Ind. Jn. of Agri.Econ.
Vol.63, No.3, July-Sept. 2008

Estimation of the Negative Externalities of Textile Dyeing Industry Effluents on Crop Productivity and Value of Farm Lands in Tamil Nadu

T. Sivasakthi Devi*, **C. Ramasamy****, **S. Gurunathan***** **and S. Menaka***

Environmental problems due to rapid industrialisation are very common in areas where polluting industries like textile dyeing units, tanneries, pulp and paper processing units and sugar factories are located. The effluents discharged by these industrial units have led to severely polluted surface, ground water sources and soils, which has ultimately affected the livelihood of the common man. Agricultural practices with uncontrolled extensive use of agrochemicals and fertilisers, urbanisation and industrialisation discharge untreated industrial effluents and dump domestic wastes on large scale. The flow of sewage into waterways leads 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 (Sherbinin *et al.*, 2005). India ranks 101 in the list. Generally the high-middle ranking reflects top performance on issues such as water quality and environmental protection capacity. India comes under bottom-rung results on issues, such as waste generation and greenhouse gas emissions (Appendix).

India has comparative advantage in certain export industries, such as textiles, and leather because of its raw materials adundance and cheap labour. These agro-based industries cause various forms of pollution, which contaminate the air, water and land resources. 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 (Appasamy, 2001).

The negative externalities of these industries are leading to loss in crop area and production, changes in cropping pattern, health problems, and socio-economic imbalance in the regions. Moreover industrial pollution causes labour migration, unemployment or changes in employment pattern and decrease in share of farm income to the total household income (Govindarajalu, 2003).

*Ph. D Scholar, **Vice Chancellor and ***Senior Research Fellow, respectively, Department of Agricultural Economics, Centre for Agriculture and Rural Development Studies, Tamil Nadu Agricultural University, Coimbatore- 641 003 (Tamil Nadu).

There are 502 dyeing and bleaching units located in and around the town of Karur itself. The effluents generated from the dyeing units is discharged without any treatment into Amaravathy River, which is the main source of water for drinking, and agricultural purpose. Thus the river is very much polluted and water is not used for agriculture and household consumption purposes (Thanasekaran and Kurianjoseph, 2003).

The present study was undertaken to analyse the impact of dyeing effluents caused pollution on agricultural productivity, crop land value and income pattern of the farmers who are residing in the areas where dyeing industries are prevalent in Karur district.

DATA AND METHODOLOGY

The study was carried out in Karur and Aravakurichi taluks of Karur district of Tamil Nadu since these two taluks have larger proportion of polluted land areas among the four taluks of this district. Six villages two each of highly, moderately and less affected categories of the area were selected based on the loss of ecology report of Centre for Environmental Studies, Anna University, Chennai. They classified the study area as follows based on the Electrical Conductivity (EC) and Total Dissolved Solids (TDS) (Table 1).

TABLE 1. CRITERIA FOR CLASSIFICATION OF STUDY AREA

Class (1)	Criteria: TDS (mg/L) (2)	Criteria: EC (μS/cm) (3)	Impact Description (4)	Classification (5)
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*, Centre for Environmental Studies, Anna University, Chennai, 2003.

Taking into consideration the statistical requirement, time and other facilities at the disposal and the sample size required to minimise the sampling error, 50 farm holdings were selected randomly from two villages each in the three categories, viz., highly affected, moderately affected and less affected areas to make a total sample size of 150 farms in the study region.

The following statistical tools were employed for the analysis.

1. Hedonic Pricing Technique,
2. Agricultural Loss Function.

Hedonic Pricing Technique

This is a market approach, attempting to assess the value attributed by buyers to the environmental attributes of a dwelling. It is based on hedonism, in economic language it means that the hedonic measures the value of some parameters by its effect on the pleasure of the individual to live in a given region.

Hedonic model is used to find out the value of agricultural land in relation to prices of attributes. It can be done through hedonic price function, which describes the equilibrium relationship between land values and attributes. The results of the scatter diagram advocated linear model (Sekar, 2001).

The hedonic model formulated for the present study was of the following:

$$VCL = a_0 + a_1\ FI + a_2\ IWQI + a_3\ LQI + a_4\ DFPR$$

Where,

VCL	=	Value of cropland (in Rs./ha),
FI	=	Farm income (in Rs./yr),
IWQI	=	Irrigation water quality index,
1	=	Poor,
2	=	Moderate,
3	=	Good,
LQI	=	Land quality index,
1	=	Poor,
2	=	Moderate,
3	=	Good,
DFPR	=	Distance between the farm and polluted river (in kilometres),
a_0	=	Regression constant,
a_1 to a_4	=	Regression coefficients.

Loss Function

Loss function comes under the indirect valuation technique. This yield loss function might be either physical loss concerned with physical damage, or value loss function aimed at value of the damage. The function can be written as:

YL = f (Q), if no averting inputs were used.
YL = f (Q, Z), if averting inputs were used.

Where,

Z = Averting inputs.

This type of loss function is termed as physical loss function and other type is the value loss function. The value loss function relates value of loss to quantity of emissions in tonnes per year or concentration of residual in parts per million (ppm) (David, 1992).

In the present study, agricultural yield loss function was employed. In this loss function, assessment of pollution level (YL) was captured through variables like land quality index, irrigation water quality index, pollution averting expenditure on land and distance between the farm and polluted river. The results of the scatter diagram advocated linear model.

Agricultural Value Loss Function

$$YL = a_0 + a_1 PAE + a_2 LQI + a_3 IWQI + a_4 DFPR$$

Where,

YL = Yield Loss (in Rs./ha)
PAE = Pollution averting expenditure for land (in Rs./ha)
LQI = Land quality index
1 = Poor
2 = Moderate
3 = Good
IWQI = Irrigation water quality index
1 = Poor
2 = Moderate
3 = Good
DFPR = Distance between farm and polluted river (in kilometres)
a_0 = Regression constant
a_1 to a_4 = Regression coefficients.

RESULTS

Factors Deciding the Value of Polluted Farm Lands - Results of Hedonic Model

The hedonic regression model was used to find out the influence of qualitative and quantitative parameters on the value of cropland. In the present study, the qualitative and quantitative characteristics such as farm income, land and irrigation water quality indices and distance between farm and polluted river were found to influence the values of croplands. Hence these variables were used for the estimation of the parameters in hedonic regression analysis. Separate regression models were estimated for three different farm categories and the results of hedonic regression analysis are presented in Table 2.

TABLE 2. ESTIMATES OF HEDONIC MODEL

Variables (1)	Highly affected farms (2)	Moderately affected farms (3)	Less affected farms (4)
Constant	586.51	5371.73	4587.43
	(1.53)	(0.71)	(0.03)
Farm income	6.94*	5.13	5.53
	(2.73)	(0.50)	(1.83)
Irrigation water quality index	4.232	10.96*	12.29
	(0.94)	(2.89)	(0.90)
Land quality index	7.066	15.09	18.59*
	(0.10)	(2.08)	(2.76)
Distance between farm and polluted river	322.03**	600.51*	1040.18**
	(4.68)	(2.75)	(3.14)
R^2 values	0.89	0.79	0.78

Note: Figures in parentheses are t values.
** and * indicate significance at 1 and 5 per cent levels respectively.

Highly Affected Farm Lands

The analysis of the results indicated that about 89 per cent of the variation in the land value was explained by the independent variables. Table 2 further showed that the coefficients of all the independent variables were positively determining the value of cropland. The t-statistics indicated that the variables farm income and distance between farm and polluted river were influencing the value of cropland significantly at five and one per cent levels respectively.

It could be inferred from the Table 2 that the increase in farm income by one rupee, would increase the value of cropland by Rs.6.94 per ha for highly affected farm areas, when the other variables remained constant. Similarly, one kilometer increase in distance between farm and the polluted river would increase the value of land by Rs.322.03 per ha, *ceteris paribus.*

Moderately Affected Farm Lands

For the moderately affected area, the R^2 value indicated that about 79 per cent of the variation in the cropland value was explained by the independent variables. The coefficients of all the independent variables were positively influencing the value of cropland. The t-statistics indicated that the irrigation water quality index and distance between farm and polluted river were influencing the value of cropland significantly at 5 per cent level.

It could be inferred from Table 2 that, if the irrigation water quality index shifts from medium to good, the value of cropland would increase by Rs.10.96 per ha, keeping other variables constant. Also, one kilometer increase in distance between farm and polluted river would increase the value of cropland by Rs.600.51 per ha, *ceteris paribus.*

Less Affected Farm Lands

The results showed that about 78 per cent of the variation in the cropland value was explained by the independent variables. The coefficients of all the independent variables were positively determining the value of cropland. The t-statistics indicated that the land quality index and distance between farm and polluted rivers were influencing the value of cropland significantly at five and one per cent level.

It could be inferred from the table that if the land quality index shifts from medium to good, the value of cropland would increase by Rs.18.59 per ha, keeping the other variables constant. Likewise, one kilometer increase in distance between farm and polluted river would increase the value of cropland by Rs.1040.18 per ha, *ceteris paribus.*

RESULTS OF AGRICULTURAL VALUE LOSS FUNCTION

Agricultural Value Loss in the Affected Areas

One of the objectives of the study was to analyse and assess the effects of dyeing industry effluents on crop yield and farm income. The study in general indicated that the dyeing effluents had caused damage to crop growth, resulting in sizeable yield loss.

The agricultural value loss function relates the value of agricultural loss to pollution averting expenditure on land, irrigation water quality index, land quality index and the distance between farm and polluted river. Hence it was used for the estimation of the parameters of agricultural value loss function. The results of agricultural value loss function analysis are presented in Table 3.

TABLE 3. ESTIMATES OF AGRICULTURAL VALUE LOSS FUNCTION

Variables (1)	Highly affected farms (2)	Moderately affected farms (3)	Less affected farms (4)
Constant	8690.67 (35.23)	9120.91 (11.66)	9295.70 (4.96)
Pollution averting expenditure	-0.31** (-3.46)	-0.81 (-1.19)	-1.95** (-3.58)
Irrigation water quality index	-93.95 (-0.56)	-120.02* (-2.95)	-155.87 (-0.62)
Land quality index	-473.77 (-0.08)	-631.47** (-4.81)	-712.16 (-2.07)
Distance between farm and polluted river	-319.05** (-4.75)	-915.40 (-1.29)	-1115.14** (-3.45)
R^2 values	0.90	0.85	0.67

Note: Figures in parentheses are t values.
** and * indicate significance at 1 and 5 per cent level respectively.

Highly Affected Farm Lands

About 90 per cent of the variation in the yield loss was explained by the independent variables. From the Table 3, it could be inferred that the coefficient of all the independent variables were negatively related to the yield loss. The t-statistics indicated that the pollution averting expenditure and distance between farm and polluted river were statistically significant at one per cent level. A one rupee increase in pollution averting expenditure would decrease the value of agricultural loss by Re.0.31 per ha, when all other variables remain constant. Similarly one kilometer increase in the distance between farm and polluted river decreased the agricultural value loss by Rs.319.05 per ha, *ceteris paribus.*

Moderately Affected Farm Lands

About 85 per cent of the variation in the yield loss was explained by the independent variables. The coefficients of all the independent variables were negatively related to the yield loss. The t-statistics indicated that the irrigation water quality index was statistically significant at five per cent level while the land quality index was significant at one per cent level indicating that if the irrigation water quality index shifts from medium to good, the agricultural value loss would decrease by Rs.120.02 per ha when all other variables remained constant. Similarly if the land quality index shifts from medium to good, the agricultural value loss would decrease by Rs.631.47 per ha, *ceteris paribus.*

Less Affected Farm Lands

About 67 per cent of the variation in the yield loss was explained by the independent variables in less affected lands. Pollution averting expenditure and distance between farm and polluted river were statistically significant at one per cent level indicating one rupee increase in pollution averting expenditure would decrease the value of agricultural loss by Rs.1.95 per ha, when all other variables remained constant. Also, increase in one kilometer distance between farm and polluted river would decrease the agricultural value loss by Rs.1115.14 per ha, *ceteris paribus.*

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

Based on the hedonic pricing model, agricultural value loss and pollution averting expenditure model the estimated values are presented in Table 4. It could be inferred from the table that value of the land decreases with increase in the intensity of pollution and vice versa as the pollution averting expenditure increases with increase in the intensity of pollution.

TABLE 4. ESTIMATES OF LAND VALUE, AGRICULTURAL YIELD LOSS AND POLLUTION AVERTING EXPENDITURE

Sl. No. (1)	Particulars (2)	Highly affected farms (3)	Moderately affected farms (4)	Less affected farms (5)
1.	Land value (Rs./ha)	284134	189078	135597
2.	Agricultural yield loss (Rs./ha)	2859.05	4626.39	6611.44
3.	Pollution averting expenditure (Rs./ha)	1743.83	2616.49	3534.21

CONCLUSION

The intensity of negative externality of polluting effluents from these factories is getting reduced as the location of the farm moves away from the factory site. This paper clarifies that the value of cropland was mainly determined by the farm income and distance between farms from the polluted river in highly affected area. The pollution averting expenditure and distance of the farms from the polluted river were inversely influencing the value of agricultural loss in highly affected areas.

The cropland value decreases and agricultural loss increases due to the impact of pollution. The farmers have incurred pollution averting expenditure as additional cost of production. Households with higher income were willing to pay more towards pollution averting expenditure. As the value of the lands and their productivity have already dipped to low level the farmers could not depend heavily on their farm income. Hence proper tax mechanism should be evolved to collect the money from dyeing factories letting out untreated effluents and compensate the farming community. Monitoring the effluent treatment plants by the enforcement authorities should be done effectively in order to minimise the negative externalities created by the dyeing factories.

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APPENDIX

ENVIRONMENTAL SUSTAINABILITY INDEX (ESI)

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

Source: www.yale.edu/esi