9) shows clearly that gross water productivity of paddy in non-system tanks is only two-thirds of system tanks. In the dry year, productivity values have gone up considerably in both types of tanks but still the system tanks perform much better. However, within the categories of tanks one may find wide variations in productivity levels, which ranges between 0.98 Rs/cum and 2.66 Rs/cum in the system tanks in the normal year and from Re 0 to 0.72 Rs/cum in the non-system tanks. But for sugarcane and other crops, productivity during normal year is higher than that of dry year. This indicates, if the available supply is inadequate for these crops it retards the crop output considerably.

Table 3.11 Crop wise Gross Water Productivity per Cubic Meter of Diverted Water in Normal and Dry Years: System and Non-system tanks

Tank	Gross Diverted Water Productivity per Cubic Metre (per Season)					
	Normal Year			**Dry Year**		
	Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
	(Rs / CuM)			(Rs / CuM)		
1	2	3	4	5	6	7
Vakkadai	1.83			3.27		0.58
Kovilur	1.95			**3.93**	**0**	
Erumbur	1.45		2.65	1.36		
Purisai	0.98	1.70		1.22	1.06	4.57
Irumbedu	**2.66**		6.04	2.95		1.01
System	**1.77**	**1.70**	**4.34**	**2.55**	**1.06**	**2.06**
Pelasur	1.18	1.19	2.04	0.72	0.40	
Smangalam	1.08					
Non-system	**1.13**	**1.19**	**2.04**	**0.72**	**0.40**	**0.00**

Note: In the dry year sugarcane crop withered in Kovilur tank. Blank entries denote nil.
Sugarcane value is converted into seasonal average (Gross / 3 seasons).

Source: Survey, December 2004.

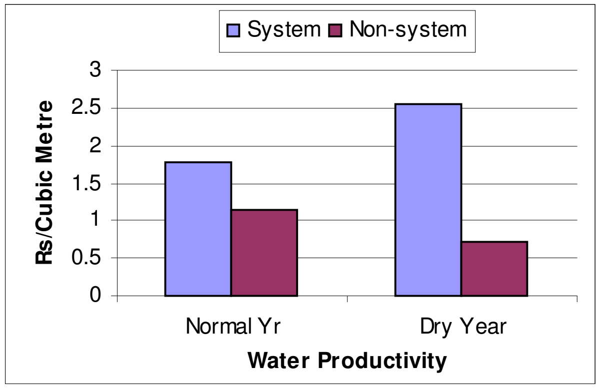


Figure 3.9 Gross water productivity for paddy (Rs/cum)

Comparison between Well Intensive and Less Well Intensive Tanks

Gross Land Productivity: The importance of wells as a sole source as well as supplement to tank supply may be found out through analysing the farmers under well intensive tanks as well as less well intensive tanks. **Table 3.12** shows that in the normal year only a little variation is found in the gross land productivity between farmers with wells and without wells. However, in the dry year the differences are very high. Actually, the farmers in well intensive tanks have average productivity value of more than 2 times than that of less well intensive tank farmers. The graph (figure 3.10) indicates that the gross land productivity in the dry year is the lowest in the less well intensive tanks. Since the type of crops grown in the "other crops" category vary much, the productivity comparison is not possible. However, in general it may be observed that productivity during dry year is more than that of normal year in both categories of tanks. Also,

Table 3.12 Gross Land Productivity in Well Intensive and Less-well Intensive Tanks

Tank	Gross Land Productivity per Hectare (Season Ha)					
	Normal Year			**Dry Year**		
	Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
	Rs / Ha			Rs / Ha		
1	2	3	4	5	6	7
Vakkadai	19152			24299		5200
Irumbedu	**21344**		**10868**	20896		18261
Well Intensive	**20248**		**10868**	**22598**		**11730**
Erumbur	19346		5293	**8731**		
Purisai	13505	10147		12350	8022	**24700**
Less Well Intensive	**16426**	**10147**	**5293**	**10541**	**8022**	**24700**

Note: Blank entries denote nil.
Sugarcane value is converted into seasonal average (Gross / 3 seasons).
Source: Survey, December 2004.

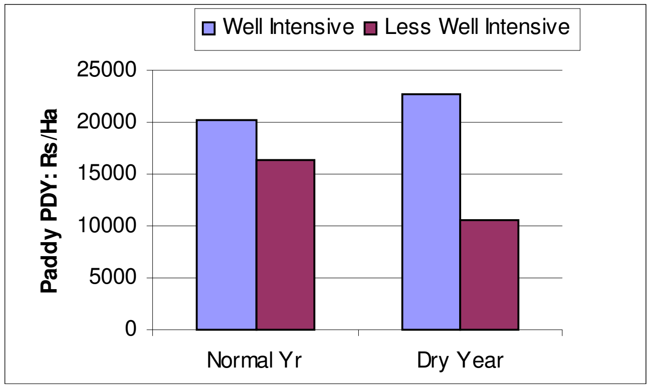


Figure 3.10 Gross land productivity of paddy in well intensive and Less-well intensive tanks

less well intensive tanks perform much better than well intensive tanks. This situation is not truly comparable since the type of crops grown varies a great deal across both types of tanks. For instance vegetables and pulses or grams grown even in a small extent by using well water can fetch more value than other crops such as cholam, cumbu, ragi etc. But the labour input requirements and crop management practices are considered to be more for vegetables, pulses and grams crops cultivation. Further price factor is also an important constraint for raising a particular type of crops by farmers. For instance tomato price fluctuates from Rs. 2 / kg to Rs. 20 / kg in a very short period. Due to these factors, comparison of land productivity has to be judged cautiously.

Gross Water Productivity: As observed earlier, the dry year productivity values are slightly higher than the normal year values. This also applies in the well intensive and less well intensive tanks. The average dry year gross water productivity of paddy in the well intensive tanks is 0.57 kg per cubic metre of water used whereas the same being 0.41 kg/cum in the normal year. In the case of less well intensive tanks both the dry year values and normal year values of gross water productivity are more or less the same (**table 3.13**). Figure 3.11 provides paddy productivity in a graphical form.

Table 3.13 Crop wise Gross Water Productivity per Cubic Metre of Diverted Water in Normal and Dry Years: System Level

Tank	Gross Diverted Water Productivity per Cubic Metre (per Season)					
	Normal Year			Dry Year		
	Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
	(Rs / CuM)			(Rs / CuM)		
1	2	3	4	5	6	7
Vakkadai	1.83			3.27		0.58
Irumbedu	**2.66**		6.04	2.95		1.01
Well Intensive	**2.24**		**6.04**	**3.11**		**0.80**
Erumbur	1.45		2.65	1.36		
Purisai	0.98	1.70		1.22	1.06	4.57
Less Well Intensive	**1.22**	**1.70**	**2.65**	**1.29**	**1.06**	**4.57**

Note: In the dry year sugarcane crop withered in Kovilur tank. Blank entries denote nil.
Sugarcane value is converted into seasonal average (Gross / 3 seasons).

Source: Survey, December 2004.

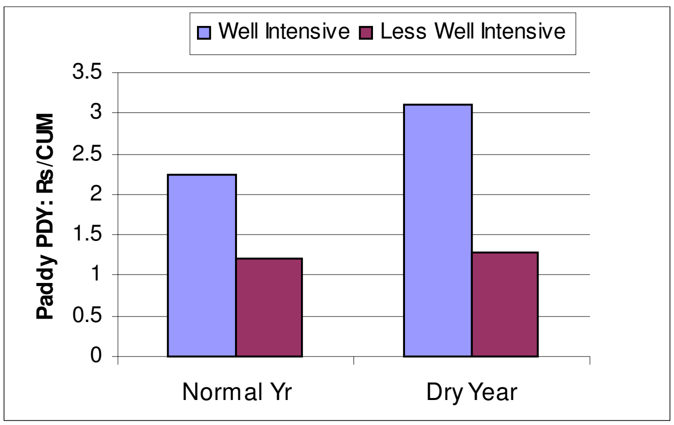


Figure 3.11 Gross water productivity of paddy per CUM of water in well intensive and less well intensive tanks

Comparison of Well and Non-Well Farmers

GIA as Percentage of Operational Holdings: The analysis of well and non-well individual farmers in a system and non-system tanks throws some light on what actually happens among the farmer groups at farm level. The analysis of the data of four farmers selected from each of the two tanks (Kovilur and Pelasur) gives us some inferences (**table 3.14** and figure 3.12). In the normal year, the GIA as percentage of operational holdings of the farmers in the head reach of both the tanks is considerably more than the farmers under tail reaches. The poor performance of tail reach farmers in both the tanks indicate that apart from reach factor, some other factors might have contributed to this decline. The main reason attributed to this low percentage of GIA by the

Table 3.14 Gross Irrigated Area as % of operational holding in normal year: Farm level

Tank	Reach	W/NW	Well and Non-well Farmers	GIA as % of OHs in	
				Normal Year	Dry Year
Kovilur	H	W	**1**	**66**	**100**
Kovilur	H	NW	2	103	0
Kovilur	T	W	**3**	**23**	**34**
Kovilur	T	NW	4	24	0
Pelasur	H	W	**1**	**190**	**0**
Pelasur	H	NW	2	120	0
Pelasur	T	W	**3**	**17**	**0**
Pelasur	T	NW	4	63	0

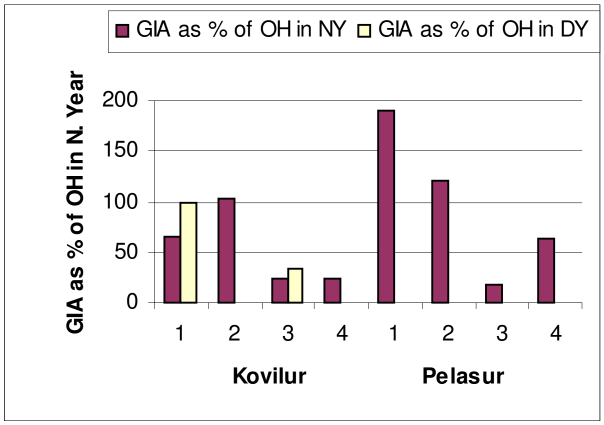


Figure 3.12 Gross Irrigated Area as % of operational holding in normal year: Farm level

well farmers was very poor recharge of well supply coupled with remote location of the plot which did not ensure better tank water access even during the normal supply year. In the dry year due to water scarcity except the well farmers in Kovilur no other farmer had cultivated anything at all.

Gross Land Productivity at Farm Level: The well farmers' land productivity of paddy is the highest compared to non-well farmers. However, between well and non-well farmer groups one can find that land productivity among farmers in the system tank is invariably higher than the non-system tank. Except one well farmer in Pelasur, no other farmers had cultivated either sugarcane or other crops (**table 3.15** and figure 3.13).

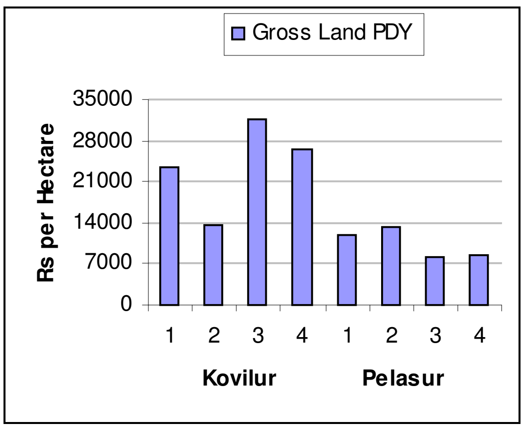
Gross Water Productivity at Farm Level: Between the well and non-well farmers group the gross water productivity of paddy is relatively high for well farmers in the system tank. The non-system tank farmers perform poorly with less return per cubic metre of water used.

Table 3.15 Crop wise Land and Water Productivity of Sample Farmers in Normal Year: Farm Level

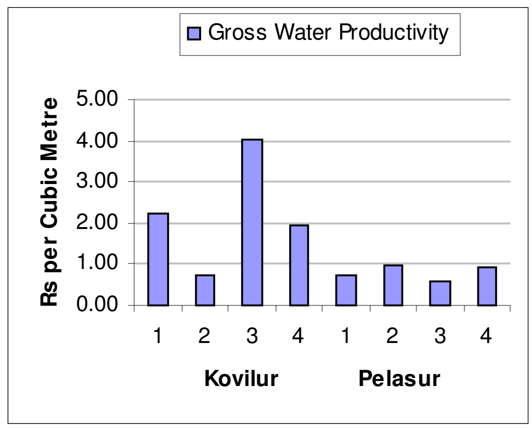
Tank	Well and Non-Well Farmers		Reach	Land Productivity			Water Productivity per Cubic metre		
				Paddy	Sugarcane	Other Crops	Paddy	Sugarcane	Other Crops
				Rs / Ha			Rs / CuM		
Kovilur	W	1	H	**23547**	NC	NC	2.22	NC	NC
Kovilur	NW	2	H	13514	NC	NC	0.75	NC	NC
Kovilur	W	3	T	**31549**	NC	NC	4.02	NC	NC
Kovilur	NW	4	T	26436	NC	NC	1.96	NC	NC
Pelasur	W	1	H	11724	NC	6767	0.73	NC	0.46
Pelasur	NW	2	H	**13175**	NC	NC	0.98	NC	NC
Pelasur	W	3	T	8012	NC	NC	0.58	NC	NC
Pelasur	NW	4	T	**8491**	NC	NC	0.94	NC	NC

Note: Although two farmers in Pelasur had raised Sugarcane, the sample farmers as selected for this farm level exercise did not cultivate sugarcane. NC = No Crop.

Source: Survey, December 2004.



Gross Land Productivity (Paddy)



Gross Water Productivity (Paddy)

Figure 3.13 Gross land and water productivity of paddy of sample farmers in normal year: Farm level

Section IV

System Wise Land and Water Productivity

In the previous section, an analysis was carried out to find out the land and water productivity at the tank level. However, differentiation of land and water productivity basically requires classification of tanks and farmers into specific categories such as **(a) system and non-system tanks and (b) well and non-well farmers.** Apart from these, other variables like area under crops, gross water use, and percentage of well water use also make differences in land and water productivity. These were not dealt with in detail in the previous section. Hence, by taking all these variables into account an analysis was carried out and the results are presented in this section. In our study, as we have seen in the previous section, a majority of farmers (90 %) grow paddy almost in all seasons both in the normal and in dry years. Moreover, most of the other seasonal crops are grown purely by rainfed conditions in a few villages. If we leave these out, then the remaining other seasonal irrigated crops are only negligible in proportion. Hence, the season wise analysis concentrates only on the paddy crop, but the overall productivity details for sugarcane and other seasonal crops are given at the end of this section.

Method of Analysis: As noted in the methodology in section III and by using the data from appendix 4 and 5 the overall variations in productivity are analysed by using four typology (1. all sample **well** farmers in **system** tanks and all sample **well** farmers in **non-system** tanks; 2. all sample **non-well** farmers in **system** tanks and all sample **non-well** farmers in **non-system** tanks; 3. clubbing all sample wells together, that is, taking overall **sample well** farmers in **system** and **non-system** tanks; and 4. overall **non-well** farmers in **system** tanks and **non-system** tanks. The details for selected variables such as area under crops cultivated, gross water use for paddy, ratio of consumptive use requirement to gross water utilisation and land and water productivity for all these typologies are given in Appendix 6 (cropping pattern of sample farmers) and Appendix 7 (all the other variables for the normal and dry years). Based on this information the productivity analysis is carried out and the results are given below:

Cropwise Percentage of Area under Cultivation in Normal and Dry Years

Well Farmers: Taking all sample farmers together, a glance at **table 4.1** indicates that the percentage of land cultivated by the well farmers in the normal year is invariably the highest in almost all seasons and for all crops compared to the dry year. Among the crops, paddy is predominantly grown in all seasons in both the normal and dry years. However, the percentage of paddy cultivation is still the highest in the normal year. Across seasons, the mean total area cultivated per farmer dominates in season 1 (0.28 hectare). But there has not been much difference in the mean total area cultivated across seasons. Even for paddy, the variations in mean area devoted ranges between 0.30 hectare in season 1 and 0.26 hectare in season 3. Next to paddy sugarcane is an important crop for well farmers. Sugarcane is cultivated invariably both in the normal and dry years. However, both the area (mean 0.20 hectare) and percentage of farmers (10%) cultivating sugarcane is very little compared to paddy. Between system and non-system tanks, the mean area under paddy is the highest in seasons 1 and 3 (0.26 hectare) among system tank well farmers, whereas in the non-system tank well farmers it is in season 2 (0.40 hectare). Gross area devoted for paddy is comparatively higher in all seasons in non-system well farmers compared to system tank well farmers. This indicates that crop diversification did not take place much for the non-system tank farmers. It is important to note that in the dry year even among well farmers in the non-system tanks the area cultivated among all types of crops in all seasons is negligible. **This clearly shows that in the absence of tank supply and poor rainfall, well irrigation is not feasible for cropping for non-system tank farmers and adequate recharge of wells is possible only through the tanks, when they get filled.**

Non-well Farmers: For non-well farmers paddy is a sole crop, which is grown in the first two seasons. One has to notice (table 4.1) a sharp deviation in the percentage of farmers cultivating paddy among non-well farmers between system and non-system tanks. In both types of tanks mean area under paddy is reported to be more in season 1. Between system and non-system tanks difference in the mean paddy area is negligible. Even though tank water is possible for seasons 1 and 2, tank supply for paddy crop is more favourable in season 2 in system tank non- well farmers (as percentage of farmers cultivated is more: 74) and the same being in season 1 for non-system non-well farmers (both mean area and percentage of farmers cultivated are more). **The gross area under paddy indicates that non-well farmers under system tanks are more vulnerable than non-well farmers under non-system tanks.**

Table 4.1 Crop wise Percentage of Area under Crops Cultivated and Mean and Coefficient of Variation for Cultivated Sample Farmers (Mean Area in Hectares)

Type of Sample Farmers	Season	% Cul-tivated Mean and CV	Total (System + Non-System)								System Tanks								Non-system Tanks							
			Normal Year				**Dry Year**				**Normal Year**				**Dry Year**				**Normal Year**				**Dry Year**			
			WELL																							
			Total	Paddy	SC	OC	Total	Paddy	SC	OC	Total	Paddy	SC	OC	Total	Paddy	SC	OC	Total	Paddy	SC	OC	Total	Paddy	SC	OC
Well Farmers	S1	% Cultd	82	70	10	2	52	44	8	2	78	64	8	3	67	56	8	3	100	86	14	0	14	14	7	0
		Mean	0.28	0.30	0.20	0.14	0.25	0.27	0.25	0.23	0.23	0.26	0.15	0.14	0.23	0.25	0.14	0.23	0.36	0.38	0.29	0	0.47	0.17	0.59	0
		CV	0.73	0.73	0.44	0	0.60	0.58	0.94	0	0.69	0.63	0.44	0	0.45	0.42	0.59	0	0.74	0.77	0.11	0	0.97	0	0	0
	S2	% Cultd	92	82	10	0	30	18	8	4	94	86	8	0	39	25	8	6	100	71	14	0	7	0	7	0
		Mean	0.27	0.28	0.20	0	0.31	0.35	0.25	0.23	0.24	0.24	0.15	0	0.29	0.35	0.14	0.23	0.33	0.40	0.29	0	0.59	0	0.59	0
		CV	0.81	0.82	0.44	0	0.78	0.75	0.94	0.96	0.79	0.79	0.44	0	0.82	0.75	0.59	0.96	0.91	0.78	0.11	0	0	0	0	0
	S3	% Cultd	62	46	10	6	26	18	8	0	61	53	8	0	33	25	8	0	100	29	14	21	7	0	7	0
		Mean	0.26	0.26	0.20	0.36	0.22	0.21	0.25	0	0.24	0.26	0.15	0	0.19	0.21	0.14	0	0.19	0.26	0.29	0.36	0.59	0	0.59	0
		CV	0.59	0.64	0.44	0.16	0.67	0.53	0.94	0	0.69	0.68	0.44	0	0.56	0.53	0.59	0	0.87	0.50	0.11	0.16	0	0	0	0
Non-Well Farmers	S1	% Cultd	41	39	0	2	2	2	0	0	32	29	0	3	3	3	0	0	73	73	0	0	0	0	0	0
		Mean	0.26	0.27	0	0.23	0.26	0.26	0	0	0.26	0.26	0	0.23	0.26	0.26	0	0	0.27	0.27	0	0	0	0	0	0
		CV	0.56	0.57	0	0	0	0	0	0	0.67	0.69	0	0	0	0	0	0	0.42	0.42	0	0	0	0	0	0
	S2	% Cultd	69	69	0	0	0	0	0	0	74	74	0	0	0	0	0	0	73	55	0	0	0	0	0	0
		Mean	0.21	0.21	0	0	0	0	0	0	0.20	0.20	0	0	0	0	0	0	0.19	0.26	0	0	0	0	0	0
		CV	0.69	0.69	0	0	0	0	0	0	0.77	0.77	0	0	0	0	0	0	0.70	0.29	0	0	0	0	0	0
	S3	% Cultd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Note: S1, S2, S3 = Seasons 1, 2 and 3. SC = Sugarcane. OC = Other Seasonal Crops. Mean and CV represent the farmers who cultivated among the samples.
% cultd = percentage of farmers cultivated among the total samples.
For details of total samples and number of them cultivated in each sample group refer appendix 6.

Source: Derived from Appendix 4 and 5.

The dry year paddy crop wholly depends upon the availability of well water supply. Between system and non-system well farmers, the latter perform poorly. **On the whole, the area analysis indicates that non-system tank well farmers perform better in the normal tank supply year and they are unable to crop the land in the dry year. Whereas the system tank well and non-well farmers devoted a less area under paddy and the variability is also more (CV is around 70%).**

Gross Water Use for Paddy in Normal Year: 1998-99

In a normal tank supply year, whenever tank supply is inadequate or uncertain, farmers can supplement well water where its access is possible. Further, in a normal period, when tank supply is adequate to serve the entire ayacut no farmer goes for well supply even though free power supply is given to pump sets. Since a majority of tanks store only one or at the maximum two seasons supply, farmers tend to use well water in the third season if they desire to cultivate. However, cultivation in the third season purely depends upon the availability of well supply. With this general notion one may analyse the gross water use (both tanks and wells) for paddy cultivation between well and non-well farmers. The system and non-system wise seasonal segregation of data for gross water use and ratio of consumptive use requirement to gross water use for normal and dry years are given in **table 4.2**.

Gross Water Use by Well Farmers in the Normal Year: The data indicate that in the case of **well** farmers both in the **system and non-system tanks**, the mean water use per hectare in seasons 1 and 2 is more than the annual average of 1.01 hectare metre and it is the lowest in the third season (0.82 ham). **This higher use in the first two seasons may be due to relative abundance of supply available from the tanks**. But in the third season tank supply is a constraint and only well supply is possible. As a result, use of water is decreased considerably. The annual water use, in all seasons, indicates that **well farmers in system tanks relatively used a less supply per hectare (0.98 ham) compared to well farmers in non-system tanks (1.08 ham).** Also, the overall consistency of supply is favourable to non-system well farmers (CV 26%) compared to system tank well farmers (32 % variability). The effect of well water supply may be captured only in the third season when tank supply is almost nil. As one could observe this in season 3, well water used by system tank farmers is relatively more (0.84 ham) than that of the non-system tank farmers (0.73 ham).

Table 4.2 Season wise Mean Area, Gross Water Use and Ratio of Consumptive Use Requirement to Gross Water Use for Paddy for Cultivated Sample Farmers (Paddy Area in Hectares; Gross Water Use in Hectare metre)

Type of Sample Farmers	Season	% Cultivated Mean & CV	Total (System + Non-System)						System Tanks						Non-system Tanks					
			Normal Year			Dry Year			Normal Year			Dry Year			Normal Year			Dry Year		
			Area	GWU	Ratio *	Area	GWU	Ratio *	Area	GWU	Ratio *	Area	GWU	Ratio *	Area	GWU	Ratio *	Area	GWU	Ratio *
Well Farmers	S1	% Cultd	70	70	70	44	44	44	64	64	64	56	56	56	86	86	86	14	14	14
		Mean	0.30	1.08	0.26	0.24	0.80	0.32	0.26	1.09	0.25	0.25	0.81	0.32	0.38	1.04	0.27	0.17	0.73	0.35
		CV	0.73	0.33	0.27	0.42	0.13	0.13	0.63	0.32	0.26	0.42	0.14	0.13	0.77	0.34	0.29	0.22	0.01	0.01
	S2	% Cultd	82	82	82	18	18	18	86	86	86	25	25	25	71	71	71	0	0	0
		Mean	0.28	1.06	0.57	0.35	0.72	0.85	0.24	1.00	0.60	0.35	0.72	0.85	0.40	1.22	0.46	0	0	0
		CV	0.82	0.42	0.59	0.75	0.34	0.81	0.79	0.43	0.61	0.75	0.34	0.81	0.78	0.40	0.40	0	0	0
	S3	% Cultd	46	46	46	18	18	18	53	53	53	25	25	25	29	29	29	0	0	0
		Mean	0.26	0.82	0.88	0.21	0.73	1.20	0.26	0.84	0.82	0.21	0.73	1.20	0.26	0.73	1.14	0	0	0
		CV	0.64	0.39	0.45	0.53	0.35	0.74	0.68	0.37	0.31	0.53	0.35	0.74	0.50	0.52	0.70	0	0	0
	Annual	% Cultd	90	90	90	48	48	48	92	92	92	61	61	61	86	86	86	14	14	14
		Mean	0.62	1.01	0.93	0.43	0.78	0.82	0.56	0.98	1.00	0.46	0.78	0.87	0.80	1.08	0.72	0.17	0.73	0.35
		CV	0.74	0.30	0.53	0.66	0.18	0.77	0.72	0.32	0.47	0.63	0.18	0.74	0.72	0.26	0.69	0.22	0.01	0.01
Non-well Farmers	S1	% Cultd	39	39	39	2	2	2	29	29	29	3	3	3	16	16	16	0	0	0
		Mean	0.27	1.22	0.23	0.26	0.99	0.26	0.26	1.34	0.21	0.26	0.99	0.26	0.27	1.05	0.26	0	0	0
		CV	0.57	0.29	0.29	0	0	0	0.69	0.28	0.33	0	0	0	0.42	0.25	0.21	0	0	0
	S2	% Cultd	69	69	69	0	0	0	74	74	74	0	0	0	12	12	12	0	0	0
		Mean	0.21	1.30	0.40	0	0	0	0.20	1.32	0.39	0	0	0	0.26	1.17	0.46	0	0	0
		CV	0.69	0.27	0.31	0	0	0	0.77	0.24	0.29	0	0	0	0.29	0.39	0.36	0	0	0
	S3	% Cultd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Annual	% Cultd	82	82	82	2	2	2	84	84	84	3	3	3	16	16	16	0	0	0
		Mean	0.30	1.27	0.37	0.26	0.99	0.26	0.26	1.32	0.36	0.26	0.99	0.26	0.47	1.08	0.40	0	0	0
		CV	0.91	0.25	0.32	0	0	0	1.07	0.24	0.33	0	0	0	0.39	0.21	0.28	0	0	0

Note: S1, S2, S3 = Seasons 1, 2 and 3. GWU = Gross Water Use per hectare. Mean represents the farmers who cultivated among the samples.
Ratio* = Ratio of Consumptive Use Requirement to Gross Water Use. For details of total samples and number of them cultivated refer Appendix 7.

Source: Derived from Appendix 4 and 5.

Also, the variability in water use is much less (37 %) in the system tanks than in the non-system (52%) tanks. As it is noted in the previous table that paddy is more intensively cultivated in the first two seasons compared to the third season. As this confirms clearly, that gross water use (tank plus well supply) is more in the first two seasons compared to the third season. Further, it may be observed that the highest (1.22 ham) and lowest (0.73 ham) quantum of water use per hectare is seen only with the well farmers in the non-system tanks.

Gross Water Use by Well Farmers in the Dry Year 2003-04:

The above discussion pertains to the normal year situation in which both the tank and well supply are possible. Contrary to this, in the dry year (in terms of deficit seasonal rainfall which leads to no storage in the tanks) tanks do not get any supply even during the monsoon period. As a result, farmers had two options for cropping: (i) rainfed crop cultivation by using the scanty rainfall during the monsoon period; and (ii) cultivation by solely using the well water. There is difference between the two. Farmers using wells may also grow rainfed crops, but irrigated crops (by using wells) are not possible to non-well farmers. This situation was exactly prevailing in the dry year almost in all our survey tanks.

Even for the tank command wells, water availability depends upon both the seasonal rainfall and the tank storage. Most wells (especially in shallow depth) do not get adequate recharge. As a result, most well farmers do not crop the land. Even if they ventured for cultivating dry irrigated crops, expecting good showers, during monsoon but when it fails, immediately they incur total loss due to withering of crops. This situation is reported in many of the study tanks, especially in the non-system tanks. This type of unavoidable situation only makes agriculture to be referred as a “gamble in monsoon”. In the light of the background, let us examine the gross water use by sample farmers in the dry year.

Regarding the quantum of gross water use for paddy a comparison (of well farmers) with the normal year shows that the **dry year gross water use is relatively less both in the system and non-system tanks**. As one refers to table 40, nowhere can it be seen that the gross water use in the dry year is more than that of the normal year. Taking all seasons together, between system and non-system tanks, **well water use per hectare is marginally higher in the system tanks**

(0.78 ham) compared to non-system tanks (0.73 ham). Further, in the non-system tanks, cropping was possible for 14 % of sample cultivators in a single (first) season only. This indicates one clear point that **in the absence of tank storage wells do not contribute much for better cropping even when they are located within the tank command**.

Gross Water Use by Non-well Farmers in the Normal and Dry Years: Compared to well farmers, the non-well farmers tend to use relatively more quantum of supply per hectare both in the first and second seasons. The system tank non-well farmers relatively use more quantum of supply in all seasons compared to the non-system tank farmers. **Overall results indicate that system tank non-well farmers tend to use more water (1.32 ham) than non-system tank non-well farmers (1.08 ham).** However, between the system and non-system tanks the variations in water use among non-well farmers (the variability is only 24% and 21%) are much less. **This shows that non-well farmers are equally benefited from tanks of both types. No preference is possible for the non-well farmers in the system tanks**. In the dry year, cultivation is not possible for non-well farmers of both the system and non-system tanks.

Ratio of Consumptive Use requirements to Gross Water Use:

In our study tanks, paddy cultivation dominates over all other crops. Hence it is important to find out the ratio of how much water is required for paddy cultivation as per the crop water requirement and how much water is actually supplied by farmers for that crop. As it is noted in section 1, in this study, crop water requirement of paddy takes into account of both consumptive use (CU) requirement as well as land preparation (LP). Accordingly, the first season paddy requires 2570 cubic metre (CUM) of water per hectare (1070 CUM for CU and 1500 CUM for LP); second season requires 4780 CUM/ha (3780 CUM for CU and 1000 CUM for LP) and for the third season the requirement is 6230 CUM/ha (5230 CUM for CU and 1000 CUM for LP). By using these calculations one can easily compute season wise ratio of consumptive use requirements (CUR) to gross water use (GWU) for paddy crop. Seasonwise details of CUR to AWU are given in **table 4.2**.

Well Farmers: Normal Year: Taking all tanks together the mean ratio of CUR to GWU increases steadily from season 1 (26%) to season 3 (88%). This indicates that the quantum of water supplied is utilised more effectively in the third season compared to season 1. In other words, in season 3, 88 % of GWU is utilised for paddy and the same is only 26 % in season 1. **Between system and non-system tanks the mean ratio of water use (or the efficiency of water use) is relatively higher in system tanks, which ranges between 25 % in season 1 and 82% in season 3**. The annual ratio between system and non-system tanks is 100% and 72% respectively. In the case of non-system tanks in season 3, the mean ratio being 114%, which indicates that about 14% of gross supply given, falls short of CUR and this shows that deficit supply was given than what was required for the CUR.

Well Farmers: Dry Year: During the dry year, the non-system tank well farmers did not raise crop in seasons 2 and 3. But the system tank well farmers raised crop in all three seasons and the efficiency of water use in terms of mean ratio is gradually increasing from seasons 1 to 3. Especially in season 3 the mean ratio is 120%, which indicates that gross supply falls short by 20% of CUR.

Non-well Farmers: In the case of non-well farmers, cultivation in the normal year is possible only in the first two seasons. The efficiency of water use (in terms of ratio of CUR to AWU) is relatively high in season 2 in both types of tanks compared to season 1. However, this efficiency is only less than 50%. This means that farmers are using 50% more water than what is required for CUR. In the dry year cultivation is not possible for non-well farmers.

Percentage of Well Water Use for Paddy in Normal Year: 1998-99

In the tanks under survey, tank irrigation is supplemented with well irrigation to a considerable extent since half of the respondents owned wells. Wells are useful in several ways for better crop production. As a private source with individual's control the quality of irrigation (assured, adequate and timely supply of water) is considered more assured under wells. However, one cannot fully rely upon wells due to its severe supply constraints. As a result, wells are mostly considered as a supplemental source rather than sole irrigation source. Wells are more dependable for additional irrigation when the tank supply is inadequate or uncertain. Further, when the tanks are continuously dried up for a few years, sole irrigation by wells is possible only to a limited extent due to hydro geological conditions, which permits very poor recharge.

In the tanks under study even though total number of farmers using wells is equal to total non-well farmers, there has been lot of variations in its contribution in the selected tanks. In this context, it is useful to find out the contribution of wells to enhance crop productivity among farmers using wells. The relevant data for season wise percentage of use of well water is given in **table 4.3**. Across seasons, one can observe a lot of combinations in the use of well water between system and non-system tanks. In season 1, only 20 % of well water is used under system tanks whereas, it is 78 % under non-system tanks. In season 2, both in the system and non-system tanks, most farmers use well water. The variations in percentage of its use are also low. A larger proportion of farmers under system tanks use more of well water compared to non-system tanks.

Table 4.3 Variability in Well Water Use for Paddy among Sample Farmers, 1998-99

Details	Season 1		Season 2		Season 3		All Seasons	
	System	Non-system	System	Non-system	System	Non-system	System	Non-system
% of wells used	11	21	44	50	39	21	72	64
Total Wells	36	14	36	14	36	14	36	14
MEAN	20	78	84	61	84	75	45	44
CV (%)	53	48	40	63	44	67	32	79

Source: Derived from Appendix 4.

As noted earlier, the tank supply is not possible in the third season. As a result, it is observed only well irrigation is possible for cropping both in system and non-system tanks. On the whole, it may be concluded that percentage of well water use under system tanks are more widespread than the non-system tanks. In season 1, well farmers under non-system tanks are intensively using well water (78 %) than under system tanks (20%). Regarding variability, well water use under system tanks is more consistent (with less variability - maximum is 53 %) than under non-system tanks (variability is between 48 % and 79 %). As one may also expect from this result that system tanks well water use is more consistent so the productivity levels may also be consistent among the well farmers.

Land Productivity for Paddy in the Normal Year: 1998-99

Productivity of crop depends upon many factors. However, land and water are the prime factors to achieve crop's potential productivity. When other factors such as use of fertilizers, and crop management practices remain constant, the land and water are the twin factors deciding the crops maximum productivity. In the tanks under study let us examine the land productivity of paddy during normal and dry years. Season wise and system wise productivity details (in terms of kilograms per hectare) are presented in **Table 4.4.**

Some clear pattern on the levels of productivity exists between system and non-system tanks. Also, one can find that well farmers have achieved higher productivity than non-well farmers. Further, across seasons productivity in season 1 is less than that of Seasons 2 and 3 in system tanks. This is mainly because of the fact that during the tank supply period, especially in season 1, when the tanks reach its full capacity, the seepage effect of tank storage creates problems of drainage for the head reach farmers. If proper drainage is not available it retards productivity levels considerably. The table shows that all well farmers who served by system tanks have achieved only lower productivity (the minimum being 3240 kg/ha in season 1) compared to seasons 2 and 3. Between seasons 2 and 3 under system tanks more yields are reported in season 3 (maximum yield is 3940 kg/ha). This is also due to better sunlight during seasons 2 and 3 and less pest attack.

Exactly the opposite picture is noticed in well farmers under non-system tanks. Here, in all seasons, well farmers achieved a lower productivity (maximum is 2350 kg/ha in season 3) than the system tank well farmers. This may validate our argument that well irrigation under system tanks helped to achieve more yields. Further, non-system tanks are not filled up frequently compared to system tanks. Hence, recharging capacity of wells under non-system tanks are much less compared to system tanks.

Taking well farmers under system and non-system tanks together, a clear picture may be observed. Interestingly, all well farmers in all seasons have attained higher productivity (maximum is 3660 kg/ha in season 3) compared to non-system well farmers (highest yield is 2346 kg/ha). Mostly the same trend is noticed (but with lower productivity levels in all seasons) in the non-well farmers groups between system and non-system tanks.

On the whole, it is observed that the productivity levels are invariably higher in system tanks in all seasons compared to non-system tanks. Across seasons productivity is invariably the highest in season 3 in both types of tanks. More importantly the productivity levels between these two types of tanks are more consistent and the variability is very less in all seasons.

Table 4.4 Season wise Mean Land and Water Productivity of Paddy for Cultivated Sample Farmers (Land Pdy in '000 Kg/Ha. Water pdy in Kg / Cubic metre)

Type of Sample Farmers	Season	% Cultivated Mean & CV	Total (System + Non-System)						System Tanks						Non-system Tanks					
			Normal Year			Dry Year			Normal Year			Dry Year			Normal Year			Dry Year		
			Land PDY	Water PDY		Land PDY	Water PDY		Land PDY	Water PDY		Land PDY	Water PDY		Land PDY	Water PDY		Land PDY	Water PDY	
				C U	Diverted		C U	Pumped		C U	Diverted		C U	Pumped		C U	Diverted		C U	Pumped
Well Farmers	S1	% Cultd	70	70	70	44	44	44	64	64	64	56	56	56	86	86	86	14	14	14
		Mean	2.86	1.11	0.29	4.33	1.69	0.54	3.24	1.26	0.33	4.43	1.72	0.55	2.13	0.83	0.22	3.35	1.30	0.46
		CV	0.37	0.37	0.48	0.30	0.30	0.29	0.33	0.33	0.46	0.29	0.29	0.29	0.31	0.31	0.40	0.28	0.28	0.29
	S2	% Cultd	82	82	82	18	18	18	86	86	86	25	25	25	71	71	71	0	0	0
		Mean	3.18	0.67	0.39	3.19	0.67	0.42	3.54	0.74	0.45	3.19	0.67	0.42	2.06	0.43	0.19	0	0	0
		CV	0.39	0.39	0.87	0.63	0.63	0.64	0.32	0.32	0.81	0.63	0.63	0.64	0.36	0.36	0.43	0	0	0
	S3	% Cultd	46	46	46	18	18	18	53	53	53	25	25	25	29	29	29	0	0	0
		Mean	3.66	0.59	0.51	3.63	0.58	0.47	3.94	0.63	0.54	3.63	0.58	0.47	2.35	0.38	0.39	0	0	0
		CV	0.31	0.31	0.44	0.54	0.54	0.53	0.26	0.26	0.42	0.54	0.54	0.53	0.26	0.26	0.47	0	0	0
	Annual	% Cultd	90	90	90	48	48	48	92	92	92	61	61	61	86	86	86	14	14	14
		Mean	3.19	0.37	0.36	3.88	1.01	0.51	3.57	0.41	0.42	3.93	0.98	0.51	2.14	0.26	0.21	3.35	1.30	0.46
		CV	0.36	0.56	0.69	0.35	0.73	0.32	0.29	0.54	0.64	0.35	0.77	0.33	0.27	0.36	0.31	0.28	0.28	0.29
Non-well Farmers	S1	% Cultd	39	39	39	2	2	2	29	29	29	3	3	3	16	16	16	0	0	0
		Mean	2.67	1.04	0.23	4.66	1.81	0.47	3.01	1.17	0.24	4.66	1.81	0.47	2.20	0.85	0.22	0	0	0
		CV	0.23	0.23	0.35	0	0	0	0.15	0.15	0.35	0	0	0	0.24	0.24	0.36	0	0	0
	S2	% Cultd	69	69	69	0	0	0	74	74	74	0	0	0	12	12	12	0	0	0
		Mean	3.20	0.67	0.27	0	0	0	3.45	0.72	0.29	0	0	0	2.04	0.43	0.20	0	0	0
		CV	0.48	0.48	0.57	0	0	0	0.46	0.46	0.56	0	0	0	0.34	0.34	0.63	0	0	0
	S3	% Cultd	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Annual	% Cultd	82	82	82	2	2	2	84	84	84	3	3	3	16	16	16	0	0	0
		Mean	3.13	0.66	0.26	4.66	1.81	0.47	3.40	0.73	0.28	4.66	1.81	0.47	2.05	0.37	0.20	0	0	0
		CV	0.45	0.54	0.52	0	0	0	0.42	0.49	0.52	0	0	0	0.22	0.35	0.30	0	0	0

Note: S1, S2, S3 = Season 1, 2, and 3. CU = Consumptive Use. Mean and CV for cultivated sample farmers. PDY = Productivity.
% cultd = % of farmers cultivated among the total samples. For details of total samples and no. of them cultivated in each sample group refer appendix 7.

Source: Derived from Appendix 4 and 5.

Land Productivity for Paddy in the Dry Year: 2003-04

As noted earlier the quality of irrigation (adequate, assured and timely supply of water) is sine-quo-non-for better crop productivity, and this is possible mostly through conjunctive use of tank and well water. Details of dry year land productivity for paddy in system and non-system tanks are given in table 4.4.

Contrary to our expectation (**that use of more water will help to get more yield**), a glance at the data given in the normal and dry year land productivity show that almost both in system and in non-system tanks the dry year land productivity is invariably higher than the normal year land productivity. As observed in the previous table, the annual water use in the dry year is comparatively less in both types of tanks compared to the normal year. These observations clearly indicate that in the normal year farmers tend to over use water than what it is required for crop needs. In other words, **over use of water retarded the land productivity in the normal year.** Further, it may also be argued that in the dry year farmers are solely dependent on well water and in the normal year mostly tank water is used. It is known, that current system of tank water is not controlled to provide only the required quantum of supply for crop growth. Majority of farmers reported that daily supply was adopted for paddy crop in the normal year. Even that supply was not controlled and over supply was given as depicted below. In Purisai tank, one of the respondents revealed that due to over supply of tank water by the adjacent plot holder the respondent's plot manured with fertilizers was affected because of flooding of water from one field to the other.

In the case of well water use in the dry year, even though limited supply was provided to the crop (compared to normal tank supply period), **it was considered 'adequate', 'timely' and also 'regular'. Consequently, well water supply helped farmers to achieve more yield**. Even then, if one finds any difference in the yield level it is due to much deficiency / inadequacy of supply (due to poor water yield from wells) to crops in the dry year. It is inferred from the data that between the system and non-system well farmers, the land productivity among system farmers is relatively more (3930 kg/ha) compared to non-system well farmers (3352 kg/ha). Moreover, variability in productivity levels is also less between these two types of tanks (variability in system tanks is 35 % and for non-system tanks 28 %).

The analysis clearly brings out the differences between system and non-system tanks, and indicates that higher productivity levels were achieved by system tanks. So, preference should be given to improve the system tanks in all possible ways, especially providing adequate drainage networks and other required infrastructure facilities to improve further and to achieve the potential yield levels. It should also be noted that non-system tanks are also equally important. As observed in some good years the productivity levels in the non-system tanks also reaches to appreciable level. Since, a major portion (about 60%) of area is still under unirrigated condition, attention should also be given to integrate the non-system tanks with run off from the local watersheds – to link / create facilities to withhold all precipitation during the monsoon rains.

Diverted Water Productivity for Paddy in the Normal Year: 1998-99

Diverted water refers to the quantity of water used (both from tank and well supply) for the entire crop growth period. This water productivity analysis tells us farmers' effectiveness in utilisation of available water supply to maximize their crop yield. **Table 4.4** presents data on system wise well and non-well farmers' **diverted** water productivity (in terms of kilogram per cubic meter of water used) for paddy crop in the normal tank supply year and the dry year.

In the normal year, the mean diverted water productivity (kg/cum) of well farmers in the system tanks in all seasons is relatively higher than the non-system tank well farmers. The overall well farmers analysis indicates that in all seasons, system tank well farmers produce more output per unit of water applied compared to non-system tank well farmers. The annual water productivity under system tanks is 0.42 kg/cum compared to a half that level achieved in the case non-system well farmers. However, the variability in water productivity is much less (31%) in the latter group compared to the former (64%). Between the system and non-system non-well farmers, the system tanks non-well farmers relatively produce more output per cubic meter of water applied (overall 0.28 kg/cum). However, the instability is relatively more (52%) in this group. **It should be noted that in the third season due to water scarcity, even in the normal year, not even a single farmer in the non-well respondents cultivated paddy.** On the whole, it may be concluded that **although system tanks perform much better in achieving higher productivity levels but the variability is much higher compared to non-system tank farmers. This means, that there is still a possibility to enhance system tank output levels if one introduces better water management practices**.

Pumped Water Productivity for Paddy in the Dry Year: 2003-04

Since water productivity is derived mainly from the land productivity whatever variations we find for land productivity in the dry year also applied to water productivity. As it is noted, in the dry year due to efficient well water use, productivity is reported to be higher than the normal year. As a result, water productivity is found higher especially in season 1 in the dry year in both types of tanks and the variability is also found to be less (see table 4.4). In the system tanks, mean pumped water productivity in season 1 is more (0.55 kg/cum) than the annual average of 0.51 kg/cum. However, in seasons 2 and 3, the productivity level is lower than the annual average.

In the non-system tanks, cropping was done only in season I, where the mean productivity is 0.46 kg/cum. The overall picture indicates that system tank water productivity is higher (0.51 kg/cum) than that of the non-system tank (0.46 kg/ha). However, the variability in productivity levels under system tanks is marginally higher (annual mean variability is 33 %) than the non-system tanks (29 %). Since paddy is a water intensive crop the non-well farmers could not crop the land in the dry year in all seasons.

Taking both system and non-system tanks together, it may be observed that dry year pumped water productivity is higher in all seasons compared to normal year (except in season 3) and the annual mean productivity is 0.36 kg/cum in the normal year and the same being 0.51 kg/cum in the dry year. This indicates that in the normal year over use of water supply leads to a reduction in productivity levels, which is evident in comparison with dry year water productivity values.

Land and Water Productivity for Sugarcane and Other Seasonal Crops

Other than paddy some ten percent of area is devoted for sugarcane and other seasonal crops cultivation. An analysis is made to find out the land and water productivity for these crops for the normal and dry years. Relevant data are given in **table 4.5**.

Sugarcane: Among the 99 sample farmers, only five in the normal year and four (in which crop withered for one) in the dry year cultivated sugarcane. The mean area cultivated by a farmer in the system tanks is less (0.15 hectare) than that of non-system tank sample farmers (0.29 hectare) in the normal year. The area cropped is highest (0.59 hectare) in the dry year. Since tank supply

Table4.5 Mean Land and Water Productivity for Sugarcane and Other Crops: All Tanks Total: Normal Year 1998-99 (GWU in Hecta metre)

CLASSIFICATION OF FARMERS	Sugar-cane Area	Gross Water Use / Ha	Gross Yield /Ha	Productivity per Cubic Meter of Water SUGARCANE		Other CropsArea S1	Gross Water Use / Ha	Other Crops	Productivity per Cubic Meter of Water OTHER CROPS		Other CropsArea S3	Gross Water Use / Ha	Other Crops	Productivity per Cubic Meter of Water OTHER CROPS	
	Ha		Tons / Ha	CU (Kg)	Diverted (Kg)	Ha		Gr.Val/ Ha Rs.	CU (Rs)	Diverted (Rs)	Ha		Gr.Val/ Ha Rs.	CU (Rs)	Diverted (Rs)
1	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
SYSTEM: WELL															
MEAN	0.15	1.794	140	10.31	7.83	0.14	0.18	10868	12.64	6.04					
No. of Cultivated samples	3	3	3	3	3	1	1	1	1	1					
SYSTEM: NW															
MEAN						0.23	0.20	5293	6.15	2.65					
No. of Cultivated samples						1	1	1	1	1					
NS: WELL															
MEAN	0.29	2.375	131	9.64	5.51						0.36	0.275	5161	1.23	1.88
No. of Cultivated samples	2	2	2	2	2						3	3	3	3	3

Mean Land and Water Productivity for Sugarcane and Other Crops: All Tanks Total: Dry Year: 2003-04 (GWU in Hecta metre)

CLASSIFICATION OF SYSTEMWISE, REACHWISE WELL AND NON-WELL FARMERS	Sugar-cane Area	Gross Water Use / Ha	Gross Yield /Ha	Productivity per Cubic Meter of Water SUGARCANE		Other CropsArea S1	Gross Water Use / Ha	Other Crops	Productivity per Cubic Meter of Water OTHER CROPS		Other CropsArea S2	Gross Water Use / Ha	Other Crops	Productivity per Cubic Meter of Water OTHER CROPS	
	Ha		Tons / Ha	CU (Kg)	Pumped (Kg)	Ha		Gr.Val/ Ha Rs.	CU (Rs)	Pumped (Rs)	Ha		Gr.Val/ Ha Rs.	CU (Rs)	Pumped (Rs)
1	2	3	4	5	6	2	3	4	5	6	2	3	4	5	6
SYSTEM: WELL															
MEAN	0.21	2.112	111	8.17	4.87	0.23	1.80	18261	21.23	1.01	0.23	0.843	8306	2.75	0.99
No. of Cultivated samples	2	2	2	2	2	1	1	1	1	1	2	2	2	2	2
NS: WELL															
MEAN	0.59	1.674	30.58	2.252	1.83										
No. of Cultivated samples	1	1	1	1	1										

Note: Blank entries denotes nil. Withered crops and rainfed crops are excluded from the analysis.

Source: Appendix 6 and 7.

is favourable in the normal year, gross water use per hectare is relatively more (maximum 2.375 hectare metre) than the dry year (maximum 2.112 hectare metre). The gross land productivity is higher (140 tonnes per hectare) in the normal year and the same being 111 tonnes per hectare in the dry year. Water productivity of sugarcane between system and non-system tanks indicates that under both categories of farmers, normal year water productivity is higher than that of dry year. Further, in the non-system tanks between normal and dry years, the dry year water productivity is much less (1.83 kg/cum) compared to the normal year (5.51 kg/cum). All these clearly bring out that **system tank well farmers are relatively better off to achieve more of land and water productivity of sugarcane than non-system tank well farmers**.

The land and water productivity variations suggest: (a) system tanks perform better than non-system tanks; (b) land productivity during the normal year is considerably more than that of dry year values; and (c) between normal and dry years the non-system tank normal year land productivity is more than four times than that of dry year values. This clearly depicts that **in the absence of adequate water supply annual crop cultivation curtails its productivity to a large extent**.

Other Seasonal Crops: In the tanks under study, only limited farmers had grown other seasonal irrigated crops. Those crops are groundnut, cholam/cumbu and vegetables. Some farmers raised rainfed groundnut, cumbu and ragi that are excluded from the analysis. Only those crops, which are irrigated are taken into account. In the normal year in season 1, both the well and non-well farmers devoted a limited extent for other crops cultivation. Since the types of crops grown vary between farmers only the actual monetary values are used in this exercise to compute the land and water productivity.

In the normal year, the gross water use per hectare is 0.18 hectare metre for well farmers and 0.20 hectare metre for non-well farmers. However, regarding the farmers using wells the land productivity in the system tank is nearly two times (Rs. 10868 per hectare) than that of non-well farmers (Rs. 5293 per hectare). The value difference is mainly because of the type of crops grown by the farmers rather than differences in water use. Actually, the former sample cultivator raised groundnut and the latter cultivated blackgram. Even though water supply was adequately given (as per respondent's view) for both crops, the productivity did not help much to achieve more yields for blackgram. The same pattern is also observed in the water productivity also. In the dry year, only one system tank well farmer had grown cholam in season 1. For that crop a supply of 1.80 ham per hectare was provided, which resulted in a good land productivity of Rs. 18,261 per hectare. The pumped water productivity for cholam crop is Re. 1 per cubic meter of water used. In season 2, two sample farmers had grown vegetable (brinjal) and blackgram crops and they used 0.843 hectare metre of water. The average land and water productivity of these crops are respectively Rs. 8306/hectare and Re. 0.99 per cubic metre of water used.

In the system tanks in the normal year in season 3, only the non-system well farmers had grown blackgram, cumbu and ragi. The gross water use per hectare is 0.275 hectare metre. The land and water productivity are respectively Rs. 5161/hectare and Rs. 1.88 for diverted water.

Farmers' Preference of Paddy over Other Crops

It is interesting to note that why farmers mostly prefer paddy cultivation rather than any other crops even in the water deficit dry years. As one can observe from the table 4.6 that in the normal year average seasonal water productivity of paddy is Rs. 1.59 per cubic metre, whereas for sugarcane it is only Rs. 1.44 per cubic metre. Although 'other crops' water productivity in season 1 is comparatively very high which is Rs. 4.34 per cubic metre but its value is not consistent in the other season. In the dry year also one can observe that water productivity of paddy is more than three times that of sugarcane values and more than two times that of 'other crops' values. This higher return of water productivity amply induces farmers to cultivate paddy even during the dry year when water scarcity is high. This specific trend is observed in almost all parts of Tamil Nadu with different sources of irrigation such as canals, tanks and wells.

Table 4.6 Comparison of Profitability of Paddy over Other Crops

Year	Unit	Paddy Cultivation S1	S2	S3	Gross	Average/ Season	Sugarcane Annual	Average/ Season	Other Crops S1	S2	S3
NY	LPDY (Rs/ha)	15213	16324	19062	50599	16866	88230	**29410**	**8081**	-	**5161**
	WPDY (Rs/M^3)	1.38	1.11	2.28	4.77	1.59	4.33	**1.44**	**4.34**	**-**	**1.88**
DY	LPDY (Rs/ha)	24695	15814	18475	58984	19661	46038	**15346**	**18261**	**8306**	**-**
	WPDY (Rs/M^3)	2.70	1.62	2.40	6.72	2.24	2.18	**0.73**	**1.01**	**0.99**	**-**

Note: NY=Normal Year. DY=Dry Year. LPDY=Land Productivity. WPDY=Water Productivity.
S1, S2, S3 = Seasons 1, 2 and 3. Rs/ha = Rupees per hectare (values are converted into 2003-04 prices).
Paddy value is Rs. 5.50 per kg. Sugarcane value Re. 0.65 per kg. Other Crops value (per Kg): Black gram Rs. 11; Groundnut Rs. 5.50; Small Millets Rs. 3.50; Brinjal (vegetable) Rs. 2.
Source: Derived from Tables 4.4 and 4.5.

Section V

Summary and Conclusions

To cope with the objectives stated in section I, a field survey in 7 tanks was conducted in the Cheyyar sub-basin of the Palar basin. The survey covered 99 sample farmers and data were collected for two-reference years viz. a normal tank supply year and a dry year. The overview of tank wise analysis (section II) shows that the cropping pattern was predominantly paddy that was grown (around 90 % of total area under cultivation) in all the sample tanks in both the reference years. However, the total area devoted for paddy was very less during the dry year due to paucity in well supply. Reduced supply to the tank leads to gross reduction in the area under cultivation in all the seasons, which is clearly observed in this study. Sugarcane occupies only 6 to 7 % of cultivated land and, all the other crops were grown to a limited extent. Supplementation of well supply was possible only during the normal supply year. In the dry year well water use was limited due to poor recharge from the aquifers. For lifting water, mostly electrified 5-horse power motor was used by farmers. Taking all seasons and all tanks together, the average number of watering provided by a farmer for paddy crop was 75 and the average number of hours of water supplied per hectare was 12 per watering. Neither water sale nor water purchase was reported among the sample farmers. Since the dry year did not get any water from the tank, only well water was solely used for cropping.

The analysis of tank level land and water productivity as presented in section III provides the following results. The importance of adequate and reliable water supply for cultivation of annual crops is realised in this analysis. Due to severe water shortage the output values are drastically cut down in the dry year and in the absence of tank storage well water use is much limited. In other words, although there are wells, they are ineffective unless tank water recharges them. In the tanks under study, the values of water use for paddy indicate that in the normal tank supply year only the head reach farmers use a higher quantum of supply with 10 % of more water compared to the middle and tail reachers. Although normal year gross water use for paddy is considerably higher but the land productivity is less. As against this, paddy land productivity during the dry year is higher than that of the normal year. This means providing less water induces to achieve more yields especially under paddy crop. From this observation, it may be clear that judicial use of normal year water supply helps to increase not only the existing yield level but also the savings in water supply brings some more area under cultivation which could finally enhance the overall production.

The specific system wise analysis of land and water productivity carried out in section IV gives the following results. It is found that crop diversification did not take place almost in all surveyed tanks even in the dry year among well farmers because the area cultivated under less water intensive crops is negligible. **This shows that in the absence of tank supply and poor rainfall, well irrigation is not feasible for cropping for most farmers and adequate recharge of wells is possible only through the tanks, when they get filled. Cultivation of gross area under paddy indicates that non-well farmers under system tanks are more vulnerable than non-well farmers under non-system tanks. This is mainly due to managerial problems associated with tank water regulation. The area analysis indicates that non-system tank well farmers perform better in the normal tank supply year and they are unable to crop the land in the dry year. This indicates better water regulation adopted by non-system farmers during normal supply year.**

The normal year well water use indicates that system tanks well water use is more consistent and hence the productivity levels may also be consistent among the well farmers. This is proved with our study results. Exactly the opposite picture is noticed in well farmers under **non-system tanks**. Here, in all seasons, well farmers achieved a lower productivity (maximum is 2350 kg/ha in season 3) than the system tank well farmers. This may validate our argument that well irrigation under system tanks helped to achieve more yields. Further, non-system tanks are not filled up frequently compared to system tanks. Hence, recharging capacity of wells under non-system tanks are much less compared to system tanks.

As noted, the quality of irrigation (adequate, assured and timely supply of water) is sine-quo-non-for better crop productivity, and this is possible mostly through wells. Our survey has clearly brought out this point in the context of dry year **land productivity**. Contrary to our expectation (**that use of more water will help to get more yield**), the normal and dry year land productivity show that almost both in system and in non-system tanks the dry year land productivity is invariably higher than that of the normal year land productivity. As indicated above, the gross water use in the dry year is comparatively less in both types of tanks compared to the normal year. These observations clearly indicate that in the normal year farmers tend to over use water than what it is required for crop needs. In other words, **over use of water retarded the land productivity in the normal year.** Further, it is known, that current system of tank water is not controlled to provide only the required quantum of supply for crop growth. Majority of farmers in the system tanks reported that daily supply was adopted for paddy crop in the normal year. Even that supply was not controlled and over supply was given. On the whole, it may be concluded that **although system tanks perform much better in achieving higher productivity levels but the variability is much higher compared to non-system tank farmers. This means, that there is still a possibility to enhance system tank output levels if one introduces better water management practices**.

The land and water productivity variations in respect of sugarcane and 'other seasonal crops' suggest: (a) system tanks perform better than non-system tanks; (b) land productivity during the normal year is considerably more than that of dry year values; and (c) between normal and dry years the non-system tank normal year land productivity is more than four times than that of dry year values. This clearly depicts that **in the absence of adequate water supply annual crops cultivation curtails its productivity to a large extent**.

The analysis of the field survey amply indicates that the land and water productivity differ considerably with its location from the source of supply, access to well water supply and duration of tank supply available for cultivation. One of the important findings is that either the tank supply alone or the well water alone does not help the farmer to get more returns. The required condition is that both these sources should be used conjunctively to maximize returns from their cropping. It is also found that normal year paddy productivity in the head reach of system tanks is much lower than that of the non-system tanks. Hence, on-farm development works in the system tanks must be intensified to further increase the yield level. The other interesting finding is that water productivity of paddy is invariably higher in both the reference years compared to all other crops cultivated, which induces farmers to cultivate paddy over other crops. Especially in the dry year, the values of water productivity of paddy are more than four times that of sugarcane and three times that of other crops cultivation. Further, it is suggested, that construction of a community well in each tank command and its proper management would help to enhance equitable sharing of available tank supply especially to non-well farmers even during the normal tank supply period.

Abbreviations

CAS	-	Cheyyar Anicut System
CM	-	Centimetre
CU	-	Consumptive Use
CUR	-	Consumptive Use Requirement / Rate
CUM	-	Cubic Metre
CV	-	Coefficient of Variation
DoI	-	Depth of Irrigation
DY	-	Dry Year (2003-04)
ET	-	Evapo-Transpiration
GCA	-	Gross Cropped Area
GIA	-	Gross Irrigated Area
GR	-	Gross
GWU	-	Gross Water Use
HA	-	Hectare
HR	-	Head Reach
HAM	-	Hectare Metre
HP	-	Horsepower
HYVs	-	High Yielding Varieties
KG	-	Kilogram
LP	-	Land Preparation
MM	-	Millimetre
MR	-	Middle Reach
NS	-	Non-system
NW	-	Non-well
NY	-	Normal Year (1998-99)
PE	-	Potential Evaporation
PET	-	Potential-Evapo Transpiration
OH	-	Operational Holdings
PDY	-	Productivity
QTM	-	Quantum
RF or Rfall	-	Rainfall
RS	-	Rupees
S	-	System
SC	-	Sugarcane
STDEV	-	Standard Deviation
S1	-	Season 1
S2	-	Season 3
S3	-	Season 3
TR	-	Tail Reach
T+W	-	Tank plus Well
W	-	Well

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