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ENVIRONMENTAL EFFECTS DUE TO TRANSFORMATION OF CROPLAND INTO INDUSTRIAL USES: THE FARMERS' PERCEPTION OF AN INDUSTRY-DOMINATED AREA IN BANGLADESH

M Rayhan Sojib, M Zulfikar Rahman*, M Golam Farouque, M Asaduzzaman Sarker

Department of Agricultural Extension Education, Bangladesh Agricultural University, Bangladesh.

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ABSTRACT

In recent years, the issue of environmental pollution in the industry sector has been a prime concern. The industrial sector contributes significantly to the economy but also incurs significant environmental costs due to environmental pollution, a reduction of cultivable land and land fertility, etc. Connecting to these concerns, the study aimed to determine farmers' perception of environmental effects due to the transformation of cropland into industrial uses and to explore the influences of some selected characteristics of farmers upon the perception of environmental effects. Besides, attempts were made to explore the extent and reasons behind the transformation. A total of 113 farmers from 565 farmers of three villages of Kaliakair upazila under Gazipur district in Bangladesh were selected using a simple random sampling method. Data were collected using an interview schedule through personal interviews during July, 2021. Five-point Likert scale was employed to measure farmers' perception of the issues investigated. Most of the respondents (79.6%) had a highly favorable perception of environmental effects compared to only 6.2% having a moderately unfavorable perception. Regression analysis revealed that three variables, namely 'extended media contact,' 'years of schooling,' and 'organizational participation,' explained 64.5% of the variation in farmers' perception levels. Almost all the farmers (96.5%) claimed that their land had been transformed at 0.63% annually over the last 15 years. The main reasons for transformation were the lower price of agricultural products, the selling of land due to high prices of the land, and the low productivity of cropland. Therefore, these aspects may be considered when developing policy directives that support both sustainable environmental development and agricultural growth.

Corresponding Author: M. Zulfikar Rahman

Email: zulfikar@bau.edu.bd

INTRODUCTION

Environmental degradation i.e. any change or disturbance to the environment perceived to be deleterious or undesirable (Johnson *et al.,* 1997), has emerged as a major global concern, with the world's environment continuously deteriorating, which has already created severe pressure on the comfortable living of flora and fauna. Agriculture and the environment have always been closely interlinked (Tudi *et al*., 2021). Agriculture takes up more than half of the world's cultivable land (Fróna *et al*., 2019). The sustainable development goals (SDGs), among other things, strongly emphasize environmental sustainability to end hunger, making agriculture a vital contributor to

food security (Anderson and Rivera-Ferre, 2021). In Bangladesh, agriculture is one of the main arms of the economy, providing livelihood to 40% of the labour force, and thus, land is the most valuable resource (BBS, 2020). On the other hand, due to construction projects, housing, and various infrastructural development activities, the area of cultivable land available for crop production is gradually shrinking, exacerbating the crisis. The current cultivated per capita land is approximately 0.05 hectares (World Bank, 2020). In recent years, many factors have driven land use and land cover changes (LULCC) in Bangladesh, such as population dynamics, swift economic change, climate change, the building of new roads and highways, electrification, new residential infrastructure, and so forth (Xu *et al*., 2020).

Agriculture accounts for 13.48% of Bangladesh's GDP (BBS, 2020). This can only be possible with the aid of land resources. It needs no further justification of how extremely valuable this is in Bangladesh. Croplands are disappearing due to unplanned industrial growth and infrastructural development, despite their importance to GDP growth. With booming industrial growth and a relatively small area of land, environmental sustainability is quickly becoming a deciding factor in the industrial development process (Patnaik, 2018). The transformation of cropland into industrial uses is common in some industry-dominated areas in Bangladesh. Gazipur district is one such industrial hub where unplanned, rapid industrial growth has significantly impacted the environment (Ruba *et al*., 2021).

The scenario serves as a wake-up call for future environmental disasters. The repercussions of industrialization on croplands would interest our policymakers. Actual users of cropland will understand this. Because of the gravity of the concern, an in-depth study of the effects of industrialization on the environment is considered imperative. Therefore, it is crucial to properly understand farmers' perceptions of environmental effects. Assessing farmers' perceptions is important as perception refers to an individual's actions for acquiring information about an issue (Otter *et al*., 2013). De Lange (2018) stated that perception is strongly facilitated by prior experience and information; therefore, if a person has little knowledge and experience about a topic, they cannot accurately perceive it or make an opinion about it. Therefore, this study is thought to be a timely one to investigate farmers' perception of environmental effects due to the transformation of cropland into industrial uses and explore the influences of selected characteristics of farmers upon the perception of environmental effects along with figuring out the extent and reason behind the transformation of cropland into industrial uses.

MATERIALS AND METHODS

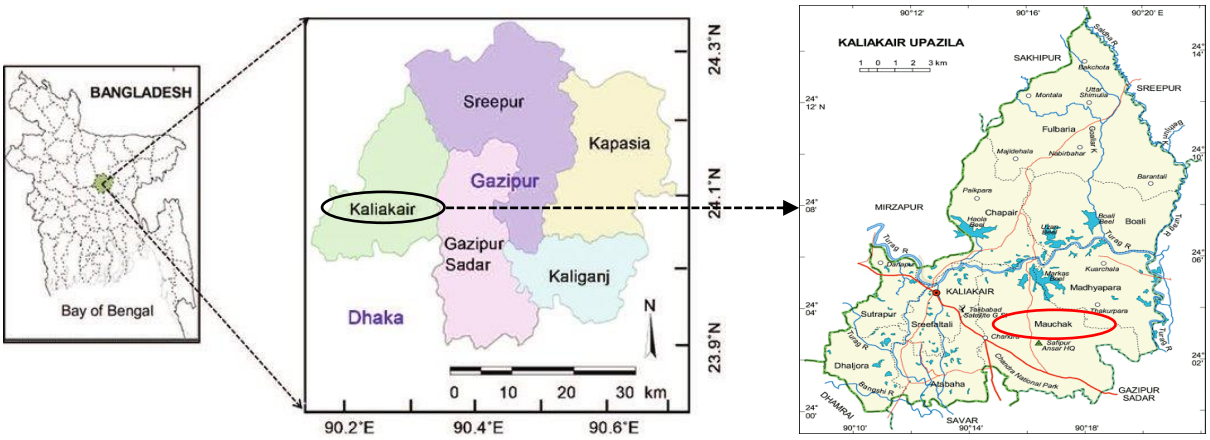
Study area, population and sample

Three villages of Kaliakair upazila (sub-division) under the Gazipur district of Bangladesh were purposefully chosen as the study locations. Ex-post-facto research design has been followed (Lord, 1973) as well as the study also adopted the 'mixed method' way of collecting and analyzing the data of this study. Gazipur district is gradually growing into an industrial area of Bangladesh though this region has always played a significant role in agricultural production. But due to its closeness to Dhaka, it has become an industrial zone over the past 15 years. The industries like garments, textile, tannery, packaging, pharmaceuticals, and food processing daily produce huge volumes of waste that contain toxic metals (Ruba *et al*., 2021). Cropland transformation for industrial purposes is a prevalent scenario in this location, have influenced the researcher's decision to investigate these locations. The study location is shown in Figure 1. The farmers facing the potential consequences of cropland transformation to industrial uses and living near the industries were this study's key population (565 farmers). The population was identified in accordance with the report from the local Agriculture Office of the Ministry of Agriculture. A simple random selection method was used to choose a 20% sample from the population, and thus, the sample size constituted of 113 farmers.

Instrumentation

The researchers designed an interview schedule to collect data. In addition to the interview schedule, qualitative techniques, including focus group discussions, were used to get the data needed from the respondents. The interview schedule included 15 statements (positive and negative) to assess the farmers' perceptions related to environmental effects compiled after taking into account previous work along with the socio-economic, political, and environmental conditions discussed with environmental concerns (Hossain *et al.,*

2010; Proshad *et al.,* 2018; Afrad *et al.,* 2020; Patnaik, 2018; Kim, 2006; Rokonuzzaman, 2016; Umanath *et al*., 2016). A five-point Likert scale was employed to measure perception, and the responses were 'strongly agree', 'agree', 'undecided', 'disagree', and 'strongly disagree' with corresponding scores of 5, 4, 3, 2, and 1 respectively for positive statements while the inverse approach was utilized for the negative statements (Likert, 1932). Each statement in the index was suitably phrased to reflect the Likert-type responses. Finally, the total score value was calculated by combining all the frequency counts of each of the scale's cells.



= Study area (The Mouchak Union)

Figure 1. Map of Bangladesh presenting the study area.

Multiple regression analysis (both entry and step-wise methods) was used to identify the influential characteristics of farmers on their perception of environmental effects. Step-wise regression analysis aids in measuring the individual input of variables by removing irrelevant variables from the model (Quddus and Kropp, 2020). The variance inflation factor (VIF) was employed to control the multicollinearity. The following are the equations for multiple regression analysis (Equation 1):

$$y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + i \quad \text{....(1)}$$

Where;

y_i = farmers' perception of environmental effects, β_0 = constant, X_1= age, X_2= years of schooling, X_3 = farm size, X_4 = household farm size, X_5 = annual household income, X_6 = extension media contact, X_7= organizational participation and $\in_i$= Error term.

To measure the extent of the transformation of cropland into industrial uses, data were collected from 2006 to 2020, and year wise total area of cropland was measured in hectares at 15 years back. Then the year-wise percentage of land transformation in the last 15 years was calculated using the following formula {(Equation 2)} (Quasem, 2011).

For example,

$$\text{Percentage of transformation in the year 2006} = \frac{\text{Transformed land in the year 2006} \times 100}{\text{The total area of land in the year 2006}} \quad \text{.....(2)}$$

To measure the reasons for the transformation of cropland into industrial uses, a four-point rating scale was used and the responses were 'strongly agree', 'agree', 'moderately agree', and 'not agree' with corresponding scores of 3, 2, 1, and 0 respectively. Reasons for the transformation of cropland into industrial uses were investigated based on the opinion of the farmers who are facing the possible consequences due to the transformation of cropland into industrial uses and residing nearby the industry i.e., the farmers were supposed to give their opinion about the reasons for transformation. For understanding the intensity of reasons, rank order was made following the Cumulative Reasons Score (CRS) of the specific reason (Kowsari, 2014). Finally, by adding all the frequency counts of each of the scale cells, the value of CRS was calculated. By using the following formula, the CRS was calculated (Equation 3).

$$CRS = N_1 \times 3 + N_2 \times 2 + N_3 \times 1 + N_4 \times 0 \text{.....(3)}$$

Where;

CRS = Cumulative Reasons Score; N_1, N_2, N_3 and N_4 represent the Number of respondents who perceived the reason as 'strongly agree', 'agree', 'moderately agree', and 'not agree' respectively.

Data collection and analysis

During July 2021, data were assembled from both primary and secondary sources. Primary data were collected from the 113 respondents using an interview schedule through personal interviews as well as FGDs were conducted in each village, each group comprising of eight farmers. Thus, a comprehensive outcome was achieved by analysing the information qualitatively collected through a total of three FGDs conducted in the three selected villages. The secondary data were collected from the Bangladesh Bureau of Statistics along with different agricultural and rural development reports. Descriptive and inferential statistics were employed using Statistical Package for Social Science (SPSS) version 20.

RESULTS AND DISCUSSION

Environmental effects of transformation of cropland into industrial uses

The major focus of the study was the environmental effects of transforming cropland into industrial uses as perceived by the farmers. Perception scores varied from 31 to 69 against the possible range from 15 to 75, averaging 61.43 and a standard deviation of 8.13. Based on the possible range of scores, the perception of farmers was classified into five categories, as shown in Table 1.

Table 1. Distribution of respondents based on their perception of the environmental effects of transformation of cropland into industrial uses.

Categories of Perception (unit: score)	No. of Farmers (n=113)		Mean	Standard Deviation
	Number	Percent		
Highly unfavorable (15-29)	0	0		
Moderately unfavorable (30-44)	7	6.2		
Neutral (45)	0	0	61.43	8.13
Moderately favorable (46-60)	16	14.2		
Highly favorable (61-75)	90	79.6		
Total	113	100		

Table 1 shows that the perception level of the farmers was highly unfavorable to highly favorable. The findings indicate that the majority of the farmers (79.6%) had a highly favorable perception compared to only 6.2% had a moderately unfavorable perception, while 14.2% had a moderately favorable perception, and none had a highly unfavorable perception and neutral point of perception regarding environmental effects of industry. Different factors like years of schooling, extension media contact and organizational participation etc. played a vital role in developing a favorable perception of the environmental effects of industry. Afrad *et al*. (2020) and Akter *et al.* (2013) also found that most of the respondents had a favorable perception of environmental issues in their respective studies.

Perception statements of the farmers were assessed based on rank order and total score. Table 2 responds to each statement aimed at capturing farmers' perceptions of environmental effects. The statement with the highest agreement level was, "Surface water quality is deteriorating day by day". Also, high in the agreement was, "Soil fertility has reduced in your area".

On the other hand, there was a general disagreement with the statement, "Drinkable water is not being decreased in this area". Similarly, farmers disagreed with the statement, "Air quality is not being decreased". The result is supported by the study of Tatlidil *et al*. (2009), who worked with 21 perception statements on sustainable agriculture, and Kabir and Rainis (2012), who worked with 15 perception statements on the adverse effects of pesticides on the environment.

Farmers' characteristics profile

Farmers' perception of the environmental effects of cropland transformation into industrial uses becomes influenced by their characteristics. Seven selected socio-economic characteristics of the farmers were considered in this study. The data in this regard are given in Table 3.

Table 2. The rank order of the statements related to farmers' perception.

	Statements	Total Score	Rank order
Effects on soil	(+) Soil fertility has reduced in your area	516	2
	(-) Crop productivity is not decreased in this area	427	12
	(+) The quantity of beneficial organisms of soil (eg. earthworm) are being decreased by the effect of industrial waste	432	11
Effects on water	(+) Surface water quality is deteriorating day by day	529	1
	(-) Drinkable water is not being decreased in this area	408	15
	(+) The level of ground water is going down in your locality	472	6
Effects on air	(+) The temperature in the area has increased in recent times	516	3
	(-) Air quality is not being decreased	415	14
	(+) Rainfall is less in this area after establishment of industry	449	8
Effects on habitat	(+) Forests are cut down regularly for expansion of industrial establishments	516	4
	(-) Suitability of surrounding environment of community and habitat structure is not being decreased	423	13
	(+) Extinction of wild animal species	456	7
Effects on human health	(+) Skin disease is prominent in this locality	506	5
	(-) Respiratory disease (Asthma, Tuberculosis, Pneumonia) is not common in this area	443	9
	(+) Health hazards of human and animal in various ways are being appeared as soil and water are polluted	434	10

Table 3. Socio-economic characteristics of the farmers (n=113).

Characteristics (Measuring units)	Range		Respondents (N=113)		Mean	SD*
	Possible	Observed	Category	(%)		
Age (Years)	-	25-80	Young (18-35)	10	50.47	10.81
			Middle aged (36-50)	41		
			Old (Above 50)	49		
Years of schooling (Years)	-	0-16	Illiterate (0)	17	5.19	3.61
			Primary (1-5)	41		
			Secondary (6-10)	35		
			Above secondary (>10)	7		
Household size (No. of members)	-	3-9	Small (Up to 4)	21	5.37	1.12
			Medium (5-6)	67		
			Large (Above 6)	12		
Household Farm size (Hectares)	-	0.06-2.48	Landless (0.002-0.02)	0	0.45	0.38
			Marginal (0.021-0.2)	35		
			Small (0.21-0.99)	58		
			Medium (1.0-3.0)	7		
			Large (>3)	0		
Annual household income ('000' Tk)	-	15-600	Low (Up to 200)	88	128.9	99.39
			Medium (201-400)	10		
			High (Above 400)	2		

Extension media contact (Scale score)	0-36	10-28	Low (Up to 12) Medium (13-24) High (Above 24)	4 83 13	20.15	3.97
Organizational participation (Scale score)	0-30	0-24	No participation (0) Low (1 to 10) Medium (11-20) High (Above 20)	14 39 44 3	9.29	6.53

SD* = Standard Deviation, Source: Field survey, 2021

Table 3 indicates that most farmers (49%) were old, and a substantial proportion (41%) had primary education. The majority (67%) of the farmers had medium-sized households, while the majority (58%) had small household farm sizes. Data on annual household income specify that most of the farmers (88%) were in the low-income class, but a suitable proportion (83%) had medium extension media contact. Data also revealed that farmers (44%) had medium organizational participation. The results are more or less similar to those of Hasibuan *et al.* (2020) and Wossen *et al.* (2017).

Estimation of factors influencing farmers' perception of environmental effects by linear regression analysis

Multiple linear regression analysis was used to identify the factors and their contribution to predicting the dependent variable, i.e., farmers' perception of environmental effects due to the transformation of cropland into industrial uses. The findings of the analysis are shown in Table 4. The Variance Inflation Factor (VIF) was used to examine the multicollinearity between the model's variables. Multicollinearity was not an issue because the maximum VIF value was 1.680 and the variables had high tolerance values. Based on the findings, three independent variables out of seven were significant, with an adjusted R^2 value of 0.636 and an F value of 28.95. Therefore, the findings indicate that about 63.6 percent of the variation in farmers' perception of environmental effects was explained by the joint effects of independent variables. The coefficient of years of schooling ($t=3.659$ and $p<0.05$), extension media contact ($t=7.417$ and $p<0.05$), and organizational participation ($t= 3.292$ and $p<0.05$) were significant.

Table 4. Summary of multiple regression explaining farmers' perception of environmental effects.

Variables	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	37.043	4.147		8.934	.000		
Age (X_1)	-.033	.052	-.044	-.635	.527	.678	1.475
Years of schooling (X_2)	.608	.166	.270	3.659	.000	.595	1.680
Household size (X_3)	-.036	.481	-.005	-.076	.940	.740	1.351
Household farm size (X_4)	-.811	1.319	-.038	-.615	.540	.847	1.180
Annual household income (X_5)	.000	.005	-.003	-.054	.957	.880	1.136
Extension media contact (X_6)	1.045	.141	.511	7.417	.000	.685	1.459
Organizational participation (X_7)	.261	.079	.210	3.292	.001	.799	1.252
R^2= 0.659, adjusted R^2= 0.636, F-value =28.95							

Significant if $p< 0.05$, the importance level is set at 95%.

Based on the findings, the years of schooling of farmers showed a positive coefficient, implying that farmers in the research area were less likely to have difficulty perceiving the concerns as their educational level improved. In other words, for every unit of increased schooling, the farmers' limitations would be reduced by 0.608. Education broadens farmers' perspectives and views, allowing them to perceive situations better. A parallel finding was reported by Elahi *et al.* (2018). The coefficient of extension media contact showed positive findings that implies extension media contact was the factor that exercised the greatest influence on the

farmers' perception of environmental effects (Tatlidil *et al.,* 2009). The organizational participation coefficient positively and significantly predicted farmers' perceptions of environmental effects. The findings of Rokonuzzaman (2016) are consistent with the findings of this study.

Estimation of individual factors' contribution influencing farmers' perception of environmental effects by step-wise multiple regression analysis

A step-wise multiple regression analysis was conducted to comprehend each variable's contribution to the farmers' variation in the perception of environmental effects in the study area. The findings of the analysis are shown in Table 5.

Based on the findings, three significant socio-economic characteristics, such as extension media contact, years of schooling, and organizational participation, entered into the model. The findings indicate that these three variables together explained a 64.5 percent variation in farmers' perception of environmental effects in the study area.

Table 5. Summary of step-wise multiple regression analysis.

Model	Variables Entered	R	R^2	Adjusted R^2	R^2 Change (% contribution)
Constant + X_6	Extension media contact (X_{06})	0.734	0.539	0.535	53.5
Constant + X_6 + X_2	Years of schooling (X_{02})	0.789	0.622	0.615	8
Constant + X_6 + X_2 + X_7	Organizational participation (X_{07})	0.809	0.655	0.645	3

Extension media contact of the respondents was the first variable entered into the model (R^2=0.535), and it contributed the highest (53.5%) to interpreting the variation in the dependent variable. Extension contact was the factor that exercised the greatest influence on the farmers' perception level regarding the environmental effects of industry. Extension contact is important because if farmers have high extension contact, they can easily perceive the environmental effects. These findings are consistent with the findings stated by Kabir and Rainis (2012).

Years of schooling of the respondents was the second variable entered into the model, and it was shown that this variable alone could account for 8% of the variation in the dependent variable. Education is the process of shaping a person's intellect; it strengthens their capacity for observation, comprehension, judgment, and adjustment of environmental issues. Education broadens the outlook and horizontally expansion the knowledge. Years of schooling are crucial for information acquisition and the development of a positive attitude. Uddin *et al.* (2021) also found education significantly aids in the evaluation of many choices when responding to a challenge. However, the respondents' participation in extension media contact and years of schooling together (R^2=0.615) had a 61.5 percent contribution to the variation in farmers' perception of environmental effects. The third variable entered into the model was the respondents' organizational participation, which accounts for a 3 percent contribution in explaining the dependent variable. Organizational participation was the factor that exercised the greatest influence on the farmers' perception level regarding the environmental effects of industry. Organizational participation is important because if farmers have high organizational participation, they can easily perceive the environmental effects as endorsed by Rahman *et al.* (2021).

The extent of the transformation of cropland into industrial uses

The extent of cropland by farmers transformed to industrial uses ranged from 0 to 52.17% during the last 15 years, with an average of 9.46% and a standard deviation of 11.35. Data shown in Table 6 indicates that most farmers (96.5%) claimed their land had been transformed to a low extent. It may be due to the availability of influencing factors of transformation. Islam (2011) also reported in his study that 19% of farmland transformed into non-farm uses.

During the fifteen years from 2006 to 2020, 9.46 percent of agricultural land was transformed into industrial uses for the selected respondents. Findings show that the cropland was being converted into exclusively industrial uses at an annual rate of 0.63%, which is extremely frightening for the country and significant enough for farmers to inevitably lose their way of life. Islam (2011) also found a more than one percent of annual transformation rate in his study.

Table 6. Distribution of respondents according to their cropland transformed into industrial uses.

Categories of Transformation (unit: Percentage)	No. of Farmers (n=113)		Mean	Standard Deviation
	Number	Percent		
Low (Up to 33)	109	96.5		
Medium (34-66)	4	3.5	9.46	11.35
High (Above 66)	0	0		

Table 7. Amount of cropland transformed during the period of 15 years from 2006 to 2020.

Land use	Total cropland transformed in 15 years (%)	The annual rate of cropland transformation (%)
Industry	9.46	0.63

Reasons for the transformation of cropland into industrial uses

Reasons for the transformation of cropland into industrial uses could range from 0 to 33 while the observed scores ranged from 9 to 25 with an average of 15.16 and a standard deviation of 2.75 as shown in Table 8. Based on the possible score, the reasons were classified into three categories, as shown in Table 8.

Table 8. Distribution of respondents according to reasons for the transformation of cropland into industrial uses.

Categories of Reasons (unit: score)	No. of Farmers (n=113)		Mean	Standard Deviation
	Number	Percent		
Less significant (Up to 11)	9	8		
Partially significant (12-23)	102	90.3	15.16	2.75
Significant (Above 23)	2	1.8		

Among the respondents, 90.3% responded on the reasons for transformation as partially significant, whereas 8% and 1.8% responded on the reasons for transformation as less significant and significant, respectively. The intensity of individual reasons for the transformation of cropland has been examined by computing rank order through the opinion of the farmers is shown in Table 9. For better understanding, the Cumulative Reasons Score (CRS) was computed.

Table 9 shows that the farmers' Cumulative Reasons Score (CRS) of eleven selected reasons for transformation ranged from 49 to 331 against a possible range of 0 to 339. However, the major five reasons for transformation have been discussed here. The first one is 'The lower price of agricultural products (CRS-331)'. They find that the cost of production is higher than that of sales because of the lower price of the product. So, farmers were inspired to transform their land.

Table 9. The rank order of the reasons for the transformation of cropland into industrial uses.

Reasons	Cumulative Reasons Score	Rank Order
The lower price of the agricultural products	331	1
Selling of land due to high prices of the land	303	2
The low productivity of cropland	298	3
Rapid urbanization	178	4
The easiest way of increasing income	177	5
Neighbouring dwellers sell their land, which influences me	112	6
A short distance from the capital city	82	7
Political pressure	71	8
Pressure from industry authority	57	9
Geographical position	56	10
Conventional farming	49	11

The second one is 'Selling of land due to high prices of the land (CRS-303)'. Due to rapid urbanization, land price emerges at a high rate. Farmers are motivated to sell their land, and they can get a good amount of money and can invest in a prosperous issue. The third one is 'The low productivity of cropland (CRS-298)'. Due to the frequent establishment of industry in cropland areas, the soil fertility rate is decreasing daily for the haphazard discharge of industrial waste; hence production is decreased. Kowsari (2014) also almost found these reasons for transformation in her study.

CONCLUSION

The industrial sector is crucial to Bangladesh's economy, but it also has a significant negative impact on the environment due to the country's rapid economic growth experiencing environmental pollution, decreased cropland area and water bodies, land fertility, etc. The study's result indicates that most farmers had a highly favorable perception of the environmental effects of the transformation of cropland into industrial uses. The three variables i.e. years of schooling, extension media contact, and organizational participation influenced significantly the farmers' perception of environmental effects. So, these three factors might be considered while taking any functional step and making policy guidelines.

According to the study, almost all farmers stated that little land transformation had occurred. The farmers claimed that the yearly rate (0.63%) of agricultural conversion to industrial uses over the past fifteen years is quite concerning for a country. The transformation rate is so high because of the continuous installation of industries that pose a serious threat to the country's food security as well as environmental safety. It was observed that a majority of the farmers in the study area responded to the reasons for transformation as partially significant. As the farmers opined, the lower price of the agricultural products, the selling of land due to high prices of the land and the low productivity of cropland were identified as the three major reasons for transformation. It is significant to highlight that although farmers were aware of the repercussions of industrialization on the environment, these three variables were more significant to farmers. Therefore, using croplands for industrial purposes is less of a concern. While croplands are still being converted to industrial purposes, it is yet unknown how to strike a balance between protecting the farmers' way of life, the environment, and the valuable land resources needed for high GDP growth.

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