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AN ASSESSMENT OF THE IMPACT OF INDUSTRIALIZATION ON PHYSICAL ENVIRONMENT AND SOCIO-ECONOMIC CONDITIONS AROUND THE ALIPUR INDUSTRIAL AREA, BANGLADESH

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ABSTRACT

Massive industrialization promotes economic growth and causes environmental pollution and degradation. The purpose of this research is to determine the impact of industrialization on the physical environment and socio-economic condition at Alipur industrial areas, Habiganj, Bangladesh, by measuring water, soil, air, sound quality parameters and a random sampling questionnaire survey on socio-economic conditions. Most of the measured physicochemical parameters exceeded the acceptable limit of inland surface water. The pH of the effluent water ranged from 4.83 to 8.58, which was found lower than the standard level for two points. The DO level was within the range of 1.98 to 3.32 mg/L indicating that aquatic life is in danger because of the lower level of DO. BOD, COD, TSS, and TDS ranged from 133 to 255.8 mg/L, 330 to 566 mg/L, 1960 to 2170 mg/L and 4110 to 5500 mg/L, respectively. The concentration of Nitrates (14.63 mg/l), Phosphate (10.33 mg/l), and Copper (5.49 mg/l) in the water samples found more than the inland surface, public sewer STP, and Irrigated land standard. The concentrations of CO (10.71), NO₂ (90.56), and SO₂ (104.34) in the air are near the acceptable level, indicating that the air was moderately polluted. The Durbin-Watson statistic is 0.495 from the model summary indicating the research model has a positive auto-correction, and the coefficient of significance is at 0.00, and Test F at 150.345 suggests that the model is suitable. Furthermore, the coefficient of the land area lost due to industrial park construction is found at 0.00, indicating household income increased when people lose land and non-agricultural sectors like building houses, investing in services, traffic systems. On the other hand, it is undeniable that few members whose land is acquired turned unemployed during industrial parks, resulting in the high number of unemployed workers being high and income declines.

Keywords: Industrialization, Physicochemical parameters, Water disposal system, Socio-economic condition, Contamination level, Environmental pollution.

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INTRODUCTION

Massive industrialization to be the key to a country's development. Moreover, rapid industrialization; almost every industrial establishment uses natural resources in various ways (Islam et al., 2012). Industrialization promotes economic growth but accelerates environmental pollution and degradation. The industrial sector in Bangladesh is a vast contributor to economic growth, where Ready-Made Garments (RMG) leads the way as a primary source of foreign exchange earnings. The government has already built several industrial zones where businesses can set up factories to produce goods and services (Tarafder, 2017). Environmental pollution such as air, water, the soil is a primary concern for developing countries like Bangladesh due to unplanned industrial growth. Industrial waste discharged without proper treatment in channels, agricultural fields, and this wastewater

entered into the river system (Sultana et al., 2009). Industrial development has begun to harm the atmosphere, presenting severe problems. Trace and heavy metals such as Fe, Mn, Co, Cr, Ni, Cu, Ag, As, Cd, Zn, and Pb were higher in an industrial area that causing a reduction in soil productivity. The amounts of heavy metals in the water samples well surpassed the expected values for surface water quality and also the reason for soil degradation (Zakir et al., 2006). Water bodies near factories can pollute if wastewater is discharged without adequate treatment. They examine whether the water samples are appropriate for marine life, human use, irrigation, and domestic use (Mahbub et al., 2014). Industrial effluents significantly impacted soil quality that had contaminated soil nutrients and made it less fertile (Ladwani et al., 2012). Some air pollutants such as VOCs, SO₂, and NO_x cause respiratory problems (Poboon et al., 2012). The air pollution in industrial areas was much worse than compared to residential areas. The industrial area had high levels of nitrogen oxides (NO_x), nitric oxide (NO), nitrogen dioxide (NO₂), and carbon monoxide (CO). NO₂ and CO are particularly toxic and detrimental to human health (Ingaldi et al., 2013). Socio-economic conditions of the workers involved with this industrial area were not in a lofty stage (Bhuiyan 2012). Local people faced severe health problems such as asthma, skin rashes, breathing problems, blood pressure, joint pains, heart problems, gastric problems, diabetes, typhoid due to excessive air pollution (Behera et al., 2015). Industries in Alipur has started manufacturing around 2013 but expose to severe environmental pollution within this short period. Industries in the study area have Effluent Treatment Plant (ETP) to treat wastewater, but the canal and river near the sectors are getting polluted. That means ETPs are not well functioned, and wastewater is appropriately not treated. Surface water quality is degrading due to the use of the Shoiljura canal for discharging wastewater. Farmer uses this canal for irrigation, but much-polluted water ruins soil fertility and reduces crop production. The air quality of the study area is not satisfactory, and constant air pollution is causing severe problems for human health. Industries have created better economic opportunities but overlooked the environment.

The present study focuses impacts of industrialization on the physical environment, such as water, soil, air, and social settings like life and livelihood patterns in Alipur industrial areas. Thus, physicochemical parameters pH, alkalinity, turbidity, TS, TDS, TSS, DO, BOD, COD, Nitrates, Phosphate, Boron, Chromium, Cadmium, Zinc, Copper, Lead, and Arsenic was measured for water quality measurement. In addition, soil pH and organic matter composition, air pollution, and noise pollution were measured and analyzed. Besides, a household-level questionnaire survey determines the socio-economic effects, including economic diversification, living standards, cultural diversification, social bonding, health status, environmental awareness, and people's attitudes toward industrialization.

MATERIALS AND METHODS

Study area

Alipur industrial area (**Fig 1**) is situated at the Nurpur union under Habiganj Sadar Upazila, approximately within at 24.2703° North latitude and 91.3837° East longitude. Due to flexible road infrastructure, availability of cheap labor force, and easy access and availability of power. A water body, the Sutang River, is linked with the industrial effluent meets with the river at 4 or 5 km distance through the effluent carrying canal named Shoiljura. According to Waterkeeper, industrial wastes from the Habiganj Industrial Zone near Alipur contaminate the river Sutang, posing significant hygiene and environmental risks in the surrounding villages, i.e., Korab, Lukra, Nurpur, and Rajiura (Deshwara, 2016). Various factories regularly discharge a substantial volume of industrial effluent here, and some farmers irrigate crops such as corn, vegetables, and fruits with the water from this canal. However, the canal's water is rapidly becoming unusable.

Data Collection

Primary Data Collection Water, Soil, Air, and Noise Sample Collection

Total three stations were selected for the water samples and collected in sterilized and purified plastic bottles for laboratory analysis. The water sample was collected from the canal, keeping a 50-meter distance from each point. The soil samples were taken from agricultural fields at three stations and waste disposal points of industries from the surface at 0 – 20 cm depth. Air samples were collected randomly based at different distances away from factories at nine points to assess the concentrations of contaminants in the air. Six sampling station points select for sound samples for noise pollution.

Sampling Design for Questionnaire Survey

Data impacts of industries on the socio-economic condition of local people in the study area were collected using questionnaires administered personally to the respondents to obtain desired information. Also, observation and field photo methods were employed.

The total number of households in the study area is 209 (BBS 2011). , Total of 138 households were selected at a 95% confidence level (having a 5% level of precision) to conduct the questionnaire survey. The simple random sampling procedure is used to select the households. The sample size is determined based on the following formula (Yamane, 1967).

$$\begin{aligned}\text{Sample Size, } n &= N / (1 + Ne^2) \\ &= 209 / \{1 + 209 \times (0.05)^2\} \\ &= 138 \text{ (Approximately)}\end{aligned}$$

Here, N = Population (Total Number of Household); e = Level of precision (5%)

So, with 5% precision, 138 sets of household surveys were conducted in this study, and another 62 respondents were included randomly from the worker's level means the total number of respondents was 200.

Secondary Data Collection

This study's secondary data sources were previous studies, journals, books, reports, and different websites. In addition, various books, journals, periodicals, magazines, newspapers, and articles consider and discussed to collect secondary data.

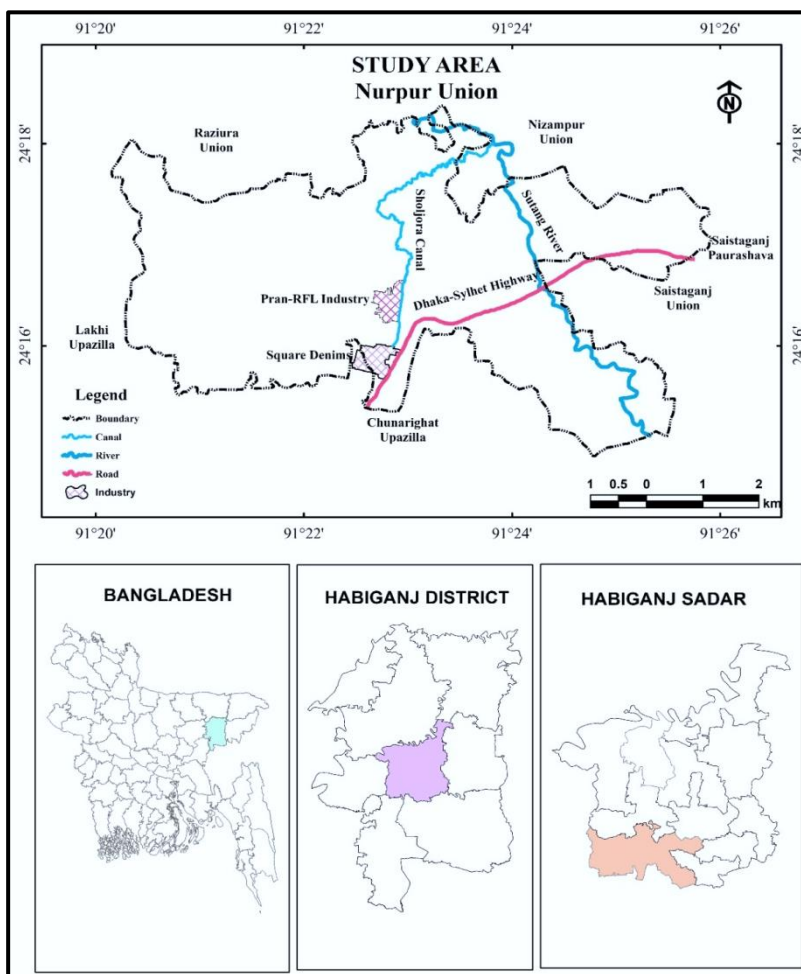


Fig 1: Study Area Map

Data Processing and Analysis

After analyzing the samples, the findings compare with the WHO and DOE standards for confirmation. Moreover, cross-tabulation, frequencies, percentages, mean, and regression coefficient are used for quantitative data.

Water Sample Analysis

The following parameters (Table 1) analyze for the water quality in the study area.

Table 1: Parameters for the Water Quality Analysis in the Study

Sample Type	Parameter Properties	Parameter		
Water	Physical	TS	TSS	TDS
		Alkalinity	Turbidity	p ^H
	Chemical	DO	BOD	COD
		Nitrates	Phosphate	Copper
		Chromium	Cadmium	Boron
		Arsenic	Lead	Zinc
	Microbiological	Total Coliform		

Determination of Dissolved Oxygen (DO)

The Winkler titration, initially designed to calculate DO in water samples, is one of the most effective iodine titrations (Eq. i).

$$DO = \frac{\text{ml of } Na_2SO_4 \text{ used} \times 0.025 \times 8000}{\text{Sample Volume}} \text{ mg/L} \quad (i)$$

Determination of Biochemical Oxygen Demand (BOD)

Under aerobic conditions, BOD describes the amount of oxygen needed by bacteria and other microorganisms during organic matter's biochemical degradation and transformation (Eq. ii).

$$BOD \text{ at Day 5} = DO \text{ at Day 1} - DO \text{ at Day 5} \quad (ii)$$

$$BOD_{(5)} = DO_{(1)} - DO_{(5)}$$

Determination of Chemical Oxygen Demand (COD)

The oxygen-consumed assessment determines how much oxygen is required to oxidize hazardous material in a sample using potassium permanganate in an acid solution (Eq. iii).

$$\text{Oxygen Consumed (COD)} = \frac{\text{ml of } KMnO_4 \text{ Used in Step No.5} \times 100}{\text{ml of Sample Used}} \text{ mg/L} \quad (iii)$$

Determination of p^H

The p^H is the hydrogen ion activity of a solution. The p^H determines using a glass electrode pH meter (Hanna pH meter, model No. HI 2211).

Determination of Total Solid (TS)

The equation to measure TS is in Eq. iv and Eq. v.

$$\text{Weight of Solid} = (A - B)g \quad (iv)$$

A = Weight of the beaker with solid; B = Weight of the cup without solid.

$$\text{Total Solid (TS)} = \frac{\text{Weight of Solid} \times 1000}{\text{Sample Size}} \quad (v)$$

Determination of Total Dissolved Solids (TDS)

The equation to measure TDS is in Eq. vi and Eq. vii.

$$\text{Weight of Dissolved Solid} = (A - B)g \quad (vi)$$

A = Weight of the beaker with dissolved solid; B = Weight of the beaker without dissolved solid.

$$\text{Total Dissolved Solid (TSD)} = \frac{\text{Weight of Dissolved Solid} \times 1000 \text{ mg}}{\text{Sample Size}} \text{ L} \quad (vii)$$

Determination of Total Suspended Solid (TSS)

The equation used to measure TSS is in Eq. viii.

$$\text{Total Suspended Solid (TS)} = \text{Total Solid} - \text{Total Dissolved Solid} \quad (viii)$$

Determination of Total Coliform

In this study Membrane Filter (MF) method was used to calculate total coliform. The process is based on the filtration of a known volume of water through a membrane filter consisting of

a cellulose compound with a uniform pore diameter of 0.45 μm ; the bacteria retain on the surface of the membrane filter (Eq. ix).

$$\text{Total Coliform} = \text{Fecal Coliform (FC)} + \text{Non Fecal Coliform (NFC)} \quad (\text{ix})$$

Determination of Other Water Parameters

The other chemical properties of the water, such as Nitrates, Phosphate, Chromium (Hexavalent), Cadmium, Zinc, Copper, Lead, and Arsenic, are determined using Spectrophotometer. It measures color value, but specific wavelengths of light help classify the exact properties of chemical components found in various water sources.

Soil Sample Analysis

Determination of Organic Matter

The importance of soil organic matter in supplying nutrients contributes to cation exchange capacity, improving soil structure, and adjusting N, S, herbicide, and lime recommendations (Eq. x and Eq. xi).

$$\% \text{ Carbon} = \frac{V_1 - V_2}{W} \times 0.003 \times 100 \quad (\text{x})$$

$$\% \text{ Organic Matter} = \% \text{ C} \times 1.72 \quad (\text{xi})$$

V_1 =volume of $\text{K}_2\text{Cr}_2\text{O}_7$; V_2 =volume of ferrous ammonium sulfate;
W= Weight of soil

Determination of Soil p^H

Soil and water were mixed in 1:2 ratios to make a soil suspension. First, a ten-gram soil sample in a 50-milliliter beaker was then filled with 20 milliliters of distilled water. The solution immediately stirred for 30 minutes on a glass rod just before taking the p^H , and it stirred once more. After each measurement using a p^H meter, the electrodes wash with distilled water. Two buffer solutions with known p^H values ($p^H 4$ and $p^H 7$) standardize the p^H meter.

Air Sample Analysis

The air quality of the study area determines using Portasans II portable gas leak Detector (model C16). NO_2 , CO, and SO_2 were determined using different sensors. These values were analyzed using AQI to assess pollution levels and their impact on human health (Table 2).

Table 2: Air quality Index for Selected Pollutants

AQI Range	NO_2	CO	SO_2	Health impact
Good (0–50)	00-40	00-1.0	00-40	Minimal impact.
Satisfactory (51–100)	41-80	1.1-2.0	41-80	May cause minor breathing discomfort to sensitive people.
Moderately polluted (101–200)	81-180	2.1-10	81-380	May cause breathing discomfort to people with lung disease such as asthma and distress to heart disease, children, and older adults.
Poor (201–300)	181-280	10-17	381-800	May cause breathing discomfort to people on prolonged exposure and discomfort to people with heart disease.
Very poor (301–400)	281-400	17-34	801-1600	May cause respiratory illness to the people on prolonged exposure. The effect may be more pronounced in people with lung and heart diseases.
Severe (401–500)	>400	>34	>1600	May cause respiratory impact even on healthy people, and severe health impacts people with lung/heart disease.

Source – US EPA Standard

Noise Pollution Analysis

The noise level was analyzed by using **Lutron Sound Level Meter SL-3113B**. Later, the values compared with Bangladesh's standard for noise in an industrial area.

Questionnaire Analysis

The questionnaire was analyzed using SPSS software version 18.0 and Microsoft Office Excel 2016. Different tables, graphs, charts use for the presentation of findings.

Socio-economic Impact Analysis Using Model

Different socio-economic indicators assess the industrial development impact on the local households living around the Alipur Industrial Park using a regression model.

Dependent and Independent Variable of the Model

The household income, which reveals total income in a year (USD) were used as the dependent variable in this model as used in previous research by Tuyen (2013), Tuyen and Huong (2014), and Siegel (2005). The independent variables are in **Table 3**.

Table 3: The Independent Variables

No	Indicator	Description
1	Lost land	The total area of land (m ²) lost by the household due to industrial park development (Van Suu, 2009)
2	Policies accessibility	It signifies the accessibility of policies of households which ranges from 1 (household with entrance to incentives) to 0 (when unavailable)
3	Investment	Household investment (USD/year) for non-agricultural activities (building houses, investing in services)
4	Transportation system	Change in a transport system after industrial parks establishment returns 1 for very bad, two terrible, 3 for normal, 4 for good, and 5 for the excellent transportation system
5	Jobs available after industry establishment	Phong (2007) and Tran Quang Tuyen (2013) stated that people's income increased contributed by a new number of jobs
6	Workers in industrial parks	Total employee number who are working directly in the industrial park
7	Unemployed laborers	Unemployed number in each household (unemployed after the industrial park establishment) as poverty caused by unemployment (Van Suu, 2009 and Lê Du Phong 2007)
8	Workers in the household (control variable)	Actual eligible employee number in the household

Using the indicators in **Table 3**, the final model for the research stands as:

$$Y_i = a + X_1 (\text{lost land}) + X_2 (\text{policies accessibility}) + X_3 (\text{investment}) + X_4 (\text{transportation system}) + X_5 (\text{jobs available after industry establishment}) + X_6 (\text{workers in industrial parks}) + X_7 (\text{unemployed laborers}) + X_8 (\text{workers in the household}) + U_i$$

Map Preparation

Map of the study area prepared using ArcGIS, ArcMap, Google Earth Pro, and Eradus Imagine.

RESULTS AND DISCUSSION

Impact of Industrialization on Physical Environment

Water Quality of the Study Area

The Value of DO of stations 1, 2, and 3 is 3.45, 1.98, and 2.40 mg/L, respectively (Fig 2), where the standard Value for DO is 4.5 mg/L. The pH value of stations 1 and 2 is shallow (5.89 and 4.83 respectively), under the standard range, where station 3 (pH 9.58) exceeds the optimum range of pH (Fig 2). So the water of all these stations is not suitable for aquatic life. The Value of BOD in stations 1, 2, and 3 is 133, 255.8, and 240.64 mg/L, respectively (**Fig 2**), while the DOE standard is 50 mg/L. That means all the stations exceed the optimum value by a higher margin for BOD, which causes damage to the biodiversity of the water ecosystem. The COD value for Station 2 and station 3 is higher as compared to station 1. COD values ranged between 330-566 mg/L (**Fig 2**), much higher than the standard value. This result represents that the industrial effluents discharge at a higher rate with more chemical components. Station 2 is much more polluted in the study area than the other two stations, where the value of station 1 was 4110 mg/L, and station 3 was 4250 mg/L (**Fig 2**). According to the standard value, all these stations contaminate with the dissolved substance.

The TSS of all three stations is almost similar (**Fig 2**) and exceeds the standard value for TSS in Bangladesh.

The study's findings show that the concentration of organic matter in the water in most samples is less than the standard level set by the Bangladesh Department of Environment (DOE). For alkalinity, turbidity and EC standard value are not as follows. On the other hand, the concentration of Nitrates, Phosphate, and Copper in the water samples is more than the standard value. Nitrous is beneficial for irrigation, but people use sewage for producing their crops that cause socio-economic and health risks to the local people.

Assessments of other water parameters have, and standard values are in **Table 4**.

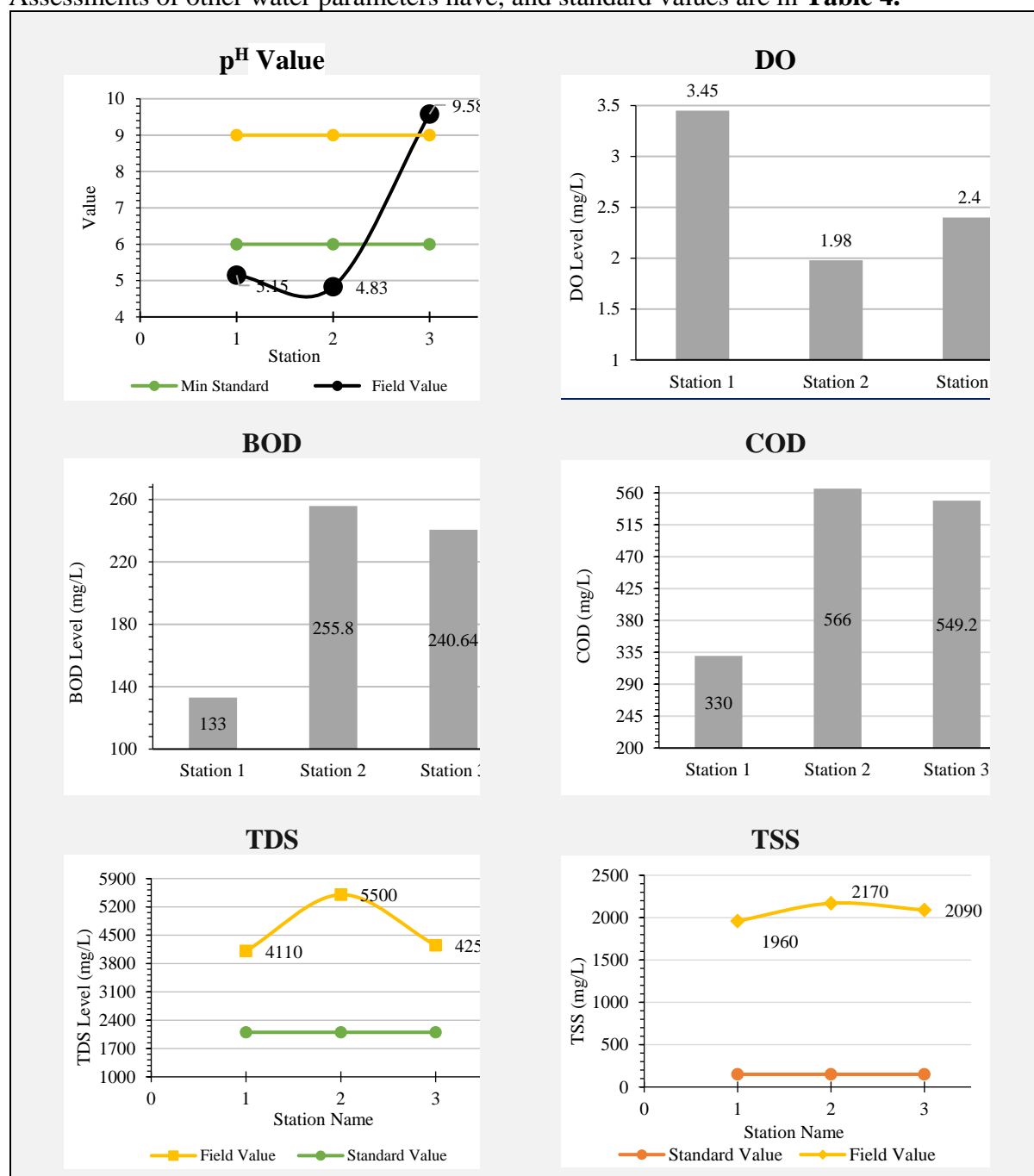


Figure 2: Water pH, DO, BOD, COD, TDS, TSS of the Study Area

Soil Quality of the Study Area

Two essential soil properties, soil pH and organic matter (OM), were analyzed to determine the current state of the soil in the study region. The pH of the soil is a measurement that

indicates whether the soil is alkaline (higher p^H) or acidic (lower p^H). Soil p^H range of 5.5 to 7.0 is optimum for organic matter and some fertilizers operators. So, nutrients are most available to plants in the optimum 5.5 to 7.0 range. In the study area, the p^H of the soil has not differed as much. The values are almost similar for the three sampling stations, and the values are 6.45, 6.32, and 6.15, respectively (**Fig 3**). Therefore, the p^H value of this area was suitable for soil and cropping production.

Table 4: Assessment of Other Water Parameters

Sl. No	Parameter	Unit	Standard			Sample Concentration		
			Inland Surface	Public Sewer STP	Irrigated Land	A	B	C
01	Alkalinity	mg/L	---	---	---	461.0	412	480
02	Turbidity	mg/L	---	---	---	17.01	23.35	23.0
03	Electric Conductivity	----	1200	1200	1200	58.00	43.00	35.0
04	Hardness	mg/L	---	---	---	338.0	476.0	450
05	Nitrate	mg/L	10.00	---	10.00	14.00	16.50	13.4
06	Phosphate	mg/L	08.00	08.00	10.00	12.00	07.70	11.3
07	Chromium	mg/L	00.50	01.00	10.00	0.013	00.03	0.04
08	Cadmium	mg/L	00.05	00.50	00.50	00.00	00.00	0.00
09	Zinc	mg/L	05.00	10.00	10.00	00.12	00.08	0.11
10	Copper	mg/L	00.50	03.00	03.00	01.80	01.59	2.10
11	Lead	mg/L	00.10	00.10	00.10	00.00	00.00	0.00
12	Arsenic	mg/L	00.20	00.50	00.20	00.00	00.00	0.00
13	Total Coliform	Concentrate /100mg	1000 or less	1000 or less	1000 or less	12.00	08.00	14.0

Accumulated organic matter is a nutrient storehouse for plants. Good soil should have more than 3.5% organic matter content, but the highest OM concentration recorded at sampling point two is 1.70%, and the lowest at S3 is 1.41% (**Fig 3**). Thus, OM concentration is much lower than the standard level for crop and grain production.

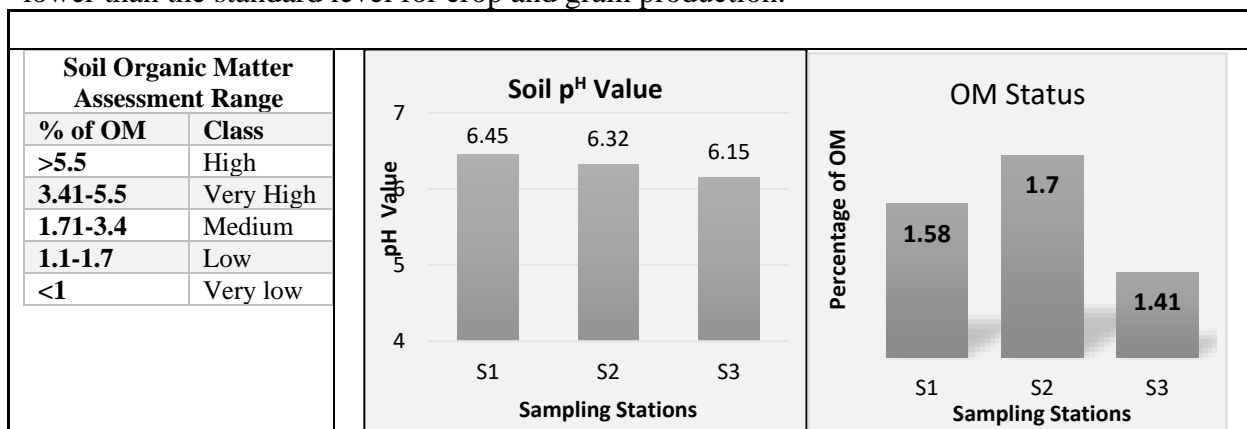


Fig 3: Assessment of Soil p^H and Organic Matter.

Air Quality of the Study Area

Nitrogen Oxides (NOX) are one of the most hazardous pollutants found in the atmosphere. Most of the industrial areas cause a more significant amount of air pollution. Therefore, ten stations and three parameters are selected to measure the air quality of the study area, such as NOX, CO, SO₂. The present study found that NO_x ranged from 124 $\mu\text{g}/\text{m}^3$ to 55.6 $\mu\text{g}/\text{m}^3$ in the study area (**Fig 4**). The highest value was found in station four as opposed to the least in station 9. Carbon monoxide (CO) gas emits when carbon-rich fuels are burned with insufficient oxygen, resulting in incomplete combustion. As per result, the air was unhealthy for the locals. The CO of most of the stations exceeds the standard value, where the highest contaminated station is station 6 (**Fig 4**). The combustion of fossil fuels produces gas.

Sulphur Dioxide (SO₂) is produced by the oxidation of Hydrogen Sulphide, which releases by decaying organic matter. Station 4 is more contaminated with 131.8 µg/m³; on the other hand, station 2 is suitable compared to other stations (Fig 4).

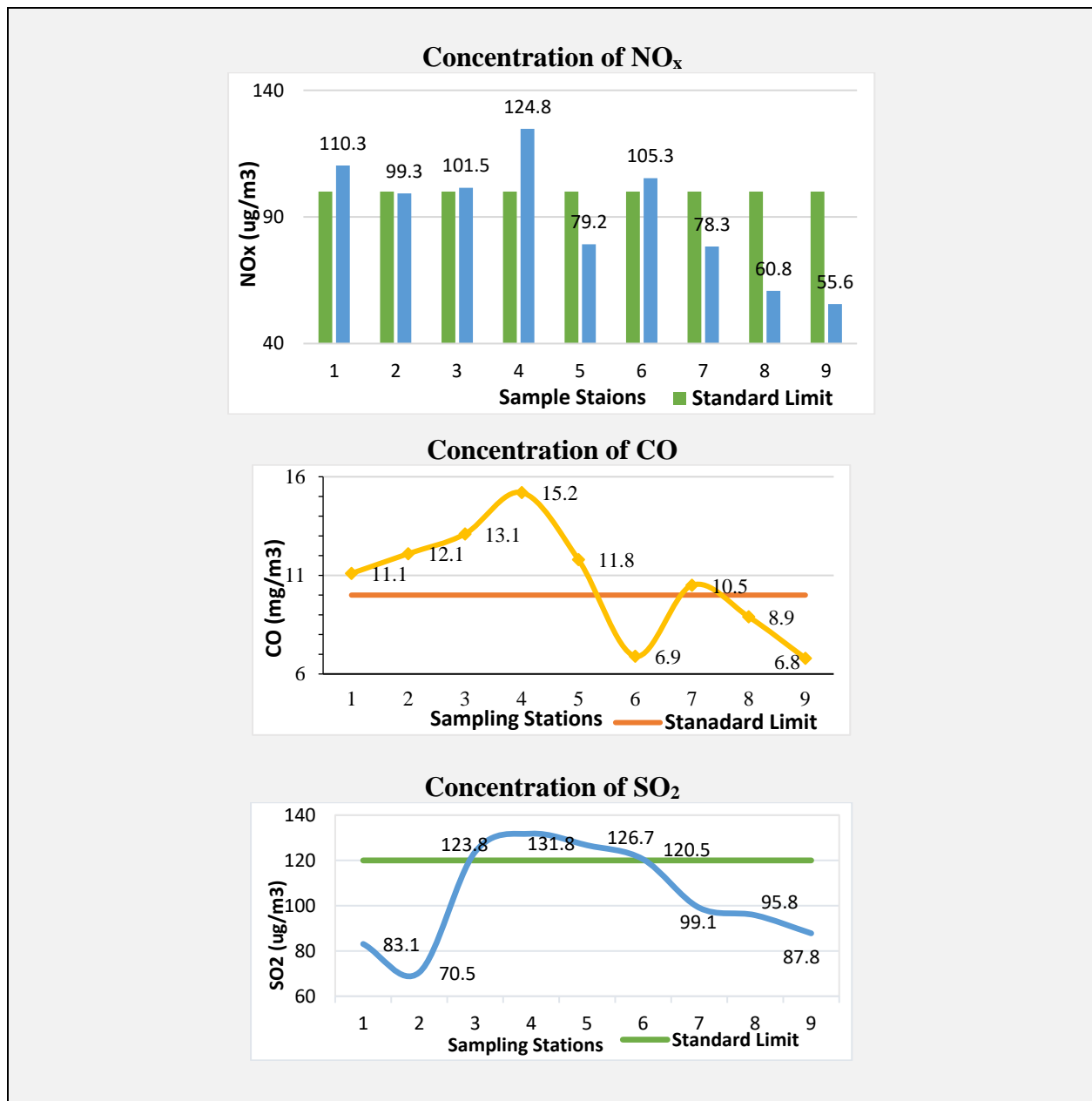


Figure 4: Air Quality of the Study Area

Noise Level of the Study Area

Harsh sounds generated through excessive use of machinery and the industrial workers affected most by this. Six stations chose to measure the sound quality level where day and night time considered. As a result, both the day and night-time noise levels are not satisfied compared to the standard level and crossed the optimum value (Table 5).

Table 5: Noise Conditions in the Study Area

Noise Level	Bangladesh Standard	Sample Station					
		1	2	3	4	5	6
Day Time	75dB	78	98	82	84	79	76
Night Time	70 dB	81	88	82	78	81	73

Impact of Industrialization on Socio-economic Condition

The study's findings clearly show that industrialization created more job opportunities, resulting in higher household incomes and causing significant socio-economic and behavioral changes in the region's people.

Land and Industries

Two-thirds of respondents said that industries in this locality build on fellow land, and the rest said enterprises bought cultivated lands for their industry set up (**Fig 5**). Less than half of the total respondents at Alipur Union (49%) sold their land to the industry stakeholders. However, one-third of all respondents were happy with the price, approximately half of those who sold their lands through agents did not receive a reasonable price. According to them, the majority of the land companies are purchased by fellow landowners (**Fig 5**).

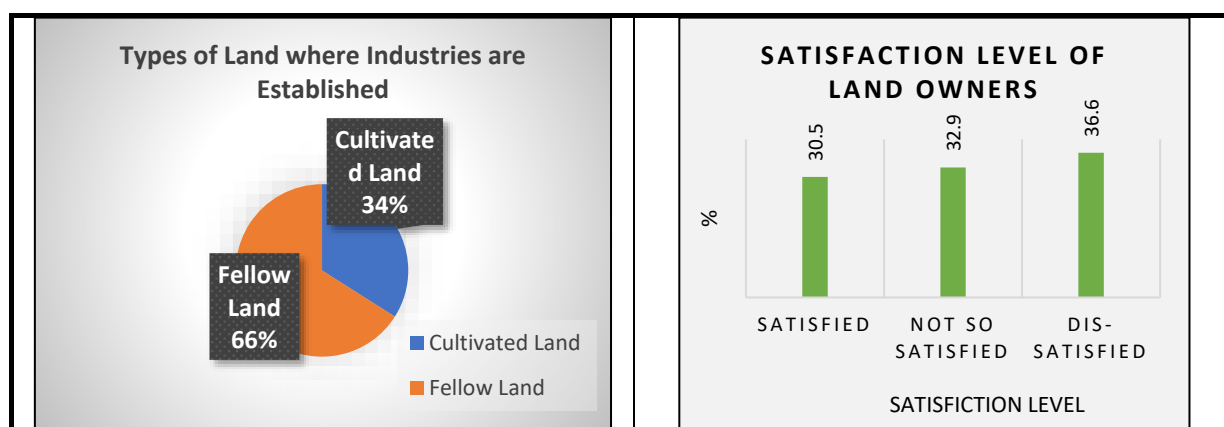


Fig 5: Land Where Industries are Established and Satisfaction Level of Land Owners.

Industrialization and Economic Benefits

Around half of the people in the sample are now working in the industry in various sectors (**Fig 6**). After industries establish, about 27% of the total respondents started new businesses, such as grocery stores, chemist shops, restaurants, and clothing stores. Almost three-quarters replied that industrialization has a direct impact on occupational diversification sectors (**Fig 6**). The current study shows that local people got more priority than the outside people. About sixty percent indicated that local people prefer jobs where forty percent were from other locality (**Fig 6**). According to respondents, women between 20 and 30 are mainly employed in industrial employment (**Fig 6**). Women dominate the packaging and processing industry. Following the establishment of the industrial sector, most poor women from here now work in these factories. Industrialization brings economic solvency to the study area. An overwhelming more than eighty percent of respondents stated that the financial condition of workers is better now than previous. Only less than one-fifth of participants gave a negative answer and said they did not see any change in the economic situation (**Fig 6**). Respondents gave positive responses to explain the better financial condition; 61.8% said that most young people were unemployed before industrial set-up, but now they are employed. Other 38.2% of respondents said that people of the study area were farmers or day laborers who moved their occupation to the industrial worker. Thus, most study areas lead a life with stable economic security sectors (**Fig 6**). The effect of economic opportunity provided by industry is positive, according to 85 % of respondents (**Fig 6**). Respondents said that the industry has strict laws regarding worker employment. All of the participants stated that child labor is strictly prohibited in industries at Alipur. Not even a single child is engaged in any work. No one under eighteen years old gets a job in the industry. Thus, the overall economic influence of the industries in the study area is very positive.

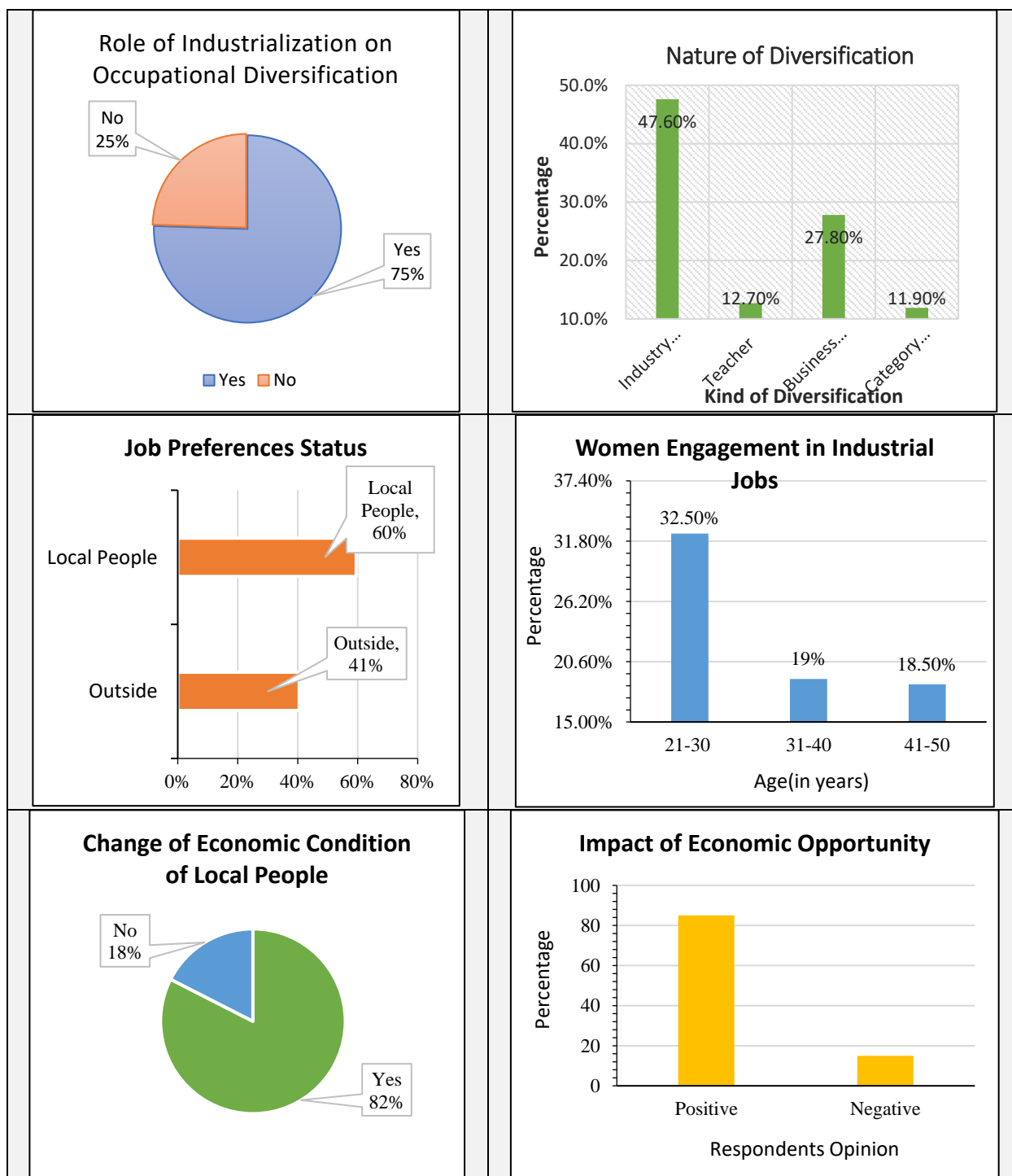


Fig 6: Industrialization and Economic Benefits

Cultural Change at Industrial Area

Half of the participants believe they had a friendly relationship with an outsider, while the remaining respondent's strick with their ideologies is incompatible (**Fig 7**). Around one-fourth of those thinks that people from other places influenced their society's norms and values. However, most claim that Bangladesh is a small nation and cultural diversity is not severe (**Fig 7**). The current study discovered that as the area's industrialization grows, so do anti-social behaviors. For example, 53.5 % said stealing is their primary concern. In comparison, 8% said drug addiction is on the rise and remained 39% of respondents said that anti-social activities were less significant in the area (**Fig 7**).

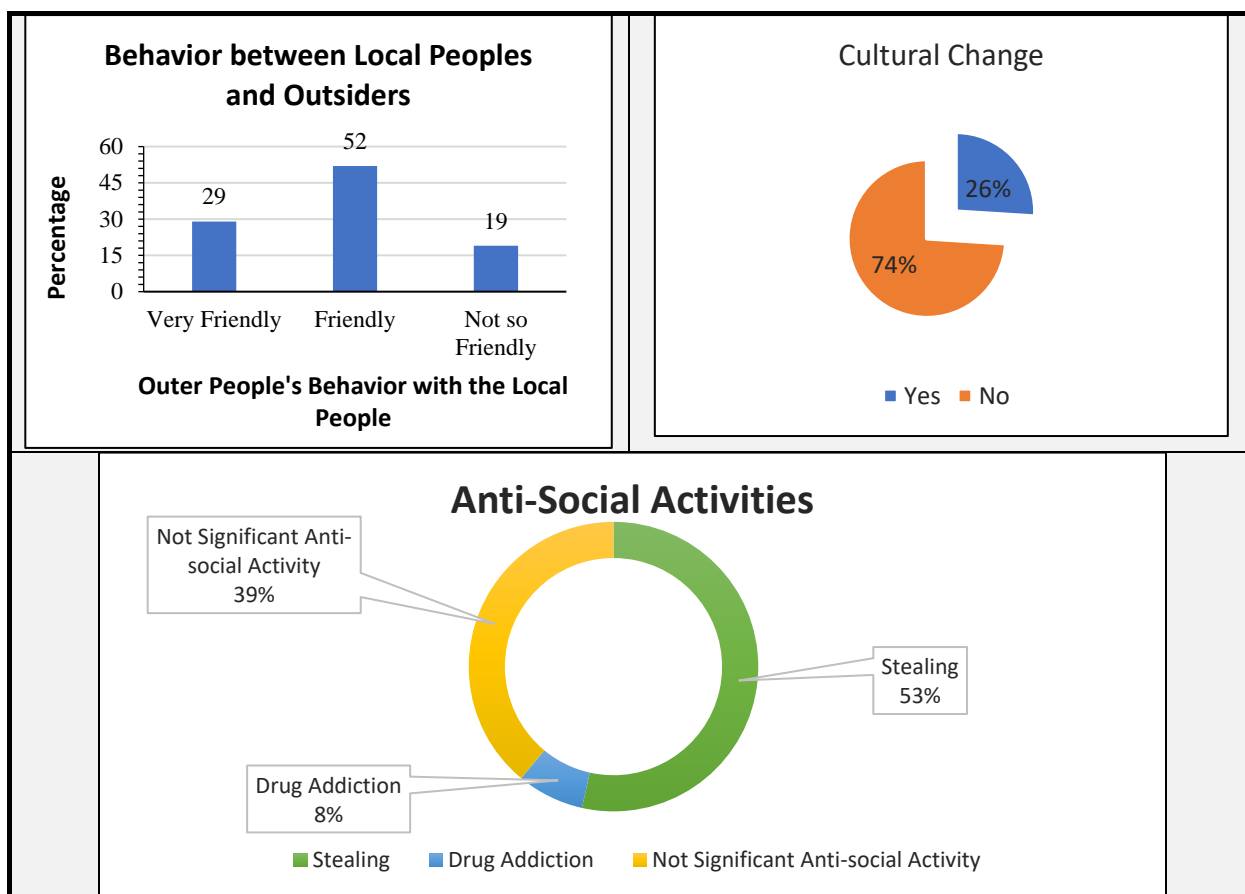


Fig 7: Culture Change at Industrial Area

Waste Disposal System

Effluent Treatment Plant (ETP) is mainly designed to purify industrial wastewater to reuse and release safe water to the environment from the harmful effect caused by the effluent. The present study revealed that industries discharge their wastewater through the Shoiljura canal to the Sutang River. In the study area, existing industries have ETPs. However, only 12% of participants strongly agreed, while 25% disagreed with this, and 35% did not know about ETP's function (**Fig 8**).

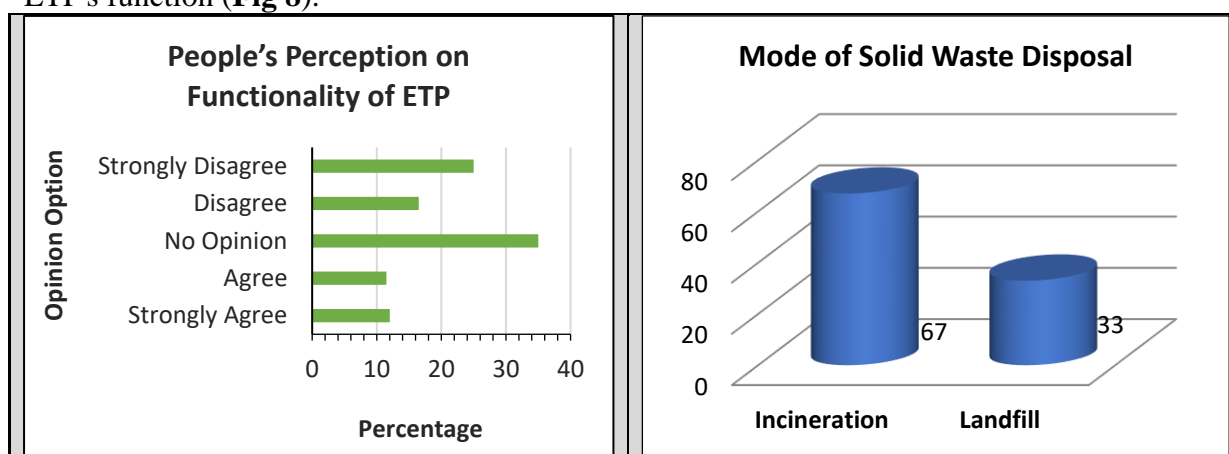


Fig 8: Waste Disposal System

The present study found that the solid waste disposal method adopted by industries was entirely satisfactory. Two-third of the total respondents said that industries followed the incineration process to dispose of solid waste (**Fig 8**). Incineration physically explains organic materials' thermal decomposition (by combustion) into simpler gases and particles, mainly carbon dioxide, water, and ash. The main goal of incineration is to destroy the organic

material and decrease its volume, together with lowering its toxicity. The rest of one-third respondents said that the landfill process is for solid waste dumping. A landfill site is a site for the disposal of waste materials by burial.

The industry's solid waste disposal system was very satisfactory. According to the current survey findings, two-thirds of all respondents said companies used the incineration process to dispose of solid waste (**Fig 8**). The landfill method was used for solid waste dumping by the remaining one-third of respondents.

Pollution due to Industrialization

Water quality in the study area has deteriorated dramatically as a result of rapid industrialization. One-fourth of respondents considered the water quality in the area satisfactory, while 69 percent said the water condition in the area is terrible. Only twelve percent of participants said that odor is one of the harmful effects of polluted water. Due to the severe lousy smell, it was sometimes impossible for them to stay at home. However, half of the respondents reported that this polluted water was unsuitable for irrigation and harmed crop production, but some farmers are bound to use this. Another 17.39% stated that fishes are not available in canals and the river like before. About 13.04% mentioned that there was a rise in waterborne diseases due to polluted water. This contaminated water is causing severe health problems to local people. Remained 12.32% of respondents said that livestock animals die by drinking contaminated water (**Fig 9**). Soil contamination is high near river areas where people depend on river water for irrigation, according to 34% of respondents. Soil pollution is currently at a low level, according to 37% of respondents, but it is rising day by day (**Fig 9**).

The present study revealed that noise pollution level was not so significant in the study area. One-third of respondents reported that there was no noise pollution. At the same time, less than ten percent of respondents said that noise pollution is very unpleasant, and its intensity increased during the night (**Fig 9**).

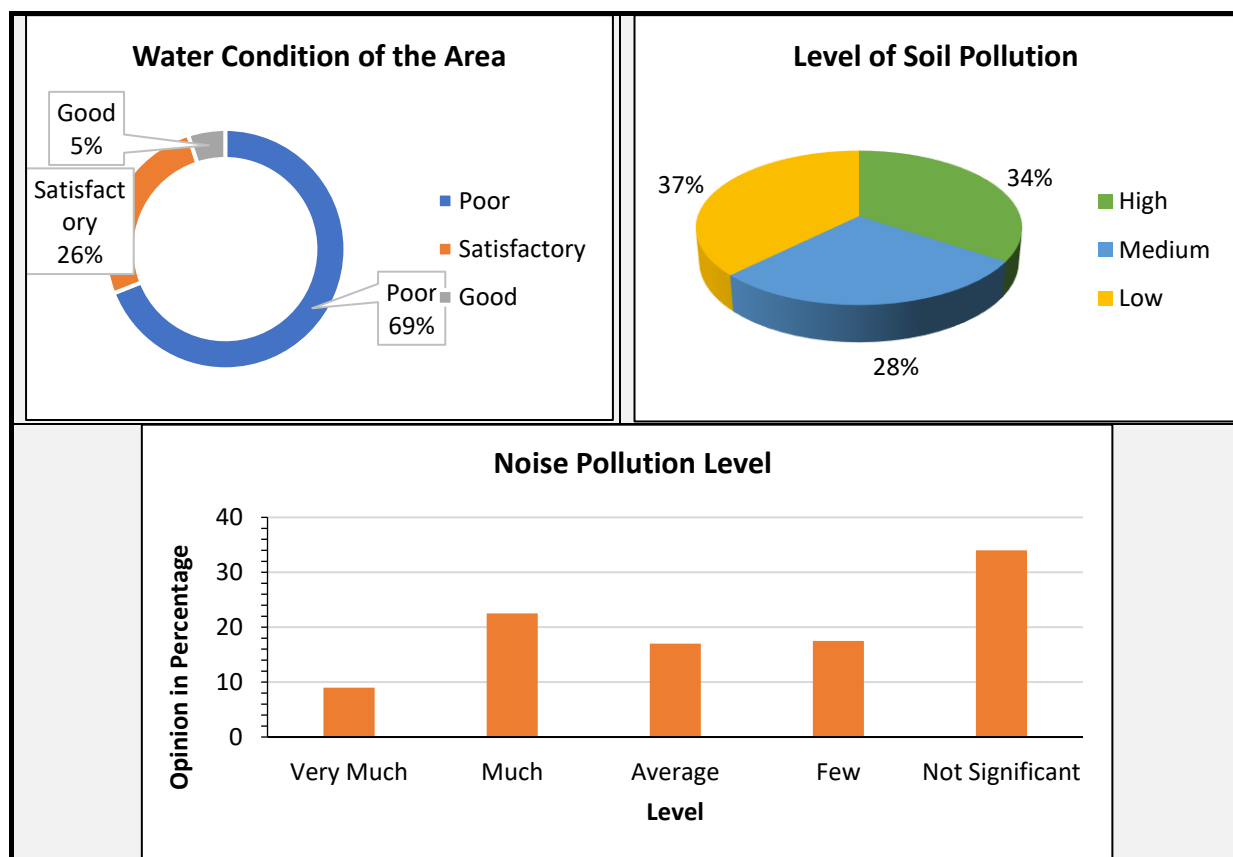


Fig 9: Impact of Industrialization on Environmental Pollution

Impact on Human Health

About 18% of those surveyed said they were suffering from some other health issues. Almost half of the population was afflicted with skin diseases, with diarrhea afflicting about 17%. Some fewer people claimed to have respiratory issues. However, 14% of respondents said no significant health problem in the area (**Fig 10**).

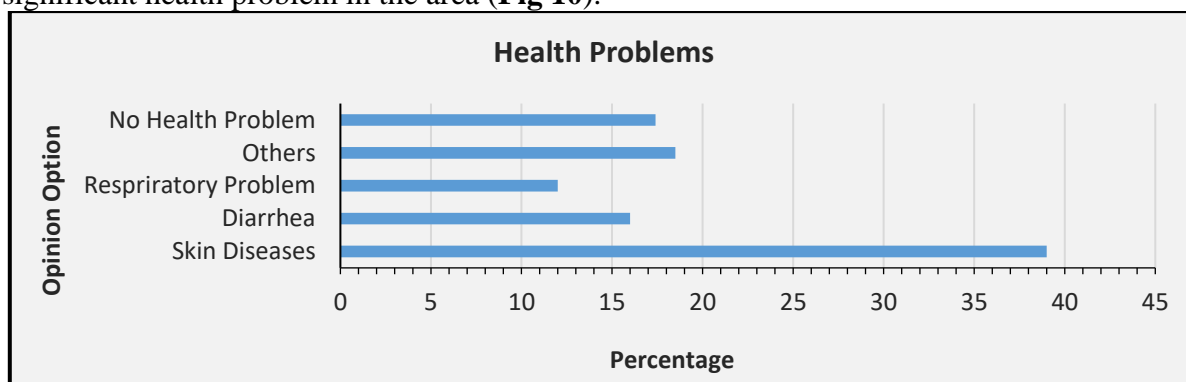


Fig 10: Impacts on Health in the Study Area

Impact on Agriculture

The present study found that water and soil pollution have a tremendous impact on local agriculture. As a result, rice production is decreasing day by day. Respondents The majority of respondents (more than half) said that pollution affected their agriculture greatly, while one-fourth said that effect was few (**Fig 11**).

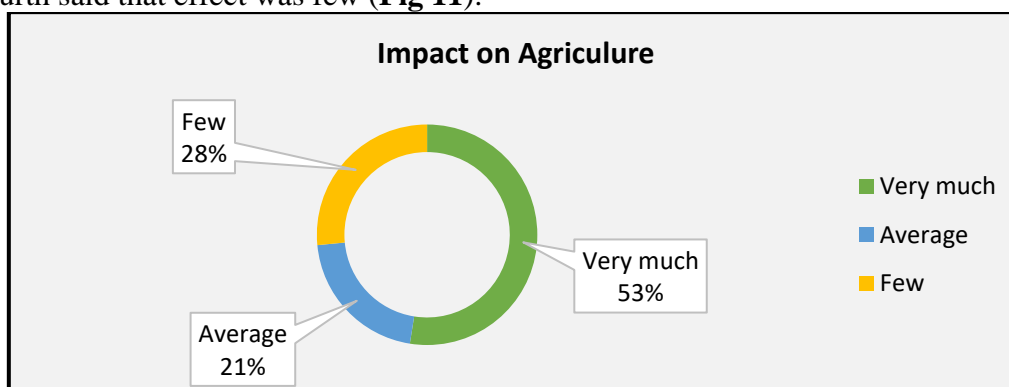


Fig 11: Impact on Agriculture

Suggestions on Proper Industrial Development

The majority of respondents (more than half) placed a high priority on proper waste management. Another 19.5 percent believe that workers' salaries should rise for them to be more efficient. The remaining one-fourth of respondents made no suggestions (**Fig 12**).

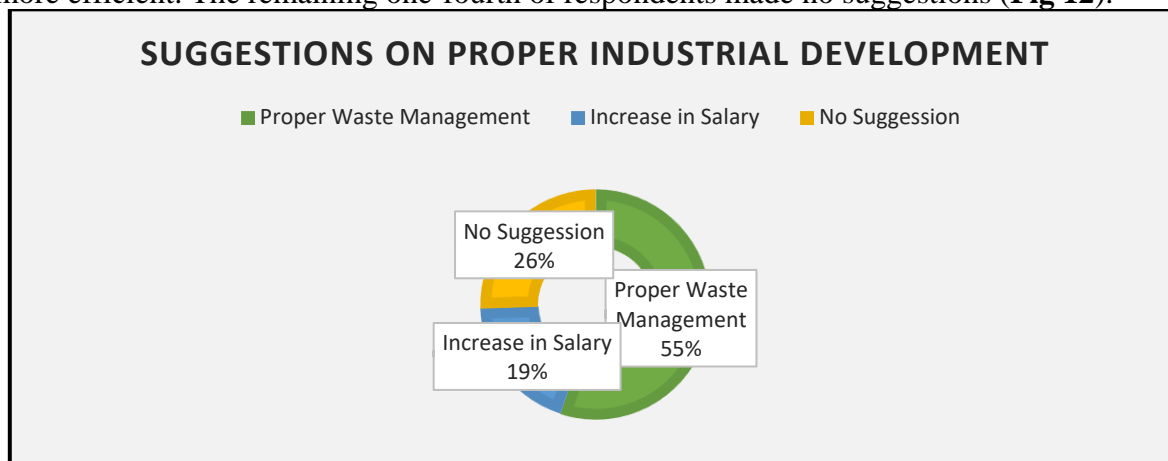


Fig 12: Suggestions on Proper Industrial Development

Socio-economic Impact

Table 6 describes the mean and standard deviation for the various socio-economic indicators.

Table 6: Descriptive Statistics of the Different Socioeconomic Indicators

No	Indicator	Mean	Standard Deviation	N
01	Household income (USD)	2432.0	1069.52	200
02	Lost land (m ²)	2350.8	885.200	
03	Policies accessibility (0-1)	0.4565	0.49900	
04	Investment (USD)	223..6	113.020	
05	Transportation system	3.1900	1.05000	
06	Jobs available after industry establishment	1.9500	1.45000	
07	Workers in industrial parks	1.3700	0.95000	
08	Unemployed laborers	1.0800	0.80000	
09	Workers in the household (<i>control variable</i>)	2.7800	1.22000	

Table 7: Summary of the Model Parameters

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics					Durbin-Watson
					R Square Change	F Change	Df ₁	Df ₂	Sig. F Change	
1	0.94	0.89	0.88	364.05426	0.890	150.34	7	130	.000	.495

The Durbin-Watson statistic is 0.495 from the model summary, indicating the research model has a positive auto-correction. The result also suggests that independent variables can explain about 89% of the dependent variable as the coefficient R squared value is at 0.89 in the model (Table 7).

Table 8: Analysis of Variance

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1.395E8	7	1.993E7	150.345	0.00
	Residual	1.723E7	130	132535.5		
	Total	1.567E8	137			

The coefficient of significance is at 0.00 and Test F at 150.345, which indicates that the model is suitable (Table 8).

Table 9: Regression Co Efficient

No	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
01	(Constant)	510.887	214.192		2.385	.019
02	Lost land (m ²)	.181	.044	0.150	4.131	.000
03	Policies accessibility (0-1)	104.846	118.868	0.049	.882	.279
04	Investment (USD)	8.377	0.400	0.885	20.946	.000
05	Transportation system	171.399	58.940	0.168	2.908	.004
06	Jobs available after industry establishment	88.082	36.443	0.094	2.417	.017
07	Workers in industrial parks	197.724	47.334	0.176	4.177	.000
08	Unemployed laborers	-18.965	46.377	-0.014	.409	.183
09	Workers in the household	7.2304	10.678	0.104	3.124	.002

Table 9 reveals that all the indicators (variables) are statistically significant as the significance value (threshold) found at 0.1 except policies accessibility (0.279) and unemployed labor (0.183). Furthermore, the coefficient of the land area lost due to industrial park construction is found at 0.00, indicating household income increased when people lost land. The result also reveals that investment in non-agricultural sectors like building houses, investing in services has increased with a value of 8.377, and research results support the opinion of Phuong et al. (2013). Finally, the coefficient of the traffic system variable after the industrial park is at 171.399, which indicates the transportation system has been improved and helpful for more income for the local people. It is undeniable that few members whose

land is acquired turned unemployed during the construction of industrial parks among the households. As a result, the number of unemployed workers remains high, and income declines. The author's research results also support previous studies of Lee et al. (2020), Van Suu (2009), and Phong (2007).

CONCLUSIONS

The surrounding area of Alipur has been growing fast due to industrialization and its economic importance. This development has resulted in the degradation of the environment through water, air, and soil pollution. DO, BOD, TDS, TSS, p^H , Nitrates, Phosphate, and Copper in the water have exceeded the standard limit, and other parameters are approaching the maximum limit. Aquatic life hardly survives in such type of condition. The study explores that the local people are getting diversified job opportunities reducing the unemployment problem, increasing income, slandered living, and economic solvency. The Durbin-Watson statistic is 0.495 from the model summary, indicating the research model has a positive auto-correction, and the significance coefficient is at 0.00. Test F at 150.345 suggests that the model is suitable. The coefficient of the traffic system indicates the transportation system has been improved and helpful for more income for the local people. However, Some people lost their households, and the number of unemployed workers remains high, and revenue declines. Industrialization brings economic solvency in the area but alters the natural environment along with socio-economic conditions. So, development should be sustainable with regular monitoring and management, which benefits society and the environment.

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