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# Evaluating Environmental Sustainability in Manufacturing: A Multi-Criteria Analysis of Chittagong's Industrial Sector

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## Abstract

Bangladesh faces significant environmental challenges stemming from improper industrialization and unsustainable commercial practices. This study aims to evaluate the effectiveness of various attributes and sub-attributes associated with manufacturing companies in Chittagong in addressing environmental sustainability. A multi-criteria decision-making approach, the Analytical Hierarchy Process (AHP), was employed to assess the natural environment through six primary attributes and 27 sub-attributes identified via a participatory process. The study determined the relative weights of these attributes and sub-attributes using a pair-wise comparison matrix. The findings revealed that Image/Relationship was the most influential attribute (35.92%), followed by Regulatory (27.6%) and Internal Voluntary (17.9%). Manufacturing organizations were found to prioritize image building, often investing significantly in environmental assessments to enhance their corporate reputation. Under the Regulatory attribute, organizations demonstrated considerable attention to monitoring, inspection, testing, and protective equipment. However, in the Internal Voluntary category, while employee health and satisfaction were highly valued, environmental audits received minimal focus. This study underscores the need for a unified framework to systematically assess and address the environmental impacts of manufacturing organizations. By establishing such a framework, organizations can better align their operations with sustainable practices. This research represents an ongoing effort to develop a standardized approach to natural environment assessment in industrial contexts.

**Keywords:** Natural environment, Manufacturing corporation, Effect on natural environment, Corporate organization in Chittagong, Sustainability

## Introduction

In today's social, ecological, and economic setup, the environment has become a central focus. In our existing world, people are more concerned about environmental issues and sustainable development than ever. As a result, it becomes an important issue for the corporate world to preserve and enhance the quality of the environment (Lee, 2011).

Environmental accountability of the business organization principally refers to the responsibility of a business organization, for the exploitation of the natural environment, implying the allocation of environmental costs to the economic activities that cause such exploitation.

Environmental protection cost, as well as some other environmental cost drivers, and especially environmental accountability of this vital segment of society, has already been the objectives of many researchers (Clarkson et al., 2008; Chowdhury, 2016; Larrinaga-Gonzalez & Bebbington, 2001). Over the years, environmental issues such as environmental pollution and environmental litigations have become more prominent economic, social and political problems throughout the world, particularly in relation to commerce and trade (Burnett & Hansen, 2007; Margolis & Walsh, 2003). Corporations are solely responsible for ensuring a sustainable environment as their activities increase tension over the natural environment. (Burnett & Hansen, 2007). Therefore, in this study, an analytical tool is tried to develop for the comparative analysis, which can be used for the assessment of the impact on the natural environment, and using the Analytical Hierarchy Process (AHP) enables more in-depth exploration of the qualitative setting contributing to the quantitative outcome.

## **Literature Review**

In the early stage of 1990, the focus has been shifted from corporate social disclosure to corporate environmental disclosure (Gray & Bebbington, 2001; Lodhia, 2001; Alam et al., 2019). There is a worldwide debate on the issue of the degradation of the natural environment by the corporate world (Taylor et al., 2001; Ahmed et al., 2022; Chowdhury et al., 2022). Most of the blame goes on the shoulders of the corporate world for the environmental impact of their operational activities subsequent to the Earth Summit held in Rio de Janeiro in 1992 (Belal, 2000; Chowdhury et al., 2020a; Chowdhury et al., 2020b; Hossain et al., 2013). During the 1990's decade, environmental issues have become almost nothing to one of the most important factors to discuss with. The purpose for this change may be partly explained by the then green revolution and the global environmental concern, especially environmental legislation and social injustice (Ahmad & Mousa, 2010; Hossain et al., 2019; Hasan et al., 2019). Other factors, such as customer awareness, supply chain relations, and activities of environmental campaigners like Greenpeace, the World Wide Foundation for Nature, etc. persuade business companies to be concerned about the environment (Seetharaman et al., 2007; Hossain & Zayed, 2016). So, during the last two decades, the impact on the natural environment has emerged in response to these mentioned issues. The developed countries are highly concerned about the impacts on the quality of their life due to the pollution of water, air, and land, i.e. natural environment. So, the accountability of corporations has developed voluntarily in the world, especially in developed countries (Perkins, 2007; Vargas et al., 2010; Islam et al., 2021a; Chowdhury et al., 2021). On the other hand, the same formula does not go with the developing countries including Bangladesh (Azim et al., 2011; Bose, 2006; Hossain et al., 2006). Bangladesh is still in its take-off zone of industrialization. However, it does not indicate that the risk of environmental destruction due to business operation is lower. Moreover, the negative impact on the natural environment by the operation is higher due to poor and weak enforcement of legislation in Bangladesh. One such incidence of the destruction of the natural environment by business operations is in Kalurghat, Chittagong. There is one Kalurghat Shilpo Area where all the factories are established. All the factories

discharge thousands of liters of liquid waste and hundreds of tons of solid wastes during or after production. Various types of products are produced in those factories. Almost every type of waste has been decomposed in the river. As a result, this once vibrant river is now a deadly poisonous river due to business activities. Bangladesh is under immense environmental stress from the corporate world as it is the world's most densely populated country, which means if any pollution occurs at any place for even one small reason; a huge population has to deal with that risk. Bangladesh is going through a transition period where it has shifted its gear from the traditional agricultural sector to non-traditional industrial and service sectors in recent years. The contribution to GDP by the industrial and service sector in 2005 was 28% and 51 %, respectively, compared to 27% and 52%, respectively, in 2004, while the contribution of the agricultural sector to GDP was 20.5% in 2005 and 21% in 2004, respectively (Sultan, 2008; Kader et al., 2021; Iqbal et al., 2021). The recent statistics show that, in 2010, the contribution of GDP from agriculture dropped down to 18.6%, while industrial and service sector contributions remained at 28.6% and 52.8%, respectively (Statistics, 2010; Mia et al., 2023; Niaz et al., 2015). Recently, Lee (2011) has tried to explore motivations, barriers, and incentives for adopting Environmental Management Cost Accounting and related guidelines in companies. But most of the authors (Lehman, 1999; Yakhou & Dorweiler, 2004; Chowdhury & Begum, 2006; Seetharaman et al., 2007) focus on either environmental management system developed or environmental accounting used as a tool for environmental management systems in recent corporate world. In Bangladesh, all of the prior work (Imam, 1999; Belal, 2000; Islam, 2002; Hossain, 2002; Bala & Yusuf, 2003; Rahman & Muttakin, 2005; Shil & Iqbal, 2005; Bose, 2006; Hossain et al., 2006; Azim et al., 2011) is on the companies' directors' report or in the chairman's statement or elsewhere in their annual reports. Most of the previous researchers conclude that the information disclosed is qualitative in nature and companies did not follow any specific or standard reporting format. Moreover, not a single company disclosed any quantitative information as to the environmental items. This is one kind of work where most of the manufacturing companies of Chittagong have been taken into consideration in assessing the impact on the natural environment made by those corporations in various ways.

## **Materials and Methods**

A succession of 20 discussion events were organized with the chief responsible officer and executives of the corporation, specialists from NGOs, lawyers, cost and management accountants, faculty members of various departments of private universities, members of the Chittagong Chamber of Commerce, social awareness program coordinators to identify the essential feature of cost center for the assessment of the natural environment. Through this participatory path, different attributes and sub-attributes cost centers were identified for assessment of impact on the natural environment.

### **Data Collection and Research Design**

There were 6 attributes with 27 sub-attributes of cost centers that were tested in the field with lower-level, mid-level, and top-level executives of the corporation (Table 1). All of the tests have been made on the manufacturing companies of Chittagong. Sub-attributes are the main pillar of the study, which helps to do the SWOT analysis in this assessment. The Analytical Hierarchy Process (AHP) was developed to enable an individual or group of individuals to define a particular problem and derive a solution based on the experience of the individual or group of that problem (Saaty, 2008; Rahman et al., 2022). AHP helps to concentrate on both subjective and objective evaluation measures, providing a useful method for checking the consistency of the

evaluations, thus decreasing biasness in decision-making (Dalalah et al., 2010; Vladimirovna & Zayed, 2021). So AHP mechanism is applied for rating a set of alternatives or for the selection of the best in a set of alternatives. In the present study, the data were collected from the different types of manufacturing corporations. Data were collected through structured interviews with 100 corporate executives (low, mid, and high-level management) by preparing a questionnaire. Interviewees were selected in the present study in a random fashion. Those who can give time to answer the questionnaire properly were chosen for the study. But it was to remind that the person who is chosen for the study must have experience and status in his organization. Each interviewee was asked to answer the questionnaire where all the attributes and sub-attributes were arranged properly. AHP methodology is already applied in numerous studies (Karimi et al., 2011; Leunga et al., 1998; Sarhan, 2011; Chowdhury & Chowdhury, 2022). In this study, for the first time, AHP is being used to decompose the impact on the natural environment incurred by the manufacturing corporation into a hierarchy that consists of different essential elements. In this study, a simple two-level structure was developed (Table 1).

**Table 1: Attributes and Sub - Attributes For Impact on Natural Environment by the Manufacturing Corporation in Chittagong**

Attributes	Sub-attributes
Regulatory	Monitoring, inspection & testing; Protective equipment; Certification & labeling; Environmental Management Plans
Internal Voluntary	Employee safety, Employee health & satisfaction, Environmentally driven R&D, Environmental audits, Feasibility studies
External Voluntary	Environmental studies & research, Environmental reporting, Environmental Training, Medical Surveillance
Remediation	Awareness seminar, Pollution treatment costs, Waste management costs, Environmental taxes & fees, Recycling
Image/Relationship	Corporate image, Relationships with investors, Relationship with customers, Relationships with regulators
Contingent	Image damages, Fines & penalties, Future compliance, Personal damages, Natural resource & ecosystem damages

#### Analytical Hierarchy Process (AHP) and Data Analysis

AHP widely used as an effective tool for multi-criteria decision making. AHP involves the construction of a pair-wise comparison matrix of different attributes and sub-attributes. To develop the pair-wise comparison matrix, ratings are systematically scored to judge the relative importance of two criteria on a continuous scale from -9 (least important) to +9 (most important), as represented in Table 2.

**Table 2: The Basic Importance Scale Used for Judging the Two Criteria Which are Relatively Important in the Decision-Making Process.**

Less Important				More Important				
Extreme	Very Strong	Strong	Moderate	Equal	Moderate	Strong	Very Strong	Extreme
-9	-7	-5	-3	1	2	4	6	8
-8	-6	-4	-2		3	5	7	9

To some extent, human judgment might not be consistent, and so the comparison matrix. Particularly, a matrix A (i, j) is said to be consistent if all its elements follow the transitivity and reciprocity rules below:

$$A_{i,j} = A_{i,k} \cdot A_{j,k} \quad (1)$$

$$A_{i,j} = 1 / A_{j,i} \quad (2)$$

where i, j and k are any alternatives of the matrix. A matrix is considered as consistent if it satisfies the following condition.

$$A \cdot w = n w \quad (3)$$

where A is the comparison matrix, w is the eigenvector, and n is the dimension of the matrix (Dalalah et al., 2010). For an inconsistent matrix, to overcome the inconsistency associated with the pairwise comparison matrix, Saaty (2001) shows that there is a relationship between the vector of weights, w, and the matrix A.

$$A w = \lambda_{\max} w \quad (4)$$

where w is the n-dimensional eigenvector associated with the largest eigenvalue  $\lambda_{\max}$ . The measure of inconsistency is based on the observation that  $\lambda_{\max} > n$  for positive, reciprocal matrix, and  $\lambda_{\max} = n$  if and only if A is a consistent matrix. Saaty (2008) gave a measure of consistency, called the Consistency Index (CI) as a deviation or a degree of consistency using the following formula.

$$CI = (\lambda_{\max} - n) / (n - 1) \quad (5)$$

Under 6 attributes, 27 sub attributes were considered for the assessment in this study (Table 1). Weight for each criterion was determined through pair-wise comparisons by 100 corporate executives throughout the lower, middle and higher level management. The six sub-attributes of regulatory, internal voluntary, external voluntary, remediation, image/relationship, and contingent were computed at first and then combined all the 27 sub-attributes to assess the impact on the natural environment by the manufacturing companies in Chittagong. Statistical analysis was performed using SPSS 18.

## Findings and Discussion

There were six attributes of cost centre used in the research work. Data was collected through a structured process from numerous managers. It can be said that the current findings provide an absolute example of how different the views of lower, middle, and upper-level managers of various corporate organizations in Bangladesh are. The weight of regulatory, internal voluntary, external voluntary, remediation, image/relationship, and contingent attributes cost center and

relevant sub-attributes cost center for impact on the natural environment by the corporate organizations of Bangladesh is determined through a pairwise comparison matrix presented in Table 3, 4 and 5. Monitoring, inspection, and testing accounts for

Table 3: The Weight and Percentage of Different Attributes (Regulatory, Internal Voluntary and External Voluntary) and Sub-Attributes on Impact Made by Manufacturing Organizations in Chittagong (100 Corporate Managers)

Attributes	Sub-attributes	Manufacturing Organizations	
		<i>Weights</i>	<i>%</i>
Regulatory	Monitoring, inspection and testing	0.3521	35.21
	Protective equipment	0.2879	28.79
	Certification and labeling	0.2129	21.29
	Environmental Management Plans	0.1471	14.71
Internal Voluntary	Employee safety	0.1721	17.21
	Employee health and satisfaction	0.4121	41.21
	Environmentally driven R&D	0.1828	18.28
	Environmental audits	0.091	9.1
	Feasibility studies	0.142	14.2
External Voluntary	Environmental studies and research	0.27	27
	Environmental reporting	0.231	23.1
	Environmental Training	0.284	28.4
	Medical Surveillance	0.215	21.5

35.21% in manufacturing corporations in Chittagong for assessing their environmental accountability. Though monitoring, inspection, and testing are the primary concerns for the executives of the manufacturing organizations 35.21% (Table 3), the concern for the protective equipment is not negligible at all (28.79%). It is to be noted that the organization is quite interested in image relationships. They also like to concentrate on building a strong corporate image (49.51%) (Table 4). Finally, in Table 5, the overall degree of six attributes for assessing the impact on the natural environment of the manufacturing corporation. This study is totally based on the manufacturing organizations. Thus, it might not be accurate for other types of industries. The weights of 27 sub-attributes have given us a fair idea about the intention regarding manufacturing corporations. The executives of the manufacturing corporations have given the

highest weight to Image Relationship (35.92%) and then regulatory (27.6%) for the assessment while making the Contingent (4.27%) the lowest. From the above discussion, we can come to the conclusion that the image/relationship attributes is the most significant in the case of manufacturing concerns with 35.92%, which is followed by Regulatory (27.6%) and Internal Voluntary (17.9%).

Table 4: The Weight and Percentage of Different Attributes (Remediation, Image/Relationship and Contingent) and Sub-Attributes on Impact Made by Manufacturing Organizations in Chittagong (100 Corporate Managers)

Attributes	Sub-attributes	Manufacturing Organizations	
		<i>Weights</i>	%
Remediation	Awareness Seminar	0.121	12.1
	Pollution treatment costs	0.199	19.9
	Waste management costs	0.211	21.1
	Environmental taxes and fees	0.215	21.5
	Recycling	0.254	25.4
Image/Relationship	Corporate Image	0.4951	49.51
	Relationships with Investors	0.219	21.9
	Relationship with customers	0.135	13.5
	Relationships With regulators	0.1509	15.09
Contingent	Image damage	0.034	3.4
	Penalties and fines	0.3632	36.32
	Future compliance	0.1928	19.28
	Personal damages	0.2217	22.17
	Natural resource and ecosystem damages	0.1883	18.83

Using the 27 sub-attributes of the cost centre as the input of the assessment helps us to develop our knowledge, adapt, and respond properly to the current issues related to the natural environment. During the study, AHP has been applied to the data collected through structured



interviews and answering a questionnaire from a good number of corporate executives who have a very good notion about the situation. Their practical field knowledge regarding the changing circumstances of the natural environment throughout the world helps us to collect more evidence on the issue. The finding from the study is each attribute and sub-attribute is important to the corporations that are directly involved in production.

Table 5: The Overall Weight of Six Attributes of the Environmental Assessment for Manufacturing Organizations in Chittagong during the Research

Attributes	Manufacturing Organizations	
	<i>Weights</i>	%
Regulatory	0.276	27.6
Internal Voluntary	0.179	17.9
External Voluntary	0.0862	8.62
Remediation	0.0569	5.69
Image/Relationship	0.3592	35.92
Contingent	0.0427	4.27

They might or might not show interest in any particular sub-attribute, but they definitely compensate the negative impact in any other possible way. This approach can also be used as an important tool for different regulatory government organizations of Bangladesh, the Department of Environment, Commerce and Industrial Ministry, and Chamber of Commerce to assist the development process in Bangladesh. In the end, the Government can advise the manufacturing organizations to develop the policy, wherever necessary, by providing various supports and resources.

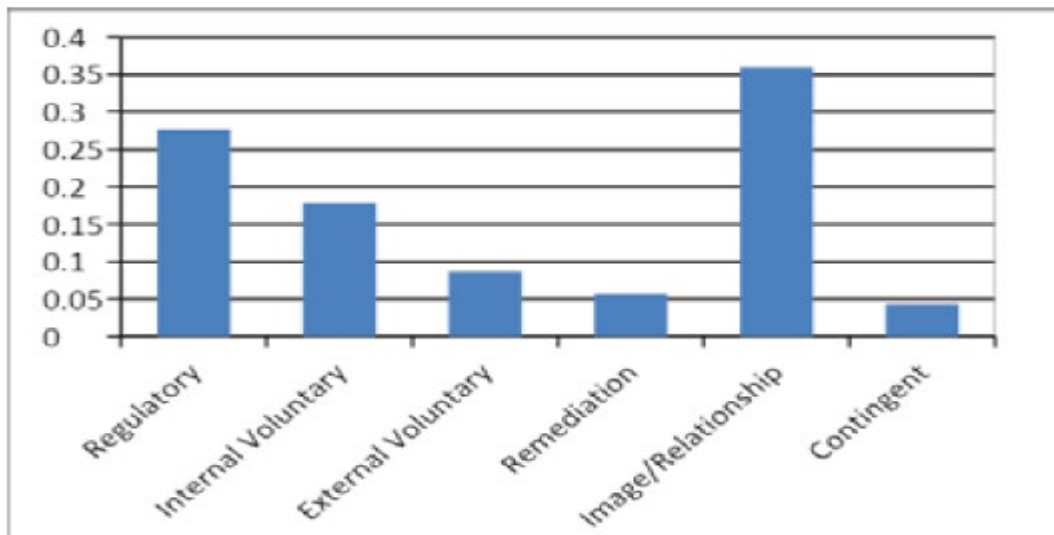


Figure 1: Graphical Presentation of Overall Weight of Six Attributes of the Environment

## Assessment for Manufacturing Organizations in Chittagong during the Research

Thus, we can say that this study concentrates on the negative impact made by manufacturing organizations by producing hazardous products and dumping waste here and there and what they are doing in return to society (Figure1).

### Conclusion

Economic development should not come at the expense of environmental sustainability. For Bangladesh, achieving economic progress while preserving its natural environment is critical. Manufacturing organizations play a significant role in driving the country's economic growth, but their environmental impact cannot be overlooked. This study utilized the Analytic Hierarchy Process (AHP) tool to assess the adverse effects of manufacturing organizations in Chittagong using quantitative data. The findings are summarized below:

Under the Regulatory attribute, the analysis of sub-attributes reveals that manufacturing organizations in Chittagong are relatively proactive in areas such as monitoring, inspection, testing, and the use of protective equipment. However, their performance in environmental management planning is notably inadequate. This indicates that most organizations lack comprehensive strategies to manage their environmental responsibilities effectively.

For the Internal Voluntary attribute, employee health and satisfaction emerged as a priority, receiving the highest rating. Conversely, environmental audits were rated the lowest, indicating that while organizations prioritize their workforce's well-being, they neglect regular assessments of their environmental impact.

In the case of Corporate Image building, organizations are heavily focused on improving their public image and are willing to allocate significant resources to environmental assessments. However, this appears to be driven by reputational concerns rather than a deep commitment to environmental sustainability.

To address these gaps, it is essential to foster greater environmental responsibility among corporate executives. Establishing industry-wide standards and benchmarks can motivate organizations to adopt more sustainable practices. While developed nations impose significant pressure on corporations to mitigate environmental harm, Bangladesh must establish at least the minimum criteria for environmental compliance as a starting point.

Policy development is key. A robust environmental framework can serve as a foundation for generating innovative ideas and sustainable practices. If the current trajectory of environmental degradation continues, it will compromise the quality of life for future generations, rendering economic progress meaningless.

This study specifically focused on manufacturing organizations operating within Chittagong. Future research could explore other sectors in Chittagong or extend the analysis to manufacturing organizations in other cities. Such studies would provide a broader understanding of the environmental challenges and opportunities across different industries and regions.

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