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Farmers' Willingness to Pay to Avert the Negative Externalities of Pollution of Dyeing Industry in Tamil Nadu[§]

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Abstract

Effluents discharged by several industries, particularly the textile dyeing industry, have led to severe pollution of surface and groundwater sources and soils, which have ultimately affected the livelihood of the poor. Environmental problems in the agricultural sector caused by dyeing industrial pollution in Karur district have been discussed in this study. Averting Expenditure Approach and Contingent Valuation technique have been employed for this purpose. The farm income and distance between farm and polluted river have been found significant in deciding the value of polluted lands. The pollution averting expenditure incurred by the farmers increases with increase in the intensity of pollution. It is mainly the farm income that determines the pollution averting expenditure. The farmers in the study area are well aware about the detrimental effects of pollution and they have expressed their willingness to pay for internalizing the pollution effects even though it is mainly the duty of the polluters.

Introduction

In recent times environmental problems due to rapid industrialization are very common in areas where the polluting industries, viz. textile dyeing, leather tanning, pulp and paper processing and sugar manufacturing are located. The effluents discharged by these industries have led to severe pollution of surface and groundwater sources and soils, which has ultimately affected the livelihood of the poor. Agricultural practices with uncontrolled and extensive use of agrochemicals and fertilizers, urbanization and industrialization resulting in the release of untreated industrial effluents, dumping of domestic wastes and flow of sewage effluents into waterways lead to water pollution.

The Environmental Sustainability Index (ESI) ranks countries on 21 elements of environmental sustainability covering natural resource endowments, past and present pollution levels, environmental management efforts, contributions to protection of the global commons, and a society's capacity to improve its environmental performance over time (Esty *et al.*, 2005). India occupies the 101th rank in this index. Generally, a high-middle ranking reflects top-tier performance on issues such as water quality, environmental protection capacity, etc. India comes under bottom-rung results on issues such as waste generation and greenhouse gas emissions (Appendix 1). India has comparative advantage in certain export industries, such as cotton, textiles, leather, etc. due to larger availability of raw materials and cheap labour. These agro-based industries cause various forms of pollution, which contaminate the surrounding air, water and land. Often they turn out to be 'water consuming' industries since they require large quantities of water for processing. These industries discharge the untreated or partially treated effluents on land or water bodies, which end up in polluting the environment.

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The effluents released by many industries like paper industry, dyeing industry, leather industry, tannery industry, and food-processing industry cause adverse effect on soil properties, and seed germination and also cause reduction in the growth of seedlings. The negative externalities of industries have led to loss in crop area, production, changes in cropping pattern, health problems, and socio-economic imbalance in these regions. The pollution from dyeing industry is causing labour migration, unemployment, change in employment pattern, decrease in share of farm income in total household income, etc. Though there are several empirical studies on agriculture-related environmental problems, such as soil degradation, wind erosion and water erosion, only a few studies have dealt environmental problems in the agricultural sector caused by the pollution of dyeing industry.

In Tamil Nadu, two major districts that have dyeing industries are: Coimbatore and Karur. Out of these two districts, not many studies have dealt with the pollution of dyeing industry in the Karur district. There are 502 dyeing and bleaching units located in and around Karur town. The effluents generated from these dyeing units are discharged without any treatment into the Amaravathi river, which is the main source of water for drinking, and agricultural purpose. Thus, the river is highly polluted and water is not suitable for agricultural and household purposes. Hence, the present study was undertaken to analyse the impact of pollution due to effluents of dyeing industries on crop yield, cultivated area, labour migration, income pattern and health problems of the farmers residing in the areas where dyeing industries are located in the Karur district.

Methodology

The study was carried out in Karur and Aravakurichi taluks of the Karur district of Tamil Nadu since these two taluks have larger proportions of highly affected, moderately affected and less affected areas across the four taluks of the district. The intensity of negative externality of polluting effluents from these factories is directly related to the distance of the farm from the factory site. Six villages, two each from the above three categories of area, were selected from the affected areas based on the loss of ecology based on the classification recommended by Centre for Environmental Studies, Anna University, Chennai.

Taking into consideration the statistical requirement, time and other facilities at the disposal and the sample size required to minimize the sampling error, 50 farm holdings were selected randomly from each of the two villages from the three area categories, making the total sample size of 150 farms.

The following statistical tools were employed for the analysis:

(1) Pollution averting expenditure approach, and

(2) Contingent valuation technique

Pollution Averting Expenditure for Land

The averting expenditure approach is based on the fact that in some cases, purchased inputs can be used to mitigate the effects of pollution. The present study estimated the costs on additional inputs such as seed material, fertilizers, soil amendments like gypsum and

Criteria for Classification of Study Area

Class	Criteria		Impact description	Classification
	TDS (mg/L)	EC (mS/cm)		
I	<1000	<1500	No detrimental effect on agriculture and acceptable as drinking water source.	Unaffected
II	1000-2100	1500-3000	Cause for rejection as source of drinking water at TDS above 1500 mg/litre and may have adverse effects on many crops.	Less affected
III	2100-3500	3000-5250	Unfit for drinking and adverse effect on many crops.	Moderately affected
IV	3500-4900	5250-7500	Unfit for drinking, salt tolerant species may survive on permeable soils with careful management practices.	Highly affected
V	>4900	>7500	Unfit for drinking as well as for cultivation of most of the crops.	-

Source: Report on Loss of Ecology (2003) Centre for Environmental Studies, Anna University, Chennai.

manure used by farmers. The results of the scatter diagram advocated a linear model.

The pollution averting expenditure model applied in the present study was of the form of Equation (1):

$$PAE = a_0 + a_1\,FI + a_2\,DFPR + a_3\,SCLFL \qquad \ldots(1)$$

where,

PAE = Pollution averting expenditure (Rs/ha),

FI = Farm income (Rs/year),

DFPR = Distance between farm and polluted river (km),

SCLFL = Share of cropland to total farmland (%),

a_0 = Regression constant, and

a_1 to a_3 = Regression coefficients.

Contingent Valuation Technique

It is the valuation of contingent and related welfare effects of environmental degradation. It involves a resource by putting a monetary value on the response of the people affected by the change in the state of the resource. Contingent valuation method is based on the interviewing of WTP (Willingness to Pay) by the demanders, who reveal their preferences based on their income and other considerations. Contingent valuation method is applied essentially through asking the people what is there WTP for the benefit.

Willingness to pay may not necessarily mean the actual price, which an individual (or a society with some special characteristics) will be willing to pay at the current rate of its purchase. It all depends upon the shape of the demand curve (or the preferences). The amount of money income BC (i.e., willing to give up an income from M_0 to M_1) which an individual is willing to pay in order to enjoy E_0 to E_1 of an environmental good or facility, but staying at the earlier preference curve $U_{0,}$ is the estimate of minimum marginal willingness to pay for a marginal environmental gain. It is the Hicksian compensated consumer surplus (Hanemann, 1991; Shogren *et al*., 1994).

Contingent valuation is well suited for the estimation of a change in the status of environment. The theoretical basis is that an individual seeks to maximize a utility function, or equivalently minimize an expenditure function subject to a utility constraint, that includes a vector of services dependent on the environmental status. Representing the level of these services as elements, g_i, in the vector of G, the individual's maximum WTP, *W,* for a project that enhances environmental status is the total value derived from the benefits of changes in distinct services (Δg_i), each such benefit constituting a motive for WTP. For the unpriced environmental services, the WTP for a project that improves services from G_0 to G_1 is given in terms of the expenditure function (2):

$$W = e\,(G_0, P, U_0) - e\,(G_1, P, U_0) \qquad \ldots(2)$$

where, U_0 is the initial utility level and P is the vector of prices of goods in the private consumption bundle (Cooper, 2004).

Regression model in which the dependent variable or regressand evokes 'Yes' or 'No' or 'Present' or 'Absent' response are known as dichotomous or dummy dependent variable regression models. Among the methods that are used to estimate such models, four methods considered are: LPM (Linear Probability Model), Logit, Probit and Tobit regression. If the dependent variable takes two values, i.e. zero or one, then we can use either Logit or Probit regression. But, in the Tobit model the dependent variable also takes two values, i.e. zero and some value which is greater than zero. In the Tobit model, we can measure both intensity and amount spent to tackle externalities. The 'Tobit model' or 'Hybrid Tobit' described by Tobin is of the following form.

$WTP = X_i$

$b + e_i = 0 \qquad \text{if } X_i b + e_i > 0$

The dependent variable WTP for good quality of water has a normal distribution with mean μ and variance σ^2. For the respondents considered, those values of WTP that were greater than constant zero, were recorded, and otherwise the value zero was recorded. The Tobit model was specified, where b was the k*1 vector of unknown parameters, x_i was a k*1 vector normally distributed with mean zero and common variance σ^2.

$$WTP = a_0 + a_1\,AGE + a_2\,FZ + a_3\,FI + a_4\,DWR + a_5\,DWQI + a_6\,IPR \qquad \ldots(3)$$

where,

WTP = Willingness to pay (Rs/100 litres)

AGE = Age (years)

FZ = Family size (No.)

FI = Farm income (Rs/year)

DWR = Drinking water requirement (liters/yr)

DWQI = Drinking Water Quality Index (1= Poor, 2= Moderate, 3= Good), and

IPR = Interest in protection of resource (1= No interest, 2= Some interest, 3= Sufficient interest, 4= High interest)

a_0 = Regression constant, and

a_1 to a_6 = Regression coefficients.

Results and Discussion

Estimates of Land Value, Agricultural Yield Loss and Pollution Averting Expenditure

The estimated values of agricultural loss and pollution averting expenditure are presented in Table 1. As the intensity of pollution increased, the value of land decreased. And as the intensity of pollution decreased, the agricultural loss also decreased. The pollution averting expenditure increased with increase in the intensity of pollution. It is worth noting that the value of a highly-affected farmland was less than half of a farmland less-affected by pollution. To improve the quality of their land, the farmers in a highly-affected area spend almost two-times of that by the farmers of less-affected area in the Karur district.

Pollution Averting Expenditure on Affected Farms

Pollution averting expenditure was found to be a significant factor in preventing agricultural yield loss. It depended on many factors such as farm income, distance between farm and polluted river and share of cropland to farmland. The pollution averting expenditure in the present study was the additional costs incurred by the farmers on the seed materials, fertilizers, manures and gypsum to restore the previous yield level. The results of factors responsible for pollution averting expenditure are reported in Table 2.

Pollution Averting Expenditure on Highly-affected Farms

Most (H ≈ 82%) of the variation in the pollution averting expenditure was influenced by farm income, distance between farm and polluted river and share of cropland to total farmland. The signs of the coefficients

Table 1. Estimates of land value, agricultural yield loss and pollution averting expenditure in three area categories

(Rs/ha)

Sl No.	Particulars	Area		
		Less affected	Moderately affected	Highly affected
1	Land value	284134	189078	135597
2	Agricultural yield loss	2859	4626	6611
3	Pollution averting expenditure	1744	2616	3534

Table 2. Estimates of pollution averting expenditure in different farm categories in Tamil Nadu

Variables	Farm categories		
	Highly affected	Moderately affected	Less affected
Constant	102.11	1765.90	2925.11
	(2.34)	(1.69)	(0.625)
Farm income	0.16**	0.05	0.02*
	(3.90)	(0.18)	(2.87)
Distance between farm and polluted river	-1267.05	-1528.25**	-1567.19
	(-0.85)	(-3.58)	(-0.94)
Share of cropland to total farm land	9.76*	4.56	3.81
	(2.76)	(1.62)	(0.38)
R^2 values	0.82	0.74	0.55

Note: Figures within the parentheses are t-values

** and * indicate significance at one per cent and five per cent levels, respectively.

of all independent variables were as expected. The variable, distance between farm and polluted river, was negatively related to the pollution averting expenditure. The t-statistics indicated that the farm income was statistically significant at one per cent level and the variable, share of cropland to total farmland, was significant at five per cent level. An increase in the farm income by one rupee, would lead to an increase on pollution averting expenditure by Rs 0.16 per ha, when all other variables were constant. In the same way, one unit increase in the share of cropland to total farmland would increase the pollution averting expenditure by Rs 9.76 per ha, *ceteris paribus*.

Pollution Averting Expenditure on Moderately-affected Farms

The results showed that about 74 per cent of variation in the dependent variable (pollution averting expenditure) was influenced by independent variables chosen for the analysis. The coefficients of all independent variables had the expected signs. The t-statistics indicated that distance between farm and polluted river was statistically significant at one per cent level. It was understood that increase of one kilometre in the distance between farm and polluted river decreased the pollution averting expenditure by Rs 1528 / ha, *ceteris paribus*.

Pollution Averting Expenditure on Less-affected Farms

About 55 per cent of the variation in pollution averting expenditure was influenced by independent variables, viz. farm income, distance between farm and polluted river and the share of cropland to total farmland. Similar to other farm categories, the coefficients of all independent variables were found as expected. The t-statistics indicated that farm income was statistically significant at one per cent level. The variable distance between farm and polluted river was negatively related to the pollution averting expenditure.

When the distance between the farm and the polluting river was more, there was less chance of the lands getting polluted. This trend was exhibited by the negative sign of the coefficients in all the categories of farms.

The results indicated that when the share of crop land increased and in turn, farm income increased, farmers were spending much on pollution averting expenditure such as investment in agricultural inputs and other soil ameliorating inputs like gypsum, lime, green manures, sugarcane spent wash, etc. in the case of highly-affected farms. Generally, when there was an additional allocation of land for cropping, farmers had to spend more on these inputs, especially in the case of highly-polluted farms. Also, whenever farmers realized more net income, they had more dispensable income and they invested more on pollution averting activities.

Willingness to Pay (WTP) for Better Quality of Drinking Water

Dyeing effluents directly caused external costs to the society through health hazards. To avoid these, the farm households in the study area had to incur some additional expenditure for getting good quality water from the nearby sources. Hence, the farm households were asked to state their willingness to pay for better quality drinking water in the pollution affected area.

The variables considered in the Tobit model analysis included age, family size, farm income, drinking water requirement, drinking water quality index and interest in protection of resources. The results of the willingness to pay have been depicted in Table 3. As the direct interpretation of various regression parameters given in the Tobit model was not easy, these parameters were converted into elasticities for interpretation.

WTP — Highly Affected Farms

All the independent variables contributing to WTP exhibited the expected signs. All the independent variables involved in the analysis together contributed about 84 per cent to the variation in the farmers' willingness to pay. The t-statistics indicated that farm income and water requirement were statistically significant at one per cent level and drinking water quality index was significant at five per cent level. The variable age of the respondents was negatively related to the WTP, whereas the variables family size, farm income, drinking water requirement, drinking water quality index and interest in the protection of resources, were positively related to the WTP for improved quality of water from the nearby source.

It was found that one per cent increase in farm income of the respondents would increase the

Table 3. Estimates of willingness to pay for better quality of drinking water

Variables	Highly-affected farms		Moderately-affected farms		Less-affected farms	
	Coefficient	Elasticity	Coefficient	Elasticity	Coefficient	Elasticity
Constant	37.26	-	30.62	-	79.19	-
	(3.39)		(3.19)		(0.11)	
Age	-0.242	-1.20	-0.81	-5.22	-0.10	-1.44
	(-2.18)		(-0.79)		(-1.43)	
Family size	1.85	0.80	2.22	1.66	0.938**	1.22
	(1.34)		(2.21)		(4.10)	
Farm income	0.0006**	1.89	0.0008**	1.29	0.0005*	1.20
	(7.47)		(3.97)		(2.77)	
Water requirement	0.029**	0.72	0.133**	4.20	0.018	1.36
	(3.99)		(4.90)		(2.10)	
Drinking water quality index	5.32*	0.74	1.93	0.44	12.06	9.77
	(2.88)		(0.89)		(0.60)	
Interest in protection of sources	3.01	0.01	2.88	1.22	1.69	1.85
	(1.74)		(1.76)		(1.50)	
R^2 values	0.84		0.81		0.76	

Note: Figures within the parentheses are t-values
** and * indicate significance at one per cent and five per cent levels, respectively.

willingness to pay by 1.89 per cent, with all other variables remaining constant. It revealed that households with higher income levels were willing to pay more. In the same way, keeping other things constant, one per cent increase in the drinking water requirement would increase the willingness to pay by 0.72 per cent. If the drinking water quality shifts from poor to medium, the willingness to pay would increase by 0.74 per cent *ceteris paribus.* These results clearly highlighted that WTP was an income-driven attribute rather than demand driven parameter.

WTP — Moderately Affected Farms

In the these categories of farms, the age of the respondent was negatively related to the WTP, whereas variables like family size, drinking water quality index and interest to protection of resources were positively related to WTP for improved quality of water from a nearby resource. The t-statistics indicated that farm income and drinking water requirement were statistically significant at one per cent level. The higher R^{-2} value indicated that about 81 per cent of variation in the WTP was due to influence of the independent variables involved in the analysis.

It was found that one per cent increase in the farm income of the respondents would increase WTP by 1.29 per cent, when all other variables remained constant. It revealed that households with higher income levels were willing to pay more. In the same way, one per cent increase in the drinking water requirement would increase the willingness to pay by 4.2 per cent, *ceteris paribus*.

WTP — Less Affected Farms

It could be inferred from Table 3 that the coefficients of all independent variables had the expected signs in this category of farms also. The t-statistics indicated that family size was statistically significant at one per cent level and farm income was significant at five per cent level. The higher R^{-2} value indicated that about 76 per cent of variation in WTP was explained by the independent variables involved in the analysis. It was obvious that one per cent increase in the family size of the respondents would increase WTP by 1.22 per cent, when all other variables remained constant. In the same way, one per cent increase in the farm income would increase WTP by 1.20 per cent, *ceteris paribus*. It revealed that households with higher income levels were willing to pay more.

Farmers having affected lands were found highly interested to pay more for better quality of drinking water, especially when their farm income was high. Similarly, when the requirement for drinking water was high, farmers were ready to invest more on drinking water. The farmers expressed their WTP more for superior quality of water, especially those residing in highly-polluted villages. Even in less-polluted villages, if the family size was large, willingness to pay for better quality drinking water was higher.

Conclusions

The study has revealed that farm income determines the pollution averting expenditure function in all the three environments, viz. highly affected, moderately affected and less affected farms. Estimates for willingness to pay have revealed that increase in farm income, drinking water requirement and drinking water quality index influence the willingness to pay in highly-affected as well as moderately-affected farms, whereas in the case of less-affected farms, the willingness to pay is significantly influenced by the family size and farm income. This indicates that the farmers of the district are well aware about the effects of the negative externalities caused by the dyeing industry effluents. They are willing to pay to some extent to internalize the externalities caused by the industries. But, in general, it should be the responsibility of the polluting industries to pay for the pollution they cause. Such a situation draws the following policy options for an effective environment management to sustain agricultural production in the study area:

- Monitoring of the effluent treatment plants by the enforcement authorities should be done effectively to minimize the negative externalities created by the dyeing factories.
- Efforts should be made to treat the effluents in the common effluent treatment plants (CETPs) before letting out the effluents through institutional intervention by strict implementation of legal measures.
- The cropland value decreases and agricultural loss increases due to the impact of pollution. The farmers spend on pollution averting measures as an additional cost of production. Taxing mechanism should be framed to collect the money from dyeing factories letting out untreated effluents and compensate the farming community.

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Appendix 1

Environmental Sustainability Index (ESI)

ESI Rank	Country Name	ESI Rank	Country Name
1	Finland	85	Nepal
2	Norway	100	Kenya
6	Canada	101	India
10	Austria	114	Bangladesh
11	Brazil	125	Philippines
13	Australia	131	Pakistan
30	Japan	132	Iran
38	Malaysia	133	China
45	United States	135	Ethiopia
73	Thailand	143	Iraq
75	Indonesia	146	North Korea
79	Sri Lanka		

Source: www.yale.edu/esi