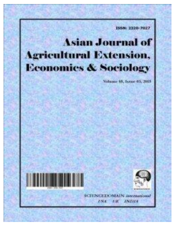

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An Economic Analysis of Technology Adoption Coupled With Conjunctive Use of Ground Water in Tank Command Area

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

This paper aims to evaluate the conjunctive use of surface and ground water, adoption of water management technologies and factors which influence the adoption of water management technologies in the tank command area since water scarcity problem is becoming major concern in most of the districts in Tamil Nadu. Dindigul district was purposively selected for the study since there are about 3,104 tanks and 30 per cent of area was irrigated by tank to total net area irrigated. Tank irrigation was also supplemented with well (open well) irrigation (i.e. conjunctive use of surface water and ground water was playing significant role). Simple random sampling technique was employed for selecting the sample farmers. Primary data was collected from 150 sample farmers and multinomial logit model was used for analysis. The result revealed that the yield was higher for farmers adopting water management technologies under conjunctive water use situation. . The adopters of water management technologies had realized increased productivity and thereby the returns in rice crop were comparatively high the farming experience, income from off and non-farm activities and contact with extension agents were found to have positive and significant influence on adoption of technology. The farm size of the farmers had negative effect on adoption of technology.

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Keywords: Water scarcity; conjunctive use; water management; tank irrigation.

1. INTRODUCTION

Water is the precursor of the entire life on the globe in particular the human kind. It is the solitary natural resource to lay a hand on all aspects of human civilization from agricultural and industrial development to cultural and holy values.

1.1 Water Scenario: A Macro View

Of the 1.4 billion cubic kilometers of water on Earth, 35 million or about 2.5 per cent of the total volume is fresh water, only about 0.3 percent of this freshwater is easily available for humans for direct use, rest is frozen or underground. Globally, the per capita water availability is estimated as15, 000 cubic meters of freshwater per annum [1].

Water crisis is becoming one of the most extended, serious ecological devastation of the earth, which lead to supplying adequate quantity of water to the global population an important task. Water scarcity is at the peak in wake of growing population coupled with sustainable development, industrialization and increasing domestic needs. The threats of climate change and global warming have also aggravated the problem of water shortage.

The world population is predicted to grow from 7.6 billion in 2018 to 8.5 billion in 2030 and 10 billion in 2050. Due to increase in population, food demand is also predicted to increase by 60 per cent in 2030 and 90 per cent by 2050 from the current [2], Since agricultural sector is the largest user of water resources, accounting roughly 70 of all freshwater withdrawals globally, doubling the food production in the next 40 years will still increase consumption of global water by approximately 90 per cent [3]. Water use has been growing at more than the rate twice of population increase this automatically leads to overexploitation of groundwater resources.

In a country like India where there is significant disparity of distribution of available water with the population, the situation becomes alarming. While, as per the international norms, with per capita available water of 1545 m3 India is definitely water stressed country [4,5]. India's total annual utilizable water resources are 1123 bcm (690 bcm surface water + 433bcm ground water). Being an agrarian country, irrigation by far is the largest user of India’s water reserve with hooping usage of 78% of total water reserve, followed by domestic sector (6%) and industrial sector (5%) [6]. Ground water is an important source for irrigation as well as for domestic and industrial usage [7].

1.2 Tamil Nadu Scenario of Water

Tamil Nadu accounts for about four per cent of the land area and 6 percent of the population, but only three per cent of the water resources of the country .The per capita water availability in Tamil Nadu is about 750 m^3. There are about 81 reservoirs, 41,127 tanks and 18.21 lakh wells in the state. The average annual rainfall of the state is 945 mm, the surface water availability is about 853 Thousand Million Cubic feet (TMC) and ground water availability is 734 TMC [8].

Water is becoming one of the scarce commodities in Tamil Nadu due to several factors which include prolonged dry spell, deficit rainfall during South-West Monsoon, disputes between the neighboring states over the allocation of inter-state water, dramatic reductions in groundwater tables, reduction in the storage capacity of the tank system, and industrial pollution. The threats of water scarcity also produce adverse effect on cropped area and area under irrigation.

The major irrigation sources of the state are canals, tanks and wells. Tamil Nadu which accounts for 5.8 per cent of population of the country is endowed with only 2.04 per cent of water resources of India [9].

Among the sources of irrigation, Tank is the only source, where the irrigated area has been declining continuously since early seventies. Further, among the States in India, the area under tank irrigation has declined more drastically in those states where tank irrigated area accounts for relatively a larger share in the net irrigated area.

Well irrigation has dominated the tank irrigation in several cases where the increase in the number of wells in the tank command had been signaling the inactiveness of the tank systems for providing reliable water supply. In fact it had been found that a large number of tanks have become defunct in less tank intensive districts (i.e.,76 per cent of Panchayat Union (PU) tanks and 64 per cent of Public Works Department (PWD) tanks have become defunct) compared to tank intensive regions, where the per cent age of defunct tanks is less [10].

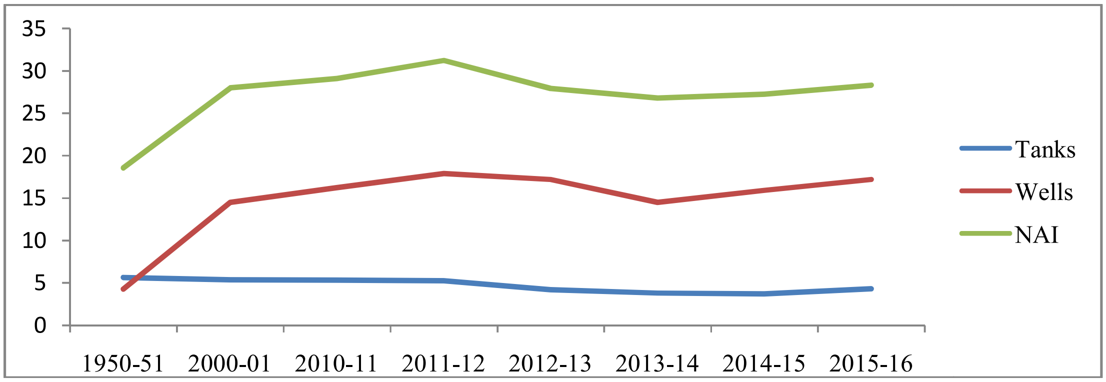

Fig. 1. Trends in net area irrigated in Tamil Nadu (Lakh Ha)
Source: Season and crop report (Various edition)

Due to emergence of wells in the tank command area, the farmers have switched over to well irrigation due to its quality irrigation by providing more yield and more crop. Hence, the traditional irrigation systems (tanks) have disintegrated. Materialization of wells in the tank ayacut has led to the decline of interest in the tank management among farmers who own wells. Realizing the importance of tank irrigation, it is important to improve the performance of the tanks and should increase the tank irrigation potential. This is possible by planned and coordinated management of surface and groundwater coupled with increased adoption of water management technologies like SRI, direct seeding, alternate wet and dry, micro irrigation.

Thus, an attempt has been made in the present study to examine in detail the conjunctive use of water, adoption of water management technologies and factors which influence the adoption of water management technologies in the tank command, in the tank command area.

2. MATERIALS AND METHODS

The study was conducted in Dindigul district of Tamil Nadu. Dindigul district was purposively selected for the study since there are about 3,104 tanks and 30 per cent of area was irrigated by tank to total net area irrigated. Tank irrigation was also supplemented with well (open well) irrigation (i.e. conjunctive use of surface water and ground water was playing significant role). In the next stage, Vaiyapuri tank from Palani block was purposively selected since it has the largest tank command area for paddy cultivation supplemented with well irrigation and sample farmers were selected employing random sampling procedure. Thus a total of 150 farmers were studied.

Simple mean comparison was used to compare general characteristics and key variables among different categories of farmers.

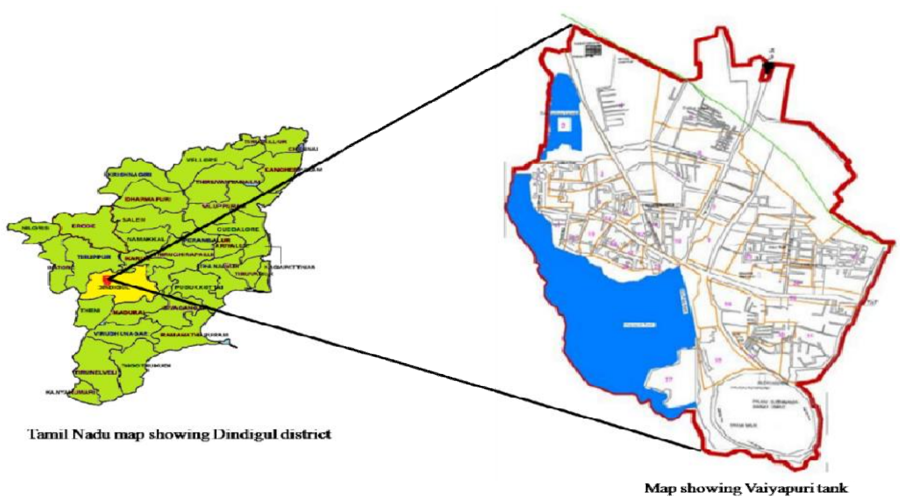

Table 1. Variables hypothesized to affect adaptation decisions by farmers in the study area

Variable label	Description and measurement	Expected sign
Tecadopt	Dependent variable (SRI=1,direct sowing=2,alternate wet and dry=3,conventional =0)	
Education	Educational level of the head of the household in years	+
Well	Well ownership (1=with well; 0=Otherwise)	+
Experience	Experience of the farmer in years	+
Income	Income from off and non-farm activities (Rs/yr)	+
Family labour	Number of member in the family as agricultural labour	+
Farm size	Farm size in hectares	+/-
Extension	Contact with the extension personnel, (dummy, 1 if contact with extension personnel; 0, otherwise)	+

The multinomial logit model is a simple extension of the binomial logit regression model. The multinomial logit model has been the most commonly used model for analysis of discrete choice data [11]. In the present study, different types of water management technology was taken into consideration like SRI method, Alternate wet and dry method, Direct sowing method and finally conventional method so logit model will not be usual method. Multinomial logistic regression involves nominal response variables with more than two categories. Response variable with k categories that generate k-1 which is a multinomial logistic regression comparing a group with the reference group, hence multinomial logit was used to analyze factors influencing farmers from adopting various technologies.

The empirical model used in the study is

$$TADOPTION = \beta_0 + \beta_1 EDUCATION + \beta_2 WELLS + \beta_3 EXPERIENCE + \beta_4 INCOME + \beta_5 FLABOUR + \beta_6 FSIZE + \beta_7 EXTENSION \quad (1)$$

3. RESULTS AND DISCUSSION

As mentioned earlier, structured questionnaire was designed to collect the necessary data of this study. This section presents the descriptive statistics that was collected from the 150 farmers through interview.

3.1 General Characteristics

The general characteristics of the sample farm households were analyzed. Here our aim was to observe significant changes among different group of farmers. For the purpose, the farmers with well and without well along with technology adoption was compared and presented in the Table 2.

3.2 Technology Adoption Percentage

Farmers in the tank command adopt various water management technologies. They adopt one or more number of technologies. In our study area, farmers adopt mainly three technologies viz., SRI, direct sowing and alternate wet and dry method, which are observed to be mutually exclusive.

From the Table 3 it is evident that among the farmers with well 45.10 per cent of the farmers adopt SRI technology, 31.37 per cent of them adopt direct sowing method and 23.53 per cent of them adopt alternate wet and dry method. Similarly, among the farmers without well, about 29.03 per cent farmers adopt SRI technology, 45.16 per cent adopter direct sowing method and 25.81 per cent adopt alternate wet and dry method.

3.3 Factors Affecting Technology Adoption

The chi-square value of 310.95 showed that likelihood ratio statistics are highly significant ($p<0.0001$) suggesting the model has a strong explanatory power. Thus, the multinomial logit analysis results revealed that the decision of technology adoption is influenced by different factors and at different levels of significance by the same factor.

Number of wells had significant effect on the SRI and direct sowing technology at 1 per cent level and has no significant effect on alternate wet and dry technology. With increase in one well by a farmer SRI technology adoption increase by 7.75 per cent and direct sowing adoption increase with 6.35 per cent.

Table 2. General characteristics of the farm households

Particulars	Farmers with well		Farmers without well	
	Adopters	Non –adopters	Adopters	Non –adopters
Number of farm household (numbers)	51	23	31	45
Number of workers in household (numbers)	1.12*	1.09	1.09**	1.13
Average Educational level	4.18**	4.22	3.48**	2.64
Farming experience	15.51**	14.87	16.55*	18.42
Income(Rs. Lakhs/year/household)	2.82**	2.02	1.75*	1.64
Gross cropped area(hectares)	2.70*	2.36	1.93**	1.06
Number of irrigation given from tank	22.56	25.04	38.35	43.23
Number of irrigation from well	14.48	17.35	..	..
Total number of irrigation	37.04	42.39	38.35	43.23
Water used (m3/ha)	9729.05*	11923.08	10263*	12323.08
Yield (Kg/ha)	6900**	5928	6500*	5000
Yield (Kg/m^3 of water)	0.71*	0.50	0.63*	0.41

Source: Primary household survey (2016-17)

Table 3. Technology adoption percentage among sample farmers (In Number)

Particulars	With well		Without well		Total
	Adopters	Non –adopters	Adopters	Non-adopters	
SRI Technology	23 (45.10)	0 (0.00)	9 (29.03)	0 (0.00)	32
Direct sowing method	16 (31.37)	0 (0.00)	14 (45.16)	0 (0.00)	30
Alternate wet and dry	12 (23.53)	0 (0.00)	8 (25.81)	0 (0.00)	20
Conventional method	0 (0.00)	23 (100.00)	0 (0.00)	45 (100.00)	68
Total farmers	51 (100.00)	23 (100.00)	31 (100.00)	45 (100.00)	150

Source: Primary household survey (2016-17); Note: Figures in parentheses indicate per cent to total

Table 4. Factors affecting technology adoption

Particular	SRI	Direct sowing	Alternate wet and dry
	Coefficients	Coefficients	Coefficients
Constant	-295.40 (129.11)	-79.66 (9.162)	-177.52 (43.61)
Education	2.25*** (0.690)	2.223*** (0.425)	0.477* (0.386)
Well	7.734** (1.659)	6.351*** (1.38)	6.79 (1.12)
Experience	1.305*** (0.169)	1.073*** (0.151)	1.054*** (0.147)
Income	0.0021** (0.001)	0.0017*** (3.60e-05)	0.0016* (0.0010)
F Labour	5.742*** (1.724)	2.422*** (0.149)	4.155** (0.601)
Fsize	-1.580** (0.426)	0.548 (0.338)	-1.388* (0.423)
Extension	1.95** (0.85)	1.49*** (0.51)	1.09* (0.51)
STDEV	1.149		
Log-livelihood	-38.97		
Chi square	310.95***		

Source: Primary household survey (2016-2017); Note: Figures in parentheses indicates the t-ratio;
***** Significant at 1% per cent level; ** significant at 5% per cent level; * significant at 10% per cent level.**

The results show that education level of the household head significantly influences the likelihood of choosing the water management technologies at 5 per cent to adopt SRI and direct sowing technology. In addition, education influences the chances of choosing alternate wet and dry method [12] also observed a positive relationship between education and the adoption. With one year increase in education level SRI adoption increase by 2.25 per cent ,Direct sowing increase by 2.23 per cent and Alternate wet and dry technology adoption increase by 0.47 per cent respectively.

Similarly Farming experience is found to significantly influencing the adoption of technologies when compared to conventional method of cultivation on the expected positive lines this result was similar with [13], that older farmers are more experienced and might have accumulated greater physical and social capital. With one year increase in farming experience SRI, Direct sowing and Alternate wet and dry water management technology adoption increase by 1.03 per cent, 1.02 per cent and 1.05 per cent respectively.

Income from off-farm and non-farm income is found to be significantly and positively influencing the adoption of various water management technologies, study by Noltze et al. [14] have also indicated that there is a positive relationship between the intensity of use of various technologies and the income earned. Thus, increasing the income generation activities in the rural areas will pave way for increased adoption of modern technologies.

Labour seems to be more concern in the decision to adoption of water management technology, specifically the probability of adopting technology depends upon the number of household members who actively provide farm labour. Thus the labour found to be significantly influencing technology adoption in the positive lines this result was in line with Langyintuo and Mungoma [13], Noltze et al. [14] with respect to family labour with one member increase in family labour technology adoption of various technologies increased by an average of 2 to 5 per cent respectively.

The choice of adoption was significantly influenced by the size of the farm. An increase in the farm size decreased the probability of adopting technology. The small land holding hinders the usage of technology compared to large holding. Regarding farm size with increase in one hectare technology adoption decreased by average of 0.5 per to 1.5 per cent respectively.

Agricultural extension services are the major sources of information for improved agricultural technologies. One means of which, farmers' access information about improved technologies is by contacting the extension agent [15] the results show that contact with an extension agent, impacted adoption of all technology choices positively. In concern with Agricultural extension services with one per cent increase in access to information water management technology adoption increased by approximately one to two percent correspondingly.

4. CONCLUSION

By means of planned and coordinated management of surface and groundwater coupled with increased adoption of water management technologies like SRI, direct sowing, alternate wet and dry Method farmers have increased their yield, income and water use efficiency.

It was also found that the farming experience, income from off and non-farm activities and contact with extension agents were found to have positive and significant influence on adoption of technology. The farm size of the farmers had negative effect on adoption of technology.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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