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An Economic Analysis of Paddy Cultivation in Fluoride affected regions in Tamil Nadu

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ABSTRACT
Groundwater is a prime source of water for agricultural and industrial uses in several regions around the globe. Scarcity of water prevailes all over the world, so ground water remains the sole choice to supplement the ever-increasing demand for water. Continuous decline of groundwater due to over abstraction of water leads to decline in groundwater quality as well as contamination in groundwater such as fluoride, arsenic and chloride. Fluoride is 13th element in the earth curst and critical ions that influence ground water quality. Fluoride contamination in groundwater is affected all over the countries. India is one among the countries and nearly 65 million peoples were affected by dental fluorosis as well as in Tamil Nadu, 23 districts were affected out 33 districts. The effect of fluoride contaminated groundwater on agriculture crop. Paddy is major crop cultivated by the farmers in the study area. The paper aims to estimate the cost and returns of paddy crop in fluoride contaminated area and to identify the constraint expressed by the farmers in fluoride affected locale. A multi-stage sampling method involving a combination of purposive and random sampling procedures was employed in drawing up the samples for collecting primary data. The results showed that cost of cultivation of paddy was high in fluoride affected locale compared to non affected locale and yield was high in non affected locale. In the response priority index method decline in groundwater was given utmost priority by the farmers.

Keywords: *Groundwater, scarcity, fluoride contamination and paddy.*
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INTRODUCTION

Groundwater is a prime source of water for human intake similarly for agricultural and industrial uses in several regions around the globe [12,11]. Because of inadequate availableness of surface water, groundwater contributes more to the necessity of human activities. Groundwater remains the sole choice to supplement the ever-increasing demand for water. The demand for quality water for irrigation of crops is ever increasing, whereas the availability of water remains comparatively constant in most parts of the world. Continuous depletion of groundwater increases global threats, including a sudden decline in agriculture [1, 20]. This leads to contamination in groundwater such as fluoride discharge in water. Fluoride is one of the critical ions that influence groundwater quality. Anthropogenic interventions such as overuse of phosphatic fertilizers in a farmers field, brick manufacturing industries, over deepening of well are lead to the release of fluoride in ground water as well as the environment [14,13]. The occurrence of the high fluoride concentrations in ground water is a problem faced by many countries, notably India, Srilanka and China, the rift valley countries in East Africa, Turkey and parts of South Africa [2]. In India, 65 million people are at risk of dental fluorosis and skeletal fluorosis. In India, many states are endemic fluorosis viz., Andhra Pradesh, Tamil Nadu, Karnataka, Gujarat, Rajasthan, Punjab, Haryana, Bihar and Kerala. These states have remarkable cases of dental fluorosis.Groundwater management includes consideration of optimum

pumping rates, especially where there exists the possibility of mixing of groundwater with deep fluoride rich groundwater (e.g., old groundwater or hydrothermal solutions), which would be increasingly drawn upward at high pumping rates [5]. According to [17], a study carried out in Bagepalli taluk revealed that one of the important on-farm effects of poor quality groundwater irrigation is declining yield of crops. The yield of chilly declined by 46.80 per cent in high fluoride affected area and in the case of low fluoride affected area chilly yield was declined by 35.90 per cent and also the cost of cultivation of major crops is more in high fluoride affected area than low fluoride affected area. The effect of fluoride on human health, intake of fluoride contaminated water leads to dental and skeletal fluorosis. The long-term impacts of ill health include loss of farming knowledge, reduction of land under cultivation, planting of less labour-intensive crops, reduction of a variety of crops planted and reduction of livestock [17].

In Tamil Nadu, The per capita water availability is about 900 m^3. The average annual rainfall of the state is 960 mm, the surface water availability is about 853 Thousand Million Cubic feet (TMC) and ground water availability is 734 TMC [7]. In India, Per cent of wells with water below ten years average (2007-16) shows Tamil Nadu ranks first with having 87 per cent of dug wells [10]. In Tamil Nadu, 23 out of 33 district were affected by fluoride contamination in water. Salem, Erode, Dharmapuri, Coimbatore, Thiruchirapalli, Dindugal, Theni, Perambalur, Vellore, Madurai, Virudhunagar and Krishnagiri are having fluoride contamination and people risk with dental and skeletal fluorosis [7]. Though there are several empirical studies on agricultural related to soil degradation, wind and water erosion, there are only few studies have dealt with problems in the agricultural sector caused by fluoride contamination in Ground water. With this background the paper aims to (i) estimate the cost and returns of paddy crop in fluoride contaminated area (ii) identify the constraint expressed by the fluoride affected farmers.

MATERIAL AND METHODS

Study area and data

Multistage random sampling method was used for the selection of study area. At first stage, District wise fluoride affected area of Tamil Nadu with the permissible limit of above 1.5 mg/L collected from [7]. In next stage, district has been segregates into different agroclimatic zones based on fluoride content and finally, western zone was selected. At third stage, two blocks from each of the districts, then three villages of each block were selected based on secondary data. For determining the sample size methodology prescribed by [4] and lastly, 248 samples was selected for the study. List of progressive farmers were collected from agriculture department and randomly selected then selected farmers were interviewed through pre tested schedule.

Tools of Analysis

Cost and Return Analysis

The cost is classified into two variable costs and fixed costs. Variable costs such as, labour cost, fertilizer cost, plant protection cost, and irrigation cost; and fixed cost items viz., rental value land, land revenue, and interest and depreciation on farm buildings and implements were worked out as per the methodology defined by [9] in order to analyze the cost and return of rice production.

Responses-Priority Index (RPI)

In thequantification of constraints expressed by the farmers using fluoride contaminated water in agriculture,there was a problem, whether emphasis should be givenfor the number of responses to a particular priority orto the highest number of responses to a constraint inthe first priority. To resolve this, a Responses-Priority Index(RPI) was constructed as a product of Proportion ofResponses (PR) and Priority Estimate (PE), where PRfor the i^{th} constraint gives the ratio of number ofresponses for a particular constraints to the total responses as per equation [16]:

$$(\mathbf{RPI})_i = \frac{\sum_{j=1}^{k} f_{ij} X_{[(k+1)-j]}}{\sum_{i=1}^{1} \sum_{j=1}^{k} f_{ij}} \qquad 0 \leq RPI \geq 5$$

Where,

RPI_i = Response Priority Index for i^{th} constraint

f_{ij} = Number of responses for the j^{th} priority of the i^{th} constraint (i=1, 2……, l; j= 1,2,3…..k)

$\sum_{j=1}^{k} f_{ij}$= Total number of responses for the i^{th} constraint

k = Number of priorities (1. Strongly agree; 2. Agree; 3. Moderate; 4. Disagree; 5. Strongly disagree)

$X_{[(k+1)-j]}$= Scores for the j^{th} priority

$\sum_{i=1}^{1}\sum_{j=1}^{k} f_{ij}$= Total number of responses to all constraints

Here, larger the RPI, higher was the importance for that constraint. In the present study, the following five constraints are identified (1. Increased soil salinity; 2. Decline in groun water, 3. Contamination of groundwater; 4. Reduced water quality; 5. Occurrence of human health diseases and 6. Occurrence of animal illness).

RESULTS AND DISCUSSION

Cost and returns of paddy crop raised by the sample respondents

The per hectare cost and return of paddy raised by the sample respondents is given in Table.1. The total cost was higher in less fluoride affected locale (Rs. 66433.10) as compared to non affected locale (Rs. 66367.80). Among the variable cost, human labour charges accounts more followed by machine labour, fertilizers and manures. [19, 8, 18 & 15] also stated that human labour charge has the highest share in paddy cultivation. Yield of paddy was higher for non affected locale (4842 kg/ha) when compared to less fluoride affected locale (4600 kg/ha). A high per hectare net income was realized by sample farmers in non affected locale (Rs. 35467.80) as compared to farmers in less fluoride affected locale (Rs.26336.90). In moderately fluoride affected locale, the total cost was higher (Rs. 67454.30) as compared to non affected locale (Rs. 66367.80). The share of human labour was highest in the total cost accounted for 27.36 per cent for moderately affected locale followed by machine and animal labour cost which accounted for 18.75 per cent for fluoride affected locale and 20.88 per cent for non affected locale. Yield of paddy was higher for non affected locale (4842 kg/ha) when compared to moderately fluoride affected locale (4283 kg/ha). The net income realized by sample farmers in non affected locale (Rs. 35467.80) was higher as compared to farmers in moderately fluoride affected locale (Rs.23960.50). Similarly in the highly fluoride affected locale on an average, total cost was higher in fluoride affected locale (Rs.67582) as compared to non affected locale (Rs.66367.80).

Table 1. Cost and returns of paddy crop raised by the sample respondents

S.No.	Particulars	Farm categories			
		Less affected	Moderately affected	Highly affected	Non affected
1.	**Operational cost**				
	Human labour	17850	18453	18845	17350
	Machine labour	13520	12645	12435	13856
	Seed	2200	2450	2526	1957
	Fertilizer & manures	12506	12960	13417	11954
	Plant protection charges	900	900	910	950
	Irrigation charges	650	650	720	600
	Interest on working capital @7%	3326.82	3364.06	3412.71	3266.69
	Total operational cost	**50852.8**	**51422.1**	**52165.7**	**49933.7**
2.	**Fixed cost**				
	Rental value of own land	8000	8400	7800	8900
	Depreciation on farm buildings	1450	1500	1400	1500
	Total fixed cost	**9450**	**9900**	**9000**	**10400**
	Subtotal (1+2)	**60302.8**	**61322.1**	**61165.7**	**60333.7**
	Managerial cost @10%	6030.28	6132.21	6116.57	6033.37
3.	**Total cost**	**66433.10**	**67454.3**	**67282.3**	**66367.1**
4.	Yield (kg/ha)	4600	4283	3987	4842
5.	Cost of production (Rs/kg)	17.10	18.25	18	18.45
6.	Total revenue	92770	91414.8	85866	101835
7.	**Net income**	**26436.9**	**23960.5**	**18283.7**	**35467.8**
8.	**Benefit and cost ratio**	**1.39**	**1.35**	**1.27**	**1.53**

***Source**: Primary household survey (2017-18)* ***Note**: Figures in parentheses indicate per cent to total*

Of the total cost, variable cost incurred was more in both fluoride affected and non affected locale indicating higher input use in affected area to offset the adverse effect of water pollution. Yield of paddy was higher for non affected locale (4842 kg/ha) when compared to highly fluoride affected locale (3987 kg/ha). Difference in yield of paddy is higher in highly fluoride affected locale (855 kg/ha) when compared to other fluoride affected locale. A high per hectare net income was realized by sample farmers in non affected locale (Rs. 35467.80) as compared to farmers in highly fluoride affected locale (Rs.18283.70). Benefit cost ratio was more in non affected locale (1.53) when compared to highly fluoride affected locale (1.27). Similar results of reduction in paddy yield due to fluoride toxicity were reported in the study conducted by [21, 3].

Table 2. Constraints faced by the Sample Farmers on fluoride contaminated water use in Agriculture

S. No	Constraints	Number in respective priorities					Total	RPI	Rank
		I	II	III	IV	V			
1	Soil salinity increased	56	68	50	8	4	186	0.43	VI
2	Decline in Ground water	80	61	28	12	5	186	0.86	I
3	Contamination of Groundwater	56	74	24	27	5	186	0.80	II
4	Reduced Water quality	54	60	48	15	9	186	0.78	III
5	Occurrence of human health diseases	50	45	56	20	15	186	0.67	IV
6	Occurrence of Animal health illness	12	8	64	79	23	186	0.62	V
	Total						1116		

Note: I. Strongly agree; II. Agree; III. Moderate; IV. Disagree; V. Strongly disagree
RPI – Response Priority Index

Constraint faced by the sample farmers on fluoride contaminated water use in agriculture. The response priority index indicated that the decline in groundwater was given utmost priority by the farmers and ranked it first with a mean score of 0.86. Second priority given by the farmers was contamination of groundwater with a mean score of (0.80) followed by reduced water quality (0.78), occurrence of human heath diseases like dental fluorosis and skin rashes (0.67), Occurrence of animal health illness (0.62) and increased in the soil salinity (0.43) respectively. This indicates, overall, the need for either reducing these parameters or taking alternative options including crop choices, irrigation methods and input use particularly organic manures.

CONCLUSION

In the study area, cost was higher in the fluoride affected locales as compared to non affected locale because of additional costs on higher inputs, fertilizers, manures and water pollution, *etc.,* Similarly net returns were higher in the non fluoride affected locale as compared to fluoride affected locale which is due to good crop stand and higher yield. In non fluoride affected locale, the total cost incurred by the respondents was Rs. 66367.10 and net return was Rs. 35467.80 and in the less fluoride locale, the total cost was Rs. 66433.10 and net return was Rs. 26436.90 Similarly in the moderately fluoride affected locale, total cost and net return were Rs. 67454.30 and Rs. 23960.50 respectively. In highly fluoride affected locale, total cost was Rs. 67282.30 and total return was Rs. 18283.70 respectively. Comparing to less and moderately fluoride affected locale, highly fluoride affected locale total cost of cultivation was high and net return was low. Difference in yield of paddy is higher in highly fluoride affected locale (855 kg/ha) when compared to other fluoride affected locale. In the response priority index method decline in groundwater was given utmost priority by the farmers. The water used for irrigation is drawn from higher depths which is contaminated by fluoride, so government should give awareness and encourage the fluoride contamination averting measures that will improve the water table, i.e. measures like effective rain water harvesting and ground water recharge.

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