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Research Note

Estimation of externalities due to impact of solid waste dumping on crop farming and valuation of crop lands in Tamil Nadu

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Abstract Growing urbanization generates large quantities of solid waste. In the absence of efficient management, this waste pollutes surface and groundwater sources and soils. We assess the effects of such externalities on agriculture in terms of crop damage. The distance of the farmland from the dump yard and averting expenditure are found negatively significant in finding the intensity of pollution and losses of yield in monetary terms. Water quality, farm size, distance between the farm land and dump yard are found to be positively significant in deciding the value of crop land, and nearness to highways negatively significant.

Keywords Municipal solid waste, agricultural damage loss, hedonic pricing

JEL classification Q53, Q1, Q51

Municipal solid waste refers to all waste generated by domestic, institutional, commercial, industrial, and street sources and by construction and collected by the local authority (Anand 2010). Growing populations and urbanization generate enormous quantities of solid waste (Krishnamurti and Naidu 2003). Insufficient collection and inappropriate disposal pollute the water, land, and air and pose risks to human health and the environment. The soil at disposal sites has high pH and electrical conductivity and contains heavy metals (Ali and Yasmin 2014). The waste disposed directly onto soil surfaces—and contaminants including heavy metals—readily penetrate the soil and eventually contaminate it and affect vegetation. Unscientific disposal practices of solid waste constitute one of the causes of global warming (Dhayagode et al. 2011), and solid landfills contribute about 60% to global methane emission.

This study attempts to quantify the loss in crop yield due to waste disposal. Policymakers can use this analysis to formulate policy for scientifically managing solid waste and disposing of it safely and also for helping farmers avoid crop damage due to solid waste.

Data and methodology

Data

The study was carried out in the Coimbatore district of Tamil Nadu, as a large proportion of its area is affected by municipal solid waste. Based on discussions with farmers and with the department of agriculture, the intensity of the negative externality from the dump yard was found to be directly related to the distance of the crop land from the dump yard. Therefore, the study area was classified into zones of circles based on their distance from the dump yard.

A circle was named Zone I if its radius is 3 km from the dumping site (highly affected), Zone II if 3–6 km (moderately affected) and Zone III if its radius is more than 6 km from the dumping site (marginally affected). Considering the time and other facilities at the disposal site, two villages from each circle and ten farm holdings from each village were randomly selected. The pretested interview schedule was used to collect details on socioeconomic characteristics; crops grown; cost of cultivation; averting expenditure on seeds, fertilizers, and pesticides; and the effects of solid waste on water and land, odour, and smoke.

Analytical framework

Agricultural damage function

To quantify the damage due to waste disposal, the agricultural productivity loss (Y_d) function was estimated with independent variables like average averting expenditure incurred on inputs, land quality, water quality, and the distance of farmland from the dump yard (Amarnath and Krishnamoorthy 2001; Anbarasi 2007; Devi et al. 2008; Amarnath and Sridevi 2016).

The yield loss is the difference between potential and average yield. The yield was calculated per hectare for major crops grown such as coarse cereals and vegetables. Then the actual farm yield was compared with the potential yields. The yield loss of major crops grown such as coarse cereals (sorghum and maize) was accounted for by the independent variable. The results of the scatter diagram advocate the use of a linear model $Y_d = a_0 + a_1 \text{ AE} + a_2 \text{ LQ} + a_3 \text{ WQ} + a_4 \text{ DS}$

where, Y_d is the yield damage loss (INR per ha), AE is the average averting expenditure incurred for inputs (INR per ha), LQ is the land quality (1 = low; 2 = medium; 3 = normal), WQ is the water quality (1 = low; 2 = medium; 3 = high) and DS is the distance of the farmland from the dumpsite (in km). a_0 is the regression constant, and a_1 to a_4 are the regression coefficients.

Hedonic price model

The hedonic price model, a revealed preference method, allows for calculating the value of a cropland due to the externality of the solid dump yard (Miranowski 1984). It is used to find out the value of agricultural land in relation to the prices of the attributes. The value can be calculated by using the hedonic price function, which describes the equilibrium relationship between land values and attributes. The hedonic pricing model is used to find the value of cropland. The valuation of farmland (Y_v) is captured through independent variables like land quality, water quality, landfill odour, the size of farmland, the distance of the farmland from the dump yard, and nearness to highways (Devi et al. 2008). The scatter diagram suggested a log linear model $Y_v = a_0 + a_1 \text{ LQ} + a_2 \text{ WQ} + a_3 \text{ FSIZE} + a_4 \text{ ODR} + a_5 \text{ DS} + a_6 \text{ HG}$

where, Y_v is the value of cropland (INR per ha), LQ is the land quality (1 = low; 2 = medium; 3 = normal), WQ is the water quality (1 = low; 2 = medium; 3 = high),ODR is the unpleasant odour (1 = low; 2 = medium; 3 = high), FSIZE is the size of the farmland (in hectares), DS is the distance of the farmland from the dumpsite (in km), and HG is the nearness to the highway (in km). a_0 is the regression constant, and a_1 to a_6 are the regression coefficients.

Results and discussion

Descriptive results

The average distance of the cropland from the dump yard is 2.13 km in Zone I, 4.77 km in Zone II, and 8.12 km in Zone III. The location of the cropland—near the Cochin highways—raises the land value. The yield loss and value of cropland are continuous and measured as means. The discrete variables are categorized as low, medium, and high, and are measured as percentages over the sample. Table 1 shows the average yield loss and averting expenditure incurred (the variables used to predict the yield loss and the value of cropland); both are inversely related to the distance of the cropland from the dump yard. On the contrary, the value of cropland is positively related to that distance. About 27% of the farmers in Zone III indicate land quality as being normal while 27% from Zone I report land quality as being poor. The farmers report that the changes in colour, taste, and turbidity were because of the leachate from the solid waste dump yard. The unpleasant odour was predominant during fire burn and the rainy and windy seasons. On average, the farm size in hectares is 4.40 in Zone I, 3.68 in Zone II, and 3.95 in Zone III. The water quality is reported as being normal by 27% of the farmers in Zone III, but 47% of the farmers in Zone I report that the water quality is poor.

Factors influencing agricultural productivity

The yield loss was calculated by taking the difference between potential yield and actual farmers' yield. In

Table 1 Variables used to predict yield loss and value of crop land

Variable	Description	Zone I	Zone II	Zone III
Y_d	Loss measured in monetary terms (INR) per hectare	59,617.50	56,080.00	32,569.00
Y_v	Value of land measured in monetary terms (INR) per hectare	862,500.00	1,225,000.00	1,606,250.00
AE	Expenditure incurred on seeds, manures, fertilizers to avert externalities measured in monetary terms (INR) per hectare	3,203.00	3,118.00	1,031.00
LQ	Based on soil fertility and availability of minerals, land has been classified into low, medium and normal/unaffected	26.67% as low	46.67% as medium	26.67% as normal
WQ	Based on the level of pH, TS, BOD, COD, Cl^-, oil and grease, colour, taste and turbidity, water has been classified into low, medium and normal/unaffected	46.67% as low	26.67% as medium	26.67%as normal
ODR	Classified as low, medium, and high based on the level of dust and smoke from the dump yard	33.33% as high	33.33% as high	3.33% as high
FSIZE	Size of farmland measured in hectares	4.40	3.68	3.95
DS	Distance of cropland from dump yard measured in kilometres	2.13	4.77	8.12
HG	Nearness of land to highways measured in kilometres	1.62	3.65	10.50

Source: Authors' estimates

Table 2 Estimates of agricultural damage loss function

Variable	Coefficients	*t*-value	Significance
Constant	197,466	17.05	***
Averting expenditure incurred for inputs	-14.34	-5.43	***
Land quality	-7138.72	-0.46	NS
Water quality	-5449.59	-0.45	NS
Distance of the land from dump yard	-14051.5	-5.09	***
R^2 value	0.76		
F-statistics	43.55		
Number of observations	60		

Source: Authors' estimates
***, ** and * denote significance at 1%, 5% and 10% levels, respectively

this study, the yield damage loss was selected as a dependent variable; independent variables include averting expenditure incurred for increased seed rate, application of organic manure and gypsum, land quality, water quality, and distance. The study indicates that solid waste effluents damage crop growth and lead to a decline in the yield. The estimates of the agricultural damage loss function are presented in Table 2. The analysis finds that independent variables contribute 76% of the variation in agricultural yield damage. It can be inferred from Table 2 that the coefficients of all the independent variables were negatively related to the yield loss. The *t*-statistics indicate that the distance of the farm land from the dump yard and averting expenditure was statistically significant at 1%. If the farm land was 1 kilometre closer to the dump yard, the agricultural yield would decrease by INR 14,052 per ha, and if the averting expenditure increased by INR 1, the yield loss would decrease by INR 15 per ha.

Factors influencing cropland value

The influence of qualitative and quantitative parameters on the value of cropland can be studied by employing the hedonic regression model. In this study, the qualitative and quantitative variables are land and irrigation water quality, distance from the dump site, nearness to highways; odour and size of the farm were found to influence the cropland value. Hence, it was

Table 3 Estimates of hedonic pricing model

Variable	Coefficients	*t*-value	Significance
Constant	12.28	199.92	***
Land quality	0.01	0.14	NS
Water quality	0.12	2.23	**
Unpleasant odour	-0.08	-1.50	NS
Size of farm land	0.03	2.16	**
Distance of the land from dump yard	0.15	6.17	***
Nearness to highway	-0.03	-3.32	***
R^2 value	0.84		
F-statistics	47.25		
Number of observations	60		

Source: Authors' estimates.
***, ** and * denote significance at 1%, 5%, 10% levels, respectively.

used for the estimation of parameters in hedonic model. The estimates of the hedonic pricing regression model are presented in Table 3. The regression results indicate that about 84% of the variation in the value of land was explained by land and irrigation water quality, distance from the dump site, nearness to highways, odour, and farm size. The coefficients of land quality, water quality, farm size, and distance from the yard were positively related to the value of cropland (Table 3). Nearness to highways and the landfill odour were negatively related to the value of cropland. The *t*-statistics in Table 3 indicate that the variables such as water quality, size of the farmland, and the distance of the farmland from the dump yard were influencing the farm land value significantly at 5% and 10% levels. It may be inferred from Table 3 that, ceteris paribus, the value of cropland would increase by 0.12% if the water quality improves from poor to medium; by 0.03% if the farmland increases by 1 hectare; by 0.15% if the distance from the yard increases by 1 kilometre; and by 0.03% if the nearness to highways decreases by 1 kilometre.

Conclusions

Rather than treating solid waste as waste, it should be considered a source of energy; the proper management of solid waste would generate biodiesel, fuel ethanol and liquid manure (Soni et al. 2016). Advanced technical measures are needed immediately to manage the waste and reduce externalities (Choudhury and Dutta 2017) such as loss in cropped area, decline in production, changes in cropping pattern, socioeconomic imbalances, labour migration, unemployment, decrease in share of farm income, changes in the employment pattern, and health problems (Govindarajalu 2003; Devi et al. 2010).

This study shows that the value of cropland is determined mainly by farm size and the distance of the farmland from the dump yard. As the farm land moves away from the dump yard, the intensity of negative externalities caused to the dumping of municipal solid waste falls. The agricultural yield loss is negatively influenced by the averting expenditure and the distance of the farmland from the yard. The decrease in crop land value and increase in agricultural yield loss is due to the impact of externalities caused by the yard; it shows that externalities fall as the distance from the yard increases. The farmers have to incur additional cost as averting expenditure to the cost of production. Hence, a proper disposal method has to be followed to prevent the leachate from affecting the soil, surface water, and groundwater. The local authorities should monitor municipal dump yards efficiently to minimize the negative externalities caused by municipal solid waste.

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