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Can Intermediate Water Storage Structures Mitigate Impact of Climate Variability? Some Evidence from Tank Command Areas in Southern India

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This paper examines whether intermediate water storage structures (farm ponds) would be a better adaptation strategy in the light of climate variability in irrigation tank commands. The study was conducted in two tanks, Pramanur tank and Kovanur tank, in Sivagangai district of Tamil Nadu state, India. To assess the impacts of farm ponds as an adaptation strategy, a sample of 30 farmers in each tank, was selected using a simple random sampling procedure. To make a comparative analysis, an equal number of farmers who do not have access to farm ponds were also studied. Thus, a sample of 120 farmers was studied. It is found that farm ponds play a crucial role in supplementing tank irrigation and help the farmers in achieving better yields. The farm ponds are found to be effective, particularly when farms depend entirely on tank water. The net profit realised from the construction and use of farm ponds is Rs.5383/ha/year. Thus, we can conclude that farm ponds are effective in mitigating climate variability in water-scarce tank command regions. Technical support in water management and cultivation of crops, cropping pattern and crop allocation advice will help farmers better cope with climate variability.

Keywords: Climate Variability, Irrigation tanks, Adaptation, Farm ponds, Southern India.
JEL Classification: Q25, Q54

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I. INTRODUCTION

The issues of climate variability and its impacts have become big concerns today. It is argued that climate variability will impact on the agricultural production systems, surface water resources, both spatially and temporally, and may well be characterised by a more frequent occurrence of extreme events (Meigh *et al.* 1998, Arnell and King 1998, Sullivan, Meigh and Lawrence 2005). The issues of climate variability are further triggered by multiple concerns (adequacy, quality, equity, sustainability, resilience and democratic governance) and multiple stressors (urbanisation and industrialisation, population growth and agricultural changes) (Veena Srinivasan *et al.* 2014). This clearly suggests that the availability of freshwater resources will need to be more rigorously examined and carefully managed in future.

Fluctuations in the rainfall have motivated many countries in Asia to build small, medium and large water harvesting and storage structures for irrigation and other purposes. India has an extensive network of small water harvesting structures, called tanks, some dating back to several centuries. In addition to medium and major irrigation projects, these tanks play crucial role in irrigation (Palanisami, Giordano and Dick 2010). Tanks have existed in India from time immemorial and have been an important source of irrigation, especially in the Southern Peninsular India. Most of these tanks were built in the 18^{th} and 19^{th} centuries by Kings, Zamindars and even by the British rulers. In India, irrigation tanks are mostly concentrated in Southern India, which comprises Andhra Pradesh, Karnataka and Tamil Nadu. Of the 2 million hectares of tank irrigated area in India, the three southern states of Andhra Pradesh, Karnataka and Tamil Nadu account for about 60 per cent.

The water level in the tanks depends mainly on the rainfall in the catchments. In times of fluctuation in rainfall or poor rainfall, farmers in the tank command areas receive poor water supply, and hence the crops and yield are affected significantly. In order to manage this situation, farmers in the tank command areas adopt various coping and adaptation strategies, namely farm level and community level strategies.

Depending on the water availability in the tank and onset of monsoons, farmers alter sowing dates of rice crop in the tank commands. Delayed sowing is the common practice followed by farmers. Inadequate water supply forces the farmers to adopt coping strategies like reducing number of irrigations, adopting water management technologies like direct seeding, partial or full adoption of rice intensification system, alternating wet and dry, etc. Adoption of micro irrigation, particularly in the cultivation of sugarcane, coconut and sometimes vegetables also has become important practice recently. Other farm level coping strategies are altering cropping pattern and farm diversification. Inclusion of less water intensive crops such as maize, sorghum, pulses under rainfed conditions and crops like vegetables, sugarcane and banana under irrigated conditions is a common practice. Inclusion of livestock has become one of the important coping strategies (Suresh Kumar, Balasubramanian and Chinnadurai 2015). The important community level strategy being followed is allowing tank water for groundwater recharge in times of partial filling of tanks. In addition, the state agencies come forward and implement various programmes to drought proof. One such mechanism is construction of farm ponds. The purpose of the farm ponds is to harvest rainwater and store it for farm purposes.

The centrality of the adaptation strategies of farmers as a consequence of climate variability, such as intermediate water storage structures like farm ponds, has not been rigorously examined, making it difficult to develop a research agenda. As monsoon failure and fluctuation in rainfall is a serious concern in southern districts of Tamil Nadu state, the construction of farm ponds assumes importance. Realising the significance of investments on farm ponds, there is a need to examine whether the farm ponds would be effective in adapting to climate variability in the tank commands. Keeping these issues in view, the present paper aims to study the impacts of construction of farm ponds as an adaptation measure in the tank command areas.

II. DATA AND STUDY AREA

2.1 Data

The study contemplates to closely examine the impact of construction of farm ponds as an adaptation strategy to climate variability. The study relies on both secondary data and primary data for the analysis. They include (i) farm household survey, (ii) village level information, and (iii) secondary data from Water Resources Department (WRD), Indian Meteorological Department (IMD) and State Ground and Surface Water Resources Data Centre, WRO, Chennai.

The study was carried out in two tanks in the Sivagangai district of Tamil Nadu state, India. Two tanks, Pramanur tank and Kovanur tank, were selected for the purpose. To assess the impacts of farm ponds as an adaptation strategy, a sample of 30 farmers in each tank was selected, using a simple random sampling procedure. In order to make a comparative analysis, an equal number of farmers who do not have the farm ponds were also studied. Thus, a sample of 120 farmers was studied for the purpose. As the watershed development programme constructs farm ponds for only few farmers, the farmers who had farm ponds and the control farmers were studied in the study tank command areas. The data were collected for the agricultural year 2013-14.

2.2 Study Area

Tanks form one of the important sources of surface irrigation in Tamil Nadu state. The tanks are classified into system tanks (which receive supplemental water from major streams or reservoirs in addition to the yield of their own catchments area) and non-system or rainfed tanks (which depend on the rainfall in their own catchments area and are not connected to major streams/reservoirs). There is also another classification based on administration.[1] There are around 41,127 tanks in Tamil Nadu state alone, with varying sizes and types. Out of these, 81 per cent are having command areas less than 40 hectares and 19 per cent having more than 40 hactares of command area.

While tanks are usually regarded as irrigation sources, there are several characteristics which make them well suited for multiple uses. First, tanks provide dispersed water storage near many of the villages. Second, the technology itself creates bodies of standing water that can be accessed by people and livestock. Further, tanks provide a combination of land and water resources that can be used for brick making, trees, grazing and fish production. Third, in water scarce regions, tanks are used for a variety of productive and domestic uses and are, therefore, very important for rural livelihood (Palanisami and Dick 2001). In spite of its multiple uses, presently a large number of tanks are turning defunct due to various maintenance issues.

There are as many obstacles to tank irrigation as there are benefits of it, due to their large number and the differences in water demand, managerial experiences, and investment needs for maintenance. During low rainfall years, the tanks would store small quantity of water, and the chain of tanks, except the first tank, would receive little supply. Using 40 years rainfall data, it was estimated that in 5 out of 10 years, the tanks will be experiencing deficient supply; in 3 years, the tanks will fail; in one year, the tanks will have surplus storage, and in one year, the tanks will be getting full supply. The effect of the same would be more profound in non-system tanks, resulting in reduction in irrigated area over the years. Since 90 per cent of the tanks are non-system tanks, the effect on area reduction would be more significant. Besides rainfall variation and tank filling, other factors such as siltation, encroachment, channel obstruction, etc. have effect on tank irrigated areas. The data on rainfall and on area irrigated by tanks over the years show that the influence of north-east

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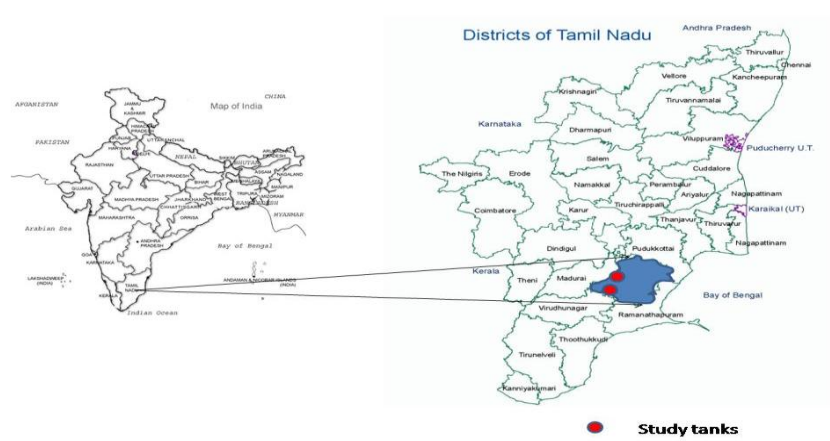
[1]The tanks are also classified into Panchayat Union (PU) and Public Works Department (PWD)[1] tanks based on the management activity. The PU tanks have a command area less than 40 hectares and under the control of Panchayat Unions. Tanks having a command area of more than 40 hectares as well as all the system tanks are maintained by the Water Resources Department.

monsoon rains on the tank irrigated areas in the State was greater than the south-west rainfall. The correlation coefficient between the area irrigated by tanks and the rainfall was found to be between 0.20 and 0.30, indicating that apart from rainfall, there are several other factors which have contributed to overall decline in tank performances over the last few decades (Palanisami, Balasubramanian and Ali 1997).

Other factors include heavy siltation in the tank bed, encroachment of tank beds, poor functioning of the sluices and surplus weirs of the upper tanks, severe encroachment in the supply channels, deforestation, erosion in catchments, conflicts over inter-tank water distribution, etc. Siltation might reduce tank water storage capacity by up to 30 per cent, although there are cases when heavy siltation has completely eliminated the storage capacity (Palanisami and Suresh Kumar 2004). It is reported that some tanks function only in normal/excess rainfall years and not so in poor/low rainfall years. Thus, the study of irrigation tanks assumes important in the light of climate variability.

The study was conducted in the Sivagangai district of Tamil Nadu, India. The Sivanagai district lies between North latitude 9° 43' and 10° 2' and East longitudes 77° 47' and 78° 49'. The total geographical area of the district is about 4,189 sq.km, which is 3.22 per cent of the total geographical area of Tamil Nadu state. The total geographical area of the district is 418,900 hectares. The district had a population of 1.34 million as per 2011 census, with a density of 274.7 persons per sq.km. The location map of the study district and tanks is given in Figure 1.

Figure 1: Map Showing the Location of Study Area and Study Tanks



The major soil types in the district are red loam soils and black soils, having shallow to moderate depth. Majority of the cultivated area is rainfed. The crops like rice, pulses, groundnut and vegetable are grown in larger area. The minor millets are predominantly cultivated in the rainfed and marginal lands. In addition, horticultural crops such as chillies, brinjal and other vegetables are also grown in this area. The main occupation in the district is agriculture. Nearly 90 per cent of the cultivated area is under food crops. The principal crops of this district are rice, groundnut, pulse, sesame and sugarcane.

The district experiences very dry and hot with humid climate, wherein four distinct seasons, viz., south-west monsoon (June-September), north-east monsoon (October-December), winter season (January-Febraury), and summer season (April-May) are experienced. The maximum temperature ranges from 28°C to 40°C and the minimum from 24.5°C to 26°C. About 40 per cent of annual rainfall is recorded when south-west monsoon sets in, usually during June period. This rainfall supports to raise paddy nursery. The remaining unsown rainfed areas are also brought under cultivation during this period. The receipt of north-east monsoon during October to December shares 40.5 per cent of annual rainfall. This helps farmers to take up second crop under rainfed condition.

The season-wise rainfall analysis revealed that the north-east and south-west monsoons are relatively more dependable than summer and winter, as evident from low coefficient of variations (Table I).

TABLE I

SEASON – WISE DISTRIBUTION AND DEPENDABILITY OF RAINFALL IN SIVAGANGAI DISTRICT

Season	Mean rainfall (mm)	Coefficient of variation (%)	Rainfall at 50 % probability	% of seasonal rain to annual total rainfall
Winter	37.93	121.00	8.82	4.00
Summer	156.83	39.78	20.58	16.56
South west	315.45	31.68	14.70	33.30
North east	437.01	30.26	8.82	46.14
Mean	947.23			

Source: Authors' own estimate.
Note: Data are collected from different issues of Season and Crop Report of Tamil Nadu, Department of Economics and Statistics, Government of Tamil Nadu, Chennai.

The Pramanur tank has a registered command area of 743.5 hectares, whereas it is 375.5 hectares in Kovanur. Of the two tanks, the Pramanur tank is a system tank, whereas the Kovanur tank is a non-system tank (Table II).

TABLE II

PROFILE OF STUDY TANKS IN SIVAGANGAI DISTRICT

Particulars	Pramanur	Kovanur
Registered command area (ha)	743.5	375.5
System/non-system	System	Non-system
Number of wells in the command area	94	38
Well density (no. of wells/ha)	0.13	0.10
Number of farmers		
Marginal (< 1.0ha)	600 (59.4)	154 (41.2)
Small (1-2 ha)	200 (19.8)	122 (32.6)
Medium (2-4 ha)	120 (11.9)	67 (17.9)
Large (>4 ha)	90 (8.9)	31 (8.3)
Total	1010 (100.0)	374 (100.0)
Average size of holding (ha)	1.02	0.98
Major crops	Rice	Rice

Source: Water Resources Department and Village Administrative Offices of the concerned tanks and villages.

Few farmers in the command areas have wells to provide supplemental irrigations. The well density[2] is 0.13 and 0.10 for the above tanks. Both the tanks are dominated by smallholders' agriculture. The marginal and small farmers account for 79 per cent in Pramanur tank and 74 per cent in Kovanur tank. Average size of holding is around one hectare in both the tanks. Rice is the major crop in both the tanks.

[2] Number of wells per hectare of command area.

III. RESULTS AND DISCUSSIONS

3.1 Impact of Climate Variability

The irrigation tanks were constructed in ancient days, mainly to cultivate rice (either single or double crop). The purpose here was to harvest rainwater and store in the tanks and later use for rice cultivation. In addition to cultivation of crops, the tank water has been used for rearing fish, growing trees, for domestic purposes and for environmental services. The monsoon failure is expected to reduce water availability in tanks and, in turn, reduce different services provided by the tanks. Reduced water availability in the tanks will result in reduced cropped area and reduced other activities such as fishing, lotus collection, and other provisioning services.

As rainfall is the major determinant of tank filling and of the irrigation in tank commands areas, the most important impact of climate variability is the decrease in the tank water availability or no water in the tanks, which is reflected in the irrigated areas. The analysis of 34 years data from 1980 to 2013 for the study tanks reveals that the mean tank performance[3] is 59.2 per cent in Kovanur and 65 per cent in Pramanur tank.

TABLE III

TANK PERFORMANCE OF STUDY TANKS

Particulars	Pramanur	Kovanur
Command area (ha)	743.5	375.9
Actual area irrigated by tank (ha)		
Mean	482.0	222.5
Standard deviation	201.0	160.2
Coefficient of variation (%)	42.0	72.0
Tank performance (%)		
Mean	65.0	59.2
Standard deviation	27.0	42.6
Coefficient of variation (%)	42.0	72.0

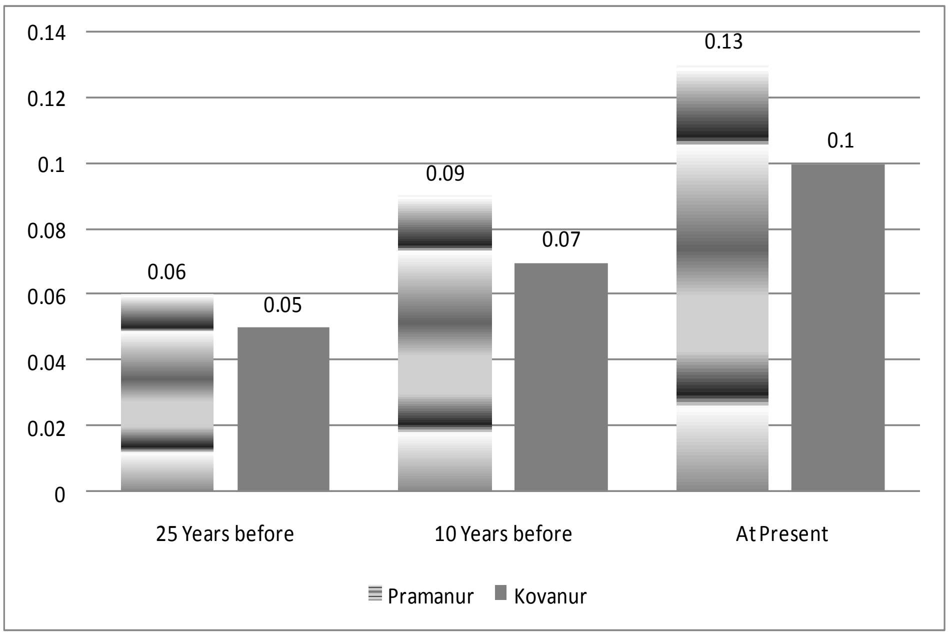
Source: Water Resources Department, Sivagangai district and Village Administrative Offices of the concerned villages.

It is observed that the major impact is no cropping or reduced cropped area under rice. In Sivagangai district, where the tank irrigation is a dominating one, a

[3]Tank performance is calculated as a ratio of actual area irrigated by tanks in a year to the potential area to be irrigated and expressed as percentage.

significant reduction in rice area is observed. Rainfed crops like cotton, maize, groundnut are increasing over the years. Due to reduced water availability, farmers have changed the cropping pattern. Farmers have successfully adapted by growing crops required less water, such as vegetables. There is a dramatic reduction in the area of **rice** (water loving crop), with a concomitant increase in the area of sugarcane. In the tank command areas which have supplemental irrigation by wells, the crops like sugarcane, vegetables attract the farmers. However, in the deficit years and seasons, the crops like groundnut, maize, pulses (black gram) and cotton are grown under unirrigated conditions.

Figure 2: Trend in Well Density in Study Tanks



Growing water scarcity coupled with monsoon failure, poor water availability in tanks and insufficient water for irrigation forced the farmers in tank command areas to drill new wells and bore wells in order to cope with the situation.

This is one of the important adaptation strategies being followed by the farmers in the tank command areas. Construction and drilling of wells is found to be common across tanks. Not only the number of wells but also the density of well has increased over the years, which is a common phenomenon in both the tanks.

3.2 Farm Ponds as an Adaptation Measure

With the ever increasing demand for and depletion of groundwater, there is a need for development of water harvesting structures. One of the important such structures found in the study area is construction of farm ponds. The water is stored in these farm ponds and the water is being used for two or three irrigations during the critical stages of crop growth. The construction of farm ponds is becoming popular among the farmers.

TABLE IV

DETAILS OF FARM PONDS IN THE STUDY AREA

Size (Meters)	Storage capacity (M^3)	Ownership	Uses of pond
Length: 40 Width : 30 Depth : 1 Cost of construction is Rs.50,000/pond	1,200	Private ownership i.e individual farmers	Pond is mainly used for water storage as a rainwater harvesting structure. The multiple uses include irrigation, groundwater recharge, livestock drinking, and domestic purposes

The farm ponds are generally constructed as part of the watershed development programmes. Only very few large farmers construct the farm ponds on their own. The farm pond is generally constructed with a size of 40 m X 30 m X 1m, so as to have a storage capacity of 1,200m^3 of water. The total cost of construction of this farm pond is worked out to be around Rs.50,000.

3.3 Who Owns Farm Ponds?

The average size of farm is 1.60 ha and 1.30 ha respectively for farmers owning farm ponds and farmers having no farm ponds. The cropping intensity and irrigation intensity are slightly higher among the farm pond farmers when compared to control farmers. The proportion of area irrigated to the total cropped area is low in both the cases, though it is little high for farm pond farmers.

TABLE V

GENERAL PARTICULARS OF THE SAMPLE RESPONDENTS

Particulars	With Farm Pond	Without farm pond
Average farm size (hectares)	1.60	1.30
Net sown area (hectares)	1.50	1.10
Gross cropped area (hectares)	1.70	1.10
Cropping intensity (%)	113.8	100.0
Net irrigated area (hectares)	0.70	0.40
Gross irrigated area (hectares)	0.80	0.40
Irrigation intensity (%)	114.3	100.0
Percentage of net sown area to total farm size	90.6	84.6
Proportion of irrigated area to total cropped area (%)	48.5	36.4

Source: *Farm Household Survey 2014-15.*

To what extent does a pond help crop diversification? The study findings suggest that there are no major differences in cropping patterns between the farms with and without farm pond (Table VI). Farmers mainly cultivate rice whenever they get water from tank. Rice is mainly grown. Rice occupies close to half of the area under crops in both types of farms. Cotton is the second largest crop, followed by chilies.

TABLE VI

CROPPING PATTERN

(Hectares)

Crops	With Farm Pond		Without farm Pond	
	Area	%	Area	%
Paddy	0.80	47.06	0.50	45.45
Cotton	0.60	35.29	0.45	40.91
Chillies	0.30	17.65	0.15	13.64
Total cropped area	1.70	100.00	1.10	100.00

Source: *Farm Household Survey 2014-15*.

Farmers in the tank command areas irrigate their crops from different sources viz., tank and wells. The well water forms one of the important supplemental irrigation in times of scarcity. Of the total fixed investments, the investment on wells accounts for 51.1 per cent for farmers owning farm ponds and 66.3 per cent for farmers without farm ponds. Growing water scarcity coupled with erratic rainfall compels the farmers to construct intermediate water storage structures. In the study area, under the watershed development programmes, few farmers have been given the intermediary storage structures i.e. farm ponds.

TABLE VII

INVESTMENT ON IRRIGATION STRUCTURE IN SAMPLE FARMS

(Rupees per hectare)

Particulars	With farm pond		Without farm pond	
	With well	Without well	With well	Without well
Investment on wells	6758.89 (51.10)	0.00	9476.67 (66.29)	..
Investment on electric motors	3122.78 (23.61)	0.00	4818.33 (33.71)	..
Farm ponds	3346.11 (25.30)	6148.00 (100.0)	0.00	..
Total	13227.78 (100.00)	6148.00 (100.00)	14295.00 (100.00)	..

Source*: Farm Household Survey 2014-15.*

These farm ponds help the farmers to store the rain water and irrigate when needed. The water is pumped from the ponds by using the portable diesel engine and then used for irrigation. As the farm ponds are very useful and save the crop from the critical stages of crop growth, it has become popular among the farmers. These structures account for 25 per cent of the total cost of investment.

Farmers irrigate crops from different sources such as tank, wells and ponds. Some of the pure rainfed farmers also irrigate the crops at critical stages by purchasing water from the well owners. On an average, farmers who own wells and farm ponds irrigate 51.8 irrigations for rice, 12.8 for cotton and 7.2 for chillies (Table VIII). Farmers who do not own wells irrigate crops from tank and pond water. Pond water is used at times of critical stages of crop growth. The pond water is mainly used for irrigating rice and chillies. The pure rainfed farmers irrigate chillies field during the period of water scarcity. In general, 3-4 irrigations are given for the crop to save it from water scarcity.

TABLE VIII

DETAILS OF IRRIGATIONS GIVEN TO DIFFERENT CROPS IN SAMPLE FARMS WITH FARM PONDS

(Number of irrigations)

Particulars	With Farm pond					
	With well			Without well		
	Rice	Cotton	Chillies	Rice	Cotton	Chillies
Tank	46.28	..	..	46.66	..	..
Wells	3.11	12.75	4.2	..	..	..
Purchased	..	..	..	..	..	..
Pond	2.42	..	3.0	3.10	..	4.10
Total no. of irrigations	51.81	12.75	7.2	49.76	..	4.10
Without Farm pond						
Tank	46.28	..	..	46.66	..	..
Wells	4.71	11.75	12.25	..	..	..
Purchased	..	..	..	..	..	..
Pond	..	..	..	..	..	..
Total no. of irrigations	50.99	11.75	12.25	46.66	..	..

Source: *Farm Household Survey 2014-15.*

The farmers who do not have sufficient water purchase water from the neighbouring farmers. They generally charge Rs.100/hour for irrigating the field. Thus, a farmer needs to irrigate his field for five hours, incurring Rs.500/ac per time. Farmers irrigating from farm ponds hire diesel engine. The customary hiring charge for diesel engine is Rs.120/hour. It needs 12.5 hours to irrigate the field of one hectare. Thus, the irrigation charge is Rs.1,500/ha/irrigation.

How does access to irrigation affect crop yields? Among the farms with farm pond, well owners have relatively higher yields in all crops **whe**n compared to non-well owners. The yield of rice is 4,388 kg/ha, which is higher than farms without farm ponds. Similarly, the yields of cotton (1,775 kg/ha) and chillies (1,680 kg/ha) are higher than the farms without farm ponds. The differences in crop yield are more pronounced in cotton (67.5 per cent), followed by chillies (12.7 per cent). However, the differences due to well irrigation are more among the farmers who do not have farm ponds. The differences due to access to well irrigation are 13.6 per cent for rice, 41.7 per cent for chillies and 61.2 per cent for cotton (Table IX).

TABLE IX
YIELD OF DIFFERENT CROPS IN SAMPLE FARMS WITH FARM PONDS

Crops	With farm pond							
	With well				Without well			
	Yield	GI	COC	NI	Yield	GI	COC	NI
Rice	4387.5	58501.8	35430.0	23071.8	4306.2	57474.1	32900.0	24574.1
Cotton	1775.0	66562.5	32800.0	33762.5	1060.0	39750.0	26000.0	13750.0
Chillies	1680.0	67200.0	27400.0	39800.0	1490.0	59600.0	26100.0	33500.0
Without Farm pond								
Rice	4062.5	54390.6	34430	19960.6	3575	48223.8	32850	15373.8
Cotton	1660.0	62250.0	32000.0	30250.0	1030.0	38625.0	25400.0	13225.0
Chillies	1630.0	65200.0	27540.0	37660.0	1150.0	46000.0	25500.0	20500.0

Source: *Farm Household Survey 2014-15*.
Note: *Yield: (Kg/ha;Gross income (GI) :Rs/ha;Cost of Cultivation (COC) :Rs/ha;Net income (NI) :Rs/ha*

Our interest here is to assess the impact, if any, due to the adoption of adaptation strategies. Thus, the comparison of the two important groups of farms with and without farm pond of non-well owners actually captures the beneficial impacts of farm pond as an adaptation strategy. Significant increase in yields of crops is observed between the two groups. Increase in yield is more pronounced in chillies (29.6 per cent), followed by rice (20.5 per cent). The farm pond water is mainly used for irrigating rice and chillies in times of water scarcity. The rice and chillies are grown as rainfed crop, and direct seeding is practiced. For rice, when tank water supply is stopped, the farmers have to rely on rainfall. During the scarcity period, farmers irrigate their crop from farm ponds. In general, 4-5 irrigations for rice and 3-4 irrigations for chillies are given, by using the pond water. The difference in yield is mainly due to increased irrigations from farm ponds.

In order to make a comparative analysis and assess the performance of farm ponds, partial budgeting has been done, comparing the returns and costs of cultivation of rice and chillies. The added returns due to the use of farm ponds from the two important crops are worked out to Rs. 22,200.30. Similarly, the added cost due to use of farm ponds is Rs.16,817.27.

This includes the amortisation cost on farm pond, additional labour cost, hiring of oil engines and increase in input costs. The net profit realised towards the construction and use of farm ponds is thus worked out to be Rs.5,383/ha/year. As the farm ponds stabilise the yield and income and help in reduction of managing the variability in rainfall, farm ponds may be constructed in the tank command areas. This will help the farmers in a big way from variability in rainfall.

TABLE X

PARTIAL BUDGET FOR WITH AND WITHOUT FARM POND IN FOR RICE AND CHILLIES CULTIVATION ((*Rs/ha)*

Credit (A)		Debit (B)	
Particulars	Amount (Rs)	Particulars	Amount (Rs)
Added returns		Reduced Returns	..
Increased income through increase in yield of crops	22200.3		
Total	22200.3		
REDUCED COSTS	..	ADDED COSTS	
		Pond cost (amortised cost)	4,827.3
		Additional labour cost for irrigation	2,700.0
		Hiring of diesel engine	8,640.0
		Increase in input costs	650.0
		Total	16,817.3
Net profit : 22,200.3–16,817.3= 5,383.0			

Source: *Farm Household Survey 2014-15.*

IV. CONCLUSIONS

Adaptation to climate variability will be cost effective if "mainstreamed" into the development processes. The study of impact of climate variability and its impact on tank irrigation management has brought out important observations that would help the policy makers to make appropriate investment options for sustainable management of irrigation tanks in the state of Tamil Nadu. The major conclusions and identified policy options are discussed here.

It is found that farm ponds play a crucial role in supplementing tank irrigation and **help** the farmers in achieving guaranteed yield. Thus, farm ponds as an intermediate water storage structure solve the problem of climate variability. Construction of farm ponds as an intermediate water storage structures may be promoted in a larger scale. The farm ponds are found to be very much effective, particularly when farms depend entirely on tank water. Thus **we can conclu**de that farm ponds are effective in mitigating the impact of climate variability in water scarce tank command regions.

There is a need for building capacity of the farming community. Also, there is a need for implementation of proper educational and training programmes for farmers, with emphasis on major issues--on the involvement of users of water on drought problems, floods, and on other extreme events. Also, adequate technical support in water management technologies and cultivation of crops, cropping pattern and crop allocation decisions will help them better cope with climate variability.

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