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Investigating Corporate Environmental Risk Disclosure Using Machine Learning Algorithm

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Abstract: The volume of the environmental risk disclosure in the annual reports of firms in the pharmaceutical and chemical, tannery, telecommunications, and paper and printing industries listed on the Dhaka Stock Exchange (DSE) in Bangladesh was analyzed in this paper. The research used a content analysis of the annual reports of 43 companies that represented four DSE sectors. To quantify the level of environmental risk disclosure reporting practiced by corporations in their annual reports, the authors established the ERDIPCI for the pharmaceutical and chemical industry, the ERDITI for the tannery industry, the ERDITeI for the telecommunications industry, and the ERDIPPI for the paper and printing industry. Similarly, the machine learning clustering algorithm, k-means clustering, is used to cluster the companies based on the completion of different environmental indices. It is observed that from four sectors, the highest number of companies from the pharmaceutical and chemical industry disclosed environmental risk disclosures, and the lowest number of companies was from the tannery industry, followed by the telecommunications and the paper and printing industries. The enterprises differ significantly in their environmental risk disclosures, and the overall scenarios of the environmental reporting practices by companies in Bangladesh are quite poor. It also shows that among the 43 companies, a limited number of enterprises are placed first. The majority of the businesses are in the midst of a cluster that reflects the increasing order of indices fulfillment. This paper provided a few specific proposals to the relevant authorities in order to establish a regularity framework in which all the firms listed on the DSE in Bangladesh will be expected to address environmental risk disclosures and conservation actions in their annual reports towards adaptation to climate change and achieving environmental sustainability.

Keywords: environmental risk disclosures; annual report; climate change; and environmental sustainability

Citation: Uddin, M.M.; Rashid, M.M.; Hasan, M.; Hossain, M.A.; Fang, Y. Investigating Corporate Environmental Risk Disclosure Using Machine Learning Algorithm. *Sustainability* **2022**, *14*, 10316. https://doi.org/10.3390/su141610316

Academic Editors: Ioannis Nikolaou, Yi-Chung Hu, Ming-Hua Lin, Jung-Fa Tsai, Phi-Hung Nguyen and Ming-Tsang Lu

Received: 2 June 2022
Accepted: 16 August 2022
Published: 19 August 2022

1. Introduction

A company's environmental risk disclosure evaluates the status of information included in financial reports in accordance with the addressing, identifying, and processing of the lapse of climate-related risk and opportunities, the climate risk management strategy, the management role, the association of climate-related risk and opportunities with the company's business strategy and financial planning, and the way of mitigating climate-related risk and opportunities [1–3]. The natural environment, economic activity, and economic growth and development are all intimately linked, both directly (sources of supplying input materials such as water, timber, and minerals) and indirectly (water purification,

flood risk management, and nutrient cycling), not only now but also in the future [4,5]. However, industrial expansion and technological advancement have been criticized for having greater environmental repercussions, and businesses have been urged to take greater environmental responsibility [6]. Companies are now believed to be responsible for their environmental repercussions. The importance of transparency in assessing the risk connected with climate change, as well as the risk associated with providing well-versed and competent capital allocation choices, has been underlined [1,7]. As a result of these factors, the demand for environmental disclosure reporting has risen intensely, and many companies have begun to disclose their environmental conservationism, activities, and performance in financial statements (balance sheets, profits, and loss accounts), notes to financial statements, annual reports, or separate environmental or sustainability reports. Climate-related disclosures have increased globally, although corporations are expected to divulge information linked to strategy and governance with the least disclosures on the resilience of strategies and governance [1,8]. However, given the absence of international environmental accounting rules, stakeholders will have to rely on voluntary environmental disclosures. Environmental disclosures are voluntary and vary from company to company, country to country, and industry to industry [9].

Therefore, environmental sustainability is required in the business operations of pharmaceutical and chemical, tannery, telecommunications, and paper and printing industries in reporting for our sustainable existence and survival. This study will evaluate the environmental risk disclosure reporting practices of the companies listed on the Dhaka Stock Exchange (DSE) in Bangladesh using content analysis. Furthermore, it will evaluate the performance of the companies with regard to environmental reporting disclosure practices over the years, using a machine learning algorithm called k-means clustering, comparing the industries and finally identifying the present status of the concentration of reporting from the index items.

2. Literature Survey

Environmental risk is closely associated with our sustainable existence and development, and this is giving importance to environmental risk disclosure reporting practices globally. Here, the studies on the involvement of industries with environmental degradation, along with global initiatives in response to the ever-rising demand for environmental risk reporting, have been identified, and a path for obtaining new results in this regard has been found.

2.1. Environmental Impacts of Selected Industries

2.1.1. Pharmaceutical and Chemical Industry

Chemicals are frequently utilized in disinfectants, cleaners, laboratory reagents, sterilants, insecticides, pharmaceuticals, medical devices, and equipment in the health business, resulting in animal welfare benefits as well as increased concern for the health and environmental repercussions [10]. Pharmaceuticals and chemicals have been widely used for biological activities [11]. Releasing pharmaceutical wastes and chemicals is the primary cause of environmental and health concerns, both directly and indirectly. These substances are neither water- nor soil-soluble, and they are extremely damaging to the environment [12–14]. The health risks of active pharmaceutical compounds have not yet been adequately addressed, particularly in underdeveloped nations [15]. Sustainable management of biomedical waste, which includes improved segregation, transportation, and disposal methods to prevent environmental pollution, is not only socially responsible but also legally required for a healthy and cleaner environment [16]. One of the major contributors to environmental pollution and climate change is the improper biomedical waste management of pharmaceutical products [17]. Pharmaceutical waste is causing environmental damage, which is widely recognized as a major issue. Open burning and dumping are the most commonly used waste management and final disposal strategies in low-income countries [18,19]. To reduce the harmful effects of pharmaceuticals on the

environment, projects, pharmaceutical combinations and manufacturing, medicaments, sales, waste management, and the mechanisms of causes with cutting-edge technologies should be integrated into daily human life and industrial operations [20]. If medications are not stored in an environmentally sustainable manner, they can have pharmacological effects on breathing creatures, causing harm to animals and ecosystems [21]. Pharmaceutical and chemical items are not properly disposed of; this will create a dangerous threat to the environment (especially to living organisms, soil fertility, and groundwater) and lead to a negative impact on climate change.

2.1.2. Tannery and Leather Industry

The tannery sector has been considered a significant contributor to Bangladesh's economic development since the beginning of industrialization, including labor orientation in employment [22,23]. Every day, despite the fact that a tannery industrial estate can treat approximately 25,000 cubic meters of liquid waste, it produces 40,000 cubic meters of liquid waste, resulting in the dumping of 15,000 cubic meters of liquid waste into the river without any environmentally friendly treatment, resulting in severe environmental pollution. Furthermore, Bangladesh's tannery industrial estate lacks adequate treatment facilities for solid waste, heavy metals, and chromium, causing serious harm to living organisms, aqua fish, and the environment [24,25]. River water is important for home, agricultural, and industrial purposes, but it is currently at risk of pollution due to metal concentrations, a shortage of soluble oxygen, and the emergence of Cu, Fe, Pb, Cd, Ni, Mn, As, and Cr from the tannery industry and leather manufacturing [26]. Hexavalent chromium, a cancer-causing toxin, can be released from tanneries' dumps, and direct discharge of tannery waste, containing high levels of chromium, cadmium, and arsenic is responsible for serious groundwater pollution, which has a significant impact on fish and shellfish species. Furthermore, unplanned tannery industry development without consideration of environmental impact assessments pollutes the environment [27]. In Bangladesh, wastes from the tannery and leather processing industries are dumped into nearby rivers, lakes, canals, ponds, and drains, severely polluting the environment due to non-operational technology, inadequate drainage systems, a lack of financial input, the exploitative attitude of company owners, and the lack of implementation of proper monitoring. Human problems, such as itching, thoughtlessness, cough, fever, diarrhea, headache, asthma, and dizziness, are also linked to improper tannery waste disposal [28]. This results in an unhealthy environment for humans, animals, livestock, agriculture, and fisheries, among other things [23].

2.1.3. Telecommunications Industry

Telecommunications play an important role in remote sensing, surface water management, natural disaster management, quick communication, online communication, geographic information systems, and natural resource management [29,30]. Telecommunications make our lives easier, but their rapid expansion may have a negative impact on our environment due to the telecommunications infrastructures, mobile phone towers, heavy overhead cables, aerial cabling, hybrid optical fiber/coaxial cable rolls, electromagnetic radiation emissions from mobile phone towers, energy use, greenhouse gas emissions, submarine cables, and other factors [31,32]. Efficient and sustainable uses of energy, telecommunications infrastructure development, mobile phone tower establishment, and efficient management of greenhouse gas emissions and electromagnetic radiation emissions are needed [31]. Telecommunications companies need to disclose their environment-friendly initiatives, environmental conservation activities, and sustainable environment-friendly development activities.

2.1.4. Paper and Printing Industry

Paper is a valuable but wasteful product, which results in paper pollution [33] every year; around 300 million tons of paper is produced worldwide. Copier paper, computer

printouts, and notepads are among the most common causes of paper consumption and landfill waste [34]. Furthermore, according to the U.S. Environmental Protection Agency, the United States alone uses 68 million trees for paper production each year. Paper is being used in increasingly diverse ways. In simple terms, we can compare the use of paper to the act of cutting down a tree. The increased usage of paper contributes to the loss of trees. Not only is this an environmental issue, but CO_2 and nitrogen dioxide are regularly released during the paper manufacturing process, and these gases are extremely detrimental to the atmosphere [35]. Furthermore, the paper and printing industries consume a substantial amount of energy and harm the environment. Increased demand for paper leads to additional deforestation, which makes our world unsuitable for our survival [36]. Air pollution, water pollution (by releasing chlorine, iodine, and sulfur dioxide), sound pollution, greenhouse gas emissions, carbon dioxide emissions, aquatic ecosystems, water acidification, and disposal of used paper are all issues that the paper and printing industry faces. It also contributes to global warming and climate change [37]. Due to the expansion of industrialization, urbanization is experiencing challenges due to the lack of clean and affordable water. Water contamination caused by waste from the paper and printing industries has a direct impact on aquatic organisms, plants, human climates, and ecosystems [38].

2.2. Industries toward Ecological Balance, Biodiversity, and Sustainability

The extraordinary progress and increase in medication for the treatment of diseases have an impact on the environment. The constant increase in the consumption of human and veterinary pharmaceuticals has an impact on the natural marine environments and ecosystems [39]. The presence of tons of human and veterinary pharmaceutical chemicals on a worldwide scale endangers aquatic and terrestrial ecosystems. Furthermore, medications and chemical compounds are leaking into the soil, groundwater, and wastewater, posing a threat to animals [40]. Pharmaceutical pollutants are threatening the aquatic world and the surface inhabitants because they are not properly quality checked and consumed. Many cytotoxic medications are regularly released from companies and hospitals around the world, and these pharmaceutical pollutants are sent to wastewater treatment plants; however, due to flawed processes, these pharmaceutical contaminants return to the environment [41]. Pharmaceutically active compounds are to blame for harming ecosystems, and pharmaceutically active compounds found in raw and treated wastewater and surface water around the world pose a threat to the environment and human health [42]. Hazaribag, Dhaka, is a pollution hotspot that exacerbates environmental problems not only for the environment but also for the social context due to a lack of proper tannery waste management, the use of outdated technology, the lack of proper waste treatment facilities, and the discharge and dumping of waste [43]. A newly established tannery industrial area in Bangladesh has been identified as the source of two probable sources of heavy metals: the biochemical and leather tanning industries and the geogenic and atmospheric deposition and traffic emissions [44]. The tanning industry found that several chemicals were employed and eventually released into the environment, causing pollution and diseases in the air, soil, and water. Furthermore, chromium, which is produced in tanneries, is extremely detrimental to the environment [45]. The telecommunications industry's power supply, antenna cables, landings, transceivers, routers, base stations, computers, peripheral devices, waste electrical and electronic equipment, water consumption and wastewater, noise emission, and changes in the landscape and habits due to infrastructural developments all have significant negative effects on the environment [31].

2.3. Global Concern for Environmental Sustainability

Raising environmental awareness about pharmaceutical-related activities and implementing measures such as green manufacturing, alternative environmentally friendly production processes, efficient operational management, and reducing unused medication led to the enrichment of green principles, as well as to the reduction in chemical and waste

use, and ultimately helped to mitigate negative climate change impacts [39]. To prevent the potentially harmful effects on ecosystems and human health, pharmaceutically active chemicals need to be removed through the utilization of modern technology [42]. The current international pharmaceuticals environmental risk assessment (PERA) criteria are not the same in detail, but the entrance paths are identical as the organism and ecological functions inside compartments are highly comparable. The two steps are also included in the environmental risk assessment guidelines for medicines [46]. The phrases "emission into the environment" and "environmental risk assessment" have been used to evaluate the danger of releasing emissions into the environment, as has "information on emission into the environment" [47]. Furthermore, exercising secrecy with regard to environmental risk assessment reports is in violation of Article 4 of the Aarhus Convention, as well as the European and international implementing provisions that require everyone to have unfettered access to environmental information on emissions. In responding to these situations, these studies propose to investigate the corporate environmental risk disclosure and formulate environmental risk disclosure indexes for four industries.

2.4. Bases of the Development of Environmental Risk Disclosure Index

2.4.1. For the Pharmaceutical and Chemical Industry (ERDIPCI)

Intercontinental frameworks for managing chemicals and wastes have been identified. Their 'Strategic Approach to International Chemicals Management (SAICM)' focused on pharmaceutical contaminants from an environmental standpoint [48]. Nanotechnologies and nanomaterials were also dealt with by the Environmental Persistent Pharmaceuticals Pollutants (EPPP) [49].

2.4.2. For the Tannery Industry (ERDITI)

These include the Environmental Impacts Guidelines for New Source Leather Tanning and Finishing Industries in the USA [50]; the Sector Specific Environmental Impacts Assessment Guidelines for Tannery Projects (Rwanda Environmental Management Authority, 2012) [51]; the Guidelines for Environmental Improvement in Leather and Tannery Sector (Central Pollution Control Board, 2019) [52]; and the Environmental Inspection Guidelines for the Tanning Industry and Basic Principles for Understanding Potential Environmental Threats Caused by the Tanning Industry (European Union Network for Implementation and Enforcement of Environmental Law, 2021/12) [53].

2.4.3. For the Telecommunications Industry ERDITeI

The Best Environmental Management Practice in the Telecommunications ICT Services Sector has been addressed and has been seen as a global initiative and as instructions calling on organizations for more environmental sustainability [31]. Additionally, the International Telecommunication Union (ITU) published "Telecommunication and the Environment: The Path to Sustainable Development" as policy guidelines based on The Rio Declaration and the Agenda 21 Program [54].

2.4.4. For the Paper and Printing Industry ERDIPPI

The Department of Environment and Conservation collaborated with the NSW Environmental Protection Authority in Sydney to produce 'Environmental Actions for the Printing Industry' [55]. Ensuring Environmental Sustainability in the Printing Industry has been initiated and developed by the Swedish University of Agricultural Science [56]. The European Union has adopted around 500 directives and rules under environmental legislation, including those concerning forest protection and chemical limits [57].

Returning now to Bangladesh, only 9.97% of pharmaceutical and chemical companies disclosed very little information in their annual report, and only two companies were identified that disclosed a maximum of 18 environmental factors in their annual report out of 74 factors [58]. On another hand, of 250 fortune global firms, only 35% of the companies disclosed an environmental report, and the other 32% of the companies disclosed other types

of environmental information. In addition, there is a considerable difference of 15–44% with regard to reporting frequencies between financial and nonfinancial factors [59]. In the product design and coefficient manufacturing process, the environmental management systems are perfect and influenced by green chemistry principles, choosing and using correct metrics. In addition, in achieving the sustainability of pharmaceutical companies, waste reduction, mitigation of carbon emissions, and legislative compliance had a positive influence and led to more flexibility and competitive advantage [60]. In a separate section on the website, in the sustainability reports or in the annual reports, companies are disclosing their sustainability activities. Most of the companies focused on energy efficiency, waste management, reducing greenhouse emissions, and health and safety but not on economic sustainability [61]. The telecommunications companies in Bangladesh reported information about social and environmental responsibility within a range of categories. In addition, the education and health sectors of Bangladesh have benefited from the telecommunications industry and are seeking to maintain legitimacy [62].

With the completion of the literature on Bangladesh, the details of the consequences of generating environmental pollutants from several industries towards climate change and global warming, along with the role of environmental reporting regulations for future sustainable existence and development, are shown in Figure 1.

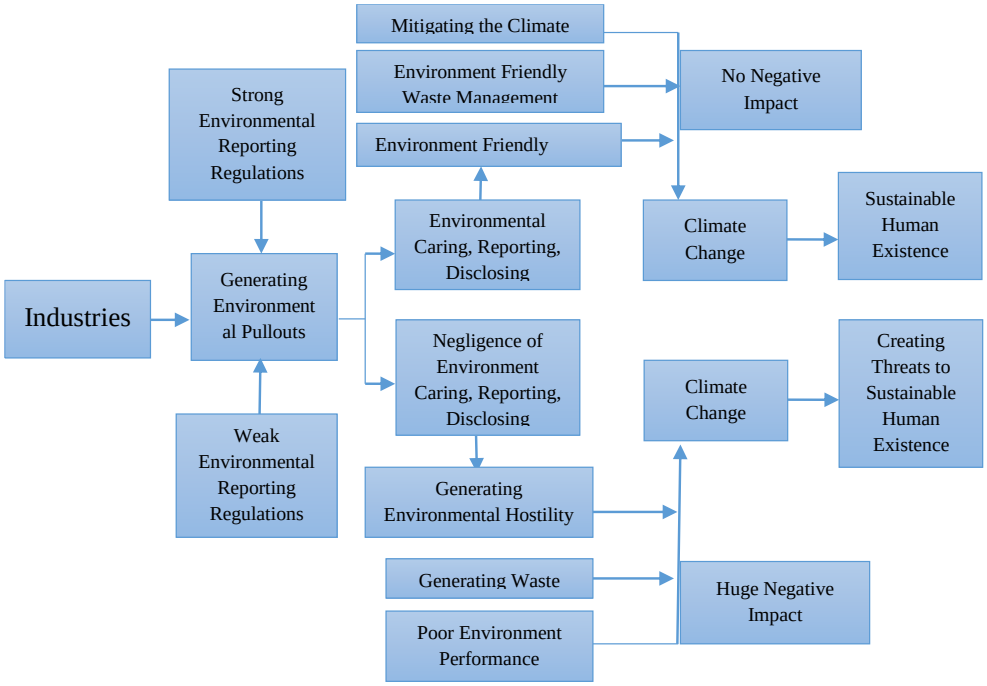


Figure 1. Details of consequences of environmental risk reporting disclosures. (Developed by authors).

As a coastal state, Bangladesh is in the most vulnerable situation for sustainable existence and development, and industries are required to account for their sustainability, which is required for adaptation to climate change and global warming. Therefore, this study proposes to evaluate the status of the companies in the pharmaceutical and chemical, tannery, telecommunications, and paper and printing industries listed in the DSE of Bangladesh in the context of the above-mentioned framework.

3. Materials and Methods

The following is the detailed flowchart of the completion of the entire study shown in Figure 2.

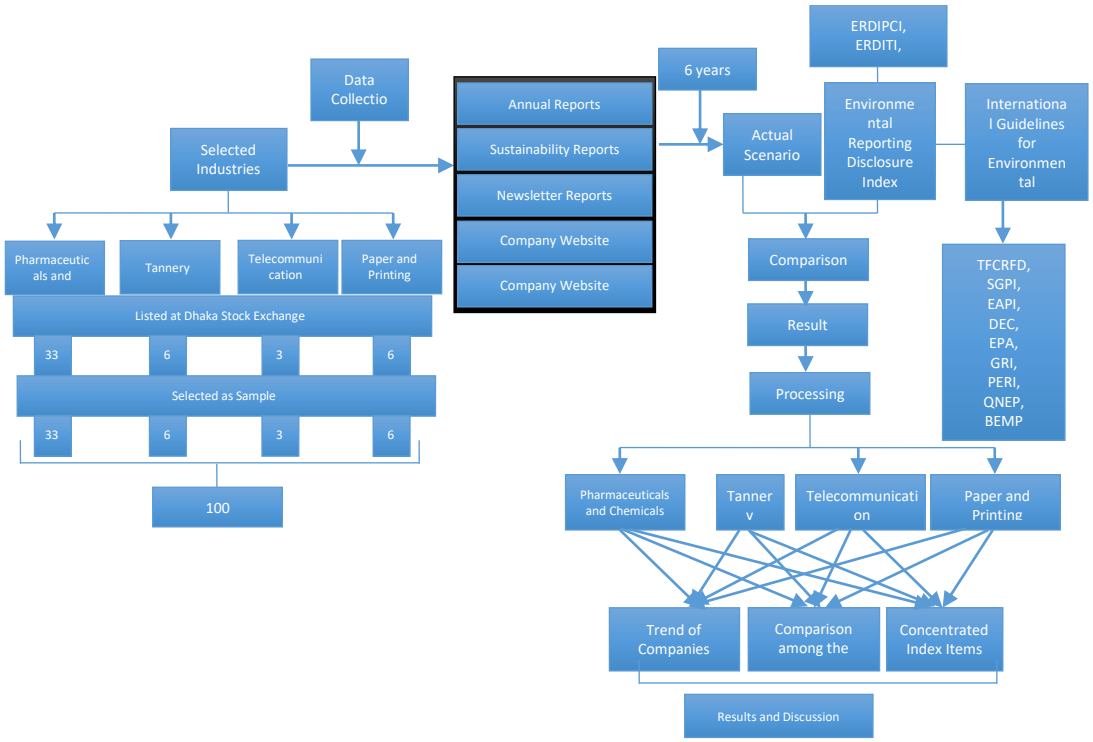


Figure 2. Detailed methodology of the study. (Developed by Authors).

To complete the study, four industries, namely pharmaceutical and chemical, tannery, telecommunications, and paper and printing, have been selected. On 1 July 2021, there were 32 companies listed as pharmaceutical and chemical industries, 6 companies as tannery industries, 3 companies as telecommunications industries, and 6 companies as paper and printing industries at the DSE. These 43 companies of the four industries were selected from the Dhaka Stock Exchange listing. Of the 43 companies, one is multinational, and 15 companies have a global presence in the exporting sense. The information on all of these companies was collected. Annual reports, sustainability reports, newsletters, and circulars, the company websites, and festivals were deeply evaluated for the collection of the data regarding environmental risk reporting from 2014 to 2020.

3.1. Development of the Environmental Risk Disclosure Index

3.1.1. For the Pharmaceutical and Chemical Industry (ERDIPCI)

The environmental risk disclosure index for the pharmaceutical and chemical industry was developed by the authors with the help and understanding of 'the 2021 Status Report, Task Force on Climate-Related Financial Disclosures (TFCRFD); 'the international standard for environmental management systems (ISEMS), ISO 14001: 2004'; The Global Reporting Initiative (GRI); the Public Environmental Reporting Initiative (PERI); and the United Nations Environment Program (UNEP) [63–67]. These are given in detail in Appendix A.

3.1.2. For the Tannery Industry (ERDITI)

The environmental risk disclosure index for the tannery industry was developed by the authors with the understanding of the Environmental Impacts Guidelines for New Source Leather Tanning and Finishing Industries in the USA; the Sector-Specific Environmental Impacts Assessment Guidelines for Tannery Projects; the Guidelines for Environmental Improvement in the Leather and Tannery Sector; the Environmental Inspection Guidelines for the Tanning Industry and Basic Principles for Understanding Potential Environmental Threats Caused by the Tanning Industry; and the United Nations Environment Program (UNEP) [50–53,67]. These are given in detail in Appendix B.

3.1.3. For the Telecommunications Industry (ERDITeI)

The environmental risk disclosure index for the telecommunications industry was developed by the authors with the understanding of the 'Best Environmental Management Practice (BEMP) in the Telecommunications and ICT Services sector', developed by the European Union, Luxembourg [68]; "Telecommunication and the Environment: The Path to Sustainable Development", guidelines based on The Rio Declaration and the Agenda 21 Program [54]; and the United Nations Environment Program (UNEP) [67]. These are given in detail in Appendix C.

3.1.4. For the Paper and Printing Industry (ERDIPPI)

The environmental risk disclosure index for the telecommunications industry was developed by the authors with the understanding of 'The State of the Global Paper Industry (SGPI) [69]; the 'Environmental Action for the Printing Industry (EAPI)' [70]; the United Nations Environment Program (UNEP) [67]; and the Environmental, Health, and Safety Guidelines Telecommunications [71]. These are given in detail in Appendix D.

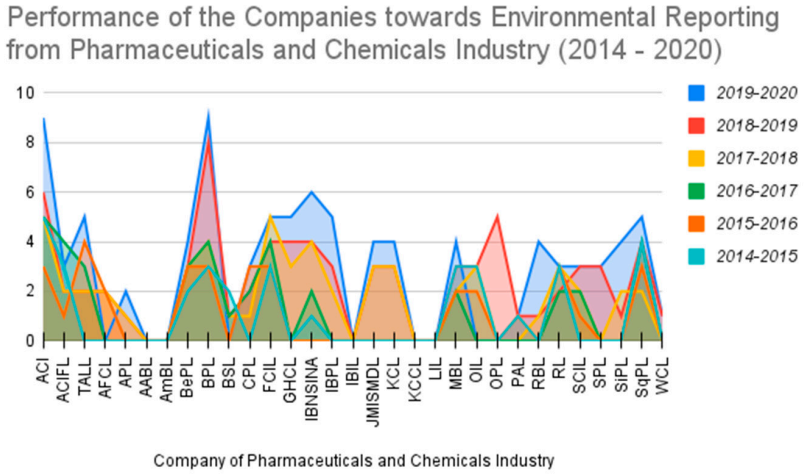
To analyze the data of the four different industries, the following procedure is used. We mainly investigate the environmental disclosure index of the different companies under the different industries. A total of three types of analysis are performed in this analysis.

In analysis 1, the addition of the different indexes is mainly calculated for each company every year, using Formula (1) and visualized in Figures 3–6.

$$\sum_{i,j,k}^{c,y,Ind} \left(X_{i,j,k} + \cdots + X_{i,j,Ind} \right) \quad (1)$$

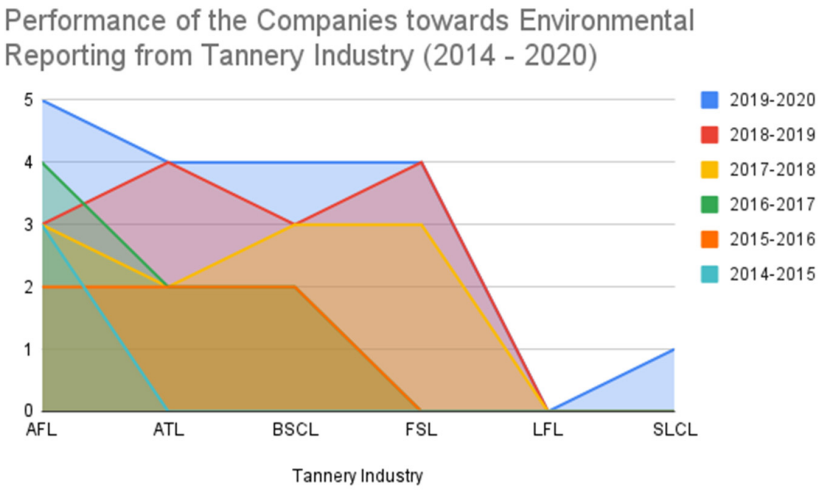
where

c = the number of companies under each industry
y = year (2014–2020)
Ind = Environmental Disclosure Index (Pharmaceutical and Chemical = 27,
Tannery = 26, Telecommunications = 23, and Paper and Printing = 28)
X indicates the particular company from the different industries and is allocated by different values of i, j, k.



(**a**)

Figure 3. *Cont.*



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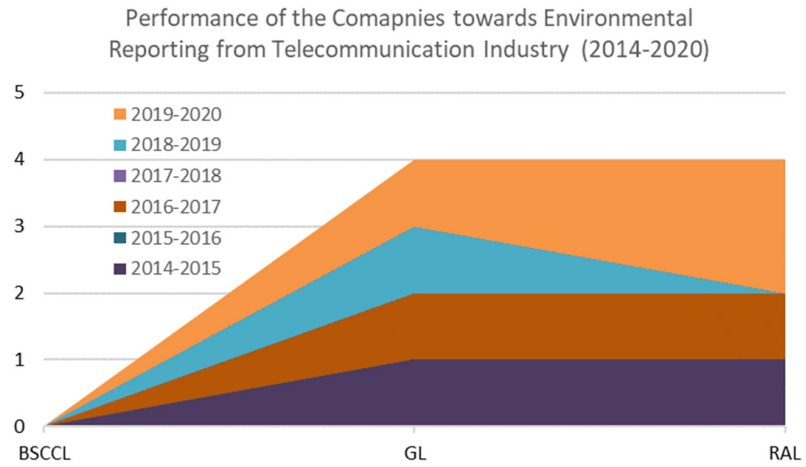
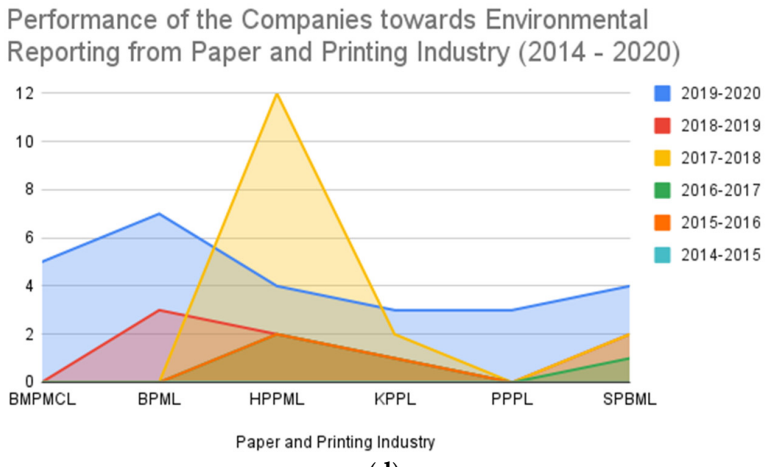


(**c**)



(**d**)

Figure 3. (**a**) Performance of PCI from 2014 to 2020; (**b**) performance of TI from 2014 to 2020; (**c**) performance of TeI from 2014 to 2020; (**d**) performance of PPI from 2014 to 2020 (generated from Excel data by authors).

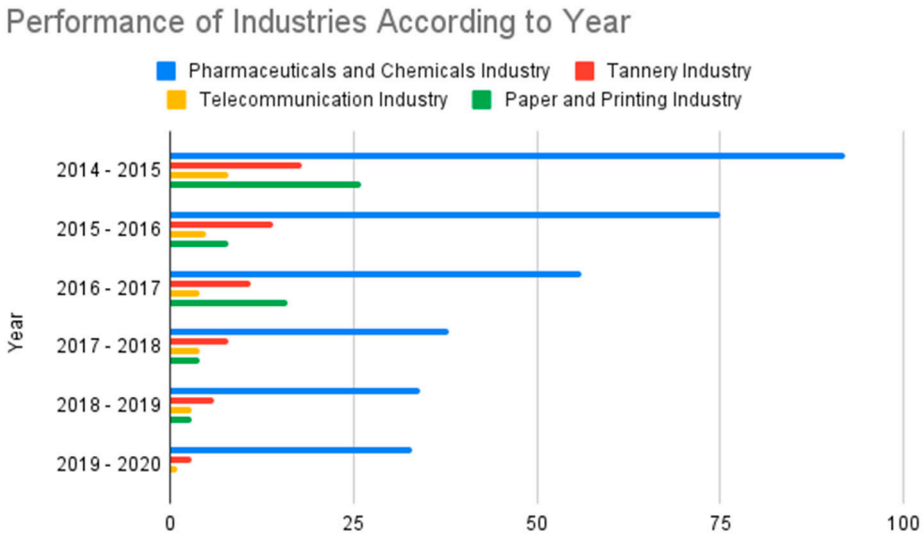


Figure 4. Yearly performance of all industries (generated from Excel data by authors).

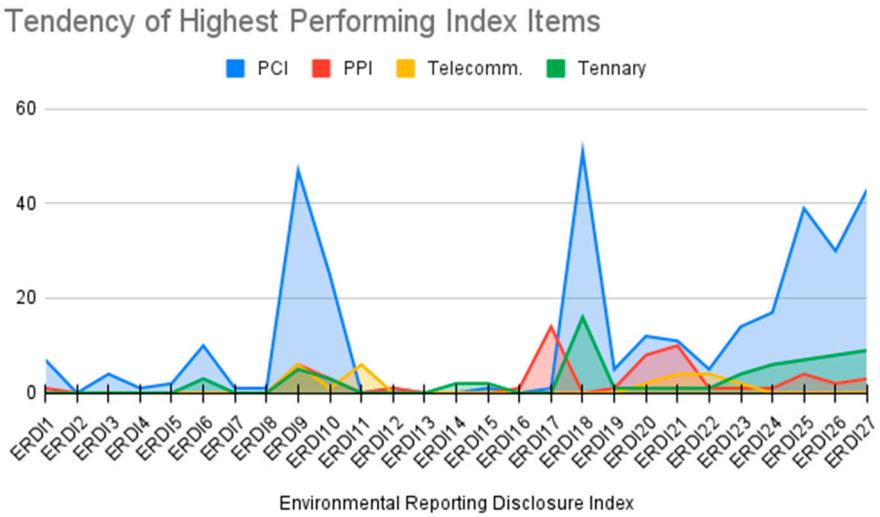


Figure 5. Tendency of highest performance of every industry (generated from Excel data by authors).

In analysis 2, the performance of different industries according to year is investigated. For each industry, all the responsible companies are added, and the addition of the different environmental disclosure indexes is calculated column-wise by Formula (2) and visualized in Figure 7.

$$\sum_{i,j,k,l}^{I,\ c,\ y,Ind} \left(I_i c_j y_k X_l + \ldots\ldots\ldots + I_i c_j y_k X_{Ind}\right)/c \quad (2)$$

where

I = number of industries
c = number of companies under each industry
y = year (2014–2020)
Ind = Environmental Disclosure Index (Pharmaceutical and Chemical = 27, Tannery = 26, Telecommunications = 23, and Paper and Printing = 28)
X indicates the particular company from the different industries and is allocated by different values of i, j, k.

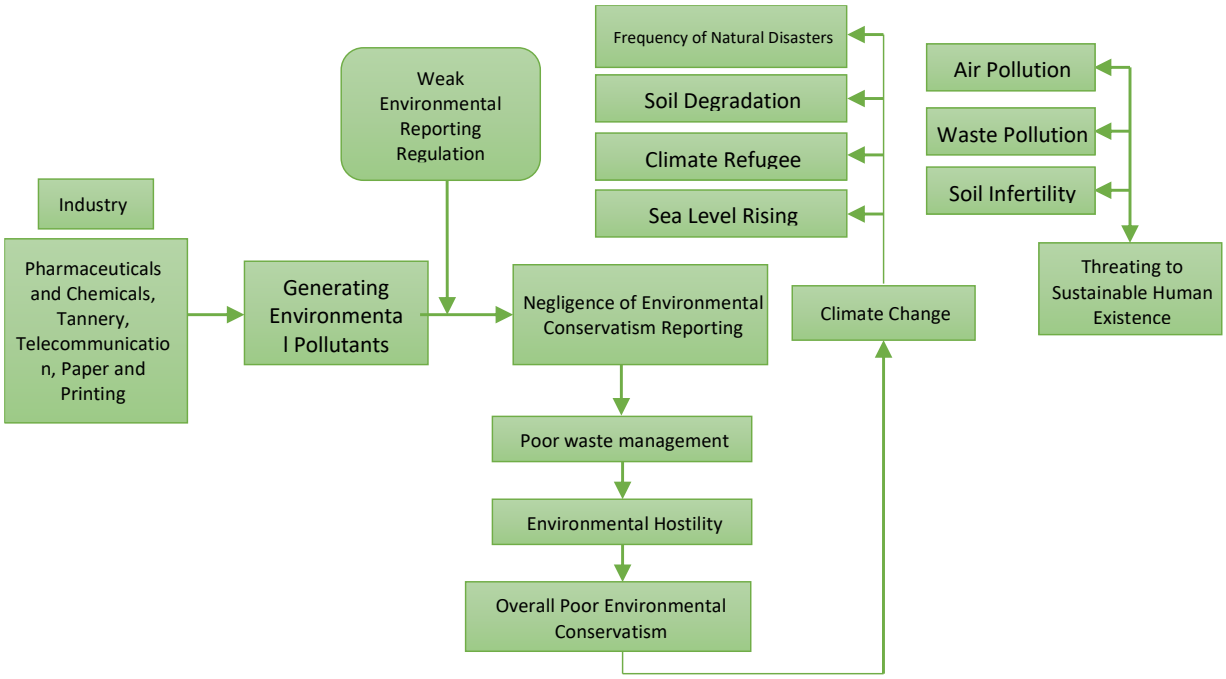


Figure 6. Findings of the analysis (developed by authors).

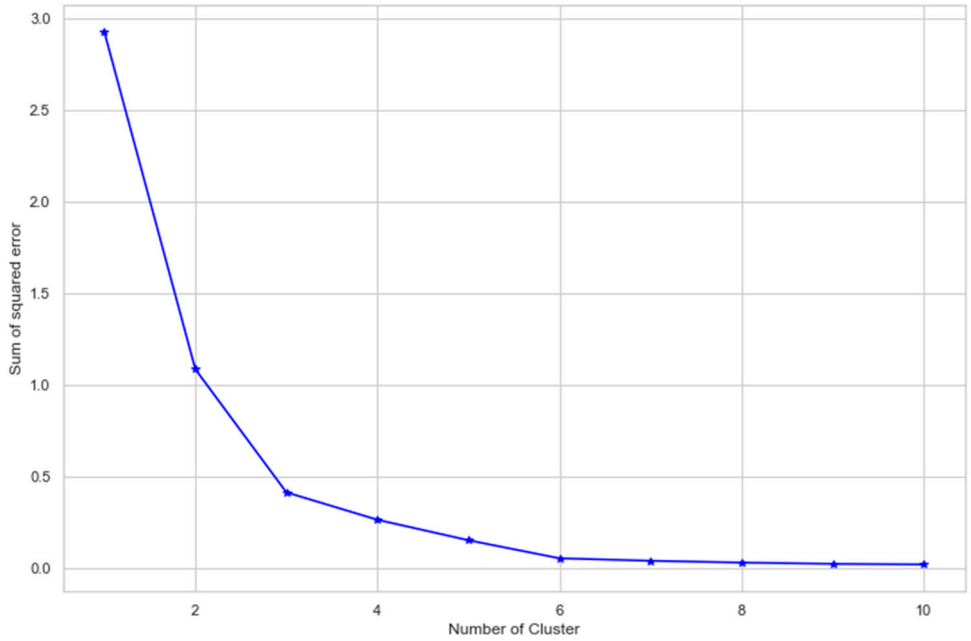


Figure 7. Elbow method to recommend the value of k in k-means clustering (Generated from Python code of analysis).

In analysis 3, the tendency of the highest performing index is calculated using Formula (3), where the sum of every environmental disclosure index for all of the companies under the different industries is calculated and visualized in Figure 8.

$$\sum_{i,j}^{Ind,(c*y)} X_{i,j} \quad (3)$$

where

c = number of companies under each industry
y = year (2014–2020)
Ind = Environmental Disclosure Index (Pharmaceutical and Chemical = 27, Tannery = 26, Telecommunications = 23, and Paper and Printing = 28)
X indicates the particular company from the different industries and is allocated by the different values of i, j, k.

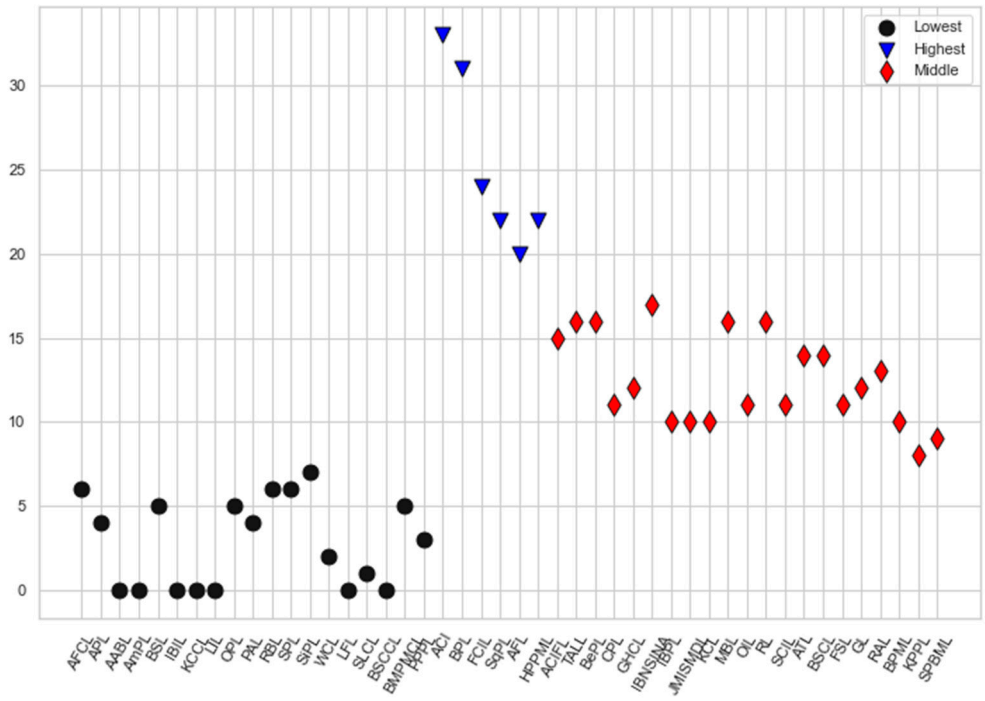


Figure 8. Categories of different companies using k-means clustering (generated from Python code of analysis).

K-Means Clustering: K-means clustering is an unsupervised machine learning algorithm that is used to categorize the unlabeled data. The target of using this algorithm is to make a group of the data based on the characteristics of the data, where the number of groups is represented by k. K is defined by the elbow method.

Elbow Method: The elbow technique runs k-means clustering on the dataset for a range of k values (say, 1–10) and then computes an average score for all the clusters for each value of k. The distortion score, which is the sum of the square distances from each point to its assigned center, is computed by default.

A cluster is a collection of data points that have been grouped together due to particular similarities. You set a target number, k, for the number of centroids required in the dataset. A centroid is a fictional or real location that represents the cluster's center. By lowering the in-cluster sum of squares, each data point is assigned to one of the clusters. To put it another way, the k-means algorithm finds k centroids and then assigns each data point to the closest cluster while keeping the centroids as small as possible. The average of the data, or the determining of the centroid, is what the 'means' in k-means refers to.

The k-means technique in data mining starts with the first group of randomly picked centroids, which serve as the starting points for each cluster, and then performs iterative (repetitive) calculations to optimize the centroids' placements.

K-means clustering is easy to implement, and it can handle large quantity of data. We can choose to cluster manually, and this algorithm can easily be adopted with the new data. These characteristics of this algorithm motivate us to use it in this study instead of hierarchical clustering models.

K-means clustering uses the Euclidean distance between two points to complete the analysis and make clusters. The equation is

$$d(p,q) = \sqrt{(q_1 - p_1)^2 + (q_2 - p_2)^2}$$

If $p = (p_1, p_2)$ and $q = (q_1, q_2)$, then the distance is given.

This algorithm works on the datapoint of the EDRI for different companies under different industries. By calculating the distance, this algorithm can find the internal relationship among the companies and assign labels to the companies and finally make a cluster.

4. Results and Discussion

The total analysis is conducted based on Equations (1)–(3) above. Mainly, the formula is generated based on the theoretical concept of this research. The results are visualized using different curves according to years, industries, and the environmental disclosure index.

The performances of the different industries are represented from 2014 to 2020 in Figure 3a–d. The performance of the companies towards environmental reporting from the pharmaceutical and chemical industry shows that the performance of the companies in this industry is improving in the index day by day. The improvement in 2015–2016 is less than in 2014–2015, but after 2016, the performance is increasing year by year, and in 2019–2020, the change is remarkable. Most companies improvise their index to archive the goal. The performance of the tannery industry is not at a satisfactory level from 2014 to 2020. Most companies are not aware of increasing the environmental reporting disclosure index. AFL is trying to improve; on the other hand, LFL is still neutral and has no improvement in this time period. Most of the environmental pollution is directly or indirectly related to this industry. Necessary steps should be taken to improve the performance of those companies. The performance of the telecommunications industry is also not satisfactory. Figure 3c indicates that BSCCL is still having no progress in increasing or taking any action to complete the environmental disclosure index. GL and RAL are trying, but the improvement is not at a satisfactory level. From 2014 to 2017, the performance of the paper and printing industry is too low. After this time period, the companies start to complete the environmental disclosure index. From 2017 to 2018, HPPML showed a remarkable change, but after that time, it goes down. In 2019–2020, it shows its maximum.

The performances of the industries according to year are shown in Figure 4. From 2014 to 2020, a bar chart is generated by calculating the values using formula 2. The performance of every industry is increased by changing the years.

Figure 5 represents the tendency of the highest performing index item of the different industries. Most of the companies are positive on the indexes 9, 10, 17, 18, 25, and 26. In this case, the performance of the pharmaceutical and chemical industry is better than the others.

4.1. Clustering of the Company According to Fulfillment of the Index

In this section, we use one of the most-used unsupervised machine learning algorithms, namely k-means clustering. Using the elbow method, we obtain a suggestion that recommends clustering the data into three different classes. The value of k in three, recommended by the elbow method, is represented in Figure 7.

Using k = 3 in k-means clustering, we obtain three subsets. We named the categories as follows. Category 1 (C1) is a company that completes more than 19 indexes; in this category, we find 6 companies of different industries. Category 2 (C2) is a company that completes less than 19 indexes but above 7 indexes; most of the companies are in this category, and the number is 20. Category 3 (C3) is a company that completes less than 7 indexes; 19 companies are listed in this group.

4.2. Implication of the Study

The acceptance and performance of a business organization are now being judged not only on its financial results but also with respect to its contribution to protecting and conserving the environment. Due to climate change, Bangladeshi companies need to include mandatory environmental risk disclosures in their annual reports. Here, the government of Bangladesh, or more specifically the ministry of finance, the DSE, the ministry of climate change, or the national board of revenue, can play a vital role in the preparation of environmental risk disclosure guidelines in Bangladesh. Environmental issues have become an important variable in the operations of the business. As a result, the accounting of environmental issues, their disclosure in the environmental issues, and their disclosure in the annual reports or by companies have become an important part of corporate accounting and reporting systems nowadays. Now all companies are disclosing environmental risk issues in annual reports voluntarily.

Bangladesh is a wetland and a coastal state with a high vulnerability to climate change, global warming, and sea-level rise. Environmental degradation has a direct impact on human health and leads to high healthcare costs. It seems that the countries with high pollution and environmental degradation have to face severe health complexities and bear a high financial burden in terms of health costs [72]. Bangladesh, with regard to adverse climate change, has observed frequent cyclones hit coastal communities and faced socio-economic crisis and poverty with high treatment costs. In comparison with other parts, the coastal parts of Bangladesh, namely Gabura, Munshigong, Atulia, Burigoaliny, and Padmapukur, are in a worsening situation with respect to drinking water scarcity, salinity hazards, and health hazards due to climate change and sea-level rise [73]. In the long run, CO_2 emissions have a positive impact on health expenditure [74]. In both public and national healthcare expenditure, CO_2 emissions, environmental pollution, and degradation exert statistically significant impacts [75,76]. The healthcare cost is relatively high in the areas where the pollution from the tannery, telecommunications, paper and printing, and pharmaceutical and chemical industries is high.

The findings of the study will give the true way of adapting measures of environmental risk disclosure practices for the companies towards climate change for sustainable futures and development in the following ways:

1. The government of Bangladesh declared the plantation of 1 million palmyra palm trees across Bangladesh to avert deaths occurring from common natural disasters, such as cyclones, lightning, and thunderstorms. In this regard, the government can engage pharmaceutical and chemical companies to achieve the target of planting 1 million palmyra palm trees.
2. The introduction of the high standards of a pollution-free environment for all the companies operating in Bangladesh, with strict monitoring and ensuring that the companies do not have any activities which are harmful to the environment and nature is needed. The Bangladesh Securities Exchange Commission, Dhaka Stock Exchange, Chittagong Stock Exchange, or other authoritative bodies need to establish a framework consisting of mandatory environmental reporting.
3. The all-inclusive waste management needs to be handled with the best available technologies (BAT), which will include an incineration plant, dust control units, and scrubbers to ensure zero discharge of solid waste that may harm the surrounding ecological system and lead to ecological imbalance.
4. Ensuring the selection of environment-friendly technology and compliance with the environmental codes.
5. Establishing guidelines to implement proper occupational health, industrial hygiene, and effluent management system in its manufacturing site.
6. Establishing a zero-tolerance policy in order to maintain the appropriate environment and pollution-free environment and to ensure that is environment-friendly, not destructive.

7. It is necessary to create a corporate culture in which safety to the environment is always the top priority and is an integral part.
8. Establishing a system of reviewing environment and safety performance on a monthly, quarterly, semiannual, and annual basis because the environmental risk is always a key focus of standardized environmental processes.
9. Rainwater harvesting should be given priority to meet the ever-increasing demand for water resources.
10. Tax holidays and tax incentive schemes need to be given to the company to achieve a specific line of action with regard to environmental conservation and environmental reporting. Community engagement in the light of waste management and waste disposal needs to be ensured on a targeted basis.
11. Establishing such a legal structure in which it will be stated that failure to ensure the eco-friendly use of machines and materials will lead to the cancelation of the legal license to operate the business in Bangladesh.
12. Initiating the establishment of the concept of the green factory and assigning the timeframe for the companies for achieving the green certificate from the authority or otherwise receive punishment for nonconformance.
13. Celebrating nationwide green exhibitions by the companies with their environmental conservatism initiatives, as well ranking the companies on the basis of their green performance in the industry, year to year, company to company, and by global standards.
14. E-waste recycling management tools need to be adopted by the telecommunications companies, and providers need to be added which provide green services to customers.

5. Conclusions

The environment is changing very fast and affecting the earth unfavorably with its consequences which intensify the manifestation of diseases, population migration risk, sea-level rise, drinking water scarcity, flooding, riverbank erosion, coastal disasters, and finally an unhealthy environment for humans, animals, livestock, crops, and fisheries. In some cases, with rising national health expenditures, environmental pollution is said to be the key determinant. In the long run, environmental degradation has a direct and indirect impact on human health, leading to the bearing of a high financial burden for health issues in healthcare costs. It is even high in the country where the pollution is relatively high. In personal, public, and national healthcare policies, environmental impacts now need to be meticulous. As responsible business entities, companies need to be highly focused on the continuous deployment of enhanced sustainable solutions for energy-efficient and environment-friendly networks. The company's first priority needs to be to reduce the CO_2 emissions generated by improving system efficiency and reducing overall energy consumption. The company's aims should optimize energy consumption by reducing the dependency on diesel generators and increasing the use of solar energy and reducing operational travel time. Economic benefits without environmental conservation hold no appeal. All that we need for our existence and security depends, either directly or indirectly, on our usual environment. This means being better stewards of our environment and our resources. A suitable environment, a sustainable environment, and an ecological balance are very essential for a healthy society and nationalized development. Several recent studies revealed that the number of deaths caused by common natural disasters, such as cyclones, lightning, and thunderstorms, in Bangladesh has increased as an ecological imbalance. The wastes generated from industrial operations have a degrading effect on the environment and ecological system. Such deaths and natural disasters may be prevented to a significant extent if the environment is protected from pollution. Here, companies can play a strong role in initiating, adapting, and implementing environmental conservatism, sustainability reporting, and environmental risk disclosure practices. As a coastal state, the developing economy's adaptive measures taken by Bangladesh are so challenging. Environmental risk reporting disclosure practices by the companies in the pharmaceutical

and chemical, tannery, telecommunications, and paper and printing industries are not at a satisfactory level.

Organizations are now not only judged on the basis of financial performance but also on the reporting which has been used to inform stakeholders about the organization's position in relation to economic aspects, environmental practices, labor practices and decent work, social human rights, society, and product responsibility. As an answerable part of the society, organizations are required to pursue environmental and social initiatives and to integrate these considerations into the product design, strategic planning, and policies and finally in the reporting which could a play role in reducing climate risk. Using the study findings as a tool for the reporting of the company's environmental issues, it will be able to focus on extending its positive arch of influences across the stakeholders and aim to mitigate climate risk, ensure a sustainable future existence, and a create strong loyal customer base.

This study only contains 4 sectors out of the 22 sectors of DSE. In future studies, it can be extended to other sectors also. We analyzed the annual reports from 2014 to 2020, but they can be extended with more years. We used k-means clustering and the elbow method as a machine learning algorithm; in the future, researchers can contribute by using other machine learning algorithms and tools.

Author Contributions: Conceptualization, M.M.U., M.H. and M.A.H.; Data curation, M.H.; Formal analysis, M.H.; Funding acquisition, M.A.H. and Y.F.; Investigation, M.M.U. and M.M.R.; Project administration, M.M.R. and M.A.H.; Supervision, Y.F.; Validation, M.A.H.; Visualization, M.M.U. and M.M.R.; Writing—original draft, M.M.U. and M.H.; Writing—review & editing, M.M.U. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by Special Funding for Soft Science Research under the Provincial Science and Technology Program of Hebei Province, (22553701D) and 2022 Humanities and Social Sciences Research Project in Colleges and Universities of Hebei Province, (SQ2022027).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Informed consent was obtained from all subjects involved in this study.

Data Availability Statement: Data are available upon special request from the corresponding author.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Development of Environmental Risk Disclosure Index for Pharmaceutical and Chemical Industry (ERDIPCI):

Coding	Items
ERDIPCI1	Total energy consumption and initiatives to reduce it.
ERDIPCI2	Total materials used and initiatives to reduce them.
ERDIPCI3	Water withdrawal and initiatives to reduce it.
ERDIPCI4	Greenhouse gas emissions and initiatives to reduce them.
ERDIPCI5	Total water discharge and initiatives to reduce it.
ERDIPCI6	Effluents, air, and nuisance and initiatives to reduce them.
ERDIPCI7	Release and transfer of chemical substances and initiatives to reduce them.
ERDIPCI8	Total weight of waste generated, waste disposed by land filling or incineration and initiatives to reduce them.
ERDIPCI9	New environmental technologies and research and development.
ERDIPCI10	Products and services designed for mitigating environmental impacts.

ERDIPCI11	Conservation of biological diversity and the sustainable use of its components.
ERDIPCI12	Ensuring biomedical waste management.
ERDIPCI13	Proper chemical waste management.
ERDIPCI14	Proper disposal manual of medical supplies.
ERDIPCI15	Ensure clean production and protecting the environment.
ERDIPCI16	Dependency on renewal energy (using alternative source).
ERDIPCI17	Handling and disposing of hazardous materials.
ERDIPCI18	Ensure social responsibility and social awareness.
ERDIPCI19	Initiating climate actions/environment-friendly initiatives.
ERDIPCI20	Funding/donating (climate risk fund/capacity building).
ERDIPCI21	Investment and cost for environmental conservation.
ERDIPCI22	Environmental guidelines and environmental plan.
ERDIPCI23	Environmental education and environmental enlightenment activities.
ERDIPCI24	Environmental laws and regulations and lawsuits.
ERDIPCI25	Contribution to society with regard to the environment.
ERDIPCI26	Sustainable manufacturing practices and statement of compliance.

Appendix B

Development of Environmental Risk Disclosure Index for Tannery Industry (ERDITI):

Coding	Items
ERDITI1	Total energy consumption and initiatives to reduce it.
ERDITI2	Total materials used and initiatives to reduce them.
ERDITI3	Water withdrawal and initiatives to reduce it.
ERDITI4	Greenhouse gas emissions and initiatives to reduce them.
ERDITI5	Total water discharge and initiatives to reduce it.
ERDITI6	Effluents and nuisance and initiatives to reduce them.
ERDITI7	Release and transfer of chemical substances and initiatives to reduce them.
ERDITI8	Total weight of waste generated, waste disposed by land filling or incineration and initiatives to reduce them.
ERDITI9	New environmental technologies and research and development.
ERDITI10	Products and services designed for mitigating environmental impacts.
ERDITI11	Conservation of biological diversity and the sustainable use of its components.
ERDITI12	Automated water and organic compacted system
ERDITI13	Proper chemical waste management.
ERDITI14	Proper disposal manual of medical supplies.
ERDITI15	Ensure clean production.
ERDITI16	Dependency on renewal energy (using alternative source).
ERDITI17	Handling and disposing of hazardous materials.
ERDITI18	Ensure social responsibility.
ERDITI19	Initiating climate actions/environment-friendly initiatives.

ERDITI20	Funding/donating (climate risk fund/ capacity building).
ERDITI21	Investment and cost for environmental conservation.
ERDITI22	Environmental guidelines and environmental plan.
ERDITI23	Environmental education and environmental enlightenment activities.
ERDITI24	Environmental laws and regulations and lawsuits.
ERDITI25	Contribution to society with regard to the environment.
ERDITI26	International certification.

Appendix C

Development of Environmental Risk Disclosure Index for Telecommunications Industry (ERDITeI):

Coding	Items
ERDITeI1	Total energy consumption and initiatives to reduce it.
ERDITeI2	Total materials used and initiatives to reduce them.
ERDITeI3	Water withdrawal and initiatives to reduce it.
ERDITeI4	Greenhouse gas emissions and initiatives to reduce them.
ERDITeI5	Total water discharge and initiatives to reduce it.
ERDITeI6	Effluents and nuisance and initiatives to reduce them.
ERDITeI7	Release and transfer of chemical substances and initiatives to reduce them.
ERDITeI8	Total weight of waste generated, waste disposed by land filling or incineration and initiatives to reduce them and E-Waste management.
ERDITeI9	New environmental technologies and research and development.
ERDITeI10	Products and services designed for mitigating environmental impacts and systems.
ERDITeI11	Conservation of biological diversity and the sustainable use of its components.
ERDITeI12	Reduce electromagnetic radiation emissions.
ERDITeI13	Efficient uses of energy (gas, coal, water, electricity).
ERDITeI14	Dependency on renewal energy (using alternative source).
ERDITeI15	Environment-friendly infrastructures (towers, heavy overhead cables, aerial cabling, hybrid optical fiber/coaxial cable roll).
ERDITeI16	Initiating climate actions/environment-friendly initiatives.
ERDITeI17	Funding/donating (climate risk fund/capacity building).
ERDITeI18	Investment for environmental conservation and adoption of green practices.
ERDITeI19	Environmental guidelines, environmental plan, and environmental management systems.
ERDITeI20	Environmental education and environmental enlightenment activities.
ERDITeI21	Environmental laws and regulations and lawsuits.
ERDITeI22	Contribution to society with regard to the environment.
ERDITeI23	International certification, rewards, and recognition.
ERDITeI23	Green company.

Appendix D

Development of Environmental Risk Disclosure Index for Paper and Printing Industry (ERDIPPI):

Coding	Items
ERDIPPI1	Total energy consumption and initiatives to reduce it.
ERDIPPI2	Total materials used and initiatives to reduce them.
ERDIPPI3	Water withdrawal and initiatives to reduce it.
ERDIPPI4	Greenhouse gas emissions and initiatives to reduce them.
ERDIPPI5	Total water discharge and initiatives to reduce it.
ERDIPPI6	Effluents and nuisance, and initiatives to reduce them.
ERDIPPI7	Release and transfer of chemical substances and initiatives to reduce them.
ERDIPPI8	Total weight of waste generated, waste disposed by land filling or incineration and initiatives to reduce them.
ERDIPPI9	New environmental technologies, research and development, and processes.
ERDIPPI10	Products and services designed for mitigating environmental impacts.
ERDIPPI11	Conservation of biological diversity and the sustainable use of its components.
ERDIPPI12	Ensuring proper waste management (reuse, recycling and disposal of inks, paper, plates and pallets).
ERDIPPI13	Efficient uses of energy (gas, coal, water, electricity).
ERDIPPI14	Dependency on renewal energy (using alternative source).
ERDIPPI15	Handling and disposing of hazardous materials.
ERDIPPI16	Maximize the recycled fibre content.
ERDIPPI17	Suitability for recycled/certified paper grades.
ERDIPPI18	Source of fibre (nonagricultural).
ERDIPPI19	Paper waste in production (inventory and initiative).
ERDIPPI20	Ensure social responsibility and caring environment.
ERDIPPI21	Initiating climate actions/environment-friendly initiatives.
ERDIPPI22	Funding/donating (climate risk fund/capacity building).
ERDIPPI23	Investment and cost for environmental conservation.
ERDIPPI24	Environmental guidelines and environmental plan.
ERDIPPI25	Environmental education and environmental enlightenment activities.
ERDIPPI26	Environmental laws and regulations and lawsuits.
ERDIPPI27	Contribution to society with regard to the environment.
ERDIPPI28	Complying with the rules.
ERDIPPI28	Social awareness.

Appendix E

As of 22 January 2022, there were 32 pharmaceutical and chemical companies listed at the Dhaka Stock Exchange (DSE):

Sl. No.	Name of Company	Coding
1.	ACI Limited	ACI
2.	ACI Formulations Limited	ACIFL
3.	The ACME Laboratories Limited	TALL
5.	Active Fine Chemicals Limited	AFCL
6.	Advent Pharma Limited	APL
7.	AFC Agro Biotech Ltd.	AABL
8.	Ambee Pharmaceuticals Ltd.	AmPL
9.	Beacon Pharmaceuticals Limited	BePL
10.	Beximco Pharmaceuticals Ltd.	BPL
11.	Beximco Synthetics Ltd.	BSL
12.	Central Pharmaceuticals Limited	CPL
13.	Far Chemical Industries Limited	FCIL
14.	Global Heavy Chemicals Limited	GHCL
15.	The IBN SINA Pharmaceutical Industry Ltd.	IBNSINA
16.	Indo-Bangla Pharmaceuticals Limited	IBPL
17.	Imam Button Industries Ltd.	IBIL
18.	JMI Syringes & Medical Devices Ltd.	JMISMDL
19.	Keya Cosmetics Ltd.	KCL
20.	Kohinoor Chemicals Company (Bangladesh) Ltd.	KCCL
21.	Libra Infusions Limited	LIL
22.	Marico Bangladesh Limited	MBL
23.	Orion Infusion Ltd.	OIL
24.	Orion Pharma Ltd.	OPL
25.	Pharma Aids	PAL
26.	Reckitt Benckiser(Bd.) Ltd.	RBL
27.	Reneta Limited	RL
28.	Salvo Chemical Industry Limited	SCIL
29.	Silco Pharmaceuticals Limited	SPL
30.	Silva Pharmaceuticals Limited	SiPL
31.	Square Pharmaceuticals Ltd.	SqPL
32.	Wata Chemicals Limited	WCL

Appendix F

As of 22 January 2022, there were 6 Tannery companies listed at the Dhaka Stock Exchange (DSE):

Sl. No.	Name of Company	Coding
1.	Apex Footwear Limited.	AFL
2.	Apex Tannery Limited	ATL
3.	Bata Shoe Company (Bangladesh) Limited	BSCL
4.	Fortune Shoes Limited	FSL
5.	Legacy Footwear Ltd.	LFL
6.	Samata Leather Complex Ltd.	SLCL

Appendix G

As of 22 January 2022, there were 3 telecommunications companies listed at the Dhaka Stock Exchange (DSE):

Sl. No.	Name of Company	Coding
1.	Bangladesh Submarine Cable Company Limited	BSCCL
2.	Grameenphone Ltd.	GL
3.	Robi Axiata Limited	RAL

Appendix H

As of 22 January 2022, there were 6 paper and printing companies listed at the Dhaka Stock Exchange (DSE):

Sl. No.	Name of Company	Coding
1.	Bashundhara Paper Mills Limited	BPML
2.	Hakkani Pulp & Paper Mills Ltd.	HPPML
3.	Khulna Printing & Packaging Limited	KPPL
4.	Bangladesh Monospool Paper Manufacturing Co. Limited	BMPMCL
5.	Paper Processing & Packaging Limited	PPPL
6.	Sonali Paper & Board Mills Ltd.	SPBML

Appendix I

Overall summary of sample selection:

Sl. No.	Name of the Industry	Listed at DSE	Selected as Sample	%
1.	Pharmaceutical and Chemical	32	32	100%
2.	Tannery	6	6	100%
3.	Telecommunications	3	3	100%
4.	Paper and Printing industry	6	6	100%
	Total	47	47	100%

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