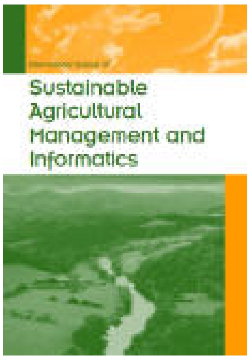

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Rony Kumar Datta, Md. Main Uddin Ahammed, A.H.M. Ziaul Haq, Md. Shamim Hossain

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Impact of environmental cost on the production cost of crops: farmers' perspective

Rony Kumar Datta

Department of Finance and Banking,
Hajee Mohammad Danesh Science
and Technology University (HSTU),
Dinajpur, Bangladesh
Email: rony.datta@hstu.ac.bd
and
Institute of Bangladesh Studies (IBS),
University of Rajshahi, Bangladesh

Md. Main Uddin Ahammed

Department of Finance and Banking,
Hajee Mohammad Danesh Science
and Technology University (HSTU),
Dinajpur, Bangladesh
Email: mainhstu88@gmail.com

A.H.M. Ziaul Haq

Department of Finance,
University of Rajshahi,
Rajshahi, Bangladesh
Email: zia_haq2001@yahoo.com

Md. Shamim Hossain*

Department of Marketing,
Hajee Mohammad Danesh Science
and Technology University (HSTU),
Dinajpur, Bangladesh
Email: shamimuibe@yahoo.com
*Corresponding author

Abstract: The aim of this study was to determine the impact of environmental factors on the production cost of paddy, corn, and potato crops in Bangladesh based on the farmers' perspective. A total of 210 cultivators of the three crops were surveyed through face-to-face interviews using an unstructured questionnaire. Environmental costs were represented by air, water, deforestation, and sound pollution costs. Multiple regression models were used to analyse the impact of environmental costs on the production cost. The results showed that air and water pollution costs have a statistically significant positive impact on the production cost of all three crops. On the other hand, sound pollution cost and deforestation cost had no significant impact on the production costs of all three crops, except for the case of deforestation cost on corn cultivation. The findings of this study can contribute to efforts to promote sustainable agriculture practices by considering intrinsic production costs that include environmental costs.

Keywords: environmental cost; production cost; pollution costs; agricultural crops; sustainable agriculture.

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Biographical notes: Rony Kumar Datta is an accomplished academic and Associate Professor in the Department of Finance and Banking at Hajee Mohammad Danesh Science and Technology University (HSTU) in Dinajpur, Bangladesh. Presently, he is engaged as a MPhil Fellow in the Institute of Bangladesh Studies, University of Rajshahi, Bangladesh. He has a passion for teaching and research in the field of sustainable finance and banking. His research interests include fintech, financial inclusion, climate finance, green finance and machine learning. He has published several research papers in international journals and presented his work at various conferences. Additionally, he has conducted several funded research projects at national level.

Md. Main Uddin Ahammed is an Associate Professor in the Department of Finance and Banking at Hajee Mohammad Danesh Science and Technology University (HSTU) in Dinajpur, Bangladesh. His research interests include financial inclusion, fintech, corporate finance, financial institutions and markets, and risk management. He has published several research papers in international journals and presented his work at various conferences.

A.H.M. Ziaul Haq is a Professor in the Department of Finance at the University of Rajshahi, Bangladesh. He earned his MPhil and PhD from the same university. He has extensive experience in teaching and research in the field of finance, with a particular focus on banks and capital markets.

Md. Shamim Hossain is an accomplished academic and a researcher in the field of marketing, with a research focus on the applications of machine learning in marketing, operations management, online business, e-marketing, self-service technologies (SSTs), e-commerce, m-banking, online customer behaviour, and other areas of business. He received his PhD in Business Management from the University of International Business and Economics (UIBE) in Beijing, China, and is currently an Associate Professor in the Department of Marketing at Hajee Mohammad Danesh Science and Technology University (HSTU) in Bangladesh.

1 Introduction

Bangladesh is one of the leading agricultural countries in the world, and the impact of environmental costs on the production cost of crops is an important issue to be studied. The contribution of agriculture to the GDP of Bangladesh is around 17%, and employment is around 45%. In rural areas, around 84% of people depend on agriculture for their livelihood, either directly or indirectly. This industry employs approximately 64% of the workforce in the country. The food security of the country completely depends on this agriculture sector. It also contributes to the country's exports by providing raw materials to the industrial sector (Moyen Uddin, 2015). Despite the fact that the modern economy is heavily reliant on industrialisation, agriculture remains the lifeblood of the Bangladeshi economy. In recent times, the contribution of agriculture to the GDP has declined, but its contribution to non-agricultural growth has shown an upward trend. Hence, agriculture is considered to be a strong driving force for the economic development of Bangladesh (Rahman, 2017).

Generally, the atmosphere of Bangladesh is suitable for cultivating the main crops, viz., paddy, corn, and potato. South Asian farmers cultivate corn twice a year: during the rainy season and the dry season (Tiammee and Likasiri, 2020). Potatoes are a major staple food for human health. It is the fourth largest crop globally after rice, wheat, and corn (Lee et al., 2008). Usually, farmers do not have adequate knowledge about the environmental costs and misuses of factors such as pesticide cost, fertiliser cost (FC), and irrigation techniques that affect the environment. The wrong utilisation of these environmentally destructive forces is the reason for ecological imbalance. It magnifies environmental costs such as useful pest deaths, soil pollution, air pollution, water pollution, sound pollution, deforestation, and medical costs.

As a rising concern, global warming and environmental imbalance have drawn more attention to world economic performance. Various parties are taking preventive actions to maintain an eco-friendly environment to ensure a sustainable future. The United Nations Framework Convention on Climate Change (UNFCCC) adopts the Paris Climate Agreement to avoid climate change in 2015 with 197 countries (Sun et al., 2020). As a part of ecology, businesses have to be concerned about whether they are affecting the environment negatively or doing supportive activities to maintain a sustainable environment. Concerns about the environment and social issues have emerged as a difficult phenomenon in the 21st century. That is why environmental performance is a source of consternation for agricultural firm top management when it comes to making strategic decisions about agricultural crop and product production cost estimation.

Geographically, Bangladesh is a country of natural disasters. The cumulative result from 2000 to 2019 of the climate risk index (CRI) indicates that Bangladesh placed 7 out of 180 countries with a score of 28.33 (Eckstein et al., 2021). Because global warming and environmental disruption are thought to be the primary causes of climate change, they are now a growing concern all over the world. As part of the sustainable development goals (SDG), Bangladesh is striving to achieve sustainable agricultural development. The sustainable development hypothesis states that it is not only economically viable but also environmentally friendly. So, to attain this sustainability, Bangladesh must create an environmentally friendly agricultural sector.

In practice, however, farmers are unaware of environmental factors when cultivating their crops. By using chemical fertilisers, pesticides, hormones, etc. farmers are polluting the water, air, soil, and the environment as a whole. Again, to expand the agricultural land, trees are being cut down and deforestation is increasing. It is obvious that more production is needed to ensure the food security of such a large population in Bangladesh. But there should be a trade-off between food production and environmental protection. Failing to maintain this trade-off can expose us to numerous natural disasters such as cyclones, sea-level rise, tidal floods, storm surges, bank erosion, etc. These natural calamities may, directly and indirectly, make the lives of the people vulnerable and miserable, which can hinder the economic development of the country.

Environmental factors are now indispensable considerations in every sector of Bangladesh. But our farmers are not conscious enough about the environment. In cultivating crops, they are polluting the environment both purposefully and involuntarily. Hence, all such activities magnify the environmental costs. Typically, farmers do not have adequate knowledge about the environmental costs and the misuse of factors such as pesticide costs, FCs, and irrigation techniques that affect the environment. The wrong utilisation of these environmentally harmful forces is the reason for ecological imbalance. It increases the cost of useful pesticides, soil pollution, air pollution, water pollution, sound pollution, deforestation, and medicine. So, various environmental factors can affect the production cost of agricultural crops. But traditionally, the farmers do not consider the environmental cost in the calculation of the production cost of various crops. So, one question can be raised; what environmental factors are significant and has impact on the production cost of crops? Therefore, this research aims to uncover those environmental factors that are significant and equally important for sustainable agricultural development in the context of Bangladesh based on the farmers' perspective.

Additionally, this study has considered air pollution, water pollution, sound pollution, and deforestation as environmental factors and their respective costs as independent variables. If environmental damages are thereby mitigated or avoided then the costs of environmental damage become the benefits of environmental protection and restoration (Ekins and Zenghelis, 2021). Demand curve approaches, ranging from direct methods based on market pricing to indirect ones such as the substitute goods method and production function can be used to assess losses when sufficient data are available. But for insufficient data, losses are assessed using either cost-based methods or the benefit-transfer method. However, if relevant information is not available at all then certain benefits could not be estimated (Croitoru and Sarraf, 2010). As instance for Bangladesh, there are no sufficient data of environmental factors is available especially regarding their impact cost on different crops.

A study conducted by Christ and Burritt (2013) explored the accountants' perceptions of environmental management accounting (EMA) for environmental strategies. Likewise, this study has considered the farmers perception and apprehension about environmental factors to calculate the environmental costs of respective crops. This study has measured the environmental costs as an opportunity cost of not considering the damages of environment done by the farmers due to the pollution of the environmental factors. Consequently, to collect the data of environmental cost the farmers are asked about their perceptions that if they had to pay compensation for polluting the air, water, sound and deforestation how much financially they were worsening off. This cost can also be seen as the preventative cost. Therefore, the environmental cost measured in this study is relative and approximate.

Based on the research problem, the specific objectives of this research are as follows:

1. To explore the environmental factors for assessing the environmental cost of the crops.
2. To examine the impact of environmental costs on the production costs of the three crops, namely paddy, corn, and potato.

2 Literature review

In Bangladesh, agriculture has been functioning as a catalyst for the growth and sustainable development of the country since independence (Rahman, 2017). Bishwajit et al. (2013) review the major food security issues in Bangladesh based on the past trend in agricultural output. They revealed that food security directly relates to the people's nutrition and health, which subsequently impact a nation's socio-economic status. According to the agricultural specialist, even though production increases, Bangladesh still needs to diversify and increase agricultural output. More investments and sustainability are needed for this implementation. To address this challenge, there is a need for more investments and sustained efforts to increase and diversify agricultural output. This can be achieved through initiatives such as providing access to technology and modern practices, promoting sustainable farming methods, and increasing research and development in the sector. By addressing these challenges and ensuring a stable and diverse agricultural sector, Bangladesh can secure its food supply and contribute to the overall well-being of its population.

Wang et al. (2010) investigate the contribution of agriculture to economic growth and find that there is a positive association between economic growth and agriculture. They conclude that, while agriculture's contribution to GDP has declined significantly over time, it continues to be an exceptional driving force for economic growth by contributing significant market, foreign exchange, and output contributions to non-agricultural growth. Wilfrid and Edwige (2004) also analyse the impact of agriculture on the GDP of China and three sub-Saharan African (SSA) countries by using multiple regression models and reveal that agriculture remains the keystone of China and the SSA countries.

Subramaniam and Reed (2009) incorporate the linkage among the manufacturing, service, agriculture, and trade sectors using a vector error correction model (VECM) for Poland and Romania. Chang et al. (2006) show that industrialisation and long-run economic growth in Japan, Taiwan, and Korea increase with higher agricultural productivity. They also conclude from the results of their study that higher agricultural productivity increases employment in the industrial sectors and hence enhances economic growth. Skinner et al. (1997) examined a study on the environmental impact of agriculture in the UK and identified the soil erosion, pesticides, nitrogen compounds, and farm animal faeces are the principal environmental factors of agriculture. Their research also considered the effects of fauna and flora, water bodies, and humans, as well as the financial expenses (such as those related to lowering pollution levels in water bodies).

Islam et al. (2021) mention that rice farmers in Bangladesh face various risks regarding environmental, climatic, and market prices. Based on this issue, they conducted a study on 600 rice farmers from three major rice-growing districts in Bangladesh. The findings show that farmers' savings, agricultural credit, off-farm income, total family income, access to information, age, distance from the farm gate to the main market, and frequent contact with extension officers are significant determinants that affect farmers' risk attitudes and perceptions.

Nguyen et al. (2019) observe that climate change is a foremost challenge for farmers. Changing farming practices can reduce emissions and help in adapting to climate change. Also, agricultural sustainability, mitigation, and adaptation can effectively lessen the effects of climate change on agricultural systems. A study by Kassam and Brammer (2013) observed that practices of conservation agriculture and cultivating diverse plant species together can protect soils against erosion and desiccation. These also increase soil organic matter contents, reduce farmers' costs of cultivation, reduce chemical pollution of rivers and groundwater, and increase carbon sequestration. The study by Skevas and Lansink (2014) assesses the productivity and environmental effects of pesticide use by applying a dynamic data employment analysis (DEA) model on Datch Arable Farms panel data from 2003–2007.

Nsibande and Forbes (2016) conclude from their study that the use of chemical pesticides affects both targeted and non-targeted pests as well as the entire ecology, including the atmosphere, water (ground and surface), soil, leaching, and pulverisation procedures. Davari et al. (2020) investigate the impacts of deforestation on soil quality indicators. The data set is from the Savan watershed, Baneh, Kurdistan, west of Iran. In the study of Mohsen et al. (2021), they examine the energy flow and greenhouse gas emissions through irrigation techniques in southern Iran. Their study considers three irrigation systems, such as furrow irrigation, sprinkler irrigation, and drip irrigation. Elfikrie et al. (2020) examine the effect of pesticides in exterior water. They also observe the efficiency level of a conventional drinking water treatment plant (DWTP) to remove pesticides from mineral water and the possible health threat to consumers if pesticides exist in the water.

Xu et al. (2020) investigate the relationship between noise pollution and economic growth in 111 Chinese cities between 1991 and 2017. Lee et al. (2021) detect the connection between corporate cash holdings and air pollution. They analyse data from the China National Environmental Monitoring Centre and the stock prices of listed companies from two provinces in China between 2013 and 2017. Guoju et al. (2013) examine the impact of climate change on potato water use efficiency (WUE) using temperature rise and precipitation simulation testing. Their study collected data from the northwest semi-arid zone of China for 50 years. Carauta et al. (2021) develop a model that combines biophysical and bio-economic models to investigate how climate change affects the profitability of double-cropping practices in Brazil.

Hien and Chi (2023) conducted a study on the green innovation in agricultural development. They proposed relationships among environment awareness, technology spillover (TS), social networks, and green innovation. To analyse the data of valid observations obtained in the structured questionnaire survey in Vietnam, the research used correlation analysis and structural equation modelling (SEM). The findings suggest that environmental consciousness and TS have significant positive influences on green innovation. Social networks also act as a catalyst for innovation in environmentally friendly agricultural production.

Debow et al. (2023) predicted and forecasted water quality using deep learning. They defined water quality (WQ) by various factors like pH, turbidity, dissolved oxygen (DO), nitrate, temperature, total and faecal coliform. The study used four-stacked LSTM models to forecast and predict water quality index (WQI). K-NN and annual mean algorithms are applied for data analysis and features selection. They concluded that predict without total coliform as the best prediction model and filtering data with RMSE = 0.013 as the best forecasting method.

In order to make informed decisions on the efficient use of production resources, Prentzas et al. (2022) tried to assess the technical efficiency of cereal and legume farms. The study used data envelopment analysis on 100 agricultural estates in the Kilkis prefecture of central Macedonia-Greece. A questionnaire survey was used to gather primary data. Every farm's gross profit served as the output. Inputs included acreage, labor, and variable expenditures for things like fertiliser, gasoline, and crop protection. The findings indicated that increasing farm efficiency requires a 48.3% reduction in inputs.

Muhamadi and Boz (2022) conducted a study to identify the variables affecting farmers' opinions of sustainable agriculture in Rwanda's Musanze district. A sample of 173 farmers who operate in this district were given a well-structured questionnaire, and this is how the data was gathered. Farmers were first split into two groups: those who felt strongly about sustainability and those who felt less strongly. To identify the variables affecting farmers' perceptions, a binary logistic regression model was used. The model's findings revealed that Umuganda, a Rwandan initiative, education level, radio listening, time spent in a nearby trading hub, farm size, and the total area of land used for agriculture were statistically significant variables that might have an impact on the region's ability to sustain agriculture.

However, from the above-cited literature reviews, it is observed that many studies have been conducted based on the relationship between agriculture and climate change. Again, some research has been performed on the effect of environmental pollution on crops and the economic development of the country. But no outright attempt has been found to examine the effect of environmental costs on the production costs of any crops. Despite the growing recognition of the impact of environmental factors on agricultural crop production, there is limited empirical evidence on the specific effect of these factors. This study addresses this gap by investigating the impact of air, water, deforestation, and sound pollution on the production costs of three major crops (paddy, corn, and potato).

3 Materials and methods

3.1 Data collection strategy

This study is empirical as well as quantitative in nature and used a primary dataset based on the objectives. Data has been collected through an unstructured questionnaire with open ended questions from the Dinajpur and Thakurgaon district of Bangladesh. Data collection period was July 2022 to September 2022. The respondents were the farmers and selected at random. This study considered the farmers of three crops namely paddy, corn, and potato that constituted 240 sample sizes (80 samples for each crop). The face-to-face interview has been conducted to fill out the questionnaire for a better understanding of the farmers and to get the true responses. The questionnaire was contained information regarding environmental costs, crop production cost, and the personal attributes of the farmers. Bangladeshi currency (BDT Taka) was used to measure the costs. Incomplete, biased, and abnormally answered responses were discarded through scrutinising process and finally accepted 210 responses (70 samples for each crop) which were used in the analysis of this study. The variables have been finalised by pre-testing and reliability testing. The final data has been analysed by the statistical software SPSS.

3.2 Econometric model

The proper method for examining the link between independent variables and dependent variables is multiple regression analysis. Multiple regression analysis has been the statistical technique that has been used the most frequently to examine the relationship between a soil property and other morphometric characteristics (Moore et al., 1993; Odeh et al., 1995; Gessler et al., 2000). Moreover, recently, several researches based on the impact of environmental factors have been conducted by using the multiple regression model (Shi et al., 2021; Hameed et al., 2022). Therefore, this study employed multiple regression models to identify the environmental factors that affect the production cost of the three crops namely paddy, corn, and potato. The models are as follows:

$$Cost_{paddy} = \beta_0 + \beta_1 APC_p + \beta_2 WPC_p + \beta_3 SPC_p + \beta_4 DFC_p + \varepsilon_i \quad (1)$$

$$Cost_{corn} = \beta_0 + \beta_1 APC_c + \beta_2 WPC_c + \beta_3 SPC_c + \beta_4 DFC_c + \varepsilon_i \quad (2)$$

$$Cost_{potato} = \beta_0 + \beta_1 APC_{po} + \beta_2 WPC_{po} + \beta_3 SPC_{po} + \beta_4 DFC_{po} + \varepsilon_i \quad (3)$$

where $Cost_{paddy}$, $Cost_{corn}$, and $Cost_{potato}$ is the total production cost (TPC) of paddy, corn, and potato and has been used as the dependent variables, β_0 represents the intercept; β_1, β_2, β_3, and β_4 represents the estimated coefficients for each of the predictors; *APC*, *WPC*, *SPC*, and *DFC* represents the air pollution cost, water pollution cost, sound pollution cost, and deforestation cost of the respective farmers and crops and has been used as independent variables to predict the dependent variables. ε_i is the stochastic disturbance term. The variables are quantitative and continuous in nature and have been measured in an appropriate scaling.

3.3 Measurement of the variables

- *Dependent variables:* this study will use the TPC per acre of the crop's paddy, corn, and potato as dependent variables. The study will consider the overhead cost (OC), seed cost (SC), FC, pesticides cost (PC), and irrigation cost (IC) to measure the TPC of the respective crops under consideration. Hence, the TPC has been calculated as follows:

  $$TPC = OC + SC + FC + PC + IC$$

- *Independent variables:* this study has been considered air pollution, water pollution, sound pollution, and deforestation as environmental factors and their respective costs as independent variables. The costs have been calculated by asking the farmers that the absence of these factors how many monetary benefits they earned.

4 Results and discussion

4.1 Descriptive statistics

In Table 1 the descriptive statistics of separate variables have been displayed. The table shows minimum, maximum, mean and standard deviation of different cost regarding the three crops of paddy, corn and potato. All costs are shown in Bangladeshi currency (BDT Taka).

4.2 Reliability and validity testing

The empirical study conducts several tests to ensure validity and reliability. The measure of the reliability of all variables indicates a satisfactory Cronbach's 'α' alpha, well above the 0.70 cut-off. Table 2 shows the overall reliability statistics of the 15 items entirely and the result indicated that the data collection procedure is reliable with a highly recommended Cronbach's alpha score of 0.710 which is considered as a good range of reliability scale (≥ 0.70) (O'Leary-Kelly and Vokurka, 1998).

Additionally, this study employs confirmatory factor analysis (Table 3) for an overall two factors model with all the variables of three crops paddy, corn, and potato. The results provide information that two of three crops fit index above 0.90 benchmark, Tucker-Lewis index for all three crops (paddy, corn and potato) are 0.984, 0.618, and 0.905 respectively; normed-fit index are 0.870, 0.718, and 0.888 respectively and the root mean square error of approximation are 0.028, 0.133, and 0.105 respectively. Therefore, the model fitted the data (Table 3). Likewise, Zhang et al. (2019) conduct a confirmatory factor analysis for an overall six-factor model of all variables, where their confirmatory factor analysis shows 0.92 which is above the 0.90 benchmarks.

Table 1 Descriptive statistics of the selected variables

Variables	*N*	*Minimum*	*Maximum*	*Mean*	*Std. deviation*
Total production cost for paddy (TPC_p)	70	10,500	93,000	36,024.57	20,896.760
Air pollution cost for paddy (APC_p)	70	100	2,300	792.14	454.258
Water pollution cost for paddy (WPC_p)	70	300	3,800	1,373.57	785.499
Deforestation cost for paddy (DPC_p)	70	200	1,500	772.14	261.772
Sound pollution cost for paddy (SPC_p)	70	200	1,000	538.57	247.329
Total production cost for corn (TPC_c)	70	10,500	118,000	34,686.86	20,228.006
Air pollution cost for corn (APC_c)	70	100	1,500	510.71	347.339
Water pollution cost for corn (WPC_c)	70	100	3,000	1,101.43	631.479
Deforestation cost for corn (DPC_c)	70	300	2,000	914.29	446.495
Sound pollution cost for corn (SPC_c)	70	0	1,000	509.29	246.320
Total production cost for potato (TPC_{po})	70	10,000	141,000	56,508.00	33,291.904
Air pollution cost for potato (APC_{po})	70	200	1,500	755.00	365.560
Water pollution cost for potato (WPC_{po})	70	200	3,000	1,085.71	643.819
Deforestation cost for potato (DPC_{po})	70	300	2,000	957.86	447.994
Sound pollution cost for potato (SPC_s)	70	100	2,000	815.00	483.072

Table 2 Reliability statistics (overall)

Cronbach's alpha	*N of items*
0.710	15

4.3 Impact of environment cost on the production cost of paddy

Table 4 indicates the model-1 summary along with the value of R square is 0.328. And it represents that the 32.8% variation of the dependent variable is explained by the independent variable and the rest are described by other factors that are not considered in this model. The p-value is 0.032 which is less than 0.05 indicating that the regression model is statistically significant and considered as a fit model. It is recommended that the value of the Durbin-Watson test of less than one or greater than three is not acceptable as a rule of thumb and is a sign of autocorrelation problem. Since Durbin-Watson statistic value is 1.416, this model has no autocorrelation problem.

Table 3 Result of confirmatory factor analyses

Model	X^2	*df*	X^2/df	*CFI*	*TLI*	*NFI*	*RMSEA*
Two factors							
Null model$_P$	20.011	19	4.279	0.991	0.984	0.870	0.028
Null model$_c$	41.267	19	4.066	0.798	0.618	0.718	0.133
Null model$_{po}$	32.896	19	8.182	0.946	0.905	0.888	0.105
One factor							
All variables combined$_p$	48.197	27	1.785	0.179	0.761	0.687	0.109
All variables combined$_c$	68.485	27	2.536	0.624	0.376	0.532	0.153
All variables combined$_{po}$	90.889	27	3.366	0.753	0.657	0.680	0.189

Note: CRI: Confirmatory factor analysis; TLI: Tucker-Lewis index;
NFI: Normed-fit index; RMSEA: Root-mean-square error of approximation.

Table 4 Model-1 summary

Model summary[b]						
R	*R square*	*Adjusted R square*	*Std. error of the estimate*	*F*	*Sig.*	*Durbin-Watson*
0.497[a]	0.328	0.297	2,055.159	2.571	0.032[a]	1.416

Notes: [a]Predictors: (Constant), sound pollution cost for paddy, water pollution cost for paddy, deforestation cost for paddy, air pollution cost for paddy.
[b]Dependent variable: TPC for paddy.

Table 5 Regression coefficients (model-1)

Model		*Unstandardised coefficients*		*t*	*Sig.*
		B	*Std. error*		
1	(Constant)	3,183.416	9,785.954	3.253	0.002
	Air pollution cost for paddy (APC_p)	2.891	5.876	–0.492	0.031
	Water pollution cost for paddy (WPC_p)	4.029	3.171	1.271	0.028
	Deforestation cost for paddy (DPC_p)	8.364	9.866	–1.152	0.084
	Sound pollution cost for paddy (SPC_p)	–11.052	10.489	1.721	0.090

Note: Dependent variable: total production cost for paddy (TPC_p).

Table 5 shows the results of regression coefficients for the model-1 regarding the impact of environment cost on the production cost of paddy. It is seen from Table 5 that the studied variables of APC_p and WPC_p are statistically significant at 5% level of significance as the p-value of both the variables is less than 0.05 as well as has a positive relationship with the dependent variable TPC_p. Again the variable DPC_p have a positive coefficient and SPC_p have negative coefficient but both are not statistically significant as the p-value exceeds from the cut-off value of 0.05.

4.4 Impact of environment cost on the production cost of corn

Table 6 shows the model-2 summary along with the value of R square is 0.257 which indicates that the 25.7% variation of the dependent variable is explained by the independent variable and the other 74.3% are described by other factors that are not studied in this model. The p-value is 0.033 indicating that the regression model is statistically significant and considered as a fit model as the value less than 0.05. The Durbin-Watson statistic value of 1.703 confirms that the model has no autocorrelation problem.

Table 6 Model-2 summary

Model summary[b]						
R	*R square*	*Adjusted R square*	*Std. error of the estimate*	*F*	*Sig.*	*Durbin-Watson*
0.483[a]	0.347	0.257	1,925.797	2.792	0.033[a]	1.703

Notes: [a]Predictors: (constant), sound pollution cost for corn, air pollution cost for corn, deforestation cost for corn, water pollution cost for corn.
[b]Dependent variable: TPC for corn.

Table 7 shows the regression coefficients results for the model-2 regarding the impact of environment cost on the production cost of corn. It is seen from Table 5 that the studied variables of APC_c, WPC_c and DPC_c are statistically significant at 5% level of significance as the p-value of all these variables are less than 0.05 as well as has a positive relationship with the dependent variable TPC_c. Again, the variable SPC_c have a negative coefficient but is not statistically significant as the p-value is far from the value of 0.05.

Table 7 Regression coefficients (model-2)

Model		*Unstandardised coefficients*		*t*	*Sig.*
		B	*Std. error*		
2	(Constant)	36,457.710	9,125.327	3.995	0.000
	Air pollution cost for corn (APC_c)	5.454	6.680	–1.266	0.035
	Water pollution cost for corn (WPC_c)	5.613	3.827	2.251	0.008
	Deforestation cost for corn (DPC_c)	0.259	5.342	–0.048	0.041
	Sound pollution cost for corn (SPC_c)	–13.162	10.057	–1.309	0.155

Note: Dependent variable: total production cost for corn (TPC_c).

4.5 Impact of environment cost on the production cost of paddy

Table 8 represents the model-3 summary and shows the value of R square is 0.454 which indicates that the independent variables alone can explain 45.4% of variation of the dependent variable and the remaining 54.6% are explained by other factors that are not considered in this model. The p-value of 0.017 which is less than 0.05 is an indicative of that the regression model is statistically significant and considered as a fit model. The Durbin-Watson statistic value of 1.688 confirms that the model has no autocorrelation problem.

Table 8 Model-3 summary

Model summary[b]						
R	*R square*	*Adjusted R square*	*Std. error of the estimate*	*F*	*Sig.*	*Durbin-Watson*
0.683[a]	0.537	0.454	3,418.160	1.691	0.017[a]	1.688

Notes: [a]Predictors: (constant), sound pollution cost for potato, deforestation cost for potato, air pollution cost for potato, water pollution cost for potato.
[b]Dependent variable: TPC for potato.

Table 9 shows the results of regression coefficients for the model-3 regarding the impact of environment cost on the production cost of potato. It is seen from Table 9 that the studied variables of APC_{po} and WPC_{po} are both statistically significant at 5% level of significance as the p-value of both the variables is less than 0.05 as well as has a positive relationship with the dependent variable TPC_{po}. Again, the variables DPC_{po} and SPC_{po} have a positive coefficient but both are statistically insignificant as the p-value exceeds from the cut-off value of 0.05.

Table 9 Regression coefficients (model-3)

Model		*Unstandardised coefficients*		*t*	*Sig.*
		B	*Std. error*		
3	(Constant)	47,659.381	15,074.147	3.162	0.002
	Air pollution cost for potato (APC_{po})	1.173	11.409	0.103	0.048
	Water pollution cost for potato (WPC_{po})	2.242	6.670	0.336	0.018
	Deforestation cost for potato (DPC_{po})	3.391	9.564	0.355	0.524
	Sound pollution cost for potato (SPC_{po})	2.798	8.635	0.324	0.747

Note: Dependent variable: total production cost for potato (TPC_{po}).

4.6 *Discussion on major findings*

This study found that cost of paddy cultivation is influenced mainly by the two environmental factors namely air pollution and water pollution cost. There is a statistically positive correlation among the cost of production, water and air pollution cost of paddy. So, increases in these environmental costs will increase the production cost of the paddy. Again, the study also found that the other two environmental factors namely deforestation and sound pollution cost has statistically no relation with the production cost of paddy.

The study also found that the air, water and deforestation cost have a positive correlation with the production cost of corn cultivation. That is, if the costs of these environmental factors increase, the cost of corn cultivation will also increase. But only the sound pollution cost found no relation with the production cost of corn in this study.

The study also discovered that the air and water pollution cost can increase the cost of potato cultivation since there is a statistically positive relation among these factors. But the study also discovered that the deforestation and sound pollution cost has no impact on the production cost of potato.

Carauta et al. (2021) found that Brazil's agriculture sector is negatively impacted by water stress and global warming. In a study of Guoju et al. (2013) concluded that the efficiency of water consumption of potato in China over the next 50 years may be favourably impacted by global climate change. Again, in another study of Skinner et al. (1997) determined that the agricultural activities, especially those connected to air and water pollutants, can have a substantial impact to miles away from their point of origin. Yet again, results of the study of Xu et al. (2020) showed that an inverse correlation exists between China's economic growth and noise pollution at the national scale which is N-shaped.

Therefore, this study revealed that the sound pollution cost has no impact on the production cost of all the three crops namely paddy, corn and potato under consideration. Again, the study also revealed that the deforestation cost has also no impact on the production cost of all three crops under consideration except the corn cultivation.

5 Conclusions

The population growth of Bangladesh calls for the high demand for crops. Especially rice, corn, and potato are the staple foods that cover a significant portion of the country's food security. Precise cultivation can only be ensured by considering environmental issues. However, the cultivation of these crops intensifies the health costs and environmental costs when it does not feel the fair market value of the environmental concern and as such damages to the environment should consider financially while investing in any agricultural project. Therefore, based on the farmers' perspective, this research focused on the environmental issues regarding measuring the production cost of the crops in reaching farmers' actual returns in Bangladesh. This study has found significant relationship between the environmental cost and production cost of crops. The findings of this study found that air and water pollution cost have the most impact on the production cost of paddy, corn and potato.

5.1 Policy implications

Several policy implications can be drawn from our research. *Firstly*, the study highlights the need for stricter regulation on air and water pollution to reduce its impact on the production cost of crops. *Secondly*, the government should consider providing financial support to farmers to adopt environmentally friendly practices in crop cultivation. *Thirdly*, the authorities should focus on promoting the use of cleaner energy sources to reduce air pollution. *Fourthly*, the government should invest in water management and treatment infrastructure to reduce water pollution. *Fifthly*, the study highlights the importance of incorporating environmental costs into the calculation of the intrinsic cost of crop production. *Sixthly*, the authorities should encourage farmers to adopt environmentally friendly practices through education and awareness programs. *Seventhly*, the government should provide incentives for farmers to adopt sustainable agriculture practices. *Eighthly*, the study emphasises the need for effective waste management to reduce the impact of environmental costs on crop production. *Ninthly*, the government should enforce regulations to prevent deforestation, especially in areas that are crucial for agricultural production. *Lastly*, the study highlights the importance of monitoring and evaluating the effectiveness of environmental policies to ensure that they are having the desired impact on crop production and the environment.

Moreover, the results of this study will assist the government in understanding the real situation concerning the environmental and climatic risk sources for agriculture and farmers and will also help the government in shaping policies to attain the SDG. Also, this study can help the government in preparing and estimating the climate fund and budget.

5.2 Academic implications

The findings of this study can contribute to create and extend the knowledge in the domain of EMA, climate finance and agricultural research. Similarly, the study can contribute to the development of theories related to sustainable agriculture practices. The findings can inform the development of new theories that account for the impact of environmental costs on production costs and promote sustainable agricultural practices. Additionally, academicians and future researchers can extend their researches from the limitations and future research directions of this study. Additionally, the findings of this study can help to develop the theories regarding sustainable agriculture. Moreover, our study can be used as a teaching resource in agricultural education to raise awareness among students about the importance of environmental protection in crop production. The study can also inspire further research on the impact of environmental costs on the production costs of other crops in different regions.

5.3 Practical applications

In Bangladesh, all development sectors are integrated with the agriculture sector either directly or indirectly. On the other hand, environmental problems are the most commonly discussed issue in the present time. The environment is polluting in numerous ways by the various acts of the farmers during cultivation. Farmers of our country do not bother with the effects of any environmental factors when calculating the TPC of crops. But this is very important for the sustainable agricultural development and food safety of Bangladesh. Hence, the findings of this study can be used to improve the efficiency of agricultural policies by policymakers relating to the agriculture sector in several ways.

Firstly, based on the farmers' perspective, the study can be used by farmers to understand the impact of environmental factors on the cost of crop production and how to reduce it. *Secondly*, the findings can inform farm owners and other stakeholders about the impact of environmental costs on the production cost of crops and how to reduce it. *Thirdly*, the results of the study can be used by the government to design policies and programs aimed at reducing the impact of environmental costs on crop production. *Fourthly*, the study provides a basis for the calculation of the intrinsic cost of crop production by incorporating environmental costs. *Fifthly*, the findings can be used to design and implement environmentally friendly agricultural practices, reducing the impact of environmental costs on crops. *Sixthly*, the study provides valuable information for the government to allocate resources for improving water and air management infrastructure, reducing the impact of pollution on crop production. *Seventhly*, the results of the study can be used by farmers to make informed decisions about the crops they cultivate, considering the environmental impact. *Eighthly*, the study provides valuable information for policymakers to design and implement waste management policies to reduce environmental costs on crop production. *Ninthly*, the results of the study can be used to create awareness about the impact of environmental factors on crop production and encourage environmentally friendly practices. *Finally*, the study can inform the government about the importance of monitoring and evaluating the impact of environmental policies on crop production and the environment.

Moreover, the findings of this research can guide the agricultural authorities, farm owners, and other stakeholders to calculate the intrinsic cost of production by considering the environmental cost which in turn can motivate the farmers to perform environment-friendly activities during cultivating crops namely, paddy, corn, and potato.

5.4 Limitations and future research directions

The study has several limitations that should be acknowledged. *Firstly*, the sample size of 210 cultivators may not be representative of the entire population of crop cultivators in Bangladesh, potentially leading to limited generalisability of the results. *Secondly*, the study relies on self-reported data from cultivators, which may introduce bias and inaccuracies into the results. *Thirdly*, the study only uses four environmental factors (air, water, deforestation, and sound pollution) as proxies for environmental costs, ignoring other potential environmental factors that could impact crop production. *Fourthly*, the study only focuses on the impact of environmental factors on the production cost of three crops (paddy, corn, and potato), ignoring other crops grown in Bangladesh. *Additionally*, the study only focuses on the impact of environmental factors on crop production costs and does not consider other important outcomes, such as crop yields, quality, and profitability. *Finally*, the study uses multiple regression models to determine the impact of environmental costs on production costs, ignoring other methods that may provide more accurate results. To address these limitations, future research should consider expanding the sample size, using more reliable and objective data sources, considering a wider range of environmental factors, studying the impact on other crops and outcomes, and exploring alternative methods for measuring the impact of environmental factors on crop production costs. Furthermore, future research should also focus on the long-term impact of environmental factors on crop production and the environment.

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Appendix 1

Table A1 Calculation of TPC

Interviewer	*PADDY*						*CORN*						*POTATO*					
	OC	*SC*	*FC*	*PC*	*IC*	*TPC*	*OC*	*SC*	*FC*	*PC*	*IC*	*TPC*	*OC*	*SC*	*FC*	*PC*	*IC*	*TPC*
1	15,000	3,000	15,000	8,000	1,500	42,500	13,000	10,000	16,000	5,000	5,000	49,000	11,000	7,000	12,000	10,000	5,000	45,000
2	15,000	2,500	10,000	4,000	11,000	42,500	10,000	7,000	11,000	4,000	4,000	36,000	7,000	20,000	15,000	8,000	3,500	53,500
3	12,000	3,500	17,000	7,000	16,000	55,500	9,000	7,000	11,000	4,000	4,000	35,000	11,000	25,000	18,000	10,000	5,000	69,000
4	8,000	1,500	8,000	3,000	8,000	28,500	3,500	4000	4,000	1,000	1,000	13,500	4,000	10,000	7,000	4,000	1,500	26,500
5	6,500	1,200	5,000	2,500	6,500	21,700	7,000	8,000	15,000	1,000	600	31,600	1,600	2,200	2,300	3,000	200	9,300
6	6,700	7,000	9,000	10,000	3,000	35,700	2,000	2,500	4,000	1,000	1,200	10,700	8,000	8,000	15,000	2,000	2,500	35,500
7	4,000	800	3,000	2,000	2,000	11,800	7,000	2,000	15,000	3,000	4,000	31,000	11,000	18,000	15,000	10,000	5,000	59,000
8	2,000	6,400	2,000	500	600	11,500	4,000	4500	5,000	3,000	3,000	19,500	8,000	15,000	7,000	4,000	500	34,500
9	1,200	500	2,300	300	1,000	5,300	15,000	10,000	15,000	4,500	5,000	49,500	2,000	500	1,000	1,000	1,500	6,000
10	15,000	2,000	10,000	12,000	5,000	44,000	5,000	3,000	6,000	2,000	2,000	18,000	1,500	2,000	3,000	1,500	500	8,500
11	15,000	4,000	15,000	6,000	15,000	55000	2,500	10,000	15,000	2,000	1,000	30,500	5,000	10,000	5,000	3,000	3,000	26,000
12	3,000	1,200	2,000	1,500	4,000	11,700	16,000	11,000	16,000	5,000	5,000	53,000	25,000	40,000	20,000	10,000	5,000	100,000
13	25,000	4,000	20,000	10,000	20,000	79,000	6,000	2,500	5,000	1,000	2,000	16,500	20,000	60,000	40,000	6,000	2,000	128,000
14	5,000	2,000	6,000	3,000	3,000	19,000	5,000	5,400	5,000	600	5,000	21,000	9,000	14,000	12,000	8,000	700	43,700
15	7,500	1,000	12,000	400	4,000	24,900	8,000	6,000	9,000	2,000	3,000	28,000	17,000	35,000	30,000	10,000	7,000	99,000
16	6,000	1,200	5,000	2,500	0	14,700	5,000	7,000	6,000	1,500	2,500	22,000	6,000	12,000	11,000	4,000	2,500	35,500
17	6,000	1,000	5,000	2,000	6,500	20,500	7,000	5,000	7,000	1,500	3,000	23500	3,000	4,000	450	1,000	1,000	9,450
18	6,000	1,500	5,000	3,000	6,000	21,500	7,000	3,000	5,000	2,000	3,000	20,000	15,000	40,000	20,000	12,000	7,000	94,000
19	13,000	4,000	14,000	7,000	15,000	53,000	4,000	2,500	4,000	1,000	1,000	12,500	10,000	20,000	4,000	500	4,000	38,500
20	7,000	2,000	4,500	2,500	5,000	21,000	13,500	8,000	10,000	4,000	4,500	40,000	1,900	7,200	3000	300	1,000	13,400
21	4,000	500	3,000	1,000	3,000	11,500	6,000	2,500	5,000	1,000	2,000	16,500	8,000	20,000	15,000	8,000	4,000	55,000
22	12,000	2,000	7,000	6,000	8,000	35,000	3,000	2,000	1,000	1,000	800	7,800	7,000	20,000	13,000	7,000	3,000	50,000
23	5,000	2,000	6,000	3,000	3,000	19,000	7000	8,000	10,000	4,000	6,000	35,000	9,000	15,000	12,000	7,000	4,000	47,000
24	2,500	750	2,000	1,700	1,600	8,550	4,000	2,000	4,000	600	600	11,200	15,000	30,000	30,000	15,000	7,000	97,000

Notes: All costs are in BDT Taka. OC = overhead cost, SC = seed cost, FC = fertiliser cost, PC = pesticides cost, IC = irrigation cost and TPC = total production cost.

Table A1 Calculation of TPC (continued)

Interviewer	PADDY						CORN						POTATO					
	OC	SC	FC	PC	IC	TPC	OC	SC	FC	PC	IC	TPC	OC	SC	FC	PC	IC	TPC
25	6,000	2,000	8,000	750	2,100	18,850	14,500	3,080	21,000	5,000	5,000	48,580	16,000	25,000	20,000	8,000	12,000	81,000
26	6,000	3,000	3,000	1,500	2,250	15,750	30,000	16,000	20,000	5,000	8,000	79,000	10,000	15,000	14,000	6,000	3,000	48,000
27	30,000	5,000	21,200	5,000	2,500	63,700	2,500	2,000	3,000	1,000	1,000	9,500	4,000	10,000	8,000	3,500	1,500	27,000
28	25,000	5,000	25,000	10,000	12,000	77,000	12,000	10,000	18,000	5,000	7,000	52,000	3,500	10,000	8,000	3,500	1,500	26,500
29	25,000	5,000	30,000	4,000	10,000	74,000	20,000	12,000	17,500	8,000	6,000	63,500	4,000	13,500	6,000	1,500	600	25,600
30	3,000	500	2,500	1,000	2,000	9,000	8,000	6,000	9,000	2,000	3,000	28,000	8,000	25,000	15,000	1,200	1,000	50,200
31	14,000	4,000	10,000	4,500	6,000	38,500	7,000	2,000	15,000	3,000	4,000	31,000	11,000	5,000	3,000	3,000	1,000	23,000
32	12,000	4,000	11,000	8,000	2,000	37,000	10,000	10,000	10,000	3,000	4,000	37,000	4,000	25,000	5,500	4,000	2,500	41,000
33	16,000	5,000	13,000	8,000	15,000	57,000	12,000	9,000	15,000	3,000	5,000	44,000	30,000	70,000	60,000	25,000	12,000	197,000
34	14,000	4,000	13,000	8,000	16,000	55,000	8,000	7,000	9,000	2,000	3,500	29,500	15,000	40,000	30,000	15,000	7,000	107,000
35	24,000	6,000	18,000	10,000	6,000	64,000	2,500	2,000	3,000	1,000	2,000	10,500	3,000	8,000	6,000	1,000	1,000	19,000
36	7,000	1,000	5,500	5,000	6,000	24,500	17,000	13,000	16,000	4,000	7,000	57,000	3,000	6,500	5,000	6,000	1,500	22,000
37	2,500	750	3,000	3,000	3,000	12,250	6,000	5,000	8,000	1,500	2,500	23,000	8,000	18,000	13,000	10,000	4,000	53,000
38	6,000	1,200	5,000	2,500	7,000	21,700	8,000	7,000	8,000	2,500	3,500	29,000	20,000	40,000	30,000	20,000	8,000	118,000
39	25,000	4,000	20,000	15,000	20,000	84,000	3,000	1,500	1,500	2,000	800	8,800	10,000	20,000	15,000	10,000	3,500	58,500
40	15,000	2,000	10,000	12,000	5,000	44,000	8,500	6,000	8,000	2,500	2,000	27,000	20,000	42,000	30,000	14,000	9,000	115,000
41	13,000	4,000	12,000	8,900	10,000	47,900	9,000	4,000	6,000	4,000	3,000	26,000	14,000	36,000	28,000	12,000	24,000	114,000
42	8,000	1,300	8,000	3,000	10,000	30,300	15,000	4,500	20,000	15,000	6,000	60,500	5,000	7,500	7,000	2,500	1,500	23,500
43	10,000	3,000	9,000	5,000	10,000	37,000	12,000	7,000	7,300	17,500	2,800	46,600	4,000	8,000	5,000	4,500	1,500	23,000
44	10,000	2,000	7,000	4,000	9,000	32,000	4,000	11,000	35,000	15,000	4,000	69,000	8,000	20,000	15,000	8,000	4,000	55,000
45	3,000	500	25,000	1,000	2,000	31,500	4,000	4,500	4,000	1,500	1,500	15,500	15,000	30,000	30,000	12,000	7,000	94,000
46	10,000	3,000	11,000	6,000	14,000	44,000	9,000	5,000	8,000	1,500	2,000	25,500	20,000	60,000	40,000	15,000	6,000	141,000
47	6,000	1,500	7,000	2,000	6,000	22,500	8,000	7,000	9,000	1,500	3,000	28,500	8,000	16,000	12,000	7,000	3,000	46,000

Notes: All costs are in BDT Taka. OC = overhead cost, SC = seed cost, FC = fertiliser cost, PC = pesticides cost, IC = irrigation cost and TPC = total production cost.

Table A1 Calculation of TPC (continued)

Interviewer	*PADDY*						*CORN*						*POTATO*					
	OC	*SC*	*FC*	*PC*	*IC*	*TPC*	*OC*	*SC*	*FC*	*PC*	*IC*	*TPC*	*OC*	*SC*	*FC*	*PC*	*IC*	*TPC*
48	16,000	3,500	13,000	6,000	12,000	50,500	5,500	8,000	2,000	2,500	900	18,900	10,000	25,000	18,000	10,000	5,000	68,000
49	10,000	2,500	8,000	2,500	8,000	31,000	6,500	5,500	8,000	2,000	3,000	25,000	12,000	30,000	22,000	15,000	5,000	84,000
50	3,000	850	3,000	3,000	3,000	12,850	4,000	10,000	8,000	4,000	2,000	28,000	9,000	25,000	20,000	10,000	4,000	68,000
51	7,500	1,500	7,000	2,500	6,000	24,500	7,000	5,000	7,000	2,000	3,000	24,000	3,000	8,000	6,000	2,000	1,000	20,000
52	4,700	500	2,000	8,000	1,240	16,440	16,000	11,000	15,000	4,000	4,000	50,000	15,000	50,000	40,000	18,000	8,000	131,000
53	6,400	1,400	1,590	8,000	7,600	24,990	20,000	16,000	20,000	5,000	9,000	70,000	7,000	7,000	12,000	6,000	3,000	35,000
54	4,500	5,000	2,500	500	2,500	15,000	15,000	12,000	16,000	3,000	5,000	51,000	13,000	25,000	25,000	10,000	5,000	78,000
55	40,000	4,000	3,200	3,600	20,000	70,800	40,000	25,000	32,000	8,000	13,000	118,000	8,000	20,000	13,000	5,000	2,500	48,500
56	1,500	1,000	7,000	4,000	1,000	14,500	21,000	12,000	24,000	6,000	1,100	64,100	3,500	8,000	6,000	4,000	1,200	22,700
57	12,000	1,500	10,000	4,000	11,000	38,500	5,000	4,600	7,000	4,500	9,000	30,100	8,000	20,000	15,000	8,000	3,000	54,000
58	14,000	2,500	11,000	6,000	1,200	34,700	3,500	3,000	3,000	1,500	1,500	12,500	3,000	3,000	2,000	1,000	1,000	10,000
59	6,000	1,300	6,000	3,000	5,500	21,800	20,000	15,000	20,000	6,000	7,000	68,000	3,200	10,000	3,730	5,000	600	22,530
60	20,000	4,400	6,400	30,000	23,000	83,800	9,000	6,000	1,000	2,000	3,000	21,000	15,000	14,000	8,000	2,000	2,000	41,000
61	6,000	1,500	5,000	2,500	6,000	21,000	6,000	6,000	7,000	2,000	3,500	24,500	10,000	31,680	11,500	7,500	10,000	70,680
62	6,000	1,000	5,000	2,000	6,000	20,000	6,000	3,000	2,000	2,500	1,500	15,000	6,000	18,000	8,000	5,000	1,000	38,000
63	5,000	2,000	5,000	3,000	6,000	21,000	6,000	6,000	2,000	800	1,200	16,000	8,000	17,000	13,000	6,000	3,000	47,000
64	10,000	3,000	8,000	5,000	9,000	35,000	8,000	7,000	9,000	2,000	3,500	29,500	8,000	18,000	15,000	7,000	3,500	51,500
65	16,000	5,000	14,000	9,000	16,000	60,000	2,500	2000	3,000	1,000	2,000	10,500	20,000	13,000	7,000	3,000	1,000	44,000
66	2,000	3,500	18,000	7,000	16,000	46,500	17,000	13,000	18,000	4,000	7,000	59,000	7,000	17,000	12,000	8,000	4,000	48,000
67	25,000	6,000	20,000	15,000	27,000	93,000	20,000	16,000	20,000	5,000	9,000	70,000	8,000	14,000	12,000	7,000	4,000	45,000
68	5,000	1,400	5,640	4,500	9,000	25,540	15,000	12,000	9,000	3,000	5,000	44,000	26,000	6,000	30,000	10,000	12,000	84,000
69	3,000	500	2,500	1,500	3,000	10,500	5,000	4,600	6,000	3,000	9,000	27,600	12,000	25,000	20,000	12,000	5,000	74,000
70	20,000	5,000	20,000	5,000	15,000	65,000	10,000	8,000	7,300	12,600	3,200	41,100	20,000	35,000	126,000	14,000	14,000	209,000

Notes: All costs are in BDT Taka. OC = overhead cost, SC = seed cost, FC = fertiliser cost, PC = pesticides cost, IC = irrigation cost and TPC = total production cost.

Appendix 2

Table A2 Environmental costs of the crops of paddy, corn and potato

Interviewer	*PADDY*				*CORN*				*POTATO*			
	APC_P	*WPC_P*	*DFC_P*	*SPC_P*	*APC_C*	*WPC_C*	*DFC_C*	*SPC_C*	*APC_Po*	*WPC_Po*	*DFC_Po*	*SPC_Po*
1	500	1,200	800	400	500	1,100	500	300	500	1,200	800	300
2	800	2,000	500	500	500	2,000	500	500	700	2,000	500	500
3	500	1,500	300	500	300	1,500	700	300	500	1,500	700	1,000
4	400	1,500	600	400	600	300	400	500	300	1,500	1,000	300
5	800	400	900	600	600	300	900	600	1,000	1,000	500	300
6	1,000	3,000	700	500	300	650	1,200	200	1,200	1,500	300	600
7	300	1,200	1,000	200	400	1,800	1,000	300	800	800	550	800
8	600	500	900	300	100	1,500	600	900	1,000	2,000	1,200	1,000
9	900	1,300	1,500	400	100	750	700	300	300	600	900	200
10	800	3,800	700	400	100	100	800	1,000	600	300	1,500	300
11	300	1,400	700	700	400	2,000	1,500	600	800	1,200	550	900
12	100	600	800	200	250	1,500	900	1,000	350	1,500	1,200	200
13	400	2,500	650	200	300	2,500	450	250	800	1,500	2,000	800
14	700	2,500	500	250	150	900	400	1,000	400	2,400	500	300
15	200	1,200	800	200	400	300	1,500	900	750	500	900	250
16	400	700	700	300	300	1,500	1,000	300	500	250	700	400
17	400	800	900	400	600	1,000	550	300	650	450	1,000	100
18	800	900	1,200	400	200	900	800	300	1,000	800	1,200	400
19	1,000	800	400	500	800	300	900	500	350	2,000	1,500	1,000
20	300	1,200	550	400	900	500	500	400	900	900	2,000	1,500
21	450	400	700	700	500	2,000	1,500	1,000	650	900	500	700
22	800	800	1,000	400	100	500	1,000	900	700	600	450	900
23	700	2,500	900	250	400	200	300	600	300	900	750	300
24	1,000	500	500	400	500	500	600	500	600	1,200	850	300

Notes: All cost in BDT Taka per Bigha. APC, WPC, SPC, and DFC represents the air pollution cost, water pollution cost, sound pollution cost, and deforestation cost.

Table A2 Environmental costs of the crops of paddy, corn and potato (continued)

Interviewer	*PADDY*				*CORN*				*POTATO*			
	APC_P	*WPC_P*	*DFC_P*	*SPC_P*	*APC_C*	*WPC_C*	*DFC_C*	*SPC_C*	*APC_Po*	*WPC_Po*	*DFC_Po*	*SPC_Po*
25	900	1,500	700	300	1,000	1,500	900	400	500	1,000	1,000	1,200
26	300	500	600	200	200	1,000	800	600	800	700	1,500	1,500
27	700	550	400	400	250	1,200	1,200	500	200	800	900	300
28	800	3000	900	1,000	500	1,000	2,000	500	700	300	2,000	1,000
29	500	1,500	1,300	1,000	500	1,000	700	500	900	200	500	600
30	1,000	500	600	900	350	400	900	0	400	500	700	1,200
31	300	700	900	800	1,500	1,000	450	400	450	1,300	500	1,500
32	1,000	2,500	1,000	900	200	1,000	1,200	500	500	500	800	2,000
33	1,000	800	700	500	1,000	1,000	1,500	500	500	500	1,000	900
34	900	2,000	500	1,000	500	2,000	1,000	500	700	2,000	900	500
35	500	2,000	800	500	1,200	500	2,000	1,000	450	500	1,200	500
36	600	2,500	700	500	300	1,500	900	300	650	500	600	1,500
37	700	2,000	900	500	1,100	600	500	700	200	2,000	1,500	2,000
38	900	1,000	1,100	500	1,500	1,200	700	300	500	1,500	1,000	1,500
39	800	800	600	1,000	200	500	2,000	900	1,000	2,000	1,500	1,000
40	1,500	2,000	900	800	900	1,300	1,200	500	900	1,000	500	1,000
41	800	1,100	550	400	800	600	1,500	1,000	1,000	2,000	1,200	500
42	1,000	2,000	800	500	700	2,200	900	400	600	1,500	700	2,000
43	500	2,000	450	1,000	200	700	2,000	500	1,000	1,000	800	500
44	1,000	2,000	1,000	1,000	300	500	700	900	500	1,000	900	900
45	1,000	3,000	900	1,000	1,500	600	500	800	700	400	1,500	1,500
46	1,500	500	700	900	1,200	1,000	750	500	500	1,000	1,000	800
47	400	1,500	400	400	900	1,000	900	500	400	600	550	1,000

Notes: All cost in BDT Taka per Bigha. APC, WPC, SPC, and DFC represents the air pollution cost, water pollution cost, sound pollution cost, and deforestation cost.

Table A2 Environmental costs of the crops of paddy, corn and potato (continued)

Interviewer	*PADDY*				*CORN*				*POTATO*			
	APC_P	*WPC_P*	*DFC_P*	*SPC_P*	*APC_C*	*WPC_C*	*DFC_C*	*SPC_C*	*APC_Po*	*WPC_Po*	*DFC_Po*	*SPC_Po*
48	600	800	500	500	800	800	1,000	700	500	1,000	1,200	800
49	200	2,000	600	400	700	1,500	1,200	300	1,000	2,000	2,000	1,000
50	1,200	1,500	800	600	200	500	1,500	300	1,000	2,000	900	1,000
51	600	1,500	900	500	400	500	500	500	1,500	3,000	2,000	500
52	1,400	1,600	1,200	500	300	900	700	700	1,200	500	550	450
53	1,000	300	600	800	200	2,000	300	400	300	1,500	750	300
54	500	1,000	800	900	300	900	500	300	1,500	600	950	900
55	300	1,000	500	500	600	1,800	1,000	300	1,500	1,300	400	300
56	2,000	1,500	900	1,000	700	3,000	1,200	200	900	500	1,000	1,000
57	1,500	700	1,500	1,000	500	1,500	1,500	200	300	2000	600	700
58	1,000	1,500	1,000	500	300	700	900	800	1,500	1800	900	500
59	1,200	1,000	800	300	250	1,000	500	300	1,200	500	600	1,500
60	1,300	900	900	500	500	1,500	1,000	700	1,000	400	1,000	900
61	300	2,500	500	500	400	1,100	300	200	300	200	500	2,000
62	2,300	500	550	400	300	2,000	500	500	300	500	1,200	500
63	300	1,000	1,100	400	200	300	400	300	550	700	400	600
64	1,500	400	1,200	300	500	2,000	1,000	500	1,500	1,000	1,500	500
65	600	1,100	500	300	900	500	700	600	1,200	800	700	500
66	500	900	600	300	300	1,500	600	300	1,000	2,000	2,000	500
67	500	1,500	900	500	200	2,000	800	400	1,500	500	700	700
68	400	300	200	600	200	200	1,000	300	900	400	500	650
69	2,,000	1,000	1,000	600	600	1,500	500	200	1,500	2,000	900	1,000
70	1,500	2,500	900	300	300	1,500	2,000	500	1,000	500	1,000	1,500

Notes: All cost in BDT Taka per Bigha. APC, WPC, SPC, and DFC represents the air pollution cost, water pollution cost, sound pollution cost, and deforestation cost.

Appendix 3

Questionnaire

Impact of environmental cost on production cost of crops

Name:

Age:

Marital status:

Educational qualification:

Status of the cultivated land: Own or contractual.

Key questions to take the interviews of the farmers of the respective crops:

A Questions relating to the production cost of the three crops namely paddy, corn and potato:

1. Do you cultivate the crops of paddy, corn or potato?
2. How much you cultivate per Bigha in a year?
3. What type of cost you incurred for the cultivation?
4. How much will be your initial/ OC for the respective crop?
5. How much cost will occur for fertilisers?
6. How much cost will occur for seeds?
7. How much cost will occur for pesticides?
8. How much cost will occur for irrigation?
9. Please mention if any other cost that you incur for the cultivation.

B Questions relating to the farmers perception regarding environmental cost of the three crops namely paddy, corn and potato:

1. Do you use any chemical fertilisers and pesticides?
2. Will the air be affected by using chemical fertilisers and pesticides?

   # If yes, then how much cost will occur to recover the health/breathing problem due to air pollution?
3. Will the water be affected by using chemical fertilisers and pesticides?

   # If yes, then how much cost will occur to recover the health problem due to water pollution?
4. Are there any trees located at your cultivated land?

   # If yes, whether you destroy or cut down trees?

   # If yes, then for this whether any human being or animal adversely affected?

   # If yes, then how much cost will occur to recover this?

5 Do you use shallow or motor pump for irrigation?

For using shallow is there any person who will be affected by hearing problem?

If yes, then how much cost will occur to recover this hearing problem?

6 If you want to comment and recommend anything else.

Thank you for spending your precious time to answer those questions.