An Inquiry in to the Industrial Growth, Agricultural Production System and Environmental Deterioration in Bhavani Taluk of Tamil Nadu

Sekar C[*], Chandrasekaran M [2] and Maheshwari M[3]

The results form a part of the study conducted by State Planning Commission, Tamil Nadu

Introduction

Importance of Textile Industry in Indian Economy

Like any other developing countries, the Textile industry in India occupies an important place in the economy. It contributes 4% to the Gross Domestic Product (GDP) and accounts for 17% of total exports. It is the largest employment provider after Agriculture and about 82 million people are either directly or indirectly associated with this industry. The market size of the Textile industry (exports & domestic) is US$ 52 billion, at present and expected to reach US$ 110 billion by 2012

The Indian textile industry is rapidly repositioning itself as a global player. Towards this end, Indian manufacturers are increasingly integrating their operations, both vertically and horizontally. Yarn makers, weavers are moving forward into producing finished goods like Home Textiles and Garments. Simultaneously, small and medium knitwear exporters are integrating backwards into yarn processing and even spinning. Firms are adopting Information Technology to not only manage supplies, but also control production and enhance productivity.

With the "explosion of expectations", driving consumer demand and investments in retailing, the Indian firms are now catering to requirements of the entire value chain from spinning to branded garments and home textiles. Coupled with increase in the purchasing power of the consumers, strong economic growth and demographic advantages, the stage is well set in India today, for production, sale and consumption of Branded goods.

Significance of Textile Industry in the Tamil Nadu State Economy

Tamil Nadu is the forerunner in industrial development and in providing massive employment in the State. The Textiles Sector in Tamil Nadu is predominantly in the private sector, spinning oriented and labour-intensive because of the preponderance of the decentralized sector in most of the segments of the industry. There are 2950 large, medium and small spinning Mills in India, of which, 1734 Mills are located in Tamil Nadu. These include 18 Cooperative Spinning Mills, 8 National Textile Corporation Mills and 26 Composite Mills. The spinning capacity of these Mills is 16.44 million spindles with a labour force of about 2.31 lakh. During the year 2004-05, 3223.52 million kg of yarn

[*] Professor, (Agrl. Economics), Post harvest Technology Centre, [2] Professor and Head, Dept. of Agricultural Economics, [3]Associate Professor, Dept. of Environmental Sciences, Tamil Nadu Agricultural University, Coimbatore-641003.

was produced in the country, of which, Tamil Nadu contributed 1261.98 million kg of yarn. Successively this State is the number one producer of various varieties of yarn in the country. Due to the liberalization of global trade, the demand for the Indian Textile goods has increased manifold.

Industrial Development, Agriculture and Externality

Textile dyeing industry is one of the important industries in our country that consumes substantial volume of water and chemicals. Many dyeing factories do not have adequate provision for treating the effluents and hence it is discharged into the river without any proper treatment thus making the river water unusable. It also pollutes the sub-soil and ground water. Though industrial growth plays an important role in the economic development of the developing countries it is apparent that the pollution effects of various industrial units in India had been alarming. Even in early eighties, there were instances that the poly fibre factories in Dharwad district of Karnataka had polluted the *Thungabhadra* river resulting in health disorders, drinking water quality deterioration, crop and milk yield decline in buffaloes and mass mortality of fish (Anonymous, 1985). Krupanidhi and Bhushan (1988) in their study indicated the effects of distillery effluents in Udaipur where the dug wells located 200 – 300 meters away from the polluting units were found to be affected, which resulted in unsuitability of water for drinking and irrigation.

As far as western Tamil Nadu is concerned, the rivers *Amaravathy, Noyyal, Cauvery and Bhavani* are polluted by the discharge of effluent water from the nearby industries of various kinds. Rivers are important in these regions as they are the lifeline of agricultural development and economic growth. They also provide recreational facilities - fishing, boating etc. and support a large variety of fauna and flora and they are part of the natural scenic heritage. Due to frequent droughts during the past two decades, the run off water in these rivers is very minimum and the effluents penetrated into the soil and caused ground water pollution. The quality of both soil and ground water has deteriorated and directly impacted the agricultural production system.

Problem Focus

Textile Dyeing Industry and Externality of Effluents on Land and Water

The textile dyeing industries in the western Tamil Nadu comprising the districts of Coimbatore, Erode and Karur occupy a major role in developing the local economy as well as polluting the land and ground water sources extensively. But due to the recent enforcement of rules and stringent action initiated by Tamil Nadu Pollution Control Board, almost all the industries have constructed either Effluent Treatment Plant (ETP) or have become a member of the Common Effluent Treatment Plant (CETP). Many industries, of late have installed Reverse Osmosis (RO) plants to neutralize and recycle the effluents. Inspite of all these efforts the net impacts of externalities are substantial and alarming.

Some of the earlier studies conducted during different points of time have also highlighted the ill-effects of the industrial effluents. One such study conducted by Prabhakaran and Lakshmanan (1995) reported that waste water discharged from textile industries affected the river basins of *Noyyal, Bhavani and Amaravathi* and tributaries of river *Cauvery* rendering the downstream unusable for drinking, bathing, irrigation and fish culture. Prabhakaran (1995) was of the view that the effluent of textile industries had affected the ground water quality through infiltration by way of increased EC (Electrical Conductivity), SAR (Sodium Adsorption Ratio) and RSC (Residual Sodium Carbonate). The influence of such untreated effluents on underground water was also reported by Muthusamy *et al.,* (1987) and Gupta and Jain (1992). All the above studies have clearly highlighted the external effects of the industrial effluents on the local resource and environment.

External Effects of Effluents on Human and Animal Health

The effluents released from the dyeing factories are variously coloured, aesthetically unpleasant, invariably turbid, not conducive for aquatic organisms and unfit for drinking and other domestic purposes leading to serious human health hazards like itching, cracks, cough, fever, wheezing, etc., and in animals, the impacts were weight loss, poor milk yield and reduced reproduction rate. The ecological consequences of the effluents are associated with the degradation of the quality of the surface water body that receives the effluents, sedimentation of soil, poor ground water quality and air pollution.

Industrial Pollution, Crop Growth and Yield

The crops cultivated in the area that is located nearer to the area where wastewater stagnates have led to degradation of soil and water and consequently poor yield due to soil salinity and sodicity. Crop establishment and productivity are greatly affected and none of the food crops grow in these affected locations. Besides, the hygienic condition is also disturbed. This inhibits the germination rate, plant height and the overall crop stand significantly. It is understood that in many instances, the effluents drastically reduced establishment of crop, vigor index in the seedlings of crops like paddy, finger millet, cowpea, soybean and maize.

Some of the recent reports have also highlighted the substantial degradation of cropland, water and production agriculture in and around the areas, where dyeing factories are located. Besides natural resources degradation, there were occurrences of people suffering from health disorders and other morbidity related incidences. However it is a matter of fact that the dyeing industries have created opportunities for the people and labourers to get additional manpower employment, increased wage earnings and enhanced family income. There were also reports of migration of farm labourer towards dyeing industries in order to get a better standard of living and modern way of life. Hence it is clear that the dyeing industries have created both positive and negative externalities. It is a matter of fact that the dyeing industries have contributed significantly in the GDP growth of the economy and add considerable amount of foreign exchange but at the same time created resource degradation, health disorders, migration of native residents etc. So it is of utmost importance to examine the long term sustainability of resources, carrying resource capacity, rural ecology, production environment as well as human welfare, while addressing the issues of economic development. Considering the foregoing issues in mind, a study was undertaken with the following specific objectives.

Objectives

a. to analyze the external effects of industrial development on the quality of land, water resources, crop land, crop output, employment, income, migration, health and other associated socio-economic attributes,

b. to study the environmental implications of dyeing factories on the agricultural eco-systems and

c. to study the attitude of the stakeholders in conserving the valuable land and water resources and suggest workable policy prescriptions for internalizing the externalities.

Data Base and Methodology

The methodology for this study was finalized in consonance with the objectives, sampling design, data collection and tools of analysis. This section thus deals with the criteria for the selection of study area, sampling design for determining the responses under question, collection of data, analytical tools etc.

Project Area of the Study

For the present study, Bhavani taluk in Erode district of Tamil Nadu was purposively selected since the deterioration of land and ground water qualities and its impact on cropland, irrigation and drinking water, crop production, human and animal health, labour employment, farm income etc., were significantly pronounced due to the high intensity of dyeing and bleaching units. For the study four villages were purposively selected; two villages to represent the affected category (Bhavani and Andikulam villages) and the remaining two normal villages (Jambai and Oorathcikottai) to compare the impact with the unaffected category. Villages were selected based on the discussions held with the Government departments like TNPCB, Revenue department, Agricultural department and experts of textile and dyeing factory associations. The critical parameters which influence crop growth like pH, EC, TDS, TSS, chloride and sulphate concentrations were also considered while selecting the study villages. The unaffected study villages selected were located near the affected study areas to ensure otherwise similarity in agro-climatic conditions. In the second stage, two different categories of the respondents namely, (i) farm households and (ii) industrial workers were selected from each of the selected villages to represent all the categories. From each village 40 respondents were contacted for collecting the data. Thus, the total sample size comprised of 160 respondents. The category of industrial workers selected for the study included employees of the local organizations, petty shop owners as well as the workers in the nearby dyeing, bleaching and knitting units.

Data

The data collection for the current investigation, unlike socio-economic research was done with greater flexibilities and caution and logistic approaches and non-conventional means of information gathering was resorted to for collecting the oral history, the dynamics of land and ground water use, management, effluent treatment methods adopted, etc. It was noticed during data collection that the degradation of land and ground water quality has consequently resulted in reduction of the cultivated area, poor soil and water quality, crop productivity, declivity in farm labour employment, farm income etc.

Data were collected both from primary and secondary sources for the study. The primary data collected for the study pertained to the year 2004-06. In the first stage, the socio-physical environment of the study area was understood. Details on the temporal distribution of physical, climatological, institutional, demographic, socio-economic, cultural and historical components were collected from the village records maintained by the grass root level functionaries of the Government departments.

Method of Enquiry

The micro economic behavior of the village inhabitants depending on land and ground water and the trend in income pattern, impact on water bodies, and the indirect effects like equity, environmental sustainability and change in quality of water and soil were studied. The impact of land and ground water quality degradation on the crop production, environment, the averting and defensive expenditures incurred, the respondents' Willingness to Pay (WTP) for replenishing the original status of their cropland or averting the influence were derived through econometric analysis for micro level planning. The study also explored linkages between crop productions. The farm level losses were viewed primarily due to the degradation of land and ground water quality, changes in agricultural production systems, labour employment, etc. The study mainly focused its attention to analyze the changes in land and water quality, share of income from farming and changes in income and employment due to reduction in the cropland area over years. The study also attempted to quantify how the earnings of the respondents varied as a result of the degradation of land and ground water quality.

Externalities on Land and Water

As discussed already, the effluents let out by the industries have created external effects on land namely, land quality deterioration, decline in crop land value, poor crop yield, abandoning of farm lands, etc., in spite of expenditure incurred by the sample respondents on averting and defensive inputs. The impacts on agricultural land were assessed based on enquiry with respondents regarding declining cropland area, labour employment, cropping pattern and expenditure incurred on defensive and averting inputs and secondary information collected from development departments.

The discharge of improperly treated effluents by the industries had changed the water quality significantly. The change in water quality led to poor land quality and resulted in loss of crop yields, loss of manpower employment in agriculture, etc. The water quality was assessed through the quality parameters such as taste, colour, odour and turbidity. The water quality index was constructed on a three-point scale of one for poor water quality, two for average water quality and three for good water quality for each of the quality parameters namely, taste, colour, odour and turbidity. The combined effect of all these qualitative attributes formed the said index.

Averting and Defensive Expenditure

The averting and defensive expenditures for land included the additional input costs on seed materials, organic fertilizers, tank silt and green manures, soil amendments like gypsum, etc. As such, farmers did not incur any expenditure towards the treatment of water used for irrigation purposes, while the respondents spent substantial amount on averting and defensive inputs for good quality drinking water, which included fetching good quality water from the nearby non polluted or less polluted areas. The opportunity cost of spending time to get drinking water was also considered and quantified.

Externalities on Human and Animal Health

The externalities caused by the changes in the qualities of surface and sub-surface water included the common health disorders namely; fever, jaundice, dysentery, headache, allergies and to some extent skin rashes, etc. The expenditure incurred on human health included the cost of treatment namely, physician cost, cost of medicine and also the opportunity cost of time spent for taking treatment in health clinics.

Reduction in animal population, poor health status of animals, reduction in milk yield, reduced calving rate were the external effects observed on animals due to the degradation of land and water quality parameters.

Externalities on Socio-Economic Characteristics

Non availability of adequate period of farm employment, poor crop stand and declining livestock income and reduction in farm and non-farm income, land selling, diversion of farm lands for non agricultural activities and labour mobility towards non farm sector were the consequences of pollution externalities observed in the study villages.

Impact Assessment Techniques

Impact assessment techniques viz., loss in productivity, agricultural and aggregate damage functions, analysis for averting and defensive expenditures on cropland and drinking water, hedonic pricing techniques for valuation of croplands, and Contingent Valuation Techniques (CVT) to study the willingness to pay of the individuals for improved environmental status were employed for analyzing the data. The details of the models used for the analysis of the data for studying the various attributes are presented below.

Damage Function

The damage function links pollution to yield. There are two types of damage functions observed in agriculture *viz.*, agricultural damage functions and aggregate value damage functions. (For details refer Cropper and Oaters, 1992). For the present study, value damage functions were developed and employed. While the agricultural damage function was limited to agricultural damages alone, the aggregate damage function considered loss in productivity of cropland and labour, crop output, livestock production, change in quality of water, damage on human and animal health, etc. The damage function used for the study was of the following form.

YDDMGE = f {AVERTECP, LQI, WQI, PCLDI}
AGDMGE = f {AEXHH, AEXDW, WQI, PCLDI}

Where,

YDDMGE - Yield Damage (Rs./ha)

AGDMGE - Aggregate Damage (Rs./household)
PCLDI - Proximity of Crop Land to Dyeing / bleaching Industries
AVERTECP - Averting Input Expenditure for Crop (Rs./ha)
LQI - Land Quality Index*
WQI - Water Quality Index*
AEXHH - Averting Expenditure on Human Health (Rs./household)
AEXDW - Averting Input Expenditure for Drinking Water (Rs./ha)

***** *Poor-1; Average-2; Good-3*

It was expected that the averting expenditure for land inputs, the quality of land and water would have a direct impact on the crop yield. It was also believed that averting expenditures on land and drinking water might have negative influence on aggregate damage. Similarly, the averting expenditures on animal and human health would have negative association with household aggregate damage. It was also assumed that the proximity of croplands to the dyeing or bleaching units would influence agricultural as well as the aggregate damages significantly. Hence, it was also considered as a variable for functional analysis. Agricultural and aggregate value damages were computed as the differences in the value of each affected farm over the value of the each item before the occurrences of such damages. The agricultural and aggregate damage functions were estimated employing log-log regression model.

Hedonic Model

A hedonic model was chosen to study the influence of land and ground water quality and their effect on cropland in deciding the final value of croplands. Miranowski (1984), Bartick (1987) and Palmquist (1989) in their studies had demonstrated the application of hedonic techniques to value croplands, cropland sales and land improvements, respectively. Literature on hedonic pricing methods also suggested that quality attributes of land, area under fallow, distance between farm and the adjacent pollution source, crop productivity and household characteristics would influence the value of agricultural land significantly. The model used was of the following form.

VCLN = f {LQI, WQI, PCLDI, CINSY, SCATFA}

Where,

VCLN - Value of Crop Land (Rs./ha)
LQI - Land Quality Index (scale*)
WQI - Water Quality Index (scale*)
PCLDI - Proximity of Cropland to Dyeing and Bleaching Industries (distance in kilometers)
CINSY - Cropping Intensity
SCATFA - Share of Cropped Area to Total Farmland Area (percentage)

**Poor-1; Average-2; Good-3*

Several qualitative characteristics determine the value of land. Land and water quality indices were considered in the model. Besides, the proximity of cropland to the dyeing units, cropping intensity, percentage of cropped area to total farmland area were expected to exert significant influence on value of land. It was expected that LQI, WQI would have positive impact on land value and there was no *a priori* assumption about the behavior of variable PCLDI. After experimenting with various functional forms, the double log form of the regression model was specified.

Models on Averting or Defensive Expenditure

Averting and defensive expenditures were incurred to counteract the consequences of pollution externalities. The mitigating expenditure involved before the occurrences of pollution, investment made on inputs for reduction of harmful effects after the occurrence of pollution and the expenditure incurred by the respondents to protect their lands, animals, water resources from the health hazards were included under this category. With and without concept was not followed since the externality effects of land and water quality degradation was found to occur throughout the village.

For instance, the cost involved in using additional quantity of seeds, organic manures, application of soil amendments like gypsum, coir pith were considered to be the land based averting expenditure due to the degradation of croplands consequent to the degradation of the quality of land and ground water by the discharge of untreated effluents. As stated earlier, the farmers in general did not undertake any treatment for irrigation water. Expenditure incurred in getting protected water from the nearby areas was considered under averting expenditure for drinking water.

The actual expenditure incurred towards human health included the cost of the physician, the cost of the medicine and the opportunity cost of time spent in taking treatment. It was assumed that the expenditures were perfect substitutes for estimating the ill effects of the dyeing factory effluents on human health.

The determinants of actual averting and defensive expenditures for croplands were estimated for the farm respondents of all the villages considered for the study and for drinking water, the determinants of averting and defensive expenditures were calculated for the affected categories of the respondents. The determinants of averting and defensive expenditure were studied by using the following Model.

Y_1 = f {FSIZE, EDN, SCATFA, PCLDI, LQI, QOMA, AWARE, WQI}
Y_2 = f {HI, EDN, HHSIZE, WQI, AWARE}

Where,

Y_1 = Actual per hectare expenditure on averting actions for croplands (Rs. /ha)
Y_2 = Actual household expenditures on averting actions for drinking water (Rs. /household)
HI - Household Income (in Rs.)
FSIZE - Farm Size (in ha)
EDN - Education (scale*)
SCAFTA - Share of Cropped Area to Total Farmland Area (per centage)
QOMA - Quantity of Organic Manure Applied (t/ha)
WQI - Water Quality Index (scale**)
LOI - Land Quality Index (scale**)
AWARE - Awareness of Environmental Externality (scale***)

HHSIZE - Size of the Family (numbers)
PCLDI - Proximity of Cropland to Dyeing unit (in km)

Illiterate-0; Primary-1; Secondary-2; Graduates-3. (*)
Poor-1; Average-2; Good-3 (**)
Poor-1; Medium-2; High-3. (***)

The model for the actual per hectare expenditure on averting actions of cropland as well as for drinking water was constructed for the sample respondents. The household income, age and educational level were expected to have a positive influence on averting actions of cropland. It was also hypothesized that education would also influence the averting actions of the respondents positively. The proximity of the cropland to the dyeing unit was also considered because it was thought that it would influence averting actions significantly.

Contingent Valuation Technique (CVT)

The CVT determines consumer's preferences by constructing hypothetical markets. CVT arrives at the Willingness to Pay (WTP) to continue receiving benefits. An attempt was made to examine the economic valuation of the land and water quality using CVT. Willingness to Pay was used to assess the value of changes in the quantity and quality of agricultural land, irrigation and drinking water in the study area. The survey schedule was designed in such a way that it did encapsulate the knowledge and the attribute of the respondents towards the land and water quality degradation, their perception and interest in correcting actions. Information was also elicited to study the dependence of the households on agriculture for employment, income, etc., problems faced by them in the collection of water, measures if any taken by the users when shortage was realized and their WTP for protecting irrigation water.

In order to get responses for the WTP, the following hypothetical situation was created. The households were asked what their major requirement to improve their agricultural activities was. Their response was good quality irrigation water and also they wanted either to deepen their well or to draw water from the unaffected locations. The households were asked to assume that local institutions sponsor a part of the expected expenditure that would be incurred. The capital cost was taken to be rupees one lakh. For meeting the rest of the expenses, each household's WTP towards its capital in monetary terms and their mode of payment was sought. (Note: The capital cost was fixed based on the information obtained during the survey from the farmers, experts and field level functionaries, income, living standards of the village inhabitants, etc).

The WTP of the households towards the capital cost for the deepening or drawing good quality water from the nearby sources was added after annualizing the capital investment, taking a life annualized capital cost time of 15 years for the capital investment at 12 per cent rate of interest. Similarly, using the wage rate per day as prevalent in the study areas during the time of survey, the labour time or days, the villagers who were willing to contribute towards the capital cost in their region were converted in to monetary values. Hence WTP for good quality water and ecological functions was the sum total of WTP for annualized capital and the mode of payment.

The explanatory variables used for analyzing maximum WTP were; age of the respondent, household composition, educational level, per capita agricultural land, per capita standard cattle unit, interest in improving agricultural activities, perception of quality of degradation of land and water, distance of dyeing units from the farm, etc.

WTP = f {AGE, HHSIZE, HHEDN, HHINCOME, PCAL, PCSCU, IIAGA, PLGWD, PCLDI}

WTP	- Willingness to Pay (Rs. / household)
AGE	- Chronological Age of the Respondent (in years)
HHSIZE	- Size of the Household (in number)
HHEDN	- Household Head's Education (scale)*
HHINCOME	- Household Income (Rs. /annum)
PCAL	- Per Capita Agricultural Land (in hectare)
PCSCU	- Per Capita Standard Cattle units (number)
IIAGA	- Interest in Improving Agricultural Activities (scale)**
PLGWD	- Perception of Land and Ground Water Degradation (scale)***
PCLDI	- Proximity of Cropland to Dyeing units (in km)

** -Illiterate-0; Primary-1; Secondary-2; Graduate-3*

***-Not interested-1, Somewhat-2, Fairly-3, Verymuch-4*

**** - Not at all-0; Somewhat-1; Very much-2*

Expected Relationship

The economic theories and existing literature on CVT suggest that WTP for improved environmental quality is directly related to the age of the respondent. It was also expected that with an increase in the number of members in the household, dependency on input for agricultural land would also increase. Higher the perception of degradation as well as the interest in improving the agricultural activities, the more was expected about the WTP. It was also expected that a person with higher education would be more concerned with the protection of the environment. The nature of the relationship also depended on other factors like income of the household, etc. Similarly, distance between the farm and the dyeing units were yet another variable expected to affect WTP significantly. Another important variable having direct link with the degradation of the quality of water was the livestock number, which was taken as per capita standard cattle units, which was assumed to have a positive coefficient particularly for the farm households. It was also expected that the per capita agricultural land would be correlated positively with WTP. Similarly, it was assumed that the proximity of the cropland to the dyeing unit would capture the effect of distance on WTP. A person residing nearer to the dyeing unit was expected to pay more for the improvement of agricultural activities due to the maximum realization of benefits.

Impact of effluent on the quality of groundwater and soil characteristics

In order to assess the changes in the quality of groundwater and the physico – chemical properties of soils, both water samples and soil samples and analyzed for various physico chemical properties.

Collection of water samples

Groundwater samples were collected from the earmarked wells as per the standard procedure. Containers were rinsed 3 or 4 times with the water sample before the sample were drawn. Collected water samples were stored in the refrigerator at 4ºC for further analysis. To avoid changes from chemical and biological activities minimum time were given between the time of collection and laboratory evaluation. The collected water samples were subjected to various physico- chemical characteristics as per the methods prescribed in Table 1.

Table 1. Standard methods followed for the analysis of water samples

Estimation	Remarks	References
pH	1: 2.5 organic waste: distilled water using pH meter	Falcon *et al.* (1987)
EC (dS/m)	1: 2.5 organic waste: distilled water using conductivity bridge.	Falcon *et al.* (1987)
Chloride (mg l^{-1})	Mohr's method	Jackson (1973)
Sulphate (mg l^{-1})	Turbidimetric method using spectrophotometer at 420 nm	Jackson (1973)
Calcium (mg l^{-1})	Versenate titration method	Jackson (1973)
Magnesium (mg l^{-1})	Versenate titration method	Jackson (1973)
BOD (mg l^{-1})	Standard procedure	APHA (1989)
COD (mg l^{-1})	Standard procedure	APHA (1989)
Heavy metals (mg l^{-1})	AAS	Lindsay and Norwell (1973)

Note: dS/m – deci Simon per mole; mg l^{-1}- milligram per litre

Collection of soil samples

The soil samples were collected from the sample villages of four taluks as per the standard methods described below.

The land was selected at random and the surface litters were removed at the sampling spots. Then the auger was used to take the sample upto a depth of 15 cm and samples were drawn. At least 10 to 15 samples were collected from each sampling unit, mixed thoroughly and from the composite samples, representative samples were taken for further processing. The sample collected from the field was dried in shade by spreading on a clean sheet of paper after breaking the large lumps. Then the soil material was sieved through a 2mm sieve. The material passing through the sieve was collected and stored in a clean container with proper labeling for laboratory analysis.

The processed soil samples were subjected to various physico- chemical characteristics as per the methods prescribed in the following Table 2.

Table 2. Standard methods followed for the analysis of Soil samples

Estimation	Remarks	References
pH	1: 2.5 organic waste: distilled water using pH meter	Falcon *et al*. (1987)
EC (dS/m)	1: 2.5 organic waste: distilled water using conductivity bridge.	Falcon *et al*. (1987)
Preparation of di acid extract	H_2SO_4 : $HClO_4$ @5:2	Biswas *et al.* (1977)
Preparation of triacid extract	HNO_3 : H_2SO_4 : $HClO_4$ @ 9:2:1	Piper *et al*. (1966)
Available Nitrogen (kg/ha)	Alkaline permanganate method	Subbiah and Asija (1956)
Available Phosphorus (kg/ha)	Colorimetric method	Olsen *et al.* (1954)
Available Potassium (kg/ha)	Neutral normal ammonium acetate extract	Stanford and English (1949)
Heavy metals	AAS	Lindsay and Norwell (1973)

Findings of the Study

The data collected from the sample respondents of the study villages were analyzed using the statistical tools explained earlier and the results are presented in consonance with the specific objectives of the study. The overall family size of the respondents was 3.67 and it was 3.93 for the unaffected category and 3.40 for the affected groups. It was inferred that about 29 per cent were illiterates in the affected villages where as it was only 18.64 per cent in the unaffected area. Only about 22 per cent had completed their secondary education in the affected area. This might be due to the availability of immense employment opportunities in and around the sample villages.

Irrigation

The river Bhavani and both the open and bore wells are the major sources of irrigation. From table 3 it could be revealed that the total numbers of open wells in the affected villages were 43 whereas, it was 56 in unaffected area. The average depth of the open well was almost equal in both the categories. But, the depth of bore well in the unaffected villages was deep by 15mts. The examination of the results also shows that the percentage of open wells abandoned in the affected villages was 6.98 whereas it was only 1.79 per cent in the unaffected area. This might be due to the non-availability of quality water in the shallow depth and improper maintenance of water table by conservation and abatement techniques.

Table 3. Well Irrigation

S. No	Particulars	Affected Village	Unaffected Village
1.	Number of wells	43	56
2.	Depth of open well (in mts.)	18.80	18.78
3.	Percentage of wells abandoned	6.98	1.79
4.	Percentage of wells with quality water throughout the year*	16.28	98.21
5.	Average depth of bore wells (mts.)	101	116
6.	Water quality (%) **		
	Good	62.50	56.36
	Medium	12.50	43.64
	Poor	25.00	-

**Percentage calculated based on the total number of open wells in the sample farms*
*** - As perceived by the respondents*

Sources of Irrigation

Table 4 reveals the share of area irrigated by various sources in the affected and unaffected areas. From the table, it is clear that in the affected villages, the crop area is irrigated only by canal and wells. But, the area irrigated by canal and wells together has increased by 24.10 per cent over the last 10 year period. The total area under irrigation has increased by 1.55 times in the affected villages, whereas, an increase of about 2.79 folds was noticed in the unaffected villages, which is marginally higher than the affected area.

Table 4. Sources of Irrigation

S.No	Sources	Affected Villages		Unaffected Villages	
		10 Years back	At the time of survey*	10 Years back	At the time of survey*
1.	Canal	46.63	27.91	12.87	7.80
2.	Well	15.45	12.45	64.35	75.90
3.	Canal + well	8.78	32.86	15.86	8.51
4.	Rainfed	23.08	21.50	6.92	5.31
5.	Bore well	-	0.23	-	-
6.	Open well+ Bore well	6.04	5.05	-	2.48

*2004

Area and Productivity

In Bhavani, the total area under irrigation has increased by 1.5 times in the affected villages whereas in the unaffected villages an increase of about 2.8 folds was noticed over a period of two decades. The productivity of majority of the crops declined in the affected villages. The critical analysis (table 5) of the productivity of crops reveals that the productivity of many of the crops declined in the affected villages. In the past, the major crops grown in the affected areas were turmeric, sugarcane, paddy, fodder cholam, cotton, vegetables, gingelly and banana. In the unaffected villages area under turmeric was about 17 per cent whereas in the affected villages it was only 8 per cent. In the affected villages, about 16 per cent of the total cultivated area was under fodder cholam compared to five per cent in the unaffected area. The yields of gingelly and coconut in the affected area were comparatively low by 9.33 and 39.04 per cent, respectively.

Table 5. Comparative Analysis of Area and Yields of Major Crops

S. No	Crops	Affected Villages		Unaffected Villages		Difference	
		Area (%)	Yield (t /ha)	Area (%)	Yield (t /ha)	Yield (t /ha)	Per cent
1.	Turmeric	8.17	7.79	17.01	12.87	(-)5.08	(-)39.47
2.	Sugarcane	23.34	90.26	23.04	96.96	(-)6.07	(-)6.91
3.	Paddy	38.41	5.02	30.49	5.11	(-)0.09	(-)1.76
4.	Fodder Cholam	16.57	6.17	5.31	6.91	(-)0.74	(-)10.71
5.	Gingelly	8.07	0.68	10.64	0.75	(-)0.07	(-)9.33
6.	Banana	3.30	110.10	-	-	-	-
7.	Coconut*	0.38	9880	2.84	16,207	(-)6327	(-)39.04
8.	Tapioca	1.36	36.68	0.71	37.05	(-)0.37	(-)1.00
9.	Green gram	0.39	1.01	-	-	-	-
10.	Groundnut	-	-	9.96	20.4	-	-

**yield in Nuts/ha.*

Attitude of the Respondents towards the Decline in Agricultural Activities

It is obvious from the table 6 that the interest of the farmers towards agriculture is declining. It is clear that about 95 per cent of the respondents in the affected villages expressed that the scarcity of water was the main reason for this decline. About 40 per cent were of the view that the declivity in agricultural income was the major reason for the poor performance of agriculture.

Table 6. Farmers Opinion towards Decline in Agricultural Activities

S.No	Particulars	Percentage
1.	Non availability of Quality Water for Irrigation	95
2.	Labour Scarcity	75
3.	Decline in Agricultural Income	40

Employment Pattern

The employment distribution of the household is reported in Table 7. In the affected villages only about two per cent of the households were engaged in agriculture alone whereas it was about 43 per cent in the unaffected villages. In the affected villages about 37 per cent of the households were employed in farm and non-farm activities whereas it was about 22 per cent in the affected villages. The farm and diary activities constituted the second largest proportion at 31.67 per cent in affected villages and it was only 6.67 per cent in the unaffected villages. The combination of all the three activities constituted 21.67 per cent in affected villages and it was 13.33 per cent in unaffected villages.

Table 7. Occupational Distribution of Households

S.No	Particulars	Affected Villages		Unaffected Villages	
		Number	Per cent	Number	Per cent
1.	Farm activity only	1	1.67	26	43.33
2.	Farm + Dairy activities	19	31.67	4	6.67
Households engaged in on-farm activities only		**20**	**33.34**	**30**	**50.00**
3.	Farm and off-farm activity	5	8.33	9	15.00
4.	Farm, non farm and off-farm activity	13	21.67	8	13.33
5.	Farm and non farm activity	22	36.67	13	21.67
Total sample households		**60**	**100.00**	**60**	**100.00**
Earning members in sample households (in numbers)		**116**		**106**	

Income

The income distribution of the sample households is given in the Table 8. When the households are considered, majority earned their wages through the combination of farm with non farm activities like working in private companies or by running own bleaching and dyeing units or renting their land either for factories or for residential purposes. The average annual income of the affected household was Rs. 1,33,610/- where as in the unaffected area the average annual income was Rs. 1,19,582/-Since the respondents has either been employed as wage earners or running their own industrial unit, the share of non-farm income is found to be substantial. In the affected villages, the income from farm activities alone constituted 44.38 per cent. This was 57.39 per cent in unaffected villages. In other categories, farm income formed a part.

Table 8. Pattern of Average Annual Income in the Sample Households

S. No	Particulars	Affected Villages		Unaffected Villages	
		Amount (Rs.)	Per cent	Amount (Rs.)	Per cent
1.	Farm income only	1,500	1.12	53,687	44.90
2.	Farm + Dairy activities	52,327	39.16	11,366	9.51
Total income from on-farm activities alone		**53,827**	**40.28**	**65,053**	**54.41**
3.	Farm and off- farm income	5,483	4.10	3,562	2.98
4	Farm, non-farm and off- farm income	20,967	15.69	14,433	12.07
5.	Farm and non- farm income	53,333	39.92	36,533	30.55
Average Annual income per Household		**1,33,610**	**100.00**	**1,19,582**	**100.00**

Labour Migration

From the table 9 it is implicit that in the affected area about 53 per cent of the households migrated from agriculture to other non-farm activities when compared to 20 per cent in the unaffected area. The percentage of people migrated from the households in the affected village was 19.92 per cent which was about 10 per cent high when compared to the unaffected area. The main reasons contributed for this migration was poor income from agricultural activities and their interest to earn more from the assured sources without much hard work.

Table 9. Migration Details

S. No	Particulars	Affected Villages	Unaffected Villages
1.	Percentage of Migration of head of the household	53.33	20.00
2.	Percentage of migration of the household members	19.92	9.25
3.	Permanent migration of the family members	95.00	-
4.	Average number of days of migration	296	74
	Reasons for Migration		
1.	Poor farm income	65.00	4.55
2.	To earn more	45.00	95.45
3.	Poor water quality	27.56	-
4.	Labour problem	20.00	-
5.	To pursue higher education	20.00	-

Externalities on Human and Animal Health

As stated already, the effluents discharged from the industries have affected substantially the quality of water and soil, which in turn created disorders in human and animal health. It could be understood from the table 10 that the respondents in the affected area had to spend more than the unaffected area. In the affected area, an average amount of Rs.100 was spent towards physician cost and Rs.30 towards the medicine. About six per cent loss in milk production was reported in the dairy sector. Other disorders like no calving and weight loss were also witnessed.

Table 10. Externalities on Human and Animal Health

S.No	Particulars	Affected village
	Human Health	
1.	Cost to physician (Rs/annum/household)	1200
2.	Cost of medicine (Rs./annum/household)	360
	Animal Health	
1.	Loss of income from milk production (Rs./ annum)	2719
2.	Percentage loss in milk yield	6.32

Opinion of Respondents about Water Quality

The respondents in the unaffected villages use their well water for drinking and other domestic purposes whereas, their counter parts in the affected areas depend on the public taps (municipality water). On an average people travel a distance of about 0.52 km to fetch water. The respondents were also asked about the deterioration in water quality in terms of taste, colour, turbidity and odour and the results obtained are reported in Table 11. As noticed in other sample villages, the quality was observed to be poor in the summer season when compared to rainy season.

Table 11. Opinion of Respondents about Water Quality

S.No	Characters	Parameters	Per cent
1.	**Taste** Summer Season	Poor	-
		medium	25
		Good	75
	Rainy Season	Poor	-
		medium	25
		Good	75
2.	**Colour** Summer Season	High	-
		Medium	25
		Low	75
	Rainy Season	High	-
		Medium	25
		Low	75
3.	**Turbidity** Summer Season	High	25
		Medium	-
		Low	75
	Rainy Season	High	25
		Medium	-
		Low	75
4.	**Odour** Summer Season	High	-
		Medium	-
		Low	100
	Rainy Season	High	-
		Medium	-
		Low	100

Willingness to Pay (WTP)

The WTP of the households to pay for improving their agricultural activities and for internalizing externalities was estimated. Majority of the households expressed that poor income was the major hurdle affecting the ability to pay. About 53 per cent of the farmers were willing to pay between Rs.25, 001 and Rs.50, 000 towards internalizing externalities. About 42 per cent were for quarterly mode of payment, 10 per cent for half yearly mode and 15 per cent for annual mode of payment.

Table 12. Willingness to Pay

S.No	Particulars	Number	Per cent
1.	Households' willing to pay	40	66.67
2.	Amount		
	Rs.20, 001-Rs.25,000	3	5.00
	Rs.25, 001-Rs.50,000	32	53.33
	Rs.50, 001-Rs.75,000	5	8.33
3.	Not willing to pay	20	33.33
4.	Mode of Payment		
	Quarterly	25	41.67
	Half yearly	6	10.00
	Annual	9	15.00

Averting and Defensive Expenditure

Dyeing factory effluents have made the farmers to incur the averting expenditure on cropland and irrigation water, which is indicated in Table 13. It is obvious from the table that farmers had to spend more for banana.

Table 13. Averting Expenditure for Crops

S.No	Particulars	Averting Expenditure (Rs./ha)
1.	Paddy	988
2.	Sugarcane	844
3.	Turmeric	823
4.	Banana	3705
5.	Tapioca	988

Soil and Water Sample Analysis

Physico – Chemical characteristics of water samples collected at Bhavani taluk

The results of the water sample analysis of Bhavani taluk is presented in table 14.

Table 14. Physico – Chemical Characteristics of water samples collected in the Study villages of Bhavani taluk

S.No	Parameters	Affected	Unaffected
1.	pH	8.56 – 9.20	6.55 – 7.22
2.	EC (ds/m)*	2.56 – 5.27	0.58 – 1.98
3.	BOD (mg/l)**	96 – 170	24 – 85
4.	COD (mg/l)	235 – 425	60 – 210
5.	Chloride (mg/l)	198 – 490	85 – 147
6.	Sulphate (mg/l)	30 – 60	15 – 45
7.	Calcium (mg/l)	610-3650	356– 1850
8.	Magnesium (mg/l)	25-85	20-48
9.	SAR	32 - 37	24 - 28
10.	Chromium (mg/l)	0.25 – 0.89	BDL – 0.003
11.	Lead (mg/l)	0.14 – 0.79	BDL – 0.003
12.	Cadmium (mg/l)	0.12 – 0.48	BDL – 0.005
13.	Nickel (mg/l)	0.17 – 0.87	0.001 – 0.08

*ds/m – deci Simon / mole; **mg/l – milligram/litre

The pH of the water samples collected from affected villages of Bhavani taluk were high (8.56 to 9.20) when compared to samples collected from unaffected villages of same taluk (6.55 to 7.22). Samples of affected region recorded higher EC value of 2.56 to 5.27ds/m which is much higher than the critical limit of 2.25 dSm^{-1} prescribed for irrigation water; It is very high when compared to unaffected regions which recorded 0.58 – 1.98ds/m which is slightly higher than the critical limit.

In general, the BOD values of samples from affected villages were found to be higher recording 96 to 170mg l^{-1} compared to 24 to 85 mg l^{-1} in the unaffected regions. The BOD values of both the regions are much higher than recommended limit 2 mg l^{-1} for drinking and also 30 mg l^{-1} for irrigation. The COD in affected area water samples are 235 – 425 mg l^{-1}, which are higher than the prescribed limit whereas in the unaffected villages it ranges between 60 and 120 mg l^{-1} only.

The chloride content recorded higher value of about 198 to 490 mg l^{-1} in the affected regions than in the unaffected areas which recorded 85 – 147 mg l^{-1}. The sulphate content in the affected regions accounts to about 30 – 60 mg l^{-1}.compared to 15 – 45 mg l^{-1} in unaffected regions. Both the chloride and sulphate values of water samples of both the affected and unaffected regions are well below the critical limits. Calcium contents of the affected samples are also very high when compared to unaffected region samples. The water samples of affected villages recorded 32-37 sodium absorption ratio which is well above the critical limit and the samples of unaffected villages also recorded SAR, which is slightly higher than the limit.

The heavy metals like chromium, lead and cadmium contents were higher in affected areas compared to unaffected areas where they are below detectable limits. Whereas, the water samples collected from affected regions recorded the Cr ranging from 0.25 – 0.89, Pb ranging from 0.14 – 0.79, Cd ranging from 0.12 – 0.48 and 0.17 – 0.87 mg l^{-1} of Ni which are higher than the maximum permissible limits.

Changes in soil properties

The soil samples collected from the study villages of Bhavani taluk are presented in table 15

Table 15. Characteristics of soil samples collected at the study villages

Parameters	Affected	Unaffected
pH	7.70 – 8.94	6.20 – 7.12
EC (ds/m)	2.14 – 3.99	0.12 – 0.69
Available Nitrogen (kg/ha)	120 – 350	115 – 169
Available Phosphorus (kg/ha)	20 – 78	10 – 36
Available Potash (kg/ha)	105 – 174	21 – 147
Chromium (mg/kg)	23 – 85	BDL
Lead (mg/kg)	1.47 – 4.25	BDL – 0.05
Cadmium (mg/kg)	1.36 – 4.78	BDL
Nickel (mg/kg)	9 - 19	0.001 – 0.07

The soil samples collected from Bhavani recorded the highest pH in affected regions (7.70 – 8.94) compared to unaffected regions (6.20 – 7.12). The EC value was also higher in samples of affected villages which recorded 2.14 – 3.99 ds/m when compared to EC values of samples of unaffected villages (0.12 – 0.69 ds/m).

The available N content higher in affected villages (120 – 350 kg/ha) which comes under the medium rating (280 - 450kg/ha). The unaffected regions showed values between 115 – 169 kg/ha which comes under the low rating (0 – 280 kg/ha). The available P content was ion the range of 20 – 78 kg/ha in affected regions and in the unaffected region, it was between 10 – 36 kg/ha. Both the samples come under high rating of >22 kg/ha. The available K content was maximum in affected regions (105 – 174/ha) which is classified under low rating (<280kg/ha) when compared with the unaffected villages which exhibited an available K content of 21 – 147 kg/ha and lies in medium rating (118 - 280kg/ha).

In general, all the four heavy metal contents were maximum in soil samples collected from affected villages than unaffected villages. The level of chromium was found to be in the range of 23 -85 ppm in affected regions but it was below detectable limit in unaffected regions. However, the chromium level of affected villages is also well with in the critical limit of 100 ppm. Concentration of lead in affected soil samples ranged between 1.47 – 4.25 ppm when compared to unaffected regions which recorded BDL – 0.05 ppm, which are well below the permissible limit 100 ppm. The heavy metal cadmium was at higher level (1.36 – 4.78 ppm) in affected villages when compared to unaffected villages (BDL). The affected villages contain higher values than the unaffected villages. It exceeds the critical limit of 3.0 ppm. The soil samples of affected villages recorded a nickel content ranged between 9- 19 ppm whereas, it was in the range of 0.001 and 0.07 in samples of unaffected regions, which are well within the prescribed limit of 50 ppm.

Workers

In the study area, both farm and non farm labourers were also contacted to understand the ill effects created by the effluents of the textile industries. The survey was undertaken in both affected and unaffected areas mainly to compare the labour employment, income, migration and household welfare.

The youths in the affected villages employed themselves in the industries located in and around the sample villages. The wage rate of the industrial units was high when compared to the agricultural labour wage. It was reported that the work culture was quite comfortable when compared to the agricultural activities.

Employment

The duration of the employment and the wages earned by the sample respondents of the workers category are presented in Table 16. It is revealed that the average days of employment in the affected area are more. Also, the average wage earning is high in the affected area by 25.39%. This is due to the luring employment opportunities provided by the industry to the people in the affected area. Also, the annual income is high in the affected area when compared to unaffected area. The employment of other family members in the affected area shows that only 36.84 per cent were found to depend on agriculture while it was about 87 per cent for the unaffected category. Employment in private sectors was 15.79 per cent in the affected area whereas it was only 6.25 per cent in the unaffected area. The income earned by the other family members in the affected area was found to be more by Rs.9,895 when compared to unaffected villages.

Table 16. Pattern of Employment

S. No.	Particulars	Affected Area	Unaffected Area
1.	Days of monthly employment	23.25	21
2.	Average wages earning (Rs./month)	2530	2170
3.	Number of family members working in their own industry	0.45	-
4.	Number of family members working in other industries	0.50	0.75
5.	Annual income of respondents (in Rs.)	30,360	24,211
	Employment of the Family Members		
1.	Dyeing	47.37	-
2.	Agricultural labourers	36.84	87.5
3.	Private company	15.79	6.25
4.	SHG	-	6.25

External Effects

The analysis of the externality has come out with the fact that about 20 per cent of workers were suffering from skin related ailment and tuberculosis (TB). The TB patients are undertaking free treatment. Some patients are undergoing treatment at their own cost by spending about Rs.250 towards physician and Rs.300 towards medicine per month. Other acute problems like cracks, boils, itching, skin rashes were also reported throughout the year. On an average, an individual spends about Rs.40 and Rs.56.67 towards physician cost and medicine cost per annum. About 40 per cent reported for no illness. The results are presented in Table 17 below.

Table 17. External Impacts on Labourers

S.No	Particulars	Affected (Per cent)
1.	Skin Cracks	35
2.	Boils, itching, etc.	20
3.	Skin rashes	5
4.	No problem	40
5.	Working days lost	Nil
6.	Cost to physician (Rs/annum)	40
7.	Cost of medicine (Rs/annum)	56.67

Results of Yield Damage Function

Agricultural yield damage was estimated for the sample households and the results are presented in Table 18.

Table 18. Estimates of Yield Damage Function

S.No	Variable	Co-efficient	t-ratio
1.	Constant	20909.92	15.096**
2.	Averting Expenditure	-0.2711	-1.052
3.	Land Quality	-2932.49	-3.495**
4.	Water Quality	-594.38	-2.192*
5.	Proximity	-2960.89	-3.476**

*R^2 = 0.57, * significant at five per cent, ** significant at one per cent level*

The critical analysis of the yield damage function reveals the fact that about 57 per cent variation in agricultural yield damage was contributed by averting input expenditure to land, proximity of cropland to dyeing or bleaching industries, water quality and land qualities. Land quality, water quality and proximity to dyeing or bleaching industries have significant influence on agricultural yield damage and the impact is found to be negative. If the land quality index shifts from poor to medium, agricultural yield damage decreases by Rs.2932.49/ha and if proximity of cropland to industries increases by one km, the agricultural yield damage decreases by Rs.2961/ha.

Estimates of Aggregate Damage Function

The results of the aggregate damage function for the household is presented in Table 19.

Table19. Estimates of Aggregate Damage Function

S.No	Variable	Co-efficient	t-ratio
1.	Constant	3817.64	8.37**
2.	Averting Expenditure on Drinking Water	-0.5363	-1.316
3.	Averting Expenditure on Human Health	-4.2791	-3.649*
4.	Water Quality	-240.03	-3.418**
5.	Proximity of Cropland to Industries	-82.03	-0.250

*R^2 = 0.32, * significant at five per cent, ** significant at one per cent level*

One could observe that 32 per cent of aggregate damage was influenced by independent variables like averting expenditure on drinking water, human health, water quality and proximity of cropland to dyeing or bleaching industries. Influence of averting expenditure on human health and water quality was found to be negative. When water quality shifts from poor to medium aggregate damage will reduce by Rs.240 per household.

Results of Hedonic Model

A Hedonic model was employed to estimate the influence of land quality, water quality, proximity of cropland to industries, cropping intensity and share of cropped area to total farmland area on the value of cropland and the influence was found to be 52 per cent. The results are presented in the Table 20.

Table 20. Estimates of Hedonic Model

S.No	Variable	Co-efficient	t-value
1.	Constant	3670.12	0.461
2.	Land Quality	179.19	0.058
3.	Water Quality	903.31	-5.194**
4.	Proximity to Industries	-10265.22	-4.196**
5.	Cropping Intensity	-86.02	-0.574
6.	Share of Cropped area	-269.01	-5.440**

*R^2 = 0.52, ** significant at one per cent level*

The analysis of hedonic pricing techniques implies that water quality, proximity of cropland and share of cropped area have significant influence on value of cropland, with proximity and share of cropped area having negative impact. When the proximity to the dyeing or bleaching industry increases by one kilometer, value of cropland would decrease by Rs.10, 265 per ha.

Land Averting Expenditure Model

The results of land averting expenditure model is presented in Table 21. It was also found out that the household income and awareness on environmental externalities have positive influence on drinking water averting expenditure. When awareness on environmental externality increases by one stage i.e., poor to medium, drinking water averting expenditure would increase by Rs.188 per household.

Table 21. Estimates on Land Averting Expenditure Model

S.No	Variable	Co-efficient	t-value
1.	Constant	2175.26	1.203
2.	Farm Size	-12.198	-0.073
3.	Household Education	554.811	3.353**
4.	Share of cropped area	7.634	0.932
5.	Proximity of Cropland to Industries	-295.591	-0.787
6.	Land Quality	-187.673	-0.476
7.	Quantity of organic manure	-552.966	-2.539*
8.	Awareness on environmental externalities	307.770	0.754
9.	Water Quality	-190.731	-2.636*

*R^2 = 0.53, * significant at five per cent, ** significant at one per cent level*

Drinking Water Averting Expenditure

Drinking water averting expenditure was found to be influenced by household income, education, household size, water quality, awareness etc. From the table 22, it could be inferred that the household income and awareness on environmental externalities have positive influence on drinking water averting expenditure. When awareness on environmental externality increases by one stage ie, poor to medium drinking water averting expenditure increases by Rs.187 per household.

Table 22. Drinking Water Averting Expenditure

S.No	Variable	*Co-efficient*	t-value
1.	Constant	-119.91	-0.847
2.	Household Income	0.0759	2.496*
3.	Education	46.90	1.767
4.	Household Size	-6.746	-0.332
5.	Water Quality Index	-5.032	-0.543
6.	Awareness on environmental externalities	187.45	5.935**

*R^2 = 0.58, * significant at five per cent, ** significant at one per cent level*

Estimates on Willingness to Pay

WTP was used to assess the values of change in the quality of agricultural land, irrigation and drinking water in the study area. The results of WTP presented in Table 23.

Table 23. Estimates on Willingness to Pay

S.No	Variable	Co-efficient	t-value
1.	Constant	-9341.351	-0.827
2.	Age	153.816	1.214
3.	Household size	-287.469	-0.379
4.	Education	601.714	0.575
5.	Per capita agricultural land	868.324	2.932*
6.	Per capita standard cattle units	464.618	12.805**
7.	Interest in improving agricultural activities	932.532	2.654*
8.	Perception on land and ground water degradation	298.982	10.200**
9.	Proximity to dyeing/bleaching units	-333.970	-1.137
10.	Income	88.834	0.856

*R^2 = 0.57, * significant at five per cent level, ** significant at one per cent level*

About 57 per cent variation in WTP was explained by age, household size, education, income, per capita agricultural land, per capita standard cattle units, interest in improving agricultural activities, perception of land and ground water degradation and proximity. The functional analysis revealed that the interest in improving agricultural activities if increases by one stage (not interested to somewhat interested) WTP would increase by Rs.933/household.

Policy Implications

i. The fiscal measures like pollution tax, subsidy and pollution permits may be enforced to minimize the external effects of the industrial effluents.

ii. The affected parties should be compensated adequately by working out the third party effects created by the industries. Effort should also be taken so that the compensation amount to be paid to the affected parties is sufficiently higher than the damage cost incurred by the stakeholders of the local resources.

iii. The non compliers should be dealt with seriously through legal measures so that the local resources are conserved and environment is protected from the externality impacts.

iv. A working group comprising of farmers, industrial partners, technocrats, policy makers, researchers, enforcement agencies, etc., should be constituted to look into the physical economic, social, environmental and ecological issues of industrial pollution, remedial abatement measures. Since both the farming and industry should co-exist for the economic welfare of the local communities as well as the state as a whole, a bench mark may be developed for the harmonious functioning of both the sectors with minimal disturbance to natural resources and environment.

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