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Impact of Waste Water Treatment on Area under Cultivation in Tiruppur District, Tamil Nadu – Projection Based on Willingness to Pay Approach

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Abstract

There is a scarcity of research on the effects of waste water treatment on the amount of land used for farming. Additionally, the researchers made the assumption that all farmers would either be willing or unwilling to participate. An equation was estimated to determine the separate area under cultivation for farmers who are willing and unwilling to engage, assuming no endogeneity. Thus, this study aimed to assess the influence of waste water treatment on the area of land used for cultivation, while considering the selectivity bias in the analysis. The Heckman sample selection model was utilised to examine the influence of willingness to pay on the extent of land under cultivation. By treating the waste water, it is possible to expand the cultivated area. While the cropping pattern may remain unchanged, around 50 hectares of land area dedicated to the same crops could be increased if the waste water is treated and the farmers are ready to bear the cost of waste water treatment. The correlation between the disposal of industrial waste and the land area was shown to be statistically significant in determining the willingness to pay. Furthermore, the impact of the desire to pay was also found to be statistically significant in determining the extent of land used for cultivation.

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Tiruppur District Water Pollution;
Willingness to Pay.

Introduction

The studies had reported that the use of untreated industrial waste water for irrigation had increased the concentrations of Nain wheat leaf tissue to the extent of 58 percent and the concentration of Ca had declined to the extent of 13 percent.[1] It caused poor calcium nutrition to the crop. The Pb concentrations had exceeded the safety limit in 24% of wheat grain samples. The water pollution was the major factor for the reduction in agricultural production.[2] An empirically proved that water pollution had significantly reduced the agricultural production.[3]

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They had proved water pollution due to untreated industrial effluent discharge was one of the reason affecting agricultural production and productivity.[4]

While the recommendation is to utilise treated waste water for irrigation, it is important to consider the potential adverse impacts on human health and soil quality. The Central Pollution Control Board has issued regulations outlining the safe usage of treated sewage and effluents from agricultural companies.[5] In May 2019, the National Green Tribunal (NGT) gave orders during a case hearing, which led to the formulation of the Central Pollution Control Board's 2019 guidelines. The NGT ruled that industries are prohibited from disposing of treated effluents on land designated for irrigation, plantation, horticulture, or gardening without conducting a prior assessment of land availability and the potential impact of such disposal on crops, plants, agriculture, and groundwater. As to the Central Pollution Control Board, the treated effluent must meet the irrigation conditions specified in the Environment (Protection) Rules, 1986/consent. In addition to the required Total Dissolved Solid (TDS) level of 2100 mg/L4 and Sodium Adsorption Ratio (SAR) range of preferably less than 18 but not more than 26, the effluent must also comply with any additional suggestions provided by an agricultural scientist, agricultural university, or agricultural institute mentioned in the IMP. These additional recommendations are dependent on the specific soil and crop conditions.

For the treatment of waste water which is used for irrigation, all the farmers located in the area should be ready to participate. It alone make the waste water treatment plan to be successful. In this backdrop, the studies analysed the impact of waste water treatment on area under cultivation is rare. Furthermore, they presumed that all farmers are either willing or unwilling to participate. An equation was estimated to determine the separate area under cultivation for farmers who are willing and unwilling to engage, assuming no endogeneity. The earlier studies analysing the impact of willingness to pay on the area under cultivation failed to include the issue of endogeneity. Thus, this study aimed to assess the influence of waste water treatment on the extent of land used for cultivation, while considering the selectivity bias in the analysis. The study has the following precise objectives.

Objectives

- To study the cropping pattern in the study area and
- To analyse the impact of willingness to pay for treating the waste water on the area under cultivation

Materials and Methods

The study exclusively use primary data. The multistage sampling technique was utilised to choose the sample farmers. The initial phase was the selection of nine revenue villages (taluks) in the Tiruppur district. The nine revenue villages include Tiruppur North, Tiruppur South, Avinashi, Uthukuli, Palladam, Dharapuram, Kangayam, Udumalpet, and Madathukulam. Due to the predominant disposal of industrial waste into the Noyyal river, which is a significant source of water and soil pollution, the taluks situated in close proximity to the river were taken into consideration. The Noyyal river traverses the taluks of Tiruppur North, Tiruppur South, Avinashi, Uthukuli, Kangayam, and Madathukulam. For the study, the taluks mentioned above were identified in the second stage. Among the aforementioned taluks, Kangayam was chosen in the third stage due to its significance as the first taluk to be impacted in agriculture. The Pollution Control Board has identified Tammarettipalayam, Maravapalayam, and Keranur as the villages in the Kangayam taluk that have been afflicted by pollution. Consequently, the aforementioned villages impacted by pollution were chosen in the subsequent round. For the last phase, a total of 100 farmers from the aforementioned communities were chosen using the proportionate sampling technique. The structured interview schedule was used to collect data on the socio-economic profile of the farmers, including information on the area under cultivation, farm production, and their readiness to pay for waste water treatment. The gap in the interview schedule was adjusted according to the findings of the pilot study. The conclusive survey was carried out in 2022. The collection of primary data was conducted through face-to-face interviews with a sample of farmers.

Specification of Econometric Model

In the current study, the impact of willingness to pay on the cropping pattern involves selectivity bias and the problem of endogeneity. The area under cultivation equation in the impact assessment, could not be specified as an ordinary regression model as it is biased which involves selectivity bias. Heckman sample selection model is one of the solutions for the selectivity bias. Heckman sample selection model include estimation of selection equation that is probit equation showing determinants willingness to pay for the water treatment and the outcome equation of area under cultivation. In the selection equation showing the probability of willingness to pay the dependent variable was binary dependent (willingness to pay and not willing to pay). In regressions, involving binary dependent variables, the problem of hetroscedasticity arises, making the ordinary least squares estimation of the standard errors biased. In addition, the disturbance terms are bounded and only approximated to normal distribution. The probit model is more suitable in the case of binary dependent variable model.[6]

The outcome equation estimated in the study was area under cultivation, the Heckman sample selection model was specified for both regimes of the farmers who willing to pay and not willing to pay.

Willingness to Pay Equation – Probit Equation

The willingness to pay was specified as probit model. The form of the willingness to pay specified in the study was

$$G^* = \gamma z + \varepsilon$$[7.8]

Where G = probability of willingness to pay
γ = parameter co-efficient
Z = 'Dumping of industrial waste in the nearby water bodies', (Score value), age, size of land savings and sources of irrigation. ε is a random disturbance term.

Area under Cultivation Equation

$$Y_1^p = a^p X_i + \delta^p pf_i + \rho_{p\varepsilon}\sigma_p\lambda(\alpha).$$

For the farmers in non-polluted area, the form of the area under cultivation equation was

$$Y_1^n = a^n X_i + \delta^n pf + \rho_{n\varepsilon}\sigma_n\lambda(\alpha)$$

Y_1 = area under cultivation (in Hectares). X_i = age of the farmer head (in years), savings (Rs.), size of land (in hectares) and pf_i = pollution factors 'textile industrial waste disposal in the nearby water bodies', (Score value).

Results and Discussion

Cropping Pattern in the Study Area

The change in the cropping pattern due to water pollution was reported in the study.[9] An attempt was made to analyse the changes in the cropping pattern due to the adoption of waste water treatment for irrigation. The details of the cropping pattern are shown in Table -1.

Table 1: Cropping Pattern in the Study Area (in hectares)

Crops	Existing area under cultivation	Expected area under cultivation if pollution control technology adopted
Maize and Sorghum	58.20	102.05
Groundnut	221.68	302.04
Turmeric	109.21	176.95
Coconut	246.76	251.78
Total	158.96	208.20

Source: Field Survey, 2020-21.

The existing cropped area under maize and sorghum was 58.20 hectares. The expected area under cultivation of maize and sorghum would be 102.05 hectares if the waste water is treated and used. The existing area under cultivation of groundnut was 221.68 hectares while the expected area under cultivation of ground nut would be 302.04 hectares if the waste water is treated. The area under turmeric and coconut would also be increased if the waste water is treated and used.

Willingness to Pay for Treating the Waste Water –Probit Regression Analysis

The cannel waste water treatment plant can be established by the government if the farmers are willing to pay for the same in the form of tax or based on the usage of treated waste water for irrigation Probit regression equations was estimated to identify factors determining the willingness to pay for the technology to treat the waste water. The results of probit regression analysis showing determinants of willingness to pay to treat the water which are shown in Table-2.

Table 2: Determinants of willingness to pay – Probit Regression Analysis

Causes	Probit regression Coefficients	Z	P value
Constant	-6.998***	-10.371	0.000
Age	0.204	1.528	0.126
Size of land	0.598***	3.426	0.001
Savings	0.145	1.203	0.229
Dumping of industrial waste in the nearby water bodies	0.323*	-0.174	0.041
Sources of irrigation	0.034***	3.56	0.0008
Chi-square	0.000		
N	100		

Source: Field Survey, 2020-21.Note: * Significant at 10percent level, ** Significant at 5 percent level, *** Significant at 1percent level.

Table 3: Area under cultivation equation –Two Stage Least Squares Regression Analysis

Variables	Two stage least squares regression Coefficients							
	Polluted Area				Non – Polluted Area			
	B	Std. Error	T	Sig.	B	Std. Error	t	Sig.
Constant	0.657**	0.247	2.657	0.009	0.573***	0.079	7.286	0.000
Textile industrial waste disposal in the nearby water bodies	-0.004*	0.006	-0.708	0.481	0.038**	0.020	1.896	0.061
Age	-0.232*	0.142	-1.634	0.105	-0.089**	0.044	-2.027	0.046
Savings	-0.023*	0.016	-1.448	0.150	-0.010**	0.004	-2.261	0.026
Size of land	0.803***	0.060	13.382	0.000	0.816***	0.026	31.934	0.000
Lambda	0.001*	0.001	0.805	0.423	1.30E-007***	0.000	2.976	0.004
N	50				50			

Source: Field Survey 2020-21; Note: *** Significant at 1 percent level, ** Significant at 5 percent, * Significant at 10 percent. Figures in parentheses denote t-values.

Among the chosen variables, the disposal of industrial waste into the adjacent water sources was a noteworthy element in determining the willingness to pay. The coefficient mentioned above has a positive sign. The study demonstrated that a rise in the disposal of industrial waste into water bodies will result in an increase in the level of readiness to pay. The size of the property and the source of irrigation were both statistically significant factors in determining the willingness to pay. Their relationship was characterised by a positive correlation with willingness to pay. Expanding the land area would enhance the inclination to pay. If the source of irrigation water is surface water, there is an increased readiness to pay for the treatment of waste water. The chi-square value was estimated to be 210.78, indicating statistical significance at the one percent level. The analysis demonstrated that the estimated model had a statistically significant impact on determining the willingness to pay.

Impact of Willingness to Pay for Waste Water Treatment on Area Under Cultivation

The likelihood of being willing to pay was calculated in the initial stage equation. The latent information was incorporated into the initial probit equation and utilised as the selectivity variable in the subsequent regression model to ascertain the influence of willingness to pay on the extent of cultivated land, in addition to other factors that determine the area under cultivation. The data regarding the extent of land being cultivated is presented in Table -3.

For the farmers who were not willingness to pay for the treatment of waste water, the pollution factor ‘textile industrial waste disposal in the nearby water bodies’ had turned out to be statistically significant. To determine area under cultivation among the selected variables. The estimated two stage regression co efficient of disposable of textile industrial waste in the nearby water bodies was positive. It revealed that increase in industrial disposable had increased the area under cultivation. The estimated relationship was theoretically consistent. The non- pollution factor, size of land was statistically significant to determine the area under cultivation for the farmers who were willingness to pay. The two stage regression co efficient of size of land was positive. Increase in size land would increase the area under cultivation. Remaining factors had turned out to be statistically insignificant.

For the farmers who were not willing to pay, the pollution factor textile industrial waste disposal in the nearby water bodies’ was statistically insignificant. It reveals that if the farmers were not willing to pay for the pollution control, increase in the dumping of industrial waste would reduce the area under cultivation. The non- pollution factor such as the age of the farmer head and the size of land holding had turned out to be statistically significant. They were positive which means that increase in the age of the farmers and the size of land would increase the willingness to pay.

The variable lambda, which represents selectivity, was shown to be statistically unimportant in the equation that models the area under cultivation for farmers who were willing to pay. The analysis showed that there was no evidence of selective bias in the equation that measured the area under cultivation. The variable lambda, which represents selectivity, was shown to be statistically significant at a 10 percent level in the area under cultivation of farmers who were unwilling to pay. The analysis revealed the existence of selective bias in the equation measuring the area under cultivation for farmers who were unwilling to pay.

Area under Cultivation Loss in Polluted Area

As the water and soil pollution had reduced the area under cultivation in the polluted area, if the waste water was not treated. In this section, an attempt was made to assess the area under cultivation loss in the study area if the water was not treated. The difference in the actual area under cultivation and the expected area under cultivation. The area under cultivation loss in polluted area is given in Table-4.

Table 4: Area under cultivation loss (in hectares)

Taluks	Area under cultivation loss
Maize and Sorghum	-43.85
Groundnut	-80.36
Turmeric	-67.74
Coconut	-5.02
Total	-49.24

Source: Field Survey 2020-21.

The area under cultivation loss under the maize and sorghum would be 43.85 hectares, groundnut would be 80.3686 , turmeric would be 67.74 hectares and 5.02 hectares under coconut. In total, on an average

49.24 hectares would be lost if the waste water is not treated.

Impact of Water and Soil Pollution on Area under Cultivation Loss

As the dependent variable, area under cultivation loss was observable only for the farmers who were not willing to pay for the waste water treatment, the Tobit model was specified to assess the impact of willingness to pay on area under cultivation loss in the study area. The Heckman type Tobit model was specified with selectivity bias. The combination of the variables such as age of the farmer head, savings, size of land and pollution factor 'discharging of industrial waste in the nearby water bodies', in the area under cultivation loss equation, gave optimum solution to the model. The area under cultivation loss equation (Tobit model) with the inclusion of the above selected variables along with inverse mills ratio was estimated based on maximum likelihood method.

The estimated area under cultivation loss equation is given in Table-5

Table 5: Area under cultivation loss equation -Tobit Regression Analysis

Variables	Tobit Regression Co-efficients	t-value	Sig
Constant	9.1293***	6.31	0.000
Textile industrial waste disposal in the nearby water bodies	-0.8727***	-5.86	0.000
Age	-2.3942***	-2.15	0.002
Savings	0.8349***	4.12	0.000
Size of Land	-2.783***	-5.02	0.000
Lambda	4.62e-06***	2.89	0.004

Source: Field Survey 2020-21. Note: *** Significant at 1 percent level.

For the farmers who were not ready to adopt the water pollution control, the pollution factor, 'textile industrial waste disposal in the nearby water bodies' turned out to be statistically significant to determine the area under cultivation loss. The estimated Tobit regression co efficient was positive. It revealed positive relationship between area under cultivation loss and 'textile industrial waste disposal in the nearby water bodies'. Size of land was statistically significant to determine area under cultivation loss. It had negative sign. The increase in the size of land holding would reduce the area under cultivation loss.

The selectivity variable inverse mills ratio was statistically significant in the area under cultivation loss equation. It proved the existence of selectivity bias in the area under cultivation loss equation for the farmers who were not ready to adopt pollution control measures.

Conclusion

If the waste water is treated, the area under cultivation could be increased. The area under maize and sorghum, groundnut, turmeric and coconut were the existing cropping pattern. Though the cropping pattern might not be changed, about 50 hectares of land area under the above same crops could be expanded if the waste water is treated and the farmers are willing to pay for the waste water treatment. If the farmers are not willing to pay, on an average, about 50 hectares of land could not be cultivated for every 100 farmers. The dumping of industrial waste and the size of land were statistically significant to determine the willingness to pay. The impact of willingness to pay was statistically significant to determine the area under cultivation in the study area.

Recommendation

- The government may contribute for the waste water treatment of Noyyal river basin by imposing tax on the disposal of dyeing industrial wastes.
- For the farmers who are not willing to pay must be created awareness about the positive economic benefit due to the waste water treatment.

- Awareness must be created among the farmers about the importance of treated waste water irrigation.

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Conflict of Interest
The authors have not declared any conflict of interest.

Data Availability Statement
The data utilized in this study were meticulously gathered from primary data to ensure their viability and reliability. Rigorous validation processes were employed to verify the accuracy and consistency of the data. Additionally, measures were taken to address any potential biases or inconsistencies, thereby enhancing the robustness and trustworthiness of the findings presented in this article.

Author Contributions
I have contributed to the entire article, including conceptualization, research, and writing. I ensured accuracy and coherence throughout the process and incorporated feedback for finalization.

References

1. Saha JK, Sharma AK, Srivastava A. Impact of different types of polluted irrigation water on soil fertility and wheat grain yield in clayey black soils of central India. *Environ Monit Assess.* 2014 :186:2349-2356. doi:10.1007/s10661-013-3552-7.
2. Appasamy PP, Nelliyat P. Economic Assessment of Environmental Damage: A Case Study of *Industrial Pollution in Tiruppur. Industrial Pollution and Policy EERC Working Paper Series,* IPP-1. Madras School of Economics. 2001.
3. Khai HV, Yabe M. Rice yield loss due to industrial pollution in Vietnam. *J US-China Public Adm.* 2012:9(3):248-256.
4. Akilan ST. Textile pollution and sociological implications – A case study in the selected villages of Noyyal River belt, Tamil Nadu. *EPRA Int J Econ Bus Rev.* 2016:4(2):71-84.
5. Srivastava A, Bandhu S. Biotechnological advancements and challenges in textile effluents management for a sustainable bio economy: Indian case studies. *Case Stud Chem Environ Eng.* 2022:5:100186. doi:10.1016/j.cscee.2021.100186.
6. Sharma R, Kumar R, Satapathy SC, *et al*. Analysis of Water Pollution Using Different Physicochemical Parameters: A Study of Yamuna River. *Front Environ Sci.* 2020: 8:581591. doi:10.3389/fenvs.2020.581591.
7. Feder G, Lau LJ, Lin JY, Luo X. The relationship between credit and productivity in Chinese agriculture: A microeconomic model of disequilibrium. *Am J Agric Econ.* 1990:72(5):1151-1157.
8. Foltz JD. Credit market access and profitability in Tunisian agriculture. *Agric Econ.* 2004:30(1):229-240.
9. Cheepi P. Musi River Pollution: It's Impact on Health and Economic Conditions of Down Stream Villages-A Study. *IOSR J Environ Sci Toxicol Food Technol.* 2012:1(4):40-51.
10. Al Hamedi FH, Kandhan K, Liu Y, *et al*. Wastewater Irrigation: A Promising Way for Future Sustainable Agriculture and Food Security in the United Arab Emirates. *Water.* 2023:15(12):2284. doi:10.3390/w15122284.
11. Central Water Commission. *Annual Report* 2021-2022. Central Water Commission; 2022. https://cwc.gov.in/sites/default/files/annual-report-21-22.pdf.
12. Faroque S, South N. Water pollution and environmental injustices in Bangladesh. *Int J Crime Justice Soc Democr.* 2022:11(1):1-13.
13. Gandhiamthi. Impact of Water Pollution on Welfare Loss of Farm Households in Tiruppur District – An Imperfect Market Approach. *Sponsored Research Project. Indian Council*

*of Social Science Research.*2021.

14. Kılıç Z. The importance of water and conscious use of water. *Int J Hydrol.* 2020:4(5):239-241.
15. Kopperi H, Hemalatha M, Kiran BR, Santhosh J, Mohan SV. Sustainable consideration for traditional textile handloom cluster/village in pollution abatement – A case study. *Environ Pollut.* 2023:324:121-320.
16. Ladu JLC, Athiba AL, Lako STV, Lomoro M. Investigation on the Impact of Water Pollution on Human Health in Juba County, Republic of South Sudan. *J Environ Pollut Hum Health.* 2018:6(3):89-95.
17. Nouri-Khajebelagh R, Khaledian M, Kavoosi-Kalashami M. Investigating socio-economic factors underlying urban consumers' willingness to pay extra for drinking water. *Water Supply.* 2023:23(1):1-13.
18. Padmanaban R, Karuppasamy S, Narayanan R. Assessment of pollutant level and forecasting water pollution of Chennai coastal, Tamil Nadu using R. *Indian J Geo-Mar Sci.* 2018:47(7):1420-1429.
19. Priya K. Impact of Water Pollution on Welfare Loss of Farm Households in Tiruppur District – An Imperfect Market Approach. [dissertation]. Avinashilingam Institute for Home Science and Higher Education for Women.2018.
20. Radelyuk I, Tussupova K, Persson M, Zhapargazinova K, Yelubay M. Assessment of groundwater safety surrounding contaminated water storage sites using multivariate statistical analysis and Heckman selection model: A case study of Kazakhstan. *Environ Geochem Health.* 2021:43:1029-1050.
21. Rajput RS, Pandey S, Bhadauria S. Status of water pollution in relation to industrialization in Rajasthan. *Rev Environ Health.* 2017:32(3):245-252.
22. Reid AJ, Carlson AK, Creed IF, *et al*. Emerging threats and persistent conservation challenges for freshwater biodiversity. *Biol Rev Camb Philos Soc.* 2019:94(3):849-873.
23. Zahoor I, Mushtaq A. Water pollution from agricultural activities: A critical global review. *Int J Chem Biochem Sci.* 2023:23(1):164-176.
24. Knowles JC, Anker R. The Determinants of Internal Migration in Kenya: A District Level Analysis. Popul Employ Working Paper No. 56, *Population and Employment Project. Kenya;* 1977. doi:10.1016/0305-750X(80)90048-0.
25. Central Pollution Control Board in India. *Status of Water Quality.* Central Pollution Control Board; 2019. https://cpcb.nic.in/nwmp-data-2014/.
26. Water Quality Assessment Authority in India. *Water Quality Assessment in India. Central Pollution Control Board*; 2015. https://cpcb.nic.in/nwmp-data/.