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Comparison of Research Variables among Public and Private thermal Power Plant Groups using t-Test

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Abstract

Thermal power plants in India are categorized into two sectors: public sector and private sector plants. These two sectors exhibit contrasting approaches and priorities among their personnel. Public sector plants often view environmental responsibility as a social duty and tend to prioritize it, while private sector plants may place a greater emphasis on profit generation. Consequently, it is anticipated that their approaches to environmental management vary.

To explore these differences in environmental management practices between the two sectors, we conducted a study that involved gathering data on eleven environmental management variables from 112 thermal power plants operating in India, all of which have a capacity exceeding 100 MW. Our analysis revealed significant distinctions in most of the environmental management variables between the two sectors.

The outcomes of this research are expected to be beneficial for environmental management executives within power plants, assisting them in formulating effective strategies for environmental preservation and management.

***Key Words*:** Environmental Management, Thermal Power Plants, EM variables, EM Activities

1. INTRODUCTION

Environmental pollution is a pressing global issue that affects us economically, physically, and in our daily lives. It's linked to various contemporary diseases and has escalated due to factors such as increased industrialization, overpopulation, inefficient resource use, urbanization, adoption of less eco-friendly technologies, and poverty. In India, environmental challenges are on the rise, driven by rapid economic growth and a population that has surged from 300 million in 1947 to over one billion today. This population growth places immense strain on the environment, infrastructure, and natural resources.

A study conducted by B. Bowonde in 1986 highlighted the complexity of environmental issues in India. These complexities arise from the interplay of factors like high population density, industrialization, urbanization, and inadequate environmental management practices.

In 2010, the Central Pollution Control Board (CPCB) collaborated with IIT-Delhi to conduct a survey of 88 industrial clusters across India. The findings categorized 43 industries as critically polluted, scoring above 70 on a 100-point scale, while 32 others were classified as severely polluted, scoring between 60 and 70. Thermal power plants emerged as a significant contributor to pollution. These

plants emit pollutants like carbon dioxide (CO2), nitrogen oxides (NO), sulfur oxides (SO), chlorofluorocarbons (CFCs), and airborne inorganic particles such as fly ash and soot. Some of these emissions, particularly CO2 and CFCs, are greenhouse gases responsible for global warming, while nitrogen and sulfur oxides contribute to atmospheric acidity.

India heavily relies on thermal power as its primary source of electricity generation, with approximately 80% of its power coming from thermal power plants.

Environmental Management Systems (EMS) encompass internal policies, assessments, plans, and actions aimed at harmonizing an organization with its natural environment. The topic of EMS has gained significant attention in various social, political, and industrial circles. Recent years have witnessed a growing awareness of environmental issues and the realization that the environment is not an inexhaustible resource. Environmental management can be approached from both technological and managerial angles. Research has explored various aspects of environmental management from a managerial perspective, with a focus on pollution-prone industries like thermal power plants being of particular interest.

In India, thermal power plants are divided into public and private sectors, each characterized by distinct organizational structures, cultures, and internal attitudes. Public sector plants often emphasize social responsibility, while private sector plants may prioritize profit. Consequently, it is anticipated that their environmental management practices will differ. This study seeks to address this research issue with the following specific objectives:

a) Identify the key environmental management variables within the context of Indian thermal power plants.
b) Evaluate potential differences in these environmental management variables between the two sectors of thermal power plants.

KEY ISSUES IN ENVIRONMENTAL MANAGEMENT

Key concerns in the realm of environmental management encompass various aspects. A review of literature from the last decade to fifteen years highlights that many researchers have focused on issues such as:

1. **Stakeholder Pressure:** Examining how external stakeholders influence and pressurize organizations to adopt environmentally responsible practices.
2. **Barriers to Environmental Management Adoption:** Identifying the obstacles and challenges that hinder the implementation of environmental management initiatives within organizations.
3. **Supporting Mechanisms for EM Implementation:** Investigating the systems and resources needed to facilitate the successful implementation of environmental management practices.
4. **Environmental Management Activities:** Analyzing the specific actions and strategies employed by organizations to manage and mitigate their environmental impact.
5. **Training on Environmental Issues:** Evaluating the role of training programs in enhancing employees' awareness and knowledge of environmental issues and responsibilities.
6. **Environmental Impact Assessment (EIA) Exercises:** Assessing the effectiveness of Environmental Impact Assessments in predicting and mitigating potential environmental harm caused by projects or activities.
7. **Informal Environmental Management Systems (EMS):** Exploring the informal, non-standardized approaches that organizations use to address environmental concerns.
8. **Top Management Involvement:** Investigating the extent to which senior management actively engages in and supports environmental management initiatives.
9. **Integration of EM into Business Strategy:** Examining how organizations align their environmental management efforts with their overall business strategies and objectives.
10. **Effectiveness in Achieving Environmental Goals:** Assessing the degree to which environmental management practices lead to the achievement of established environmental goals.

11. **Contribution of EMS to Organizational Performance:** Studying how the implementation of Environmental Management Systems influences an organization's overall performance, including its financial, operational, and reputational aspects.

These issues represent critical areas of research and practice within the field of environmental management, reflecting the multifaceted nature of environmental concerns in today's world. There are several issues related with environmental management. Literature review over the past ten to fifteen years suggest that most of the researchers have dealt with issues like stakeholder pressure, barriers against adoption of EM, supporting mechanisms for EM implementation, EM activities , training on environmental issues, Environmental Impact Assessment (EIA) exercise, informal EMS, top management involvement, integration of EM to business strategy, effectiveness of achieving environmental goals, contribution of EMS to organization's performance etc.

2.1 Stakeholder Pressure

Stakeholders are commonly defined as groups or individuals who have the potential to impact or are influenced by an organization's objectives, as articulated by Freeman in 1984. Savage, Nix, Whitehead, and Blair (1991) further refined this definition, describing stakeholders as groups or individuals who possess an interest in the organization's activities and have the capacity to exert influence over them.

Ross Hughes (1998) conducted an analysis of more than 30 Environmental Impact Assessment (EIA) processes in Tanzania, revealing that stakeholder involvement in EIA can face various constraints that may differ based on specific circumstances and contexts.

In another study by Yi-Chun Huang (2005) conducted in Taiwan, the focus was on comprehending the circumstances surrounding environmental management and the impact of stakeholders on enterprises. The research also explored the relationship between environmental management practices and stakeholder influence, examining potential differences among various industries. The study encompassed Taiwan's top 1000 manufacturers, spanning conventional industries such as textile, papermaking, and printing, fundamental industries like chemicals and steel, and technology-intensive sectors including electronics, information, and telecommunications.

The findings of this study indicated several noteworthy observations. Firstly, environmental management practices showed a positive correlation with regulatory stakeholders, organizational stakeholders, community stakeholders, and the media. Additionally, the research revealed that technology-intensive industries tended to exhibit more robust environmental management practices compared to their conventional industry counterparts.

2.2 Barriers against Adoption of EM

The literature on Environmental Management (EM) underscores the significance of comprehending barriers to effective environmental management, as evidenced by the works of Chan (2008), Luken and Van Rompaey (2008), and Van Hemel and Cramer (2002). Among these studies, there is a notable focus on investigating barriers to environmental management within smaller businesses (Brío and Junquera, 2003; Perez-Sanches, Barton, and Bower, 2001; Zhang, Bi, and Liu, 2009). However, the research conducted by Hilary (2004) stands out for categorizing these barriers into two dimensions: internal and external factors.

In the Indian context, B. Bowonder (1986) examined literature related to environmental management problems and identified several significant factors contributing to the growing severity of these issues. These factors included a lack of political commitment, the absence of a comprehensive environmental policy, low levels of environmental awareness, and limited mass media attention. Bowonder emphasized the necessity of administrative support through the modification of government regulations, laws, and procedures to address these challenges.

Charbel Jose Chippetta Jabbour (2011) conducted a study to identify the primary barriers to EM in two clusters of small businesses, one in Brazil and the other in Japan. This research involved conducting 20 interviews. In the Brazilian cluster, the predominant barrier was found to be a lack of information, while in the Japanese cluster, the main obstacle was the gradual decline of traditional and environmentally friendly production knowledge.

The literature consistently highlights several well-documented barriers that hinder the adoption of eco-efficiency and other environmental initiatives. These include a scarcity of available resources, information barriers, and internal attitudes and perceptions. Adequate resources, particularly financial resources, are essential for the successful implementation of various environmental initiatives. Financial constraints often manifest as issues such as insufficient funding for environmental projects or extended return on investment periods (Vernon et al., 2003).
Hillary (2004) summarized the primary internal and external barriers to Environmental Management System (EMS) implementation in small and medium-sized enterprises (SMEs). She concluded that the most critical barrier for SMEs was the lack of human resources.

2.3 Supporting Mechanisms for EM Implementation

Supporting mechanisms for the successful implementation of Environmental Management (EM) encompass factors such as senior management commitment, regular meetings, training and awareness programs for internal staff, suppliers, and customers, as well as the availability of necessary resources. Among these, senior management's commitment to the development and execution of an Environmental Management System (EMS) stands out as a pivotal factor. It is often regarded as the most critical determinant of an EMS's overall success. Without the wholehearted commitment of senior management, the EMS team's efforts may be severely constrained, potentially leading to its failure. An empirical study conducted by Goh Yen Nee in 2011 demonstrated the significance of organizational capital resources as a key challenge in implementing ISO 14001 EMS.
Within just a few years of the publication of ISO 14001, numerous organizations worldwide had adopted this standard. Nicole Darnall, Deborah Rigling Gallagher, Richard N.L. Andrews, and Deborah Amaral (2000) conducted research on the experiences of organizations with EMS adoption and implementation, investigating whether the benefits outweighed the challenges. Their findings revealed that, despite the hurdles encountered during EMS implementation, the majority of organizations believed that the advantages of implementing EMSs far outweighed any drawbacks.
Nicole Darnall (2000) also conducted theoretical and empirical research to identify the factors contributing to a facility's decision to signal its environmental strategy. The study evaluated motivations for EMS implementation across three types of organizations: publicly traded facilities, privately owned facilities, and government facilities. It was found that drivers for EMS adoption varied among these types of organizations. However, a common thread among them was the significance of regulatory pressures on facilities. Additionally, the study provided evidence that government support, in the form of technical assistance and regulatory incentives, played a substantial role in motivating facilities to embrace EMS.
Regenerate

2.4 EM Activities

The significance of environmental activities has grown in both research and practical applications. However, there has been limited systematic exploration of such activities within firms, particularly in the context of environmental management. Environmental management activities are recognized as a crucial means of integrating environmental considerations into corporate decision-making, requiring both financial and ecological performance.

Up to this point, there has been a lack of comprehensive understanding regarding the importance of Human Resource Management (HRM) activities, such as training programs on environmental issues, in comparison to other technical and organizational activities aimed at reducing material, water, and energy consumption, for instance.
One specific environmental management activity that has gained attention as a facilitator at both the firm and individual levels is the provision of environmental training programs by companies for their employees. It has been emphasized that such training can heighten environmental awareness and consequently support pro-environmental behaviors among individual employees (Fernandez et al., 2003). This, in turn, can potentially yield economic benefits (Brio et al., 2007). A case-based exploratory research conducted by Arun Sahay (2009) focused on the population residing near the

Talcher Super Thermal Power Plant (TSTPP) in the Angul district of Orissa. The study aimed to assess the outcomes of TSTPP's environmental management practices, with a specific focus on social, environmental, and legal aspects. The research also examined the environmental impact, including health hazards arising from stack emissions and water pollution resulting from ash pond discharge.
The findings indicated that the local residents around TSTPP were aware of the environmental pollution caused by the plant, although they lacked detailed knowledge. The survey revealed that TSTPP's commitment to ash utilization was inadequate, and more efforts were needed to increase and achieve 100% ash utilization within a specified timeframe. The survey results also reflected a lack of education and awareness about environmental issues among the local population. Nevertheless, the study served as a foundation for ecological research in the area and provided insights for conducting an economic cost-social benefit analysis.

2.5 Training on Environmental Issues

The National Round Table on the Environment and the Economy (1991) emphasizes the pivotal role of education and communication in enabling employees and managers to understand their responsibilities in implementing sustainable development within a corporation. To engage employees effectively, companies must provide environmental awareness education and training to some extent (Milliman J, Clair J, 1996; Miller J, 1996). This perspective is well-supported within the corporate world (CBI; 1992).
Research conducted by Saunders et al. (1993) identifies employee education as one of the most frequently recommended elements by organizations to be included in an environmental management system. Cook and Seith (1992) discovered that environmental training serves as a motivator for employees to actively participate in environmental initiatives. Organizations should implement environmental awareness training programs that impart lasting knowledge to employees. This knowledge should encompass not only the organization's environmental management scheme and policy but also its environmental impacts (Hale M, 1995; Cohen-Rosenthal E, 2000; Miller 1996; Burleigh, 1997).
The benefits of environmental awareness education and training in business are well-documented and encompass: fostering a sense of ownership among employees regarding the company's success; enhancing the ability to retain qualified employees; attracting high-achieving graduates; reducing staff turnover; increasing job satisfaction; strengthening employee alignment with corporate goals and culture; boosting staff motivation; and elevating the company's reputation as one that cares for the environment (Hui et al. 2001; Cramer JM, Roes B, 1996; Schneider B, Bowen 1985; Reinhardt, 2000).
While environmental education and awareness training programs are crucial for transforming business practices, it's important to recognize that even well-designed programs may not always achieve the desired environmental behavior changes necessary for sustainability (Stern, 1999).
Companies may find the need to conduct environmental training programs for various reasons, including shifts in their corporate environmental philosophy, heightened liability concerns, and a complex regulatory landscape (Cook and Seith, 1992). Implementing specific training efforts related to environmental issues can yield multiple advantages, such as ensuring compliance with regulatory requirements, clarifying employee responsibilities and liabilities within the organization, enhancing the company's public image, encouraging employees to become environmental stewards, and motivating them to actively participate in proactive environmental management (Cook and Seith, 1992).

2.6 EIA Exercise

Environmental Impact Assessment (EIA) has been variously defined since its inception (Yanhua et al., 2011; Samarakoon and Rowan, 2008; Snell and Cowell, 2006; Bruhn-Tyskand Eklund, 2002; Perez-Maqueo, 2001; Duinker and Greig, 2007; Lee and George, 2000). It is therefore difficult to comprehensively define EIA, however, it can be described as a systematic process for identifying, examining, analyzing, evaluating, and predicting the impacts of planned activities or policies; involving consultation with affected stakeholders, and using the results of the analysis and

consultations in planning, authorizing and implementation of the activity (Toro et al., 2012; Kwiatkowski and Ooi, 2003; Yanhua et al., 2011; Cashmore, 2004). EIA is thus an anticipatory (futuring), participatory environmental management tool and as such, it is based on principles such as transparency, public involvement and accountability (CENN, 2004; RTPI, 2001). EIA is a useful tool for facilitating intra-generational and intergenerational equity (Yanhua et al., 2011) hence promoting sustainable development and ecosystems protection. It is therefore not surprising that it has been adopted world-wide within four decades (Jay et al., 2007). EIA differs from one country to another. Several studies including, Wood (2003a) and Okello et al (2008), suggests that legislation(s) is/are essential for EIA to be effective. Some countries have EIA legislations requiring approval of projects before their commencement but other countries rely on regulations, guidance or ad-hoc procedures (Glasson et al., 2000).

2.7 Informal EMS

The concept of an informal Environmental Management System (EMS) arises when efforts are not readily observable and demand a degree of flexibility. An informal EMS is essentially a system that is created on an ad-hoc basis within a firm, without adhering to any pre-established framework. Comparing standardized EMS to traditional environmental command-and-control policies, proponents argue that voluntary approaches provide companies with the flexibility to tailor their EMS to suit their specific operations, characteristics, location, and risk levels (Rondinelli and Vastag, 1996). However, it has also been suggested that opting for a standardized EMS may introduce some degree of rigidity, as these systems necessitate a highly structured set of procedures.

In a study by Eduard Aonso and Francisco J Andre (2011), they proposed a model that shed light on the advantages of an informal EMS, characterized by its flexibility and lack of strict adherence to predefined rules. They concluded that such a system allows managers to make swift decisions without being overly constrained by established protocols. However, it's worth noting that with an informal EMS, a firm may relinquish some degree of internal control.

The analysis by the authors focused primarily on the internal management dimension of environmental management systems, deliberately omitting several other pertinent factors to maintain tractability. One of these unaddressed issues is the connection between EMS and corporate social responsibility, as well as the environmental commitment assumed by the firm.

2.8 Top Management Involvement

The support of top management plays a crucial role in determining the success of an Environmental Management System (EMS). It can influence success by empowering employees to enact changes, shaping the organizational culture to align with these changes, establishing systems to promote desired behaviors (such as reward or incentive programs), providing training, and enhancing communication throughout the organization (Gupta and Sharma, 1996; Leitch et al., 1995). Argyris (1998) described commitment as a force that generates human energy and engages the human mind. Without commitment, the implementation of any new initiative is unlikely to succeed. The degree of top management's involvement in EMS activities serves as a gauge of their strong commitment and support for continuous improvement in environmental management, pollution prevention, regulatory compliance, and resource allocation.

In a research study conducted by Chin and Pun (2001) focusing on the Printed Circuit Board (PCB) industry in Hong Kong, the importance of top management commitment became evident. Their findings highlighted that top management commitment is a significant factor in the successful implementation of EMS ISO 14001. For top management to effectively implement an EMS, it is essential for them to comprehend the existing organizational culture. Once this understanding is achieved, top management can take steps to reshape the organization's culture, making it more adaptable and responsive to change. Cultural transformation is not an immediate process and often unfolds over an extended period. However, as determined by Wilms et al. (1994) in their study, people within the organization tend to follow the direction set by management. Therefore, the actions, direction, and level of commitment exhibited by top management dictate the organization's ultimate

trajectory. Top management can also serve as champions of change, facilitating a smoother and more comprehensive transition within the organization.

2.9 Integration of EM to Business Strategy

The literature on the integration of environmental concerns into business strategy is fragmented, lacking a solid theoretical foundation and empirical observations. Despite the fact that both researchers and practitioners began considering environmental issues several years ago, the environmental literature continues to expand rapidly. It is well-recognized that companies are significant contributors to pollution and often resist more radical changes in environmental standards. However, it is also true that many companies have shifted their attitudes toward the natural environment in recent years. While a couple of decades ago, many managers were skeptical about whether ecology would become a crucial determinant of their strategies, today an increasing number of companies worldwide are implementing proactive environmental programs (Min & Galle, 2001). These programs encompass various aspects, such as integrating environmental concerns into business processes (e.g., producing environmentally friendly products, waste reduction, recycling, energy conservation, and developing reusable packaging), establishing dedicated environmental departments, fostering an environmentally sensitive organizational culture, extending environmental principles to suppliers, communicating environmental issues throughout the value chain to customers and other stakeholders, and integrating comprehensive environmental management into corporate planning processes (Handfield et al., 1997).

Corporate-level strategies, situated at the highest organizational level, address the balance of a company's strategic business units and the connections among these units (Wheelen & Hunger, 2006). Corporate environmental strategies, in this context, pertain to the degree to which environmental considerations are integrated into a company's decisions regarding new business ventures, technology choices, plant locations, and research and development investments (Banerjee et al., 2003). Functional-level strategies, on the other hand, focus on strategic questions within different business functions (Wheelen & Hunger, 2006).

In an empirical study conducted by A. Suryanarayana and Rambabu Pentyala (2010) within the Indian processing industry, they aimed to identify, analyze, and emphasize the importance of the environment in business decision-making, particularly its role in strategic decision-making across various business functions. Their findings concluded that environmental management (EM) is increasingly becoming an integral part of business strategies.

2.10 Effectiveness of Achieving Environmental Goals

Environmental goals are typically established to provide guidance for achieving ecological sustainability. Whether at the individual, group, or organizational level, the effectiveness of goal attainment signifies success. The achievement of any environmental goal relies significantly on how well environmental performance is assessed. The task of evaluating performance and identifying appropriate environmental performance indicators is an ongoing process. Environmental performance evaluation serves as a management tool that offers an organization reliable, objective, and verifiable information on a continuous basis to determine if it is meeting the environmental criteria established by management.

In a study conducted by Ezeanolue, M.I, Umeh, J.C., and Iorlamen, T.R (2012), the effectiveness of motivation as a tool for achieving organizational goals was examined, with Makurdi Local Government Council serving as the case study. The study recommends that management should enhance the working conditions of employees to encourage them to give their best to the organization. Furthermore, timely promotions should be provided to employees to boost their performance and productivity.

2.11 Contribution of EMS to Organization’s Performance

The ability of organizations to effectively manage their environmental performance is emerging as a

strategic concern for firms (Henri and Journeault, 2008). Previous research suggests that environmental management can potentially enhance a firm's competitiveness (Porter and Van der Linde, 1995; Trung and Kumar, 2005). The relationship between proactive engagement in environmental issues and firm performance presents a complex issue in the literature. This complexity arises because, while some studies have demonstrated a positive correlation (e.g., Aragon-Correa and Rubio-Lopez, 2007; Galdeano-Gomez et al., 2008; Nakao et al., 2007; Wahba, 2008), others have not found a clear positive impact of environmental proactivity on financial performance (Link and Naveh, 2006; Watson et al., 2004).

In her empirical research, Petra Christmann (1999) investigated the effects of best practices in environmental management on firm performance, focusing on 88 chemical companies. The results indicated a moderate relationship between best practices and cost advantages, which emerged as a significant factor in determining firm performance.

RESEARCH METHODOLOGY

3.1 Research Model

This study employs a general system model comprising Input, Process, and Output, which has been widely utilized by previous researchers in various research domains (King, 1988; Premkumar and King, 1991; Premkumar, 1992). The primary objective of utilizing this model is to establish a framework for the research. It facilitates the categorization of variables employed in the study. To comprehend the Environmental Management (EM) practices of plants, a range of variables are identified and subsequently grouped into three categories: input variables, process variables, and output variables.

3.1.1 Input Variables

The input variables in this study encompass three key factors: stakeholder pressure, barriers to the adoption of Environmental Management (EM), and mechanisms supporting EM implementation.

1. **Stakeholder Pressure:** This variable is assessed through multiple dimensions, including the influence exerted by regulatory authorities, community expectations regarding the organization's environmental actions, market-driven pressures, and internal pressures stemming from within the organization itself.
2. **Barriers Against Adoption of EM:** This input variable is gauged by evaluating the difficulties and uncertainties associated with the proactive implementation of environmental management. These barriers encompass both organizational hurdles and personal impediments.
3. **Supporting Mechanisms for EM Implementation:** The third and final component of the input variable involves identifying mechanisms that facilitate the successful implementation of environmental management practices.

3.1.2 Process Variables: Subsequently, six process variables are considered in this study:

1. **Environmental Management (EM) Activities:** This initial variable plays a crucial role in integrating environmental concerns into corporate decision-making processes, necessitating a balance between financial and ecological performance.
2. **Training on Environmental Issues:** This variable involves two primary levels of training: awareness training for employees and competency training for those whose roles impact the organization's ability to achieve its objectives and targets.
3. **Environmental Impact Assessment (EIA) Exercise:** EIA represents a comprehensive study of environmental impacts and serves as a tool to evaluate and mitigate detrimental effects on the environment.
4. **Informal EMS**: This process variable pertains to situations where efforts are not easily observable yet remain necessary for effective environmental management.

5. **Top Management Involvement:** Top management's active engagement is a driving force, emphasizing the significance of EMS as a critical component for gaining a competitive advantage.
6. **Integration of EM into Business Strategy:** The final process variable underscores how the adoption of environmental strategy can influence strategic investments and financial performance.

3.1.3 Output Variables

There are only two output variables in this study:

Effectiveness of Achieving Environmental Goals: This variable is designed to assess the extent to which environmental goals are met, guiding efforts towards ecological sustainability.

1. **Contribution of EMS to Organization's Performance:** This variable examines how the Environmental Management System (EMS) contributes to the overall performance of the organization.

All the research variables were measured using multiple indicators, each employing a five-point Likert-type scale for assessment.

DATA COLLECTION

A comprehensive questionnaire was meticulously developed to measure the various research variables. The questionnaire items were derived from an extensive review of the existing literature. To ensure the content validity of the instrument, it was submitted to two senior faculty members from a technical educational institute and five managers from thermal power plants. These individuals provided valuable feedback, leading to refinements in the questionnaire's language and sequence. After incorporating all the suggestions, the finalized questionnaire was distributed.

The questionnaire was administered along with a cover letter outlining the study's objectives. Ten sets of questionnaires were sent to the Environmental Management (EM) heads of the respective plants, with a request for their response. EM heads were further asked to collect responses from senior executives in the EM and operations departments of their plants and return the completed questionnaires to us. Approximately 2-3 weeks later, follow-up calls were made to those who had not responded, aiming to encourage their participation. Additionally, a follow-up mailing was conducted about one month from the initial distribution date. Personal visits were arranged where feasible to facilitate the data collection process.

In total, 112 plants actively participated in the study, with the number of responses obtained and the participating plants categorized by sector as presented in Table 1.

Table 1 : Statistics of Obtained Responses

Category	Responses Obtained	No. of Plants Participated	Percentage of Total Plants Participated
Public Plants	259	67	59.82%
Private Plants	192	45	40.18 %
Total	**451**	**112**	**100**

4.1 Validity and Reliability of the Research Construct

A thorough and comprehensive questionnaire was meticulously crafted to assess the various research variables. These questionnaire items were thoughtfully derived from an extensive review of the existing literature. To enhance the content validity of the instrument, it was rigorously reviewed by two senior faculty members from a technical educational institute and five managers from thermal power plants. Their valuable insights and feedback led to refinements in the questionnaire's language and sequencing. Once all the suggestions had been incorporated, the final version of the questionnaire was prepared for distribution.

Accompanying the questionnaire was a cover letter clearly delineating the study's objectives. Ten sets of questionnaires were dispatched to the Environmental Management (EM) heads of the respective plants, along with a request for their responses. EM heads were also tasked with collecting responses from senior executives in both the EM and operations departments of their plants and subsequently returning the completed questionnaires to us. Approximately 2-3 weeks following the initial distribution, diligent follow-up calls were made to those who had yet to respond, with the aim of encouraging their participation. Furthermore, a follow-up mailing was conducted approximately one month after the initial distribution date. In cases where it was feasible, personal visits were arranged to streamline the data collection process.

In total, 112 plants actively participated in the study. The number of responses obtained and the participating plants were categorized by sector, and this information is presented in

Table 1.

Table 2 : Validity of the Construct

Construct	Number of Items	Eigen Value	Variance Explained	Minimum Factor Loading
Input factors				
Stakeholder pressure	13	8.464	26.449	0.500
Barriers against adoption of EM	8	5.773	18.039	0.539
Supporting mechanisms for EM implementation	11	1.840	5.751	0.504
Process Factors				
EM Activities	9	6.139	15.741	0.560
Training on environmental issues	5	3.634	9.317	0.547
EIA exercise	10	5.393	13.829	0.504
Informal EMS	6	3.410	8.744	0.572
Top management involvement	3	2.356	6.042	0.584
Integration of EM to business strategy	6	2.689	6.895	0.502
Output Factors				
Effectiveness of achieving environmental goals	8	4.497	34.589	0.607
Contribution of EMS to plant's performance	5	2.698	20.754	0.535

Table 3 : Reliability Test

Construct	Number of Items	Mean	Alpha
Stakeholder pressure	13	2.81	0.924
Barriers against adoption of EM	8	3.32	0.798
Supporting mechanisms for EM implementation	11	3.23	0.853
EM activities	9	2.67	0.798

Training on environmental issues	5	3.62	0.727
EIA exercise	10	3.52	0.707
Informal EMS	6	3.77	0.765
Top management involvement	3	4.06	0.675
Integration of EM to business strategy	6	2.90	0.862
Effectiveness of achieving environmental goals	8	3.63	0.808
Contribution of EMS to plant's performance	5	3.85	0.924

2. RESULTS

This study encompasses thermal power plants in India, comprising both the public sector and private sector facilities. Data have been diligently collected from both sectors. The summary statistics for all research variables pertaining to these plant sectors are thoughtfully presented in Table 4, and Figure 1 provides a visual representation of these statistics.

Table 4 Mean Scores of Variables (On 1-5 Likert Type Scale)

Variables ↓ / Category of Plant →	Public Plants (Mean)	Private Plants (Mean)
Stakeholder pressure	3.32	2.13
Barriers against adoption of EM	3.30	3.27
Supporting mechanisms for EM implementation	3.07	3.22
EM activities	2.56	2.83
Training on environmental issues	3.62	3.61
EIA exercise	3.47	3.45
Informal EMS	3.81	3.73
Top management involvement	4.08	4.04
Integration of EM to business strategy	2.68	3.21
Effectiveness of achieving environmental goals	3.52	3.42
Contribution of EMS to organization’s performance	3.94	3.73

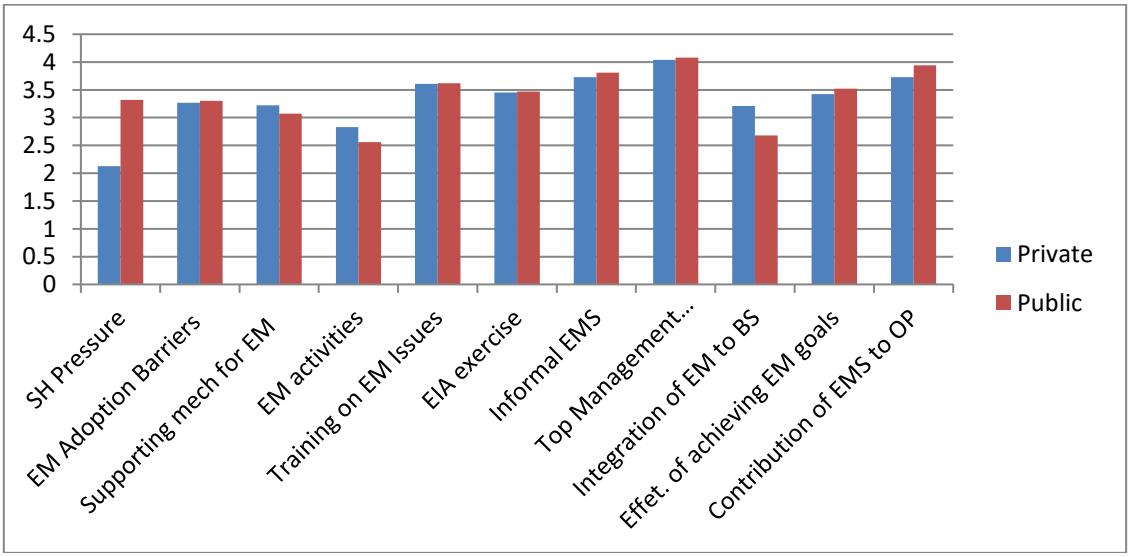

Fig. 1: Bar Chart for all Variables

The outcomes of the t-test reveal noteworthy distinctions between plant sectors in several research variables. Specifically, there are significant differences in variables such as stakeholder pressure, supporting mechanisms for EM implementation, EM activities, EIA exercise, informal

EMS, integration of EM into business strategy, and the contribution of EMS to organization's performance. These differences are particularly pronounced.

However, it's important to note that for certain research variables like barriers against the adoption of EM, training on environmental issues, top management involvement, and the effectiveness of achieving environmental goals, the disparities between plant sectors are not as substantial.

In the following sections, we provide in-depth discussions on the results pertaining to each of these variables.

5.1 Stakeholder pressure

The results of the t-test reveal a significant difference ($p < 0.0005$) in stakeholder pressure between the two groups of plants. Notably, stakeholder pressure is more pronounced among public sector plants, with a mean value of 3.32, compared to private sector plants, which exhibit a mean value of 2.13.

This divergence can be attributed to the effective influence exerted by national and regional government agencies on public sector plants, urging them to adopt more stringent environmental management practices.

Table 5 : Comparison of Research Variables among Power Plant Groups Using t-Test

S.N	Variables Names		F	Significance	T	DF	Sig. (2-Tailed)
1	Stakeholder pressure	Equal variances assumed	92.794	0.000	-45.775	449	.000
		Equal variances not assumed			-42.522	285.578	.000
2	Barriers against adoption of EM	Equal variances assumed	1.403	.237	-.232	449	.816
		Equal variances not assumed			-.232	408.851	.817
3	Supporting mechanisms for EM implementation	Equal variances assumed	82.857	0.000	7.996	449	.000
		Equal variances not assumed			7.303	260.214	.000
4	EM activities	Equal variances assumed	57.556	0.000	10.420	449	.000
		Equal variances not assumed			9.418	245.777	.000
5	Training on environmental issues	Equal variances assumed	0.726	0.395	-.127	449	.899
		Equal variances not assumed			-.127	400.359	.899
6	EIA exercise	Equal	5.362	0.021	3.362	449	.001

		variances assumed					
		Equal variances not assumed			3.162	305.871	.002
7	Informal EMS	Equal variances assumed	33.593	0.000	-2.939	449	.003
		Equal variances not assumed			-2.699	268.116	.007
8	Top management involvement	Equal variances assumed	18.083	0.000	-1.137	449	.256
		Equal variances not assumed			-1.064	297.347	.288
9	Integration of EM to business strategy	Equal variances assumed	36.271	0.000	14.397	449	.000
		Equal variances not assumed			13.605	313.769	.000
10	Effectiveness of achieving environmental goals	Equal variances assumed	4.072	0.044	-1.625	449	.105
		Equal variances not assumed			-1.547	326.947	.123
11	Contribution of EMS to organization's performance	Equal variances assumed	1.096	0.296	-4.990	449	.000
		Equal variances not assumed			-4.932	392.942	.000

5.2 Barriers against adoption of EM

The results of the t-test reveal that there is no significant difference ($p > 0.0005$) in barriers against the adoption of EM between the two groups of plants. This lack of significant difference suggests that both public and private sector thermal power plants are facing similar challenges and constraints in their efforts to implement an EMS.

In both cases, these thermal power plants are actively seeking solutions, tools, and incentives to overcome these barriers. The overarching goal for both sectors is to identify and implement strategies that remove potential obstacles and enhance economic incentives for effective environmental management.

5.3 Supporting mechanisms for EM implementation

The results of the t-test highlight a significant difference ($p < 0.0005$) in supporting mechanisms for EM implementation between the two groups of plants. Specifically, public sector plants exhibit a lower mean value of 3.07 in comparison to private sector plants, which have a higher mean value of 3.22.

These supporting mechanisms encompass various aspects such as the commitment from top management, training, and awareness among internal personnel. The findings indicate that these

supporting mechanisms are more robust within private sector plants, leading to a higher overall score in this regard for the private sector facilities.

5.4 EM activities

The t-test results underscore a significant disparity ($p < 0.0005$) in supporting mechanisms for EM implementation between the two plant sectors. Public sector plants demonstrate a lower mean value of 3.07, whereas private sector plants exhibit a higher mean value of 3.22.

These supporting mechanisms encompass a range of factors, including top management commitment, training programs, and awareness initiatives among internal staff. The data suggests that these mechanisms are more robustly established within private sector plants, resulting in a higher overall score for supporting mechanisms in this sector.

5.5 Training on environmental issues

The results of the t-test reveal that there is no significant difference ($p > 0.0005$) in training on environmental issues between the two groups of plants. This lack of significant difference can be attributed to the shared motivation of both thermal power plants to conduct environmental training programs for several compelling reasons.

These reasons include a shift in the corporate environmental philosophy, heightened concerns regarding liability, and the complex regulatory landscape they navigate. The implementation of specific training initiatives focused on environmental issues is seen as beneficial, resulting in various advantages such as compliance with regulatory requirements, clarifying organizational definitions of employee responsibility and liability, fostering a positive public image, motivating employees to become environmental stewards, and encouraging active participation in proactive environmental management.

5.6 EIA Exercise

The results of the t-test reveal a significant difference ($p < 0.0005$) in the Environmental Impact Assessment (EIA) exercise between the two groups of plants. Public sector plants, with a mean value of 3.47, demonstrate a higher emphasis on EIA exercise compared to private sector plants, which have a mean value of 3.45.

The EIA exercise encompasses the perception and analysis of impacts related to various aspects, such as air emissions, soil contamination, and more. In this regard, public sector plants excel in both perceiving and analyzing these impacts, contributing to their higher score in EIA exercise compared to their private sector counterparts.

5.7 Informal EMS

The results of the t-test reveal a significant difference ($p < 0.0005$) in informal Environmental Management Systems (EMS) between the two groups of plants. Interestingly, public sector plants, with a mean value of 3.81, exhibit a higher emphasis on informal EMS compared to private sector plants, which have a mean value of 3.73.

This finding is both surprising and intriguing, warranting further investigation to determine the underlying reasons behind the higher score in informal EMS among public sector power plants. Further research is necessary to uncover the factors contributing to this difference.

5.8 Top management involvement

The results of the t-test indicate that there is no significant difference ($p > 0.0005$) in top management involvement between the two groups of plants. In both the public and private sectors, top management plays a similar role in supporting and facilitating various aspects of environmental management. This includes communicating policies, plans, and relevant information to employees, promoting cultural changes to facilitate implementation and operations, incentivizing and empowering employees for corrective actions and improvements, and reviewing the Environmental Management System (EMS) for progress. Therefore, the study did not find any significant differences between the two sectors in terms of top management involvement.

5.9 Integration of EM to business strategy

The results of the t-test reveal a significant difference ($p < 0.0005$) in the integration of Environmental Management (EM) into the business strategy between the two groups of plants. Specifically, public sector plants exhibit a lower mean value of 2.68 compared to private sector plants, which have a higher mean value of 3.21.

This difference can be attributed to the relatively casual approach of public sector plants towards integrating EM into their overall business strategy. In contrast, private sector plants appear to place a greater emphasis on aligning their environmental management practices with their business strategies.

5.10 Effectiveness of achieving environmental goals

The results of the t-test indicate that the effectiveness of achieving environmental goals is not significantly different ($p > 0.0005$) between the two groups of plants. These results primarily reflect the perceptions of the respondents.

It appears that respondents from both the public and private sector power plants are generally satisfied with their respective achievements in meeting environmental goals, given the efforts they have put into their environmental management practices. As a result, no significant difference was observed between the two sectors in this regard.

5.11 Contribution of EMS to organization's performance

The results of the t-test reveal a significant difference ($p < 0.0005$) in the contribution of Environmental Management Systems (EMS) to organizational performance between the two groups of plants. Specifically, public sector plants demonstrate a higher mean value of 3.94, whereas private sector plants have a slightly lower mean value of 3.73.

Organizational performance in this context encompasses factors such as gaining new market opportunities through compliance with environmental standards and the efficient conservation of input resources. The reason behind public sector plants achieving a higher score in this regard could be attributed to greater pressure from government agencies. Additionally, maintaining environmental standards is mandatory for market entry, and this requirement is rigorously enforced in public sector plants.

DISCUSSIONS

The overall results affirm that both management approach and the type of plant significantly influence Environmental Management (EM) variables. Public sector power plants place a greater emphasis on providing social services, while private sector plants prioritize expanding their market share and profitability. These findings suggest that government agencies exert more effective pressure on public sector plants to maintain a better environmental track record.

Supporting mechanisms for EM implementation are found to be lacking in public sector power plants, indicating that the implementation of any plan or strategy takes more time in these plants due to bureaucratic processes. Public sector plants display a more casual approach to their EM activities, which aligns with common perceptions. However, the surprising and interesting finding is the high score on informal EMS for public sector plants, despite their lower score on environmental activities. This discrepancy calls for further focused study to uncover the reasons behind these findings.

Top management support for EM is relatively equal in both groups of plants, indicating a shared commitment to environmental initiatives.

This study can provide valuable insights for environmental management professionals in power plants for self-evaluation and process improvement. The comparative analysis presented here can help power plants in both sectors better understand their strengths and weaknesses, enabling them to formulate strategies accordingly.

The findings from this research also suggest several avenues for future exploration. Understanding the reasons behind the contradictory findings of public sector plants scoring high on informal EMS but low on environmental activities is crucial. Research should seek to identify facilitators and inhibitors

for promoting top management involvement, particularly in countries like India, where this is essential for the success of strategic activities.

However, it's important to acknowledge certain limitations of this study. Data were collected solely from EM executives, and the perspectives of other key stakeholders such as operations managers and customers were not considered. Future research could involve gathering opinions from these stakeholders to explore potential differences in perceptions and their underlying causes.

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