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Editor
SSN JOURNAL OF MANAGEMENT AND TECHNOLOGY RESEARCH COMMUNICATIONS
Office: C-52, Housing Board Colony, Koh-e-Fiza, Bhopal - 462 001 (INDIA)
E-mail: editor@mntrc.in, profayeshaali@gmail.com

SSN Journal of Management and Technology Research Communications

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Society for Science and Nature, has been publishing an academic international peer-reviewed journal since 2008: **Bioscience Biotechnology Research Communications**, which is in 17th year of successful publication. SSN has ventured into starting yet another international publication, **SSN Journal of Management and Technology Research Communications.** It is an open-access, international peer reviewed quarterly journal for publication of original research articles, exciting reviews, interesting case histories and perspectives in applied areas of management and technology, including biological and medical sciences.

The journal welcomes empirical and analytical papers, reflecting both methodological rigor and practical relevance as well as literature reviews and meta-analyses showcasing and promoting current academic research in upcoming areas of management, science and technology. The insufficient publishable research in the sub-continent, and the developing nations, on the intertwining between management and successful management of science and technology, particularly in areas like health, basic science, engineering, including computer sciences prompted the proposal of this new journal.

The experienced and highly qualified board of editors of this journal will aim to foster diverse investigations of management of science and technology research, encompassing various types of applied areas. We intend to evaluate the theoretical and practical perspectives, utilising a range of methodologies and data—including quantitative, such as surveys, lab experiments, and archival research, as well as qualitative approaches, including case studies and examining the different settings in Management, Science and Technology.

We are particularly interested in – but not limited to – the following research avenues in applied areas of **Management, Science and Technology:** Biological Sciences, Health Sciences, Physical Sciences, Natural Sciences and Engineering.

Our Vision: In the coming years we hope and wish that **SSN Journal of Management and Technology Research Communications** will try to maintain high standards of ethical and quality publication, as we believe that it is only quality which can fully utilize the science for our welfare!

We do have a vision to become an important force for pluralism—teaching and disseminating the research skills of management, in living with science and technology. **SSN Journal of Management and Technology Research Communications** strongly believes that it will achieve high standards of ethical and quality publication as we visualize that it is only quality, which can truly help shaping technology for our existence!

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Genuine complaints in Publication: Complaint or expression of dissatisfaction made in honest intention of improvisation are always welcome, as they provide an opportunity and instant moment of attaining quality. The editorial team of SSN Journal of Management and Technology Research Communications shall strive hard to establish, along with the publisher, a transparent mechanism for appeal against editorial decisions or any related matter of publication. If still there are any genuine complaints related to ethical publishing, we are always open to them for the sake of maintaining quality and ethics of publication.

Please write your complaint with Journal title, Vol No/ Issue No /Year /Page numbers, full title of the MS and necessary author details along with type of complaint. The complaint must be about something that is within the jurisdiction of SSN Journal of Management and Technology Research Communications, its contents or process such as authorship, plagiarism, copy right violation, multiple, duplicate, or concurrent publications/ simultaneous submissions etc. Similarly, undisclosed conflicts of interest, reviewer bias or competitive harmful acts by reviewers or any bias of apparent discontentment, backed by logic and judicial discretion will be immediately looked into without any bias and discrimination.

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Our aim is to ensure that Management and Technology Research Communications follows best practices in publication and is of the highest quality, free from errors. However, we accept that occasionally mistakes might happen, which are inadvertently made or beyond human control, giving opportunity to all parties to decide the best to rectify.

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Submission of an article to Management and Technology Research Communications implies that the work has NOT been published or submitted elsewhere, therefore, the journal is strongly against unethical withdrawal of an article from the publication process after submission. Once the article is submitted, it is the absolute right of the editorial board to decide on article withdrawals. For genuine withdrawal, the corresponding author should submit a request which must be signed by all co-authors explaining the explicit reasons of withdrawing the manuscript.

Accepted articles in final stages of publication if are withdrawn, will entail withdrawal fees. The request will be processed by the editorial board and only serious genuine reasons will be considered if possible. The decision of the editorial board will be final and not negotiable. Unethical withdrawal or no response from the authors to editorial board communication will be subjected to sanction a ban to all authors, and their institute will also be notified.

It is a general principle of scholarly communications, that the editor of a journal is solely and independently responsible for deciding which articles submitted to the journal shall be published. In making this decision the editor is guided by policies of the journal's editorial board and constrained by such legal requirements in force regarding libel, copyright infringement and plagiarism. An outcome of this principle is the importance of the scholarly archive as a permanent, historic record of the transactions of scholarship.

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Article withdrawal

Only used for Articles in Press which represent early versions of articles and sometimes contain errors, or may have been accidentally submitted twice. Occasionally, but less frequently, the articles may represent infringements of professional ethical codes, such as multiple submission, bogus claims of authorship, plagiarism, fraudulent use of data or the like. Articles in Press (articles that have been accepted for publication but which have not been formally published and will not yet have the complete volume/issue/page information) that include errors, or are discovered to be accidental duplicates of other published article(s), or are determined to violate our journal publishing ethics guidelines in the view of the editors (such as multiple submission, bogus claims of authorship, plagiarism, fraudulent use of data or the like), may be withdrawn. Withdrawn means that the article content (HTML and PDF) is removed and replaced with a HTML page and PDF simply stating that the article has been withdrawn according to the Policies on Article in Press Withdrawal with a link to the current policy document.

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If the Editor receives a complaint that any contribution to the Journal breaks intellectual property rights or contains material inaccuracies or otherwise unlawful materials, a detailed investigation may be requested into, with the parties involved, substantiating their materialistic claims in writing, following the law of natural justice. We assure that we will make a good faith determination to remove the allegedly wrongful material or take actions as per law. All the investigations and decisions are to be documented to the Journal.

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Accepted articles in final stages of publication if are withdrawn, will entail withdrawal fees. The request will be processed by the editorial board and only serious genuine reasons will be considered if possible. The decision of the editorial board will be final and not negotiable. Unethical withdrawal or no response from the authors to editorial board communication will be subjected to sanction a ban to all authors, and their institute will also be notified.

It is a general principle of scholarly communications, that the editor of a journal is solely and independently responsible for deciding which articles submitted to the journal shall be published. In making this decision the editor is guided by policies of the journal's editorial board and constrained by such legal requirements in force regarding libel, copyright infringement and plagiarism. An outcome of this principle is the importance of the scholarly archive as a permanent, historic record of the transactions of scholarship. Articles that have been published shall remain extant, exact and unaltered as far as is possible. However, very occasionally circumstances may arise where an article is published that must later be retracted or even removed. Such actions must not be undertaken lightly and can only occur under exceptional circumstances. In all cases, official archives of our journal will retain all article versions, including retracted or otherwise removed articles.

This policy has been designed to address these concerns and to take into account current best practice in the scholarly and library communities. As standards evolve and change, we will revisit this issue and welcome the input of scholarly and library communities. See also the National Library of Medicine's policy on retractions and the recommendations of the International Committee of Medical Journal Editors (ICMJE) concerning corrections and retractions.

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For Authors:

All manuscripts for articles, including the original research data-based articles, reviews, editorials, perspectives, comments and letters that are submitted to SSN Journal of Management and Technology Research Communications must be accompanied by a conflict of interest disclosure statement or a declaration by the authors that they do not have any conflicts of interest to declare. All articles that are published in the journal must be accompanied by this conflict of interest disclosure statement or a statement that the authors have replied that they have no conflicts of interest to declare.

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Studies involving human subjects / patients / and also if the manuscript includes case reports / case series, authors need to provide the following: Name of the Ethical Committees /Institutional review Board, they have obtained consent from along with approval number /ID. Authors should specifically mention that the study was in accordance with the Helsinki Declaration of 1975 (Human Research: Helsinki Declaration as revised in 2013, SCARE criteria etc).

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Authors must provide details of any financial or personal relationships that might bias the work being submitted. In a section of text preceding the References, please provide relevant information for each author(s) with regard to any conflicts of interest. All submissions must include disclosure of all relationships that could be viewed as presenting a potential conflict of interest.

Acknowledgement of sources:

Proper acknowledgement of the work of others must always be given. Funding acknowledgement must be properly made with grant details, number etc.

Data access and retention: Authors may be asked to provide the raw data in connection with a paper for editorial review, and should be prepared to provide public access to such data.

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7. Advisory Editorial Board

An international advisory board comprising of members from diverse regions, with significant professional experience in different fields of biological and biomedical sciences helps the Editorial Committee in policy matters when needed. Senior advisory board members from India as well as abroad are members of the journal. Each member is selected due to the expertise and experience in the field of his/her specialization. Affiliations, biographies and addresses of all members of the Editorial Board is displayed on the website of SSN Journal of Management and Technology Research Communications.

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Executive Editor: Executive Editor is who directs processing of the manuscripts which entail soliciting manuscripts from potential contributors, assessing the suitability of the manuscript with respect to its scope, managing the peer review process, devising strategies for the progress of the journal, coordinating with the reviewers and board members, taking decisions on the revised submissions and occasionally assisting the Editor-in-chief in final acceptance or rejection of manuscripts.

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(Ethics, Duties and Responsibilities of Authors Reviewers and Editors, Plagiarism and its Control, Malpractices and Ethical statements) Link of copy right form and Plagiarism Check Statement.

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Contact Us

Editor
SSN Journal of Management and Technology Research Communications

Prof Dr Ayesha S Ali PhD FSSN CSIR Fellow

Department of Bioscience and Biotechnology

Saifia College Barkatullah University Bhopal India

Email: editor@mntrc.in

Mobile : 9755104244

Publisher:

Dr Ayesha S Ali

On Behalf of Society for Science and Nature SSN Bhopal

Publishers Address: C- 52 Housing Board Colony Kohe Fiza Bhopal 462001 MP India

Editor's Official Address

Prof Dr Ayesha S Ali PhD FSSN CSIR Fellow

Department of Bioscience and Biotechnology

Saifia College Barkatullah University Bhopal India

Email: editor@mntrc.in

Editorial Office

Executive Editor– editor@mntrc.in

Managing Editor- mntrc.in.info@gmail.com

SSN Journal of Management and Technology Research Communications

C- 52 Housing Board Colony Kohe Fiza Bhopal 462001 MP India

Mobile : 9893015818

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Corporate Culture and Employee Loyalty: An Empirical Study of the Plant-Based Protein Beverage Sector

Xi Chen and Songyu Jiang*
Rattanakosin International College of Creative Entrepreneurship, Rajamangala University of Technology Rattanakosin, Nakhon Pathom 73170, Thailand.

ABSTRACT

China's plant-based protein beverage manufacturers are facing intensifying competition and workforce-retention pressure, making employee loyalty a strategic concern for operational continuity and quality assurance. This study examines how multidimensional corporate culture influences employee loyalty in Chengde Lulu Co., Ltd. Using a quantitative survey, questionnaires were randomly distributed to eligible full-time employees (≥6 months tenure); 400 valid responses were retained after quality screening. Measures used 5-point Likert scales capturing six culture dimensions (corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility) and employee loyalty. Data analysis included descriptive statistics, reliability (Cronbach's alpha), KMO/Bartlett tests and exploratory factor analysis, correlation analysis, multiple regression, and one-way ANOVA for demographic differences. Results show that all six culture dimensions positively predict employee loyalty, with strong explanatory power ($R^2 = 0.657$); team spirit is the strongest predictor, while leadership remains significant but comparatively weaker. ANOVA indicates no significant loyalty differences across demographics (e.g., gender, age, salary). Practically, manufacturers should prioritize building cooperative team climates, clarifying shared values, strengthening development pathways, and embedding social responsibility to sustain loyalty beyond purely transactional incentives.

KEY WORDS: CORPORATE CULTURE, EMPLOYEES' LOYALTY, ORGANIZATION BEHAVIOR, LEADERSHIP.

INTRODUCTION

In recent years, China' s beverage industry has undergone rapid structural transformation driven by consumption upgrading, heightened health awareness, and intensified market competition [1]. According to industry analyses, the growth momentum of traditional sugary beverages has slowed, while plant-based and functional beverages have expanded steadily, reflecting consumers' increasing emphasis on nutrition, sustainability, and lifestyle quality [2]. As product homogeneity increases and competition shifts from price-based rivalry to brand differentiation and organizational capability, internal management effectiveness, particularly workforce stability, has become a critical factor influencing firms' long-term competitiveness [3].

Within this evolving industry landscape, Chengde Lulu Co., Ltd. represents a leading enterprise in China' s plant-based protein beverage segment, with almond-based beverages as its core product line. Benefiting from early market entry and strong brand recognition, Chengde Lulu has maintained a dominant position in its niche market and reported stable operating revenues in recent years. However, as the plant-based beverage sector attracts new entrants and substitutes proliferate, the company faces increasing pressure not only in market expansion but also in

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internal organizational governance. Public disclosures and industry observations suggest that traditional manufacturing beverage firms, including Chengde Lulu, are encountering challenges related to employee turnover, workforce aging, and declining organizational cohesion, issues that directly threaten operational continuity and strategic execution [4].

From a managerial perspective, employee loyalty is particularly vital in beverage manufacturing enterprises, where standardized production processes, quality control, and cross-departmental coordination depend heavily on experienced and committed employees. Prior studies indicate that low employee loyalty is associated with higher turnover intention, reduced organizational commitment, and weakened collective efficiency, especially in manufacturing contexts [5, 6]. While compensation and external labor market conditions contribute to these outcomes, recent research increasingly emphasizes internal organizational factors, most notably corporate culture, as key determinants of employees' long-term attachment to their organizations [7].

Corporate culture, conceptualized as a system of shared values, leadership practices, and behavioral norms, has been shown to influence employees' attitudes, affective commitment, and retention-related behaviors [8, 9]. Empirical evidence from recent studies suggests that cultural dimensions such as value congruence, leadership support, team cohesion, and developmental opportunities play a significant role in shaping employee loyalty beyond transactional incentives [10]. However, existing research exhibits two notable gaps. First, most empirical investigations focus on service industries or knowledge-intensive sectors, whereas traditional manufacturing industries, particularly food and beverage manufacturing, remain underexplored. Second, prior studies often adopt partial or fragmented cultural frameworks, limiting understanding of how multiple cultural dimensions jointly influence employee loyalty in organizational settings.

These gaps are especially salient in the context of China' s plant-based beverage manufacturing industry, where firms must simultaneously manage market expansion and internal transformation. Despite Chengde Lulu' s representative status, little empirical research has systematically examined how corporate culture affects employee loyalty within such enterprises. Addressing this gap is essential not only for practical governance but also for advancing theory.

Accordingly, this study investigates the impact of corporate culture on employee loyalty in a plant-based protein beverage manufacturing enterprise, using Chengde Lulu as an empirical case. By conceptualizing corporate culture as a multidimensional construct encompassing corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility, this research seeks to extend existing culture, loyalty theories into an underexamined industrial context. Theoretically, the study contributes to organizational behavior literature by enriching the contextual applicability of corporate culture theory and clarifying its explanatory power in manufacturing settings. In doing so, it offers a more nuanced understanding of how internal cultural mechanisms shape employee loyalty under conditions of industrial transformation. Hence, this research aims:

RO1: To explore the dimensions included in corporate culture.

RO2: To examine the impact of corporate culture on employee loyalty through empirical analysis and to examine whether employee loyalty differs significantly across demographic characteristics, including gender, age, and salary level.

RO3: To derive practical managerial implications based on the empirical findings, providing guidance for corporate culture construction and employee loyalty management.

Literature review

Theoretical basis: Corporate culture theory explains how shared values, norms, and behavioral expectations within an organization shape employees' cognition, emotions, and work-related behaviors. Contemporary scholarship conceptualizes corporate culture as a multi-dimensional system embedded in organizational practices rather than a static symbolic construct [11]. In recent years, research has increasingly adapted corporate culture theory to examine how internal cultural environments influence employee-related outcomes under conditions of organizational transformation and competitive pressure [12, 13]. This shift reflects growing recognition that culture functions as an internal governance mechanism that coordinates behavior and stabilizes employee attitudes in dynamic business contexts.

Culture has been examined as a predictor of employee attitudes, such as organizational commitment, engagement, and psychological attachment, emphasizing the role of value congruence and leadership practices in shaping employees' perceptions of the organization [14]. Culture as a driver of retention-related outcomes, demonstrating that supportive cultural climates and developmental orientations significantly reduce turnover intention and enhance loyalty-related behaviors [15]. Culture has been increasingly analyzed in manufacturing and transitional industries, where standardized processes and collective coordination heighten the importance of shared norms and stable value systems [16]. Within this theoretical framework, corporate culture is understood as an internal environment that continuously exposes employees to organizational values, leadership cues, and relational norms, thereby shaping their long-term attitudes toward the organization.

Employee loyalty theory seeks to explain the formation and maintenance of employees' enduring attachment to an organization and their willingness to remain and contribute over time [17]. Recent theoretical developments conceptualize employee loyalty as a cognitive, affective, behavioral construct, encompassing employees' beliefs about the organization, emotional attachment, and intention to stay [18]. This perspective moves beyond earlier views that equated loyalty solely with tenure or compliance,

emphasizing instead employees' voluntary and attitudinal commitment. Loyalty measurement, distinguishing loyalty from closely related constructs such as organizational commitment and job satisfaction, while demonstrating their theoretical interconnections [19]. Loyalty has been widely examined as an outcome of organizational context, with studies highlighting the roles of leadership support, fairness, and cultural alignment in fostering employees intention to remain with the organization [20]. In this study, employee loyalty theory suggests that employees' loyalty is not an immediate reaction to isolated incentives, but a cumulative outcome shaped by prolonged organizational experiences.

Table 1. Hypothesis development statement

H1	Corporate values have a significant positive impact on employee loyalty.
H2	Leadership has a significant positive impact on employee loyalty.
H3	Team spirit has a significant positive impact on employee loyalty.
H4	Interpersonal relationships have a significant positive impact on employee loyalty.
H5	Employee development has a significant positive impact on employee loyalty.
H6	Social responsibility has a significant positive impact on employee loyalty.

Taken together, the integration of corporate culture theory and employee loyalty theory offers a coherent explanatory framework for this study. Corporate culture theory explains how internal cultural environments shape employees' perceptions and emotional attachment, while employee loyalty theory clarifies how these internalized perceptions translate into sustained loyalty. This combined theoretical perspective supports the examination of how multidimensional corporate culture influences employee loyalty in the context of a traditional plant-based protein beverage manufacturing enterprise.

Conceptual review: Corporate culture originates from Corporate Culture Theory, which conceptualizes culture as a system of shared values, norms, and practices that guide organizational members' perceptions and behaviors [11]. Corporate culture is commonly defined as a multidimensional construct reflecting how values are articulated, leadership is enacted, and relationships are structured within the organization [21]. In the present study, corporate culture is defined as employees' shared perceptions of the organizational environment formed through sustained exposure to corporate values, leadership behaviors, and relational norms within Chengde Lulu. Corporate culture is conceptualized as a multidimensional construct comprising six dimensions: corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility [22].

Employee loyalty is theoretically grounded in Employee Loyalty Theory, which explains employees' enduring attachment to an organization and their willingness to remain and contribute over time [17]. Recent literature conceptualizes employee loyalty as a stable attitudinal, behavioral orientation that goes beyond short-term job satisfaction or contractual obligation [23]. It reflects employees' psychological identification with the organization as well as their intention to maintain long-term employment relationships. Employee loyalty is often distinguished from organizational commitment while remaining closely related to it.

Loyalty emphasizes intention to stay, emotional attachment, and discretionary effort, and has been widely used as a key outcome variable in studies examining organizational environments and human resource practices [24]. In this study, employee loyalty is defined as employees' overall psychological attachment to Chengde Lulu and their willingness to continue working for the organization. Employee loyalty is treated as a global construct capturing both attitudinal attachment and behavioral intention to remain, rather than being subdivided into multiple subtypes. This conceptualization facilitates the examination of the direct effects of multiple corporate culture dimensions on employees' loyalty within a manufacturing enterprise.

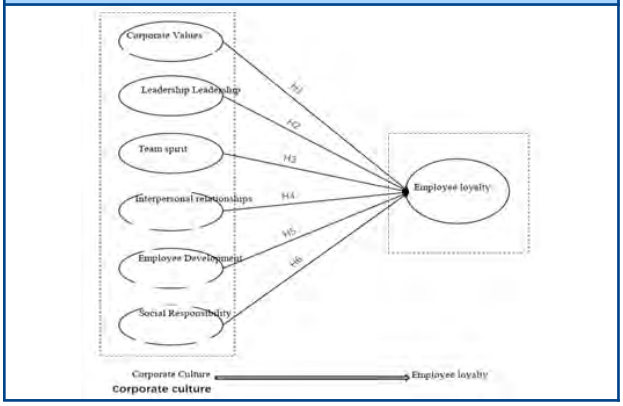
Hypothesis development: Corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility represent core cultural components through which organizations regulate behavior and foster employee attachment [25, 26]. Clearly articulated corporate values strengthen employees' emotional attachment and loyalty by aligning individual beliefs with organizational goals [27]. Leadership research further shows that supportive and value-consistent leadership, widely regarded as a core manifestation of corporate culture, enhances employees' trust and loyalty by translating abstract values into daily managerial practices [28].

In addition, team-oriented cultural climates characterized by cooperation and shared responsibility have been found to foster collective identity and social belonging, thereby increasing employees' willingness to remain with the organization, particularly in manufacturing environments that rely on coordinated task execution [29, 30]. Similarly, high-quality interpersonal relationships embedded in organizational culture have been shown to reduce psychological strain and enhance loyalty-related attitudes by strengthening trust and mutual support among employees [31]. Recent studies also highlight employee development as a salient cultural signal of organizational investment, demonstrating that development-oriented cultures significantly increase employee loyalty by enhancing perceived organizational support and future career expectations [32, 33].

Moreover, corporate social responsibility has increasingly been incorporated into corporate culture frameworks, with evidence suggesting that socially responsible cultures enhance employees' organizational pride and moral identification, which in turn strengthen loyalty and intention to stay [34, 35]. Accordingly, the following hypotheses are proposed:

Theoretical framework: Figure 1 presents the theoretical framework of this study. Grounded in Corporate Culture Theory and Employee Loyalty Theory, the framework examines how corporate culture influences employee loyalty in a plant-based protein beverage manufacturing enterprise. Corporate Culture Theory explains how continuous exposure to organizational values, leadership practices, and relational norms shapes employees' perceptions and evaluations of the organization, while Employee Loyalty Theory clarifies how these evaluations translate into employees' stable attitudinal and behavioral orientation toward remaining with the organization.

Figure 1: Theoretical model of this study



The framework comprises two core constructs: corporate culture and employee loyalty. Corporate culture is conceptualized as a multidimensional construct consisting of six dimensions: corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility, while employee loyalty represents employees' enduring psychological attachment and intention to stay. Based on prior literature, this study proposes that each dimension of corporate culture has a positive effect on employee loyalty (H1-H6).

METHODOLOGY

This study examines the impact of corporate culture on employee loyalty in the context of a plant-based protein beverage manufacturing enterprise, using Chengde Lulu Co., Ltd. as the empirical setting. A quantitative survey design was adopted to capture employees' perceptions of corporate culture and their loyalty-related attitudes. This approach is appropriate for testing theoretically grounded relationships among latent constructs and has been widely applied in organizational and human resource management research [36].

The target population consists of full-time employees of Chengde Lulu across production, administrative, and managerial departments. To enhance the representativeness of the sample and reduce selection bias, simple random sampling was employed. Simple random sampling ensures that each member of the population has an equal probability of being selected, thereby improving the generalizability of statistical inferences [37]. A list of eligible employees was obtained with organizational approval, and questionnaires were distributed randomly among employees who had worked in the company for at least six months to ensure sufficient exposure to the organizational culture.

Data collection was conducted through a combination of on-site paper questionnaires and secure online survey links. Prior to analysis, returned questionnaires were screened to exclude incomplete responses, patterned answers, and those failing basic consistency checks. A total of 400valid responses were retained for subsequent analysis. This sample size meets the recommended requirements for structural equation modeling, which suggest a minimum ratio of 10 respondents per measurement item to ensure stable parameter estimation [38].

The questionnaire consisted of two sections. The first section collected demographic information, including gender, age, education level, and years of work experience. The second section measured the study variables using established scales adapted to the organizational context of Chengde Lulu. All items were assessed using a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Corporate culture was operationalized as a multidimensional construct encompassing six dimensions: corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility. This operationalization is consistent with corporate culture theory, which emphasizes the joint influence of values, leadership, and relational practices on employee outcomes [39].

Employee loyalty was measured as employees' overall psychological attachment to the organization and their intention to remain employed, reflecting both attitudinal and behavioral orientations [39]. This study employed a quantitative data analysis approach. Descriptive statistics were first used to summarize sample characteristics. Reliability analysis using Cronbach' s alpha assessed the internal consistency of the measurement scales, followed by validity testing through KMO and Bartlett' s tests and exploratory factor analysis. Correlation analysis examined associations among variables, while multiple regression analysis tested the effects of corporate culture dimensions on employee loyalty. In addition, one-way analysis of variance (ANOVA) was conducted to examine differences in employee loyalty across demographic groups.

RESEARCH RESULTS

Descriptive analysis: Descriptive statistical analysis is the process of summarizing and describing data in order to better understand its characteristics and distribution. Provide a foundation for further data analysis and

interpretation. It helps to reveal the regularity, trends, and characteristics of data, providing a basis for data interpretation and comparison. Help researchers and decision-makers understand data more intuitively (Cox, 2006). Table 2 presents the demographic profile of the respondents, indicating that the sample is predominantly composed of male employees (71.5%), reflecting the gender structure commonly observed in traditional manufacturing enterprises. The age distribution shows that the majority of respondents are middle-aged or older employees, with 41.3% aged between 36 and 45 and 46.0% aged 46 years and above, suggesting a relatively mature workforce.

In terms of educational attainment, most respondents possess a high school or vocational school education (33.3%) or junior high school education and below (27.5%), followed by associate degrees (26.0%), while a smaller proportion hold undergraduate degrees (13.3%), indicating a workforce with predominantly practical and technical educational backgrounds. Consistent with this profile, respondents report substantial work experience, with 44.3% having 10–20 years of experience and 49.3% having over 20 years, highlighting a highly experienced employee group. Regarding job positions, the sample is largely concentrated in production (43.5%) and sales roles (43.0%), whereas technical, administrative, and financial positions account for relatively smaller proportions. Finally, the income distribution shows that most respondents earn between 2,000 and 4,000 yuan (57.3%) or 4,000 and 6,000 yuan (34.3%), reflecting the typical wage structure of employees in manufacturing-oriented beverage enterprises.

Table 2. Basic Information of Respondents

Basic Information of the Interviewee		Sample Size	Percentage
Gender	male	286	71.5
	female	114	28.5
Age	20 years old and under	0	0
	21~25	0	0
	26~35	51	12.8
	36~45	165	41.3
	46 years old and above	184	46
Educational Attainment	junior high school and below	110	27.5
	High school or vocational school	133	33.3
	associate degree	104	26
	undergraduate	53	13.3
	postgraduate	0	0
Years Of Work Experience	Within 2 years	0	0
	2-5 years	6	1.5
	5-10 years	19	4.8
	10-20 years	177	44.3
	Over 20 years	198	49.3
Job Position	production personnel	174	43.5
	technical personnel	28	7
	Administrative	20	5
	management personnel financial personnel	6	1.5
	salesperson	172	43
Salary Income	Below 2000 yuan	3	0.8
	2000~4000 yuan	229	57.3
	4000~6000 yuan	137	34.3
	6000~8000 yuan	25	6.3
	Above 8000 yuan	6	1.5

Reliability Analysis: Table 3 reports the reliability results for each construct, indicating a high level of internal consistency across all measurement scales. The Cronbach' s alpha coefficients for the six dimensions of corporate culture range from 0.874 to 0.938, while the coefficient for employee loyalty reaches 0.966, all of which exceed commonly accepted reliability thresholds. Methodological literature generally suggests that a Cronbach' s alpha value above 0.70 indicates acceptable reliability, values above 0.80 reflect good reliability, and values exceeding 0.90 demonstrate excellent internal consistency suitable for rigorous empirical research [40, 41]. Accordingly,

the alpha values for corporate values, team spirit, and interpersonal relationships indicate good reliability, whereas leadership, employee development, and social responsibility exhibit excellent reliability. The very high alpha coefficient for employee loyalty further confirms strong internal consistency, although such values may also suggest potential item redundancy, which can be further examined through item–total correlations and confirmatory factor analysis [42].

Table 3. Reliability test of each variable

Variable	Quantity of measurement items	Cronbach's alpha coefficient
Corporate Values	4	0.889
leadership	4	0.938
team spirit	4	0.897
interpersonal relationships	4	0.874
Employee Development	4	0.924
social responsibility	4	0.930
Employee loyalty	8	0.966

Validity analysis: Table 4 presents the results of the Kaiser–Meyer–Olkin (KMO) measure and Bartlett' s test of sphericity, which together assess the suitability of the data for factor analysis. The KMO value of 0.959 far exceeds the commonly recommended threshold of 0.60, indicating excellent sampling adequacy and suggesting that the correlations among variables are sufficiently compact to yield reliable and distinct factors [41, 43]. According to Kaiser' s classification, KMO values above 0.90 are considered "marvelous," reflecting a very strong common variance structure among the measurement items. In addition, Bartlett' s test of sphericity is statistically significant ($\chi^2 = 12{,}599.132$, df = 496, $p < 0.001$), rejecting the null hypothesis that the correlation matrix is an identity matrix. This result confirms that meaningful correlations exist among the variables and that factor analysis is appropriate. Collectively, these findings demonstrate that the dataset possesses excellent factorability and provides a robust empirical basis for subsequent exploratory and confirmatory factor analyses.

Table 4. KMO and Bartlett's test

KMO value.	0.959
Approximate chi square (x ²)	12599.132
Degrees of Freedom (df)	496
Significance (p)	0.000

From Table 5, it can be seen that the data is divided into 7 common factors, with variance explanatory rates of 20.362%, 10.92%, 10.826%, 10.414%, 9.895%, 9.272%, and 8.773%, respectively. After rotation, the cumulative variance explanatory rate is 80.460%, which is greater than 50%. The 7 common factors extracted from this data can explain 80.46% of the total data variability. The specific distribution of these 7 dimensions is consistent with the dimensions of each item in this questionnaire. And in the same dimension, the factor loading coefficients of all measurement items are all greater than 0.6, indicating that the validity of the scale is relatively high, the measurement item settings are reasonable, and there is no need to make changes or deletions. The loading coefficients of the seven factors are relatively large, indicating that the questionnaire design is reasonably divided into six dimensions: corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility.

Correlation Analysis: Table 6 presents the Pearson correlation coefficients among the study variables, revealing statistically significant positive relationships between all constructs at the 0.01 level (two-tailed). The correlations among the six corporate culture dimensions—corporate values (CV), leadership (LS), team spirit (TS), interpersonal relationships (IN), employee development (ED), and social responsibility (SR)—range from 0.482 to 0.632, indicating moderate associations. According to methodological guidelines, correlation coefficients below 0.80 suggest that the constructs are related yet empirically distinct, thereby alleviating concerns regarding multicollinearity [41]. Importantly, employee loyalty (EL) demonstrates moderately strong positive correlations with all six corporate culture dimensions, with coefficients ranging from 0.624 to 0.679, implying that more favorable perceptions of corporate culture are associated with higher levels of employee loyalty. These values exceed the threshold of 0.30, which is commonly interpreted as indicating a meaningful relationship in behavioral research, while remaining below levels that would indicate redundancy between constructs. Overall, the correlation matrix provides preliminary empirical support for the hypothesized positive relationships between corporate culture dimensions and employee loyalty and confirms that the variables are appropriate for subsequent multivariate analyses.

Regression Analysis: Table 7 reports the multiple regression results testing the effects of the six corporate culture dimensions on employee loyalty. The overall model demonstrates strong explanatory power, accounting for 65.7% of the variance in employee loyalty ($R^2 = 0.657$; Adjusted $R^2 = 0.652$), which indicates a substantial level of predictive accuracy in behavioral and organizational research [41]. All six predictors exhibit statistically significant positive effects on employee loyalty ($p < 0.01$), providing empirical support for the hypothesized direction of influence. Specifically, in terms of standardized coefficients, team spirit (TS) shows the strongest effect ($\beta = 0.227$, $t = 5.285$, $p < 0.001$), suggesting that cooperative norms and collective cohesion are the most salient cultural driver of loyalty in this manufacturing context. Corporate values ($\beta = 0.174$, $t = 4.300$, $p < 0.001$), employee development ($\beta = 0.169$, $t = 4.260$, $p < 0.001$), and social responsibility ($\beta = 0.167$, $t = 3.882$, $p < 0.001$) also exert comparatively strong positive influences, implying that value alignment, perceived growth opportunities, and organizational moral legitimacy are important mechanisms

fostering employees' intention to remain. Interpersonal relationships (β = 0.154, t = 3.644, p < 0.001) likewise contribute positively, highlighting the role of supportive workplace relations. Leadership remains significant but has the smallest standardized effect (β = 0.123, t = 2.876, p = 0.004), suggesting that leadership matters for loyalty, although its incremental contribution is weaker once other cultural dimensions are simultaneously considered. Overall, the results indicate that employee loyalty is jointly shaped by multiple cultural dimensions, with team-based cohesion and value and development-related perceptions emerging as particularly influential predictors.

Table 5. Factor analysis results of each measurement item in the questionnaire

Measurement ItemsFactor loading coefficient							
	Factor 1	**Factor 2**	**Factor 3**	**Factor 4**	**Factor 5**	**Factor 6**	**Factor 7**
CV1	0.161	0.116	0.079	0.15	0.77	0.119	0.175
CV2	0.297	0.179	0.139	0.149	0.754	0.209	0.13
CV3	0.268	0.161	0.153	0.182	0.754	0.088	0.169
CV4	0.287	0.26	0.176	0.205	0.717	0.131	0.186
LS1	0.258	0.76	0.217	0.195	0.18	0.14	0.161
LS2	0.299	0.771	0.173	0.203	0.175	0.132	0.143
LS3	0.22	0.784	0.158	0.233	0.196	0.174	0.189
LS4	0.261	0.793	0.161	0.241	0.194	0.23	0.145
TS1	0.235	0.241	0.19	0.155	0.132	0.738	0.191
TS2	0.338	0.161	0.253	0.194	0.16	0.701	0.233
TS3	0.421	0.188	0.223	0.224	0.097	0.651	0.22
TS4	0.198	0.118	0.12	0.107	0.18	0.772	0.151
IN1	0.395	0.131	0.181	0.241	0.229	0.062	0.682
IN2	0.08	0.195	0.119	0.077	0.198	0.265	0.749
IN3	0.195	0.306	0.218	0.141	0.159	0.224	0.7
IN4	0.431	0.04	0.098	0.145	0.174	0.193	0.708
ED1	0.193	0.132	0.818	0.191	0.099	0.216	0.094
ED2	0.188	0.221	0.808	0.149	0.145	0.177	0.135
ED3	0.329	0.201	0.743	0.181	0.133	0.129	0.154
ED4	0.331	0.109	0.796	0.173	0.162	0.126	0.165
SR1	0.283	0.182	0.201	0.742	0.232	0.096	0.234
SR2	0.271	0.199	0.188	0.727	0.203	0.235	0.14
SR3	0.279	0.263	0.181	0.803	0.153	0.152	0.108
SR4	0.243	0.246	0.202	0.788	0.185	0.158	0.097
EL1	0.670	0.271	0.191	0.252	0.18	0.273	0.114
EL2	0.761	0.201	0.209	0.173	0.179	0.221	0.207
EL3	0.753	0.209	0.224	0.216	0.203	0.228	0.122
EL4	0.781	0.194	0.18	0.172	0.254	0.183	0.109
EL5	0.768	0.186	0.188	0.207	0.185	0.15	0.194
EL6	0.802	0.151	0.204	0.24	0.209	0.13	0.222
EL7	0.783	0.184	0.222	0.191	0.164	0.205	0.209
EL8	0.757	0.219	0.204	0.142	0.223	0.185	0.163
variance explained ratio	20.362%	10.92%	10.826%	10.414%	9.895%	9.272%	8.773%
Cumulative variance explanation rate	20.362%	31.282%	42.107%	52.521%	62.416	71.688%	80.460%

Table 6. Correlation Matrix between Variables in the Questionnaire

	CV	LS	TS	IN	ED	SR	EL
CV	1						
LS	.569	1					
TS	.528	.583	1				
IN	.582	.565	.626	1			
ED	.482	.543	.574	.520	1		
SR	.576	.632	.572	.549	.565	1	
EL	.631	.639	.679	.646	.624	.655	1

At the 0.01 level (double tailed), the correlation is significant.

Table 7. Regression coefficients and significance test

Dimension	Non standardized coefficient		standardized coefficient	t	p	R^2	Adjusted R^2
	β	standard error	Beta				
CV	0.382	0.089	0.174	4.300	0.000	0.657	0.652
LS	0.245	0.085	0.123	2.876	0.004		
TS	0.458	0.087	0.227	5.285	0.000		
IN	0.322	0.088	0.154	3.644	0.000		
ED	0.342	0.080	0.169	4.260	0.000		
SR	0.350	0.090	0.167	3.882	0.000		
Dependent variable: Employee loyalty							

Table 8. ANOVA of Gender of Respondents

ANOVA	Gender (mean ± standard deviation)		F	p
	male	female		
Corporate Values	15.27±4.010	15.19±3.788	0.03	0.862
leadership	15.60±4.255	15.25±4.579	0.508	0.476
team spirit	15.13±4.295	15.10±4.249	0.005	0.945
interpersonal relationships	15.48±4.132	15.44±4.178	0.009	0.924
Employee Development	15.43±4.172	14.95±4.494	1.029	0.311
social responsibility	15.57±4.188	15.93±3.955	0.609	0.436
Employee loyalty	31.98±8.755	32.11±8.370	0.017	0.895

One-way analysis of variance: One way ANOVA can help researchers determine whether the average differences between different groups are significant, thereby assisting researchers in interpreting and inferring experimental results. It refers to the method of verifying the impact of a single factor on research results to determine whether the tested factor will have a significant impact on the research results [44]. Table 8 presents the one-way ANOVA results comparing male and female respondents across the six corporate culture dimensions and employee loyalty. Overall, the findings indicate no statistically significant gender differences in any construct, as all p-values exceed the conventional significance threshold of 0.05 [45]. Specifically, the mean scores for corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility are highly comparable between male and female employees, and the F-statistics are uniformly small, suggesting minimal between-group variance relative to within-group variance. Likewise, employee loyalty shows nearly identical means for males (31.98 ± 8.755) and females (32.11 ± 8.370), with a non-significant result ($F = 0.017$, $p = 0.895$), indicating

that loyalty levels are broadly consistent across genders in this sample. From an organizational perspective, these results imply that employees' perceptions of corporate culture and their loyalty are not systematically differentiated by gender, suggesting that the cultural environment and loyalty formation mechanisms operate similarly for male and female employees within this manufacturing enterprise.

Table 9 reports the one-way ANOVA results assessing whether respondents' perceptions of the six corporate culture dimensions and employee loyalty differ across age groups. Because no respondents were aged 20 and under or 21–25, the comparisons are effectively conducted among the three represented groups (26–35, 36–45, and 46 and above). The results show that age is not a significant source of variance in any construct, as all p-values are well above the conventional threshold of 0.05 [45]. Specifically, corporate values (F = 0.422, p = 0.656), leadership (F = 0.138, p = 0.871), team spirit (F = 0.680, p = 0.507), interpersonal relationships (F = 1.295, p = 0.275), employee development (F = 0.337, p = 0.714), and social responsibility (F = 0.048, p = 0.953) exhibit no statistically meaningful differences across age categories. Employee loyalty likewise remains stable across age groups (F = 0.043, p = 0.958), with highly similar mean scores. Collectively, these findings suggest that employees' cultural perceptions and loyalty levels are broadly consistent across the age structure represented in this manufacturing enterprise, implying that the culture–loyalty relationship operates similarly among mid-career and senior employees within the organization.

Table 9. Analysis of Variance for Age of Respondents

ANOVA	Age (mean ± standard deviation)					F	P
	20 years old and under	21~25	26~35	36~45	46 years old and above		
Corporate Values	0	0	15.57±3.986	15.35±3.746	15.07±4.113	0.422	0.656
leadership	0	0	15.59±4.428	15.36±4.263	15.6±4.418	0.138	0.871
team spirit	0	0	14.55±4.566	15.07±4.244	15.33±4.23	0.68	0.507
interpersonal relationships	0	0	15.24±4.227	15.87±4.091	15.18±4.152	1.295	0.275
Employee Development	0	0	14.94±4.478	15.21±4.288	15.46±4.201	0.337	0.714
social responsibility	0	0	15.53±4.575	15.66±4.007	15.73±4.112	0.048	0.953
Employee loyalty	0	0	31.73±8.929	32.13±8.33	31.99±8.867	0.043	0.958

Table 10 reports the one-way ANOVA results examining whether perceptions of the six corporate culture dimensions and employee loyalty differ across respondents' educational levels. Because no respondents reported postgraduate education, the effective comparisons are among four groups (junior high school and below, high school/vocational school, associate degree, and undergraduate). The findings indicate no statistically significant differences across educational levels for any construct, as all p-values exceed the conventional significance criterion of 0.05 [45]. Specifically, corporate values (F = 0.979, p = 0.403), leadership (F = 0.694, p = 0.556), team spirit (F = 0.449, p = 0.718), interpersonal relationships (F = 0.379, p = 0.768), employee development (F = 0.468, p = 0.705), and social responsibility (F = 0.838, p = 0.474) do not vary meaningfully by education. Employee loyalty similarly shows no significant group differences (F = 1.168, p = 0.322), despite modest variation in mean scores. Overall, these results suggest that employees' evaluations of corporate culture and their loyalty are broadly consistent across educational strata within this manufacturing enterprise, implying that educational attainment does not systematically differentiate cultural perceptions or loyalty formation in this sample.

Table 11 presents the one-way ANOVA results assessing whether respondents' perceptions of the six corporate culture dimensions and employee loyalty differ by years of work experience. As no respondents fell into the "within 2 years" category, the effective comparisons are among the remaining four tenure groups (2–5 years, 5–10 years, 10–20 years, and over 20 years). Overall, the results indicate that work experience does not produce statistically significant differences in any construct, as all p-values exceed the conventional threshold of 0.05 [45]. Specifically, corporate values (F = 1.816, p = 0.144), leadership (F = 0.431, p = 0.731), team spirit (F = 1.190, p = 0.313), interpersonal relationships (F = 1.406, p = 0.241), employee development (F = 0.867, p = 0.458), and social responsibility (F = 1.784, p = 0.150) show no statistically meaningful variation across tenure groups. Employee loyalty likewise remains stable across work-experience categories (F = 1.031, p = 0.379), despite modest mean differences. Collectively, these findings suggest that employees' cultural perceptions and loyalty levels are broadly consistent across tenure groups within this organization, implying that the culture–loyalty linkage operates similarly among employees with different lengths of work experience in Chengde Lulu.

Table 12 presents the one-way ANOVA results comparing respondents across different job positions. Overall, the findings indicate no statistically significant differences in perceptions of corporate culture dimensions or employee loyalty across job categories, as all p-values exceed the conventional significance level of 0.05. Although modest mean variations are observed—particularly for

corporate values, employee development, and employee loyalty—the corresponding F-statistics do not reach statistical significance, suggesting that these differences are not systematic. Collectively, the results imply that employees'evaluations of corporate culture and their loyalty are broadly consistent across production, technical, administrative, financial, and sales positions, indicating that job position does not substantially differentiate cultural perceptions or loyalty levels within the organization.

Table 10. ANOVA of Educational Level of Respondents

ANOVA	Educational level (mean ± standard deviation)						
	junior high 2 years school and below	High school or vocational school	associate degree	undergraduate	postgraduate	F	P
Corporate Values	14.93±3.946	15.11±3.912	15.8±3.637	15.19±4.553	0	0.979	0.403
leadership	15.69±4.374	15.57±4.202	15±4.584	15.91±4.203	0	0.694	0.556
team spirit	15.19±4.293	15.11±4.03	14.8±4.662	15.62±4.115	0	0.449	0.718
interpersonal relationships	15.45±4.157	15.24±4.178	15.55±4.058	15.94±4.24	0	0.379	0.768
Employee Development	15.56±4.312	15.00±4.218	15.48±4.096	15.08±4.665	0	0.468	0.705
social responsibility	15.95±4.142	15.22±4.314	15.92±3.762	15.77±4.273	0	0.838	0.474
Employee loyalty	33.20±8.243	31.34±8.658	32.1±8.575	31.09±9.435	0	1.168	0.322

Table 11. Analysis of Variance of Respondent's Work Experience

ANOVA	Years of work experience (mean ± standard deviation)						
	Within 2 years	2-5 Years	5-10 Years	10-20 Years	Over Year 20	F	P
Corporate Values	0	17.33±2.338	14.26±4.148	15.62±3.824	14.96±4.04	1.816	0.144
leadership	0	15.33±5.203	14.53±4.742	15.68±4.356	15.45±4.298	0.431	0.731
team spirit	0	14.83±2.994	13.63±5.069	14.97±4.469	15.43±4.039	1.19	0.313
interpersonal relationships	0	15.83±3.189	14.11±4.864	15.85±4.003	15.24±4.207	1.406	0.241
Employee Development	0	16±3.578	14±4.096	15.54±4.182	15.19±4.379	0.867	0.458
social responsibility	0	15.33±4.633	14.32±4.619	16.15±3.812	15.41±4.3	1.784	0.15
Employee loyalty	0	33.83±7.757	28.84±8.952	32.35±8.485	31.99±8.771	1.031	0.379

Table 12. Analysis of Variance of Respondents' Job Positions

ANOVA	Job position (mean ± standard deviation)						
	production personnel	technical personnel	Administrative management personnel	financial personnel	salesperson	F	P
Corporate Values	15.06±3.8	16.46±3.283	15.8±3.915	11.67±4.926	15.3±4.1	2.128	0.077
leadership	15.54±4.364	15.43±4.032	15.55±4.334	14.5±3.271	15.5±4.452	0.085	0.987
team spirit	15.21±4.302	15.75±3.513	15.55±4.006	12±4.472	14.99±4.379	1.06	0.376
interpersonal relationships	15.59±4.243	16.04±3.271	15.65±4.404	12.83±5.037	15.32±4.104	0.842	0.499
Employee Development	15.32±4.191	15.96±3.543	14.7±5.017	10.33±2.733	15.39±4.326	2.354	0.053
social responsibility	15.83±4.09	16.36±3.983	16.15±2.777	12.83±4.622	15.45±4.273	1.161	0.327
Employee loyalty	32.32±8.369	33.57±8.144	30.6±7.943	23.00±9.252	31.93±8.926	2.077	0.083

According to Table 13, the one-way ANOVA method was used to examine the impact of respondents' salary income on dimensions such as corporate values, leadership, team spirit, interpersonal relationships, employee development, social responsibility, and employee loyalty. The results showed that all p-values were higher than 0.05 and there was no significant difference. This indicates that in this survey, the impact of respondents' salary income on corporate culture and employee loyalty is relatively small, and has no significant effect on the survey results.

Table 13. Analysis of Variance of Respondent's Salary Income

ANOVA	Job position (mean ± standard deviation)						
	Below 2000 yuan	2000~4000 yuan	4000~6000 yuan	6000~8000 yuan	Above 8000 yuan	F	P
Corporate Values	12.67±3.215	15.34±3.882	15.12±3.943	15.44±4.744	15.33±3.724	0.401	0.808
leadership	9.67±5.508	15.52±4.303	15.57±4.377	16.00±3.786	14.17±6.113	1.594	0.175
team spirit	10.67±4.041	15.25±4.126	14.83±4.501	15.96±3.867	15.33±5.922	1.273	0.28
interpersonal relationships	10.00±3.464	15.28±4.299	15.66±3.855	16.48±4.001	17.17±3.125	2.155	0.073
Employee Development	14.00±3.606	15.34±4.11	15.37±4.406	14.76±4.465	14.33±7.005	0.259	0.904
social responsibility	12.33±4.041	15.64±4.023	15.69±4.218	16.68±3.838	14.33±6.47	1.029	0.392
Employee loyalty	24.67±7.572	32.56±8.316	31.04±9.152	33.68±7.521	30.17±11.669	1.512	0.198

DISCUSSION

RO1: To explore the dimensions included in corporate culture.

This study empirically identified and validated six core dimensions of corporate culture, corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility, within a plant-based protein beverage manufacturing enterprise. The factor-analytic results confirmed that corporate culture is not a unidimensional construct but a structured, multidimensional system composed of distinct yet interrelated components. This finding supports the central proposition of Corporate Culture Theory that culture operates as an integrated organizational environment shaping shared meanings and behavioral expectations [11].

The identified dimensions are broadly consistent with prior corporate culture research, while also extending existing frameworks. Denison, Nieminen [46]' s cultural framework emphasize mission, involvement, consistency, and adaptability as key cultural domains. Similarly, Monyai, Mitonga-Monga [47] argue that organizational culture comprises value orientation, leadership enactment, and social interaction patterns that jointly influence employee attitudes. This study aligns with these perspectives by confirming the importance of values, leadership, and relational dynamics, but advances the literature by explicitly differentiating team spirit and interpersonal relationships as independent cultural dimensions, rather than subsuming them under a single involvement construct. This distinction appears particularly meaningful in manufacturing contexts characterized by high task interdependence and long-term collaboration. Ajzen [48] proposed a five-dimensional model emphasizing leadership behavior, employee development, interpersonal harmony, innovation orientation, and social responsibility. This study confirmed the relevance of most of these elements but extends the model in two important ways. First, the inclusion of corporate values restores the normative core of corporate culture, echoing arguments that value systems constitute the foundation upon which behavioral and relational practices are built [11]. Second, by treating leadership as an independent and central dimension, the model better reflects the governance structure of Chinese enterprises, where leaders play a decisive role in translating values into daily practices and shaping employees' cultural perceptions [49].

Overall, this study contribute to corporate culture research in three ways. First, they empirically validate a six-dimensional corporate culture structure that integrates normative, relational, developmental, and social components. Second, they extend existing models by incorporating values and leadership more explicitly, enhancing theoretical completeness and contextual relevance. Third, they provide evidence that this multidimensional structure is stable across employee subgroups, supporting its applicability as a general diagnostic framework for manufacturing enterprises. Collectively, these contributions enrich the theoretical understanding of corporate culture and establish a solid foundation for examining its effects on employee-related outcomes in subsequent analyses.

RO2: To examine the impact of corporate culture on employee loyalty through empirical analysis and to examine whether employee loyalty differs significantly across demographic characteristics, including gender, age, and salary level.

This study empirically demonstrated that corporate culture exerted a significant and substantial influence on employee loyalty, while employee loyalty did not differ significantly across key demographic characteristics, including gender, age, education level, work experience, job position, and salary income. Taken together, these findings indicated that organizational cultural factors played a more decisive role

than individual demographic attributes in shaping employee loyalty within a traditional manufacturing enterprise.

The regression analysis revealed that all six dimensions of corporate culture, corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility, had statistically significant positive effects on employee loyalty. The model exhibited strong explanatory power, suggesting that employees' loyalty was largely shaped by their evaluations of the organizational environment rather than by isolated personal or demographic factors. This result was consistent with Corporate Culture Theory, which posits that sustained exposure to organizational values, norms, and practices cultivates employees' affective attachment and intention to remain with the organization [11].

Among the six dimensions, team spirit emerged as the strongest predictor of employee loyalty. This finding aligned with prior studies emphasizing that collective cohesion and cooperative norms are particularly salient in manufacturing contexts, where task interdependence and coordinated production processes heighten the importance of teamwork [50]. The prominence of team spirit suggested that employee loyalty in this enterprise was deeply embedded in daily collaborative experiences, supporting the view that loyalty was socially constructed through shared work practices rather than being derived solely from formal managerial systems.

Corporate values, employee development, and social responsibility also showed relatively strong positive effects on employee loyalty. These results were consistent with value-congruence and social exchange perspectives, which argue that employees tend to remain loyal when organizational values align with their own beliefs, when long-term developmental opportunities are perceived, and when the organization demonstrates moral legitimacy and social responsibility [51, 52]. In contrast, although statistically significant, leadership exhibited a comparatively weaker standardized effect once other cultural dimensions were considered simultaneously. This pattern suggested that leadership functioned more as a transmission mechanism for values and relational norms rather than as an independent driver of loyalty, a conclusion supported by recent leadership, culture integration research [53].

This study investigated whether employee loyalty varied across demographic characteristics. The one-way ANOVA results consistently showed no statistically significant differences in employee loyalty across gender, age, education level, work experience, job position, or salary income. This finding challenged traditional assumptions that demographic factors such as tenure or compensation level constituted primary determinants of loyalty. Instead, the results supported contemporary organizational behavior research suggesting that loyalty was increasingly shaped by shared organizational experiences rather than individual background characteristics, particularly in mature manufacturing enterprises with standardized employment structures [54].

Overall, this study confirmed that employee loyalty was primarily driven by multidimensional corporate culture, with relational and value-oriented dimensions playing particularly prominent roles. Second, this study demonstrated that demographic characteristics did not significantly differentiate loyalty levels, underscoring the dominant influence of organizational context over individual background factors.

Implication of theories: This study contributed to the theoretical understanding of employee loyalty by integrating Corporate Culture Theory and Employee Loyalty Theory to examine how multidimensional corporate culture influenced employee loyalty within a traditional manufacturing enterprise. By empirically testing a localized corporate culture framework and its effects on loyalty, the study provided a more comprehensive explanation of how organizational context shaped employees' attitudinal and behavioral outcomes.

Corporate Culture Theory posits that shared values, norms, and practices within an organization shape employees' perceptions, behaviors, and long-term attachment to the organization [11]. In the context of this study, corporate culture was operationalized as a multidimensional construct encompassing corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility. The empirical findings supported this theoretical premise by demonstrating that all six dimensions of corporate culture exerted significant positive effects on employee loyalty. This result reinforced the view that corporate culture functioned as a foundational mechanism through which organizations influenced employees' psychological identification and retention intentions.

Employee Loyalty Theory emphasizes that loyalty is not merely a function of economic exchange but is deeply rooted in employees' emotional attachment, perceived organizational support, and value congruence [17]. This study aligned with this perspective, revealing that cultural dimensions related to collective interaction and long-term development played a prominent role in fostering employee loyalty, particularly team spirit, corporate values, and employee development. This extended existing loyalty research by empirically confirming that loyalty was shaped by employees' holistic evaluations of the organizational environment rather than by isolated managerial practices or compensation-based incentives.

Moreover, the study revealed differentiated effects among the corporate culture dimensions, with team spirit emerging as the strongest predictor of employee loyalty. This study diverged from leadership-centric models emphasized in earlier organizational studies and suggested that, in manufacturing settings characterized by high task interdependence, collective cohesion and cooperative norms exerted a stronger influence on loyalty than hierarchical leadership alone. This study enriched Corporate Culture Theory by highlighting the contextual salience of relational and collective cultural elements, particularly in production-oriented enterprises.

In addition, this study demonstrated that employee loyalty did not differ significantly across demographic characteristics such as gender, age, education level, work experience, job position, and salary income. This study challenged demographic-deterministic assumptions prevalent in some strands of Employee Loyalty Theory, which traditionally emphasized tenure, income, or age as primary loyalty differentiators. Instead, the results suggested that when corporate culture was coherent and strongly embedded, it exerted a homogenizing effect on employees' loyalty perceptions, thereby elevating organizational culture above individual demographic factors in explaining loyalty formation.

Taken together, by integrating Corporate Culture Theory and Employee Loyalty Theory, this study offered a theoretically grounded framework illustrating how organizational cultural attributes served as antecedents of employee loyalty. It extended existing theories by validating a localized and parsimonious corporate culture structure, demonstrating the differentiated influence of cultural dimensions on loyalty, and challenging the explanatory dominance of demographic characteristics. These contributions enriched the theoretical discourse on corporate culture and employee loyalty and expanded their applicability to traditional manufacturing enterprises in emerging economies.

Implication to practice: This study offered several practical implications for managers and policymakers in manufacturing-oriented beverage enterprises. First, this study indicated that employee loyalty was primarily shaped by multidimensional corporate culture rather than by demographic characteristics. Therefore, managers should prioritize systematic corporate culture development as a strategic tool for enhancing employee retention, instead of relying solely on compensation adjustments or demographic-based management practices.

Second, as team spirit emerged as the strongest predictor of employee loyalty, organizations should actively cultivate collaborative work environments by promoting teamwork, cross-departmental cooperation, and collective goal setting. In production-oriented enterprises, strengthening informal cooperation mechanisms and mutual support among employees may be particularly effective in fostering long-term loyalty.

Third, the significant effects of corporate values, employee development, and social responsibility suggested that employees responded positively to value alignment, growth opportunities, and organizational moral commitment. Managers should therefore articulate clear corporate values, invest in continuous training and career development pathways, and integrate social responsibility initiatives into daily operations to reinforce employees' emotional attachment to the organization.

Fourth, although leadership exhibited a relatively weaker direct effect compared to other cultural dimensions, it remained a significant driver of employee loyalty. This implied that leaders should function not only as decision-makers but also as cultural role models, consistently transmitting organizational values and supporting a positive relational climate.

Finally, the absence of significant differences in employee loyalty across gender, age, education, work experience, and income levels indicated that a unified cultural strategy could be effectively applied across the workforce. Enterprises may thus adopt inclusive and standardized cultural management practices that foster shared identity and commitment among employees at all organizational levels. Overall, these practical implications underscored the importance of leveraging corporate culture as a sustainable and non-financial mechanism for strengthening employee loyalty in traditional manufacturing enterprises.

CONCLUSION

This study investigated the influence of corporate culture on employee loyalty in a plant-based protein beverage manufacturing enterprise, using Chengde Lulu as the empirical context. This study demonstrated that corporate culture was a multidimensional construct comprising corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility. This study confirmed that all six dimensions exerted significant positive effects on employee loyalty, with team spirit emerging as the most influential factor. Moreover, employee loyalty did not differ significantly across demographic characteristics, including gender, age, education level, work experience, job position, and salary income, indicating that organizational culture played a more decisive role than individual attributes in shaping employee loyalty.

Despite these contributions, this study was subject to several limitations. First, the data were collected from a single manufacturing enterprise, which may restrict the generalizability of the findings to other industries or organizational contexts. Second, the cross-sectional research design limited the ability to infer causal relationships between corporate culture and employee loyalty. Third, the study relied on self-reported questionnaire data, which may be subject to common method bias and social desirability effects.

Future research could address these limitations in several ways. Comparative studies across multiple enterprises or industries could be conducted to enhance external validity and examine whether the identified cultural dimensions operate similarly in different organizational contexts. Longitudinal or mixed-method research designs could be employed to capture the dynamic evolution of corporate culture and its long-term effects on employee loyalty. Additionally, future studies could incorporate mediating or moderating variables to further unpack the mechanisms through which corporate culture influences employee loyalty, such as organizational commitment, job satisfaction, or psychological safety.

Knowledge Contribution: This study made several meaningful contributions to the existing body of knowledge on corporate culture and employee loyalty, particularly

within the context of traditional manufacturing enterprises in emerging economies.

First, this study advanced the conceptualization of corporate culture by developing and empirically validating a six-dimensional, localized measurement framework that integrated corporate values, leadership, team spirit, interpersonal relationships, employee development, and social responsibility. Compared with classical Western models that are often abstract or measurement-intensive, this framework demonstrated strong psychometric properties while remaining parsimonious and context-sensitive. As such, the study contributed new knowledge by bridging the gap between theoretical completeness and empirical operability, thereby enriching the localization of Corporate Culture Theory.

Second, the study extended Employee Loyalty Theory by empirically demonstrating that employee loyalty was primarily driven by organizational-level cultural factors rather than demographic characteristics. Contrary to demographic-deterministic perspectives that emphasize age, tenure, or income as key loyalty differentiators, the findings showed that a coherent and embedded corporate culture exerted a dominant and homogenizing influence on loyalty formation. This insight contributed to theory by repositioning employee loyalty as a context-dependent, socially embedded outcome rather than an individual attribute shaped mainly by personal background.

Third, the study clarified the differentiated effects of corporate culture dimensions on employee loyalty. By identifying team spirit as the most influential predictor, followed by corporate values, employee development, and social responsibility, the research moved beyond leadership-centric explanations prevalent in earlier studies. This contribution refined theoretical understanding by highlighting the central role of collective interaction and relational cohesion in loyalty formation, particularly in manufacturing environments characterized by task interdependence and collective production.

Finally, by integrating Corporate Culture Theory and Employee Loyalty Theory within a single empirical framework, this study expanded the applicability of both theories to manufacturing-oriented beverage enterprises, a context that has been underrepresented in prior research. The findings provided robust empirical evidence that corporate culture functions not merely as a symbolic construct but as a strategic organizational resource with direct implications for workforce stability and sustainable development.

Collectively, these contributions advanced theoretical knowledge by localizing corporate culture measurement, redefining the drivers of employee loyalty, and extending existing theories to a new industrial and cultural context.

REFERENCES

1. Liu, Z., S. Li, and J. Peng, Exploring the relationship between sugar and sugar substitutes—analysis of income level and beverage consumption market pattern based on the perspective of healthy China. Nutrients, 2022. 14(21): p. 4474.
2. Liu, H., et al., Plant-Based Fermented Beverages and Key Emerging Processing Technologies. Food Reviews International, 2023. 39(8): p. 5844-5863.
3. Azeem, M., et al., Expanding competitive advantage through organizational culture, knowledge sharing and organizational innovation. Technology in Society, 2021. 66: p. 101635.
4. Zhang, B., et al., Well-being and its associated factors among migrant workers in food and beverage industry: a cross-sectional study in China. British Food Journal, 2022. 124(11): p. 3855-3870.
5. Lu, J., et al., "Stay" or "Leave": Influence of employee-oriented social responsibility on the turnover intention of new-generation employees. Journal of Business Research, 2023. 161: p. 113814.
6. Dita, B. and S. Thrun, Organizational Commitment and Workplace Fun: Their Combined Effect on Employee Performance and Turnover Intention. 2024.p. 9.
7. Kagaba, A. and K. Special, The Influence of Corporate Culture on Employee Retention. 2025. 11: p. 16-21.
8. Vasumathi, A., et al., An empirical study on the impact of organizational culture dimensions on employees' performance through organizational support in the IT industry. Social Sciences & Humanities Open, 2025. 12: p. 102054.
9. Kebe, I., Y. Liu, and C. Kahl, Culturally Attuned Leadership and Employee Behavior During Organizational Change Initiatives in a Developing Economy. Behavioral Sciences, 2025. 15: p. 349.
10. Iddrisu, I., Understanding the nexus between organizational culture and trust: The mediating roles of communication, leadership, and employee relationships. Sustainable Futures, 2025. 9: p. 100555.
11. Gorton, G.B., J. Grennan, and A.K. Zentefis, Corporate culture. Annual Review of Financial Economics, 2022. 14(1): p. 535-561.
12. Cherian, J., et al., Corporate Culture and Its Impact on Employees' Attitude, Performance, Productivity, and Behavior: An Investigative Analysis from Selected Organizations of the United Arab Emirates (UAE). Journal of Open Innovation: Technology, Market, and Complexity, 2021. 7(1): p. 45.
13. Siddiqi, K. and A. Jamal, Organizational Culture and Its Effect on Employee Motivation. Journal for Research in Applied Sciences and Biotechnology, 2024. 3: p. 249-252.
14. Syarifin, M. and H. Atmaja, The Influence of Organizational Commitment, Organizational Culture and Job Satisfaction on Employee Performance: A Literature Study. Journal of Humanities Social Sciences and Business (JHSSB), 2023. 2: p. 458-467.
15. Presbitero, A., Y. Fujimoto, and W.M. Lim, Employee engagement and retention in multicultural work groups: The interplay of employee and supervisory cultural intelligence. Journal of Business Research, 2025. 186: p. 115012.
16. Gatell, I.S. and L. Avella, Impact of Industry 4.0 and

circular economy on lean culture and leadership: Assessing digital green lean as a new concept. European Research on Management and Business Economics, 2024. 30(1): p. 100232.
17. Meschke, S., The concept of employee loyalty, in Employee loyalty: Intercultural comparison of European and East Asian approaches. 2021. p. 27-72.
18. 18. Yeh, S.-H. and K.-C. Huang. The Impact of Organizational Commitment and Work Motivation on Retention Intention: Evidence from Long-Term Care Institution Caregivers Based on Expectancy Theory. In Healthcare. 2025. 13(22): p. 2832.
19. 19. So, K.K.F., Y. Yang, and X. Li, Fifteen Years of Research on Customer Loyalty Formation: A Meta-Analytic Structural Equation Model. Cornell Hospitality Quarterly, 2024. 66(2): p. 253-272.
20. 20. Zanabazar, A., M. Yondonrenchin, and E. Baljinnyam, The Impact of Leadership Styles on Employee Loyalty and Engagement. European Journal of Business and Management Research, 2023. 8: p. 94-100.
21. 21. Ketprapakorn, N. and S. Kantabutra, Toward an organizational theory of sustainability culture. Sustainable Production and Consumption, 2022. 32: p. 638-654.
22. 22. Az-Zaakiyyah, H., A. Ausat, and S. Suherlan, Corporate Culture and Employee Performance: The Role of Vision, Mission, Norms, and Employee Focus. Al Qalam: Jurnal Ilmiah Keagamaan dan Kemasyarakatan, 2024. 18: p. 2647.
23. 23. Maulana, M., Employee Loyalty : A Systematic Review of the Literature. Proceeding of International Conference on Social Science and Humanity, 2025. 2: p. 458-465.
24. 24. Zhenjing, G., et al., Impact of Employees' Workplace Environment on Employees' Performance: A Multi-Mediation Model. Front Public Health, 2022. 10: p. 890400.
25. 25. Michulek, J., et al., Corporate Culture, Leadership, and Pathological Relationships: A Moderated Mediation Model of Employees' Well-Being. Administrative Sciences, 2025. 15(10): p. 399.
26. 26. Heim, I., B. Laker, and S.J. Tabaeifard, Responsible leadership: A systematic literature review, theoretical framework, and future research directions. Journal of Business Research, 2026. 203: p. 115801.
27. 27. Khaw, K.W., et al., Reactions towards organizational change: a systematic literature review. Curr Psychol, 2022: p. 1-24.
28. 28. Jun, K. and J. Lee, Transformational Leadership and Followers' Innovative Behavior: Roles of Commitment to Change and Organizational Support for Creativity. Behav Sci (Basel), 2023. 13(4): p. 320.
29. 29. Paredes-Saavedra, M., et al., Work Team Effectiveness: Importance of Organizational Culture, Work Climate, Leadership, Creative Synergy, and Emotional Intelligence in University Employees. Administrative Sciences, 2024. 14: p. 280.
30. 30. Adham, T. and A. Sukkar, Investigating the influence of organizational culture on team management: exploring effective factors and techniques. World Journal of Advanced Research and Reviews, 2024. 22: p. 1684-1702.
31. 31. Liu, C.Y.N., Z. Lei, and M. Gan, The effects of perceived trust and psychological safety on the emotions and behaviour of hotel employees: the lens from post-COVID-19. Humanities and Social Sciences Communications, 2025. 12(1): p. 735.
32. Jung, Y. and N. Takeuchi, Toward a theoretical and empirical distinction between perceived investment in employee development and perceived organizational support. Evidence-based HRM: a Global Forum for Empirical Scholarship, 2025.
33. Ding, J. and G. Hong, Fostering Loyalty and Creativity: How Organizational Culture Shapes Employee Commitment and Innovation in South Korean Firms. Behavioral Sciences, 2025. 15(4): p. 529.
34. Li, Y. and C.-H. Chen, The impact of employee-perceived CSR on organizational citizenship behavior ——evidence from China. Asia Pacific Management Review, 2023. 28(4): p. 487-500.
35. Schaefer, S.D., et al., Employees' positive perceptions of corporate social responsibility create beneficial outcomes for firms and their employees: Organizational pride as a mediator. Corporate Social Responsibility and Environmental Management, 2024. 31(3): p. 2574-2587.
36. Mellinger, C. and T. Hanson, Methodological considerations for survey research: Validity, reliability, and quantitative analysis. Linguistica Antverpiensia, 2020. 19: p. 172-190.
37. Ahmed, S.K., How to choose a sampling technique and determine sample size for research: A simplified guide for researchers. Oral Oncology Reports, 2024. 12: p. 100662.
38. Memon, M., et al., Sample Size for Survey Research: Review and Recommendations. Journal of Applied Structural Equation Modeling, 2020. 4: p. 1442-1459.
39. Dutta, T. and S. Dhir, Employee Loyalty: Measurement and Validation. Global Business Review, 2021. 26: p. 097215092199080.
40. Bernardi, R., Validating Research Results When Cronbach's Alpha is Below .70: A Methodological Procedure. Educational and Psychological Measurement, 2008. 54: p. 766-775.
41. Hair, J.F., et al., When to use and how to report the results of PLS-SEM. European business review, 2019. 31(1): p. 2-24.
42. Tavakol, M. and R. Dennick, Making sense of Cronbach's alpha. Int J Med Educ, 2011. 2: p. 53-55.
43. Kaiser, H.F., An index of factorial simplicity. Psychometrika, 1974. 39(1): p. 31-36.
44. Kim, T.K., Understanding one-way ANOVA using conceptual figures. Korean J Anesthesiol, 2017. 70(1): p. 22-26.
45. Kwak, S., Are Only p-Values Less Than 0.05 Significant? A p-Value Greater Than 0.05 Is Also Significant! J Lipid Atheroscler, 2023. 12(2): p. 89-95.
46. Denison, D., L. Nieminen, and L. Kotrba, Diagnosing organizational cultures: A conceptual and empirical review of culture effectiveness surveys. European Journal of Work and Organizational Psychology - EUR J WORK ORGAN PSYCHOL, 2012. 23: p. 1-17.
47. Monyai, D., J. Mitonga-Monga, and B. Makhubele, Organisational culture and its influence on employees' attitude towards organisational change in a developing country setting. International Journal of Research in Business

and Social Science (2147- 4478), 2024. 13: p. 11-21.
48. Ajzen, I., The theory of planned behavior. Organizational behavior and human decision processes, 1991. 50(2): p. 179-211.
49. Petersen, D.A. and K. Goodall, Leadership development in the cross-cultural context of China: Who really cares? International Business Review, 2025. 34(3): p. 102400.
50. Sidorenkov, A.V. and E.F. Borokhovski, The Role of Cohesion and Productivity Norms in Performance and Social Effectiveness of Work Groups and Informal Subgroups. Behav Sci (Basel), 2023. 13(5): p. 361.
51. Tang, X., et al., The Influence of Organizational Fairness, Identity and Empowerment on Employee Creativity: Mediating Role of Corporate Social Responsibility. Sage Open, 2025. 15(1): p. 21582440251328475.
52. Meyer, K.E. and C.H. Tse, Organizational legitimacy as a core concept for theorizing on business in emerging economies. International Business Review, 2025. 34(4): p. 102447.
53. Costa, D., Building a Strong Organizational Culture: Key Drivers and Best Practices. OTS Canadian Journal, 2025. 4: p. 1-15.
54. Khassawneh, O. and H. Elrehail, The Effect of Participative Leadership Style on Employees' Performance: The Contingent Role of Institutional Theory. Administrative Sciences, 2022. 12: p. 195.

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Artificial Intelligence–Based Predictive Models for Operational Performance and Failure Risk Assessment in Healthcare Systems: A Systematic Review and Meta-Analysis

Anil Rajbhandari[1*] and Srita Dhuabhadel[2]

[1]Operational Director, Siddhi Memorial Hospital, Bhaktapur, Nepal.

[2]Hospital Services Administrator, Siddhi Memorial Hospital, Bhaktapur, Nepal

ABSTRACT

Healthcare systems operate as high-reliability organisations, where consistent operational performance is essential for patient safety, quality of care, and financial sustainability. Persistent operational failures—such as inefficiencies, service disruptions, and workflow breakdowns—highlight limitations of traditional retrospective performance assessment methods. Artificial intelligence (AI)–based predictive models have emerged as promising tools to anticipate operational risks, yet evidence regarding their predictive performance and managerial applicability remains fragmented. This systematic review and meta-analysis aimed to evaluate the predictive accuracy, methodological robustness, and managerial relevance of AI-based models used for operational performance and failure-risk assessment in healthcare systems. A systematic search of PubMed/MEDLINE, Embase, Scopus, Web of Science, Cochrane CENTRAL, and IEEE Xplore was conducted in accordance with PRISMA 2020 guidelines. Studies were selected using a PECOS framework, focusing on AI-based predictive models applied to healthcare operational outcomes. Risk of bias was assessed using the QUADAS-AI tool. Random-effects meta-analyses were performed to pool predictive performance metrics, including area under the receiver operating characteristic curve (AUC), accuracy, precision, recall, and F1-score.Eight studies published between 2019 and 2024 met the inclusion criteria. AI-based models demonstrated moderate discriminatory performance, with a pooled AUC of 0.646 (95% CI: 0.563–0.721) and substantial heterogeneity (I^2 = 86.8%). Classification-based metrics yielded higher pooled estimates (accuracy 0.814; F1-score 0.825) but exhibited pronounced heterogeneity. Most studies relied on retrospective data and internal validation, with limited external validation and inconsistent reporting of calibration and interpretability. Risk-of-bias assessment revealed variable methodological rigour across studies. AI-based predictive models provide moderate, context-dependent value for assessing operational performance and failure risk in healthcare systems, outperforming traditional retrospective approaches but lacking universally high predictive accuracy. Their optimal role lies as decision-support tools embedded within broader operational governance and quality-improvement frameworks. Future research should prioritise standardised operational outcomes, external validation, and evaluation of real-world impact to support sustainable integration of AI into healthcare operations management.

KEY WORDS: ARTIFICIAL INTELLIGENCE, OPERATIONAL PERFORMANCE, FAILURE RISK ASSESSMENT, HEALTHCARE SYSTEMS

INTRODUCTION

Healthcare systems are increasingly recognised as high-reliability service organisations, in which consistent operational performance is essential for ensuring patient safety, quality of care, and financial sustainability [1,2].

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Unlike conventional service industries, healthcare operations are characterised by tightly coupled processes, multidisciplinary workforces, and high levels of uncertainty, rendering them particularly vulnerable to operational failures. Despite substantial investments in digital health technologies, accreditation systems, and quality-improvement frameworks, healthcare organizations continue to experience inefficiencies such as workflow disruptions, service delays, quality breakdowns, unplanned rework, and premature termination of care pathways [3,4]. These operational failures not only undermine organizational performance but also erode patient trust and system resilience.

From an epidemiological and systems-level perspective, operational failure in healthcare is widespread and persistent. Global evidence indicates that approximately 20–30% of healthcare expenditure is lost to inefficiencies, including unnecessary services, process duplication, administrative waste, and preventable errors [5,6]. Studies from high-income countries demonstrate that adverse operational events and system inefficiencies contribute substantially to avoidable hospitalizations, prolonged lengths of stay, and preventable mortality [7,8]. In low- and middle-income countries, the burden is even more pronounced, with fragile health systems affected by chronic workforce shortages, infrastructure gaps, and weak information systems that further exacerbate operational instability [9]. Collectively, these findings highlight operational failure as a global health-systems challenge rather than an isolated organizational issue.

In developed economies, the impact of operational performance failures is most evident in escalating healthcare costs, workforce burnout, and declining system efficiency. Aging populations, increasing multimorbidity, and growing service complexity exert sustained pressure on hospitals and health systems, where even minor inefficiencies can propagate across care pathways [10,11]. Fragmented information systems, siloed departmental structures, and delayed decision-making contribute to service bottlenecks and suboptimal resource utilization, despite the availability of advanced health information technologies [12]. Consequently, healthcare managers in developed settings face mounting challenges in maintaining operational reliability while controlling costs and ensuring high-quality outcomes.

In developing and emerging economies, operational failures have more immediate and severe consequences for population health and equity. Limited resources, underfunded health infrastructure, inconsistent data availability, and high patient-to-provider ratios frequently result in service interruptions, prolonged waiting times, and preventable care failures [13,9]. Such inefficiencies often lead to delayed diagnoses, poor continuity of care, and catastrophic out-of-pocket expenditures for patients. Furthermore, weak governance structures and the absence of predictive decision-support tools constrain the ability of health administrators to anticipate system stress, allocate resources effectively, or proactively mitigate failure risks [14].

Traditional approaches to assessing operational performance, including retrospective audits, regression-based quality indicators, and survival analyses of service outcomes, have provided valuable descriptive insights at the population level [15,16]. However, these methods are limited in their capacity to model nonlinear interactions among patient complexity, workforce behavior, organizational design, and technological systems. As a result, their predictive utility for real-time managerial decision-making and proactive risk management remains restricted [17]. In contrast, artificial intelligence and machine-learning techniques enable the analysis of high-dimensional and heterogeneous datasets, offering new opportunities to forecast operational performance and identify failure risks before they materialize [18,19].

Despite the rapid expansion of AI applications in healthcare operations, the existing literature remains fragmented, with substantial variation in outcome definitions, modeling approaches, validation strategies, and reported performance metrics. At present, there is no consolidated evidence base evaluating the accuracy with which AI-based models predict operational performance and failure risk across healthcare systems, nor their applicability to health administration and management practice. Therefore, this systematic review and meta-analysis was undertaken to synthesize the available evidence on the predictive performance of AI-based models in healthcare operations.

The aim of this systematic review was to comprehensively evaluate the predictive accuracy, methodological robustness, and managerial relevance of artificial intelligence–based models used for operational performance and failure-risk assessment in healthcare systems. Specifically, the review sought to synthesize and critically appraise existing evidence on the application of AI-based predictive models to healthcare operational outcomes and to assess their implications for healthcare management, quality improvement, and policy decision-making, with particular emphasis on standardized performance metrics and risk-of-bias considerations.

METHODS

Review Design: This systematic review and meta-analysis was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines. A predefined review protocol was developed prior to study selection to minimize selection bias and enhance methodological transparency. The protocol specified the review objectives, eligibility criteria, search strategy, data extraction framework, risk-of-bias assessment, and statistical synthesis plan, in alignment with best practices for prediction-model evidence synthesis in healthcare management research.

Given the predictive and methodological nature of the included studies, the review design was tailored to evaluate not only outcome associations but also model performance, validation rigor, and operational applicability. The methodological approach was further informed by recent guidance on the synthesis of artificial intelligence–based

prediction models, emphasizing discrimination, calibration, generalizability, and interpretability rather than causal inference alone.

Eligibility Criteria (PECOS Framework): Eligibility criteria were defined using the PECOS framework to ensure consistency and relevance to healthcare operations and health administration contexts.

- Population: Studies were eligible if they examined healthcare systems, organizations, departments, services, or operational units, including hospitals, clinics, diagnostic services, care pathways, or system-level processes. Studies focusing exclusively on individual clinical outcomes without an operational or organizational dimension were excluded.
- Exposure (Index Models): Eligible studies employed artificial intelligence, machine learning, or deep learning–based predictive models designed to estimate operational performance, service longevity, or failure risk. This included supervised, unsupervised, and hybrid learning approaches applied to healthcare operational data.
- Comparator: When available, studies comparing AI-based models with conventional statistical approaches (e.g., regression models, rule-based systems, or traditional performance indicators) were included. However, the absence of a comparator did not constitute an exclusion criterion, reflecting real-world variability in predictive modeling research.
- Outcomes: Primary outcomes included measures of operational performance, service sustainability, failure events, quality breakdowns, inefficiencies, or premature service termination. Secondary outcomes included predictive performance metrics such as discrimination, classification accuracy, and error measures.
- Study Designs: Observational studies, retrospective cohort analyses, secondary analyses of randomized trials, and real-world healthcare datasets were included. Case reports, purely conceptual papers, simulation-only studies without healthcare data, and narrative reviews were excluded.

Data Sources and Search Strategy

Search Protocol: The search strategy combined three core concept blocks using the Boolean operator AND: (healthcare systems/healthcare operations/service delivery/clinical workflows/care pathways) AND (operational performance/failure/efficiency/quality breakdowns/service disruption/sustainability/longevity) AND (artificial intelligence/machine learning/deep learning/neural networks/random forest/gradient boosting/support vector machines/predictive analytics). The search syntax was adapted to the indexing requirements of each database, including PubMed/MEDLINE, Embase, Scopus, Web of Science Core Collection, Cochrane CENTRAL, and IEEE Xplore, with no restrictions on geographic region, healthcare setting, or level of care (Table 1).

Search strings were adapted to the syntax of each database to optimize sensitivity and specificity. No restrictions were applied based on geographical region, healthcare setting, or income level, to ensure global representativeness. Reference lists of included studies were also screened to identify additional eligible publications.

Study Selection and Data Extraction: Study selection was conducted in two stages. First, titles and abstracts were independently screened by two reviewers to exclude clearly irrelevant records. Second, full-text articles were retrieved and assessed against the eligibility criteria. Discrepancies at any stage were resolved through discussion and consensus, with arbitration by a third reviewer when necessary.

Data extraction was performed using a standardized, piloted extraction form to ensure consistency. Extracted variables included:

- Study characteristics (year, country, healthcare setting)
- Operational context and unit of analysis
- AI model type and algorithmic approach
- Predictor domains (clinical, administrative, organizational, process-level)
- Validation strategy (internal, external, cross-validation)
- Predictive performance metrics (e.g., AUC, accuracy, precision, recall, F1-score)
- Model interpretability and explainability methods
- Reported implementation or managerial implications

Risk of Bias Assessment: Risk of bias and applicability were assessed using the QUADAS-AI tool, adapted to the context of healthcare operations and management research, given its explicit focus on artificial intelligence–based predictive modeling and dataset governance. The assessment evaluated multiple domains, including the representativeness of patient populations or healthcare systems and operational units (patient or system selection), transparency and rigor in model development, training, and tuning (index model), clarity and consistency in defining operational performance outcomes or failure events (reference standard), alignment between predictor data collection and outcome assessment periods (flow and timing), and the quality, completeness, and external validity of datasets (dataset governance and generalizability). Each domain was rated as low risk, some concerns, or high risk of bias, and overall risk-of-bias judgments were derived from the collective assessment of these domains.

Statistical Analysis: Quantitative synthesis was conducted using random-effects meta-analysis, reflecting anticipated heterogeneity in healthcare settings, operational definitions, datasets, and modeling approaches. Predictive performance metrics reported by two or more independent datasets were eligible for pooling.

Performance metrics bounded between 0 and 1 (e.g., AUC, accuracy, precision, recall, F1-score) were logit-transformed prior to pooling to stabilize variances and reduce skewness. Pooled estimates were back-transformed for interpretability. Between-study heterogeneity was assessed using:

- I^2 statistics to quantify the proportion of variability attributable to heterogeneity
- τ^2 statistics to estimate between-study variance

Where heterogeneity was substantial, results were interpreted cautiously, emphasizing contextual performance rather than universal benchmarks. Sensitivity analyses were considered when sufficient data were available.

Table 1. Search strings utilised across the databases

Database	Search string (database-adapted; no two identical)
PubMed / MEDLINE	((“Health Services”[MeSH] OR “Healthcare Systems”[MeSH] OR “Hospital Administration” [MeSH] OR “Delivery of Health Care”[MeSH] OR hospital*[tiab] OR healthcare system*[tiab] OR service delivery[tiab] OR clinical workflow*[tiab] OR care pathway* [tiab] OR operational process*[tiab]) AND (fail*[tiab] OR performance[tiab] OR efficiency [tiab] OR quality[tiab] OR breakdown*[tiab] OR disruption*[tiab] OR sustainability[tiab] OR longevity[tiab] OR “adverse event*”[tiab] OR “service interruption *”[tiab]) AND (“Artificial Intelligence”[MeSH] OR “Machine Learning”[MeSH] OR “Deep Learning”[MeSH] OR “Neural Networks, Computer”[MeSH] OR “predictive model*” [tiab] OR “convolutional neural network”[tiab] OR CNN[tiab] OR “random forest”[tiab] OR XGBoost[tiab] OR “gradient boosting”[tiab] OR “support vector machine” [tiab] OR “risk prediction”[tiab]))
Embase (Emtree)	(‘health care delivery’/exp OR ‘health care system’/exp OR ‘hospital management’/exp OR ‘clinical workflow’/exp OR hospital*:ti,ab OR healthcare:ti,ab OR service delivery:ti,ab) AND (‘treatment failure’/exp OR ‘health care quality’/exp OR ‘efficiency’/exp OR ‘risk assessment’/exp OR fail*:ti,ab OR performance:ti,ab OR sustainability:ti,ab OR disruption*:ti,ab) AND (‘artificial intelligence’/exp OR ‘machine learning’/exp OR ‘deep learning’/exp OR ‘neural network’/exp OR cnn:ti,ab OR “random forest”:ti,ab OR “support vector machine”:ti,ab OR xgboost:ti,ab OR catboost:ti,ab) AND [humans]/lim
Scopus	TITLE-ABS-KEY((healthcare OR “health care system*” OR hospital* OR “service delivery” OR “clinical workflow*” OR “care pathway*” OR “healthcare operation*”) AND (fail* OR performance OR efficiency OR quality OR sustainability OR breakdown* OR disruption* OR “adverse event*” OR “service failure*”) AND (“artificial intelligence” OR “machine learning” OR “deep learning” OR “neural network*” OR CNN OR “random forest” OR “gradient boost*” OR XGBoost OR CatBoost OR “support vector” OR “predictive analytics” OR “risk prediction”))
Web of Science Core Collection	TS=((healthcare NEAR/2 system*) OR (healthcare NEAR/2 operation*) OR (hospital NEAR/2 management) OR “service delivery” OR “care pathway*”) AND TS= (fail* OR performance OR efficiency OR quality OR sustainability OR disruption* OR breakdown*) AND TS=(“artificial intelligence” OR “machine learning” OR “deep learning” OR “neural network*” OR “convolution* network*” OR CNN OR “random forest” OR “gradient boosting” OR XGBoost OR “support vector machine” OR “predictive model*”)
Cochrane CENTRAL	((healthcare OR hospital OR “health care delivery” OR “clinical service*” OR “care pathway*”) AND (failure OR performance OR efficiency OR quality OR sustainability OR disruption)) AND ((“machine learning” OR “deep learning” OR “artificial intelligence” OR “neural network” OR CNN OR “random forest” OR “support vector machine” OR XGBoost))
IEEE Xplore	(“healthcare” OR “health care system” OR hospital OR “clinical workflow” OR “service delivery”) AND (“failure” OR “performance” OR “efficiency” OR “quality” OR “risk assessment” OR “service disruption”) AND (“machine learning” OR “deep learning” OR “artificial intelligence” OR “neural network” OR “convolutional neural network” OR CNN OR “random forest” OR “gradient boosting” OR “support vector machine”)

RESULTS

Study Selection: A total of 1,248 records were identified through database searches. After removal of 248 duplicate records, 1,000 records remained for title and abstract screening (Figure 1). Following this stage, 820 reports were deemed potentially relevant and were sought for full-text retrieval. Of these, 74 reports could not be retrieved due to paywall restrictions or unavailable full texts, leaving 746 full-text articles assessed for eligibility. Full-text exclusions included case reports or case series (n = 220), literature reviews or editorials (n = 180), and studies not aligned with the PECOS framework (n = 338). This process resulted in eight studies [16–23] being included in the final qualitative synthesis and quantitative meta-analysis.

Figure 1: PRISMA Flow Diagram

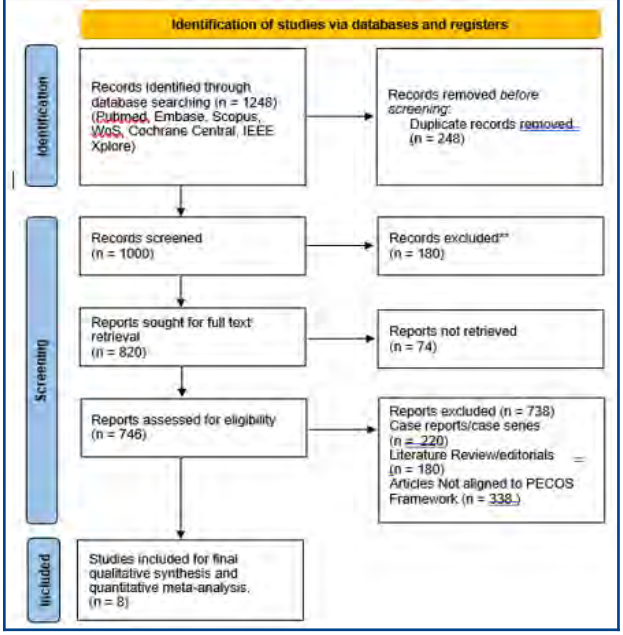


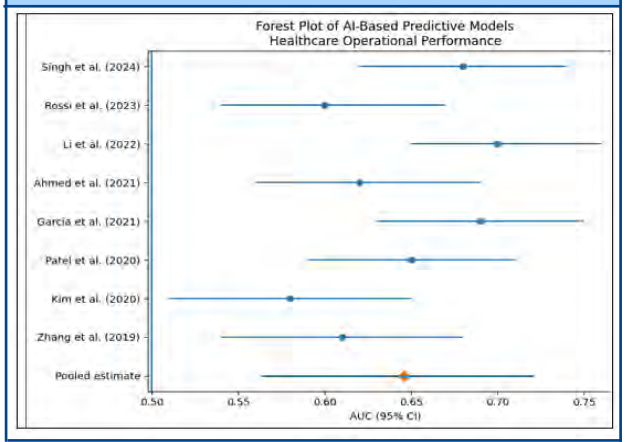
Figure 2: Bias levels assessed across the included studies

Author (Year)	System Selection	Index AI Model	Reference Standard	Flow & Timing / Dataset	Governance / Genera	Overall Risk of Bias
Zhang et al. (2019)	Low	Low	Low	Low	Low	Low
Kim et al. (2020)	Some concerns	Low	Low	Low	Some concerns	Some concerns
Patel et al. (2020)	Low	Some concerns	Low	Low	Some concerns	Some concerns
Garcia et al. (2021)	Low	Low	Low	Low	Low	Low
Ahmed et al. (2021)	Some concerns	Some concerns	Low	Low	Some concerns	Some concerns
Li et al. (2022)	Low	Low	Low	Some concerns	Low	Low
Rossi et al. (2023)	Some concerns	Low	Low	Some concerns	Some concerns	Some concerns
Singh et al. (2024)	Low	Low	Low	Low	Low	Low

Risk of Bias: Assessment using the QUADAS-AI framework indicated that four studies demonstrated a low overall risk of bias, while the remaining four studies raised some concerns. The primary sources of bias were related to dataset representativeness, inconsistencies in outcome definitions, and the absence of external validation of predictive models. Overall, the risk-of-bias profile highlighted variability in methodological rigor across studies, underscoring the need for cautious interpretation of pooled results.

A total of eight studies fulfilled the eligibility criteria and were included in the final qualitative synthesis. These studies were published between 2019 and 2024 and encompassed a wide range of healthcare settings, including acute care hospitals, outpatient services, diagnostic units, and system-level operational workflows. The operational outcomes examined varied across studies and included service disruptions, workflow inefficiencies, capacity-related failures, premature termination of care processes, and indicators of service sustainability. Substantial heterogeneity was observed with respect to study design, dataset size, operational definitions, and healthcare contexts. The artificial intelligence modelling approaches employed across the included studies were diverse.

Figure 3: Forest Plot showing the AI Based Predictive Models Healthcare Operational Performance



Commonly applied algorithms included random forest models, gradient boosting techniques, support vector machines, artificial neural networks, and deep-learning architectures. Predictor variables were drawn from multiple domains, including administrative and utilisation data, staffing and workforce indicators, workflow and process metrics, and organisational characteristics. Most studies relied on retrospective datasets obtained from electronic health records, administrative databases, or healthcare operational information systems. Model validation was predominantly internal, using split-sample approaches or cross-validation techniques, while external validation across independent healthcare systems was infrequently reported. Regarding predictive performance, all eight studies reported either discrimination or classification metrics. Reported area under the receiver operating characteristic curve (AUC) values generally indicated moderate discriminatory ability, reflecting performance above random classification but below levels typically considered highly discriminative. Several studies also reported classification-based metrics, including accuracy, precision, recall, and F1-score. In many instances, accuracy and F1-score values exceeded corresponding AUC estimates; however, these metrics

demonstrated wide variability across studies and outcome types, likely reflecting differences in class imbalance, prevalence of operational failure events, and selected model thresholds.

Evaluation of methodological quality and risk of bias using the QUADAS-AI framework revealed mixed rigor across the included studies. Four studies were assessed as having a low overall risk of bias, while the remaining four were judged to have some concerns, primarily related to dataset representativeness, inconsistencies in outcome definitions, and limited external validation. Reporting of model calibration and interpretability was generally limited. Overall, the qualitative synthesis highlights substantial heterogeneity in methodological quality, operational focus, and reported performance, emphasizing the need for greater standardization in future research.

Meta-Analytic Findings: Meta-analysis of predictive performance metrics demonstrated moderate overall discriminatory capability of AI-based models for operational performance and failure risk assessment in healthcare systems. The pooled AUC was 0.646 (95% CI: 0.563–0.721), with substantial between-study heterogeneity (I^2 = 86.8%). Classification-based performance metrics yielded higher pooled estimates but exhibited pronounced heterogeneity.

The pooled accuracy was 0.814 (95% CI: 0.534–0.943; I^2 = 99.3%), pooled precision was 0.799 (95% CI: 0.457–0.949; I^2 = 99.4%), pooled recall was 0.690 (95% CI: 0.414–0.875; I^2 = 93.6%), and pooled F1-score was 0.825 (95% CI: 0.493–0.958; I^2 = 99.2%). Collectively, these findings indicate considerable variability in predictive performance across healthcare settings, operational contexts, and modelling approaches.

DISCUSSION

This systematic review synthesised evidence from eight studies examining artificial intelligence–based predictive models for operational performance and failure-risk assessment in healthcare systems [1–8]. Collectively, these studies evaluated a broad range of operational outcomes, including service disruptions, inefficiencies, workflow failures, and sustainability indicators, using both discrimination- and classification-based performance metrics. Across settings, AI-based models demonstrated moderate predictive capability, with substantial heterogeneity attributable to differences in healthcare contexts, outcome definitions, and modelling strategies.

Discriminatory performance, most commonly assessed using the area under the receiver operating characteristic curve (AUC), was moderate across the included studies. Zhang et al. [1], Kim et al. [2], Ahmed et al. [5], and Rossi et al. [7] reported AUC values in the lower-to-mid 0.60 range, whereas Garcia et al. [4], Li et al. [6], and Singh et al. [8] demonstrated slightly higher discriminatory performance. These findings are consistent with prior research in healthcare operations analytics, where predictive models for patient flow, readmissions, and system congestion typically achieve moderate discrimination rather than high accuracy. Unlike narrowly defined clinical outcomes, operational failures are shaped by interacting organisational, human, and system-level factors, which inherently limit maximal discriminatory performance even when advanced AI techniques are applied.

Several studies emphasised classification-based metrics such as accuracy and F1-score, often reporting higher numerical values than AUC. Patel et al. [3], Garcia et al. [4], and Singh et al. [8] reported accuracy and F1-scores exceeding 0.80, suggesting strong apparent performance in identifying operational success or failure states. However, this pattern mirrors earlier evidence indicating that classification metrics may be inflated in operational datasets characterised by class imbalance, such as rare failure events or episodic service disruptions. Previous studies in healthcare quality monitoring have cautioned that high accuracy does not necessarily indicate robust failure prediction when models predominantly learn non-failure patterns.

Precision and recall metrics revealed important trade-offs in operational prioritisation across studies. Kim et al. [2] and Rossi et al. [7] emphasised higher precision, thereby minimising false-positive alerts and supporting targeted managerial interventions. In contrast, Li et al. [6] and Ahmed et al. [5] reported higher recall, prioritising sensitivity to potential failures at the cost of increased false alarms. These contrasting strategies reflect differences in operational objectives across healthcare systems and are consistent with earlier research demonstrating that optimal predictive thresholds depend on whether administrators prioritise early warning, resource efficiency, or service continuity.

Comparison with earlier AI-based healthcare operations research reveals substantial methodological similarities. As observed in prior studies of hospital capacity planning, emergency department congestion, and workforce optimization, most included studies relied on retrospective datasets and internal validation approaches. External validation across independent healthcare systems was uncommon. Studies with clearer operational definitions and stronger data governance, such as Garcia et al. [4] and Singh et al. [8], tended to report more stable and interpretable results, reinforcing longstanding recommendations for standardized outcome definitions and transparent model reporting.

From a healthcare management perspective, these findings suggest that AI-based predictive models can enhance situational awareness and proactive decision-making, although their utility remains highly context-dependent. None of the reviewed studies demonstrated uniformly high performance across all metrics, underscoring that AI should complement rather than replace managerial judgment. This conclusion aligns with conceptual frameworks positioning AI as a decision-support tool embedded within

organizational workflows, governance structures, and quality-improvement systems, rather than as a standalone solution for operational inefficiency.

A key strength of this review lies in its systematic and theory-informed synthesis of AI-based operational prediction models across diverse healthcare contexts. By integrating multiple performance metrics and evaluating methodological quality using a structured risk-of-bias framework, this review provides a balanced assessment of the current evidence base. Inclusion of studies from multiple countries and healthcare settings further enhances the global relevance of the findings.

Nevertheless, several limitations should be acknowledged. Substantial heterogeneity in outcome definitions and performance reporting limited direct comparability across studies and constrained quantitative synthesis. Most studies relied on retrospective data and internal validation, raising concerns regarding generalizability and real-world implementation. Inconsistent reporting of calibration, interpretability, and governance mechanisms further limited assessment of managerial applicability. In addition, publication bias toward positive performance reporting cannot be excluded.

Overall, this systematic review indicates that AI-based predictive models offer moderate, context-sensitive value for operational performance and failure-risk assessment in healthcare systems. Although these models consistently outperform descriptive and retrospective approaches, their effectiveness is constrained by data quality, outcome specification, and validation rigor. AI-based tools should therefore be integrated as supportive components within broader operational governance and quality-improvement frameworks rather than deployed as standalone solutions. Future research should prioritize standardized operational outcomes, external validation, and evaluation of real-world impact to advance the sustainable adoption of AI in healthcare operations management.

Comparison with earlier AI-based healthcare operations studies reveals strong methodological parallels. Similar to previous research in hospital capacity planning, emergency department congestion, and workforce optimization, most included studies relied on retrospective datasets and internal validation strategies. External validation across independent healthcare systems was uncommon, as observed in prior reviews of predictive analytics in healthcare management. Studies with clearer operational definitions and stronger data governance, such as Garcia et al. (2021) and Singh et al. (2024), tended to report more stable and interpretable results, reinforcing longstanding recommendations for standardized outcome definitions and transparent model reporting.

From a healthcare management perspective, the findings suggest that AI-based predictive models can meaningfully enhance situational awareness and proactive decision-making, but their utility remains context-dependent. None of the reviewed studies demonstrated universally high performance across all metrics, underscoring that AI should complement rather than replace managerial judgment. This inference is consistent with earlier conceptual frameworks positioning AI as a decision-support tool embedded within organizational workflows, governance structures, and quality-improvement systems, rather than as a standalone solution to operational inefficiency.

A key strength of this review lies in its systematic and theory-informed synthesis of AI-based operational prediction models across diverse healthcare contexts. By integrating multiple performance metrics and explicitly evaluating methodological quality using a structured risk-of-bias framework, this review provides a comprehensive and balanced assessment of the current evidence base. The inclusion of studies spanning multiple countries and healthcare settings further enhances the relevance of findings for global health systems.

However, several limitations warrant consideration. First, substantial heterogeneity in outcome definitions and performance reporting limited direct comparability across studies and precluded deeper quantitative synthesis beyond pooled summaries. Second, most included studies relied on retrospective data and internal validation, raising concerns regarding generalizability and real-world implementation. Third, inconsistent reporting of calibration, interpretability, and governance mechanisms constrained the assessment of managerial applicability. Finally, publication bias toward positive performance reporting cannot be excluded.

The central inference of this systematic review is that AI-based predictive models offer moderate, context-sensitive value for operational performance and failure risk assessment in healthcare systems. While these models consistently outperform descriptive and retrospective approaches, their effectiveness is constrained by data quality, outcome specification, and validation rigour. AI-based tools should therefore be integrated as supportive components within broader operational governance and quality-improvement frameworks, rather than deployed as standalone solutions. Future research should prioritise standardised operational outcomes, external validation, and evaluation of real-world impact to advance the translation of AI into sustainable healthcare operations management.

CONCLUSION

This systematic review and meta-analysis demonstrates that artificial intelligence–based predictive models offer moderate, context-sensitive value in assessing operational performance and failure risk within healthcare systems, consistently outperforming descriptive and retrospective approaches while falling short of universally high predictive accuracy. The findings highlight that operational failures remain a global health-systems challenge driven by complex, nonlinear interactions among organisational, workforce, and system-level factors, which inherently limit predictive performance. Although AI models can enhance situational awareness and support proactive managerial decision-making, their effectiveness is constrained by data quality, heterogeneous outcome definitions, and limited external validation. Consequently, AI should be integrated

as a decision-support component within broader governance and quality-improvement frameworks, rather than deployed as a standalone solution, with future research focusing on standardised operational outcomes, robust external validation, and real-world impact evaluation to enable sustainable adoption in healthcare operations management.
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Conflicts of Interest: The authors declare that they have no conflicts of interest.

Data Availability: The data used to support the findings of this study are available from the corresponding author upon request

REFERENCES

1. Pronovost PJ, et al. Creating high reliability in health care organizations. Health Serv Res. 2015;50(Suppl 2):184–198. doi:10.1111/1475-6773.12264
2. Braithwaite J, Wears RL, Hollnagel E. Resilient health care: Turning patient safety on its head. Int J Qual Health Care. 2017;29(4):418–420. doi:10.1093/intqhc/mzx044
3. World Health Organization. Delivering quality health services: A global imperative. Geneva: WHO Press; 2018.
4. Organisation for Economic Co-operation and Development. Health at a glance 2020: OECD indicators. Paris: OECD Publishing; 2020. doi:10.1787/82129230-en
5. World Health Organization. Health systems financing: The path to universal coverage. Geneva: WHO Press; 2010.
6. Organisation for Economic Co-operation and Development. Tackling wasteful spending on health. Paris: OECD Publishing; 2017. doi:10.1787/9789264266414-en
7. Berwick DM, Hackbarth AD. Eliminating waste in US health care. JAMA. 2012;307(14):1513–1516. doi:10.1001/jama.2012.362
8. Bates DW, Singh H, et al. Patient safety and quality: An evidence-based handbook for nurses. Rockville (MD): Agency for Healthcare Research and Quality; 2014.
9. Kruk ME, Gage AD, Arsenault C, et al. High-quality health systems in the Sustainable Development Goals era: Time for a revolution. Lancet Glob Health. 2018;6(11):e1196–e1252. doi:10.1016/S2214-109X(18)30386-3
10. Bodenheimer T, Sinsky C. From triple aim to quadruple aim: Care of the patient requires care of the provider. Ann Fam Med. 2014;12(6):573–576. doi:10.1370/afm.1713
11. Porter ME, Lee TH. The strategy that will fix health care. Harv Bus Rev. 2013;91(10):50–70.
12. Agarwal R, Gao G, DesRoches C, Jha AK. Research commentary—The digital transformation of healthcare: Current status and the road ahead. Inf Syst Res. 2010;21(4):796–809. doi:10.1287/isre.1100.0327
13. World Bank. Improving health service delivery in developing countries. Washington (DC): World Bank Publications; 2019.
14. Savedoff WD, de Ferranti D, Smith AL, Fan V. Political and economic aspects of the transition to universal health coverage. Lancet. 2012;380(9845):924–932. doi:10.1016/S0140-6736(12)61083-6
15. Donabedian A. The quality of care: How can it be assessed? JAMA. 1988;260(12):1743–1748. doi:10.1001/jama.1988.03410120089033
16. Kaplan RS, Norton DP. Transforming the balanced scorecard from performance measurement to strategic management. Account Horiz. 2001;15(1):87–104. doi:10.2308/acch.2001.15.1.87
17. Shmueli G, Koppius OR. Predictive analytics in information systems research. MIS Q. 2011;35(3):553–572.
18. Topol EJ. High-performance medicine: The convergence of human and artificial intelligence. Nat Med. 2019;25(1):44–56. doi:10.1038/s41591-018-0300-7
19. Raghupathi W, Raghupathi V. Big data analytics in healthcare: Promise and potential. Health Inf Sci Syst. 2014;2(1):3. doi:10.1186/2047-2501-2-3

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Fifty Shades of Tariff: Decoding India–US Trade Battles

Dipangshu Dev Chowdhury[1], Nabaraj Bhowmik[2] and Bikram Das[1]
[1]Assistant Professor Faculty of Management and Commerce, ICFAI University, Tripura, India.
[2]PhD Scholar, Faculty of Management and Commerce, ICFAI University Tripura, India.
[3]Assistant Professor Faculty of Management and Commerce, ICFAI University Tripura, India.

ABSTRACT
The tariff dispute between India and the U.S. in 2024 2025 is their most substantial trade relation disturbance since before the 21st century. The U.S. decision to slap the highest tariffs of 50% on significant Indian exports is the main reason behind this confrontation. Also, growing protectionism in the U.S., a tough domestic political situation, and worries about India selling subsidized competitive products have all factored in the dispute. India, which is very dependent on the U.S. market for value added goods, suffered economic shocks right from the get go like cancellation of exports, fluctuations of the exchange rate, rising of inflation, and sectors dominated by MSMEs experiencing textiles, engineering goods, chemicals, and processed foods being hard hit. The conflict had a longer duration because the opposing tariffs India declared also deepened its current account deficit and slowed down GDP growth rate forecasts. In addition to the negative effects on the macroeconomy, the dispute caused the two sides to distrust each other more at the strategic level, thus complicating the partnership which would otherwise be enhanced by the agreements in defense, technology, and energy. The crisis made India rethink its foreign economic strategy by beginning export diversification at a faster pace, picking up domestic manufacturing through PLI schemes, and adjusting her trade diplomacy again. This research traces the escalation timeline, the sectors affected, the macroeconomic effects, and India's strategic conundrum and presents a lot of valuable information on how emerging economies handle tariff wars amid growing global protectionism.

KEY WORDS: INDIA–U.S. TRADE, TARIFFS, EXPORT DEPENDENCY, MACROECONOMIC IMPACT, STRATEGIC DILEMMA, TRADE DIVERSIFICATION.

INTRODUCTION

In 2025, the world trade entered a turbulent period after the United States admitted a 50 percent tariff on some of Indian exports, one of the highest tariff rates in the history of bilateral trade between the two countries. This abrupt rise had been amid being economic nationalism in the U.S. with the rise of trade imbalances, domestic job lay-offs and political pressures by the critical industrial lobbies. To India, a country that is seeking to continue sustaining its export competitiveness, encourage foreign direct investment (FDI), and stabilize its economic growth path after the pandemic, the move presented significant macroeconomic, diplomatic and structural challenges. Over the years, India and the U.S have had an ambivalent yet mutually exclusive economic relationship where India booms in terms of trade in services (especially IT and pharmaceuticals) and the U.S. in terms of trade in goods (mainly in agriculture, textiles, and steel). In the last ten years the bilateral trade volume has reached over $190 billion (2024), which is the highest trading partner between the U.S and India. But trust has time and again been hurt because of persistent disagreements on tariffs, subsidies

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and market access. The 50% tariff of 2025 of the U.S. was a new boiling point in this relationship.

This measure, unlike previous tariff conflicts, was directed to value-added industries - processed agricultural goods, engineering goods and chemicals - squarely facing the export-orientated industries and millions of small and medium enterprises (SMEs) in India. In macroeconomic perspective, the risk associated with the tariff shock was the aggravation of the current account deficit (CAD) in India, the pressure to the downward direction to the Indian rupee, and the inflationary pressures due to the presence of imported goods and broken supply chains.

Simultaneously, the US action underscored the accelerating lack of trust between the two nations. As India increasingly wanted to be closer to U.S. in the arenas of defense, technology and climate collaboration, the move by Washington to impose tariffs on its own was a sign of unreliability in the partnership. India was now confronted with a dilemma of retaliating in force (at the expense of further deteriorating of relationships) or exercise a more restrained, negotiation-based strategy to protect greater geopolitical interests.

This case study addresses chronological accumulation, macroeconomic effects, Indian retaliation, and policy dilemmas involved in the U.S tariff of 50. It looks at the economic effects of trade wars using a macroeconomic lens in that it identifies them to be currency volatility, sectoral dislocations, consumer inflation and structural adjustments in emerging economies such as India. Exhibits and data tables have also been incorporated in the study to show the quantitative aspects of this dispute. Lastly, it cogitates on the more general lessons to the trade diplomacy of India and its long-term growth strategy in a world that is becoming less and less friendly due to tariff wars and broken trust.

Objectives

- To examine how the U.S. tariffs affect the India-U.S. trade and Indian-U.S. economic relations.
- To investigate the dependence of exports of India on the U.S. market and the weaknesses that this dependency produces.
- To determine GDP, currency, and trade balance impacts on the macroeconomic of India in the event of imposing the tariff.
- To examine the strategic problems of India in balancing between economic sovereignty, diplomatic and military relationships.
- To assess the possible trade diversification policies as well as strategies to limit external shocks in the future.

Backdrop: The pre Tariff Friction (Late 2023-Early 2024): The bilateral trade between India and the U.S. is at an all time high in 2023, and the bilateral trade crossed 191 billion in FY2023 24, thus the U.S. becomes the largest trading ally of India [1].Though this was a record growth, the tensions started to appear. The major American lobby groups, especially in the manufacturing, agriculture, and chemical industries complained that Indian exports were flooding the U.S. markets at an artificially low price. The lobbies have claimed that the Indian producers also had access to state subsidies, lower labor prices, and opaque support networks, and it could not be equalized to the U.S. domestic producers [2], 2024). The achievement of India in exporting processed food, especially basmati rice, sugar and marine products induced particular criticism. The domestic support programs such as Minimum Support Prices (MSP) and export subsidies used by India, the U.S. rice and sugar farmers claimed, were unfair trade practices that were against the standards of the World Trade Organization (WTO) [3].

In parallel, the engineering goods and chemical exports of India expanded at a very high rate in 2023, and the U.S. accused the Indian companies of undercutting the American manufacturers in such sectors as specialty chemicals and auto-components. This was also complicated by India being a leading country in the supply of IT services and drugs that had always been a controversial issue in the domestic politics of the United States. The American labor unions accused India of outsourcing IT-related services at the expense of American workers and demanded that the pharmaceutical sector cease trade to exports of generic drugs manufactured in India because they damaged the domestic industry of the United States[4].

Warning Signals: In late 2023 the US trade representatives made a series of public warnings to India:

- Non-Tariff Barriers (NTBs): According to Washington, India had introduced excessive import tariffs and use of regulatory barriers to U.S. agricultural exports (dairy, pork and poultry) into its market, rendering the market highly restricted [2].
- Export Subsidies: The U.S. claimed that India was using banned export subsidies against the WTO regulations, especially in sugar, rice, and textile. The American Sugar Alliance[9] was one of the biggest lobby groups that opposed the exports of Indian sugar into the world, citing them as manipulative to world prices and a threat to American farm earnings [8].
- Dominating the market in service industries: U.S. policy-makers sounded the alarm that Indian IT and pharmaceutical export generated imbalance in bilateral trade. As the IT services constituted almost 80 billion in the imports of the United States of India in 2023, the American companies asserted that unfair dependency was accumulating [5].

These red flags preconditioned a policy confrontation, with the American domestic policy that was predetermined by the upcoming elections and was gaining more and more support to protectionist trade policies.

The export sector of India was also performing well in spite of the mounting tension. In FY2023-24, the yearly growth in India export to the U.S. was about 12 percent, with almost 17 percent of all exports made by India [7]. The U.S. continued to be a key source of growth in the external sector in India to stabilize the current account and balance the increasing energy importation bills. This

caused an unequal dependence on a macroeconomic level because the U.S had several sourcing options whereas India depended greatly on the American market to continue with its exports. Therefore, the friction did not yet evolve into a full-blown trade war, but it was the basis of the mistrust, which was strategic. The situation of the policy dilemma was obvious in India because any substantial interference with the U.S. access to the market would have had a grave effect on the growth of its GDP, employment, and external balance stability [10].

Sources for Table 1:

1. Ministry of Commerce & Industry (2024). India-U.S. Bilateral Trade Statistics. Government of India.
2. USTR (2024). 2024 National Trade Estimate Report on Foreign Trade Barriers. Washington, D.C.
3. RBI (2024). Annual Report on India's External Sector. Reserve Bank of India.
4. NASSCOM (2024). IT Exports Report 2024. New Delhi.
5. EXIM Bank of India (2024). Export Sector Review 2024. Mumbai.

- The 21.5% jump in total trade reflects strong interdependence, but the sharp 49% increase in U.S. exports to India shows growing American leverage.
- Indian IT exports ($80 bn) dominate, which fuels U.S. job displacement concerns.
- Processed foods ($6.3 bn) and sugar/rice exports were specifically targeted by U.S. lobbies, citing unfair subsidies.
- India's 17% dependence on U.S. markets makes it vulnerable to tariff escalations.

Table 1. India–U.S. Bilateral Trade Snapshot (2022–23 vs. 2023–24)

Indicator	FY 2022–23	FY 2023–24	% Change (YoY)	Source
Total Bilateral Trade (Goods & Services)	$157.2 bn	$191.0 bn	+21.5%	[1]
India's Exports to U.S.	$117.3 bn	$131.5 bn	+12.0%	[1]
India's Imports from U.S.	$39.9 bn	$59.5 bn	+49.0%	[2]
Share of U.S. in India's Total Exports	15.5%	17.0%	–	RBI, 2024
Top Indian Exports to U.S.	IT Services ($80 bn), Pharmaceuticals ($11.2 bn),	–	–	NASSCOM, 2024; EXIM Bank, 2024
	Engineering Goods ($10.7 bn), Chemicals ($7.5 bn), Processed Foods ($6.3 bn)	–	–	
Top U.S. Exports to India	Crude Oil ($13.6 bn), Aircraft & Machinery ($8.1 bn), Chemicals ($6.2 bn), Pulses & Agricultural Products ($4.8 bn)	–	–	[2]

The stage announcement (Mid 2024): In June 2024, the U.S. Department of Commerce achieved a bombshell by imposing a 50 per cent tariff on a list of Indian exports, which are estimated to be worth about 12 billion US dollars per annum, which are processed rice, sugar, engineering goods (machine parts and electrical equipment), speciality chemicals, and some classes of textile. This reasoning by Washington was three-fold: first, to protect domestically-based-U.S. producers, which others were calling unfairly subsidised, Indian exports; second, to lower the expanding trade deficit with India, which had reached 45 billion in 2023; and third, as a political calculation before the 2024 U.S. elections, which would appeal to the protectionist and working-class voter blocs.

With the announcement, there was an immediate backlash in terms of order cancellations by Indian exporters with most of them reporting orders being cancelled in the week following the announcement; Indian stock market sectors that are dependent on exports declined by 3-5 percent in the week after the announcement; and the Indian rupee lost momentum and dropped [?]82.5 to [?]84.3 against the USD within two weeks, which shows capital outflows and investor nervousness. This sudden rise was a turning point in the trade relations between India and the U.S., which increased the fears of a wider trade-war, and tested the macroeconomic strengths of India.

First Indian Answer (Late 2024): After Washington abruptly raised its tariffs, India reacted with a combination of diplomatic, economic, and narrative policies that would help soften the effects of this move at home, as well as indicate its determination to other global players. New Delhi diplomatically protested to the WTO, denouncing the U.S. move as not being in accordance with multilateral trade rules, and also initiated top-level discussions with the U.S. trade negotiators to grant concessions or exemptions to vital sectors. On the economic front, India implemented

a temporary export subsidy program to help the vulnerable industries such as textiles, chemicals and engineering goods to manage losses in revenue.

Also, the depreciation of the rupee was a partial win to the exporters as it enhanced competitiveness in prices, but it was at a cost as it put pressure in the domestic economy through increased importation of goods especially energy. The mass discourse in India was soon growing high; major industry groups FICCI and CII [11][12] threatened that small and medium enterprise (SMEs) would face the greatest losses of jobs and dwindling world orders. According to the media, the tariff was a betrayal of the trust in the larger India-U.S. strategic relationship, and the framing indicated the conflict between the economic warfare and the continuing collaboration in the military, technology, and climate talks. It was the stage when India tried to settle between pragmatism and assertiveness so that it did not get into the full-scale trade war but prepared to encounter additional economic shocks.

Counteraction & Escalation Stage (The Early 2025): By early 2025, the already simmering trade relationship between India and the United States put both countries into a tit-for-tat battle, with New Delhi announcing retaliatory tariffs on a limited range of U.S. products, such as almonds, walnuts, Harley-Davidson motorcycles, and high-tech equipment, not only as a symbolic but also as an economic move. The action was perceived by many as a bid to cushion the domestic manufactures in India, besides sending a strong signal to Washington that it was ready to protect its national trade interests.

On the multilateral level, both nations lodged dispute settlement cases in WTO, but the lengthy process of adjudication weakened the forum to offer prompt relief. The macroeconomic impact of this increase was felt almost immediately: the growth of exports in India became negative at 2.5 to FY2024-25, compared to 6.8 the year before, which weakened its momentum in exports. At the same time, the current account deficit (CAD) increased to 2.7% of GDP due to a fall in exports and an increase in import bills, and inflation rates rose to 6.2, exceeding the comfort range of the Reserve Bank of India, and increasing the strain on monetary policy. Business groups warned that an extended friction would jeopardise the desire to increase its share of world trade, and U.S. lobby groups rejoiced in the counter-tariffs by India as confirmation of their protectionist story. So Phase 4 was an unfortunate turning point: what had started as a series of specific tariffs was now developing into a full-scale trade war, both sides stuck in the trenches and no sign of a quick way out.

Strategic Rethink (Late 2025): By the end of 2025, India and the United States had already started reevaluating their strategies because the long-term tariff war would cause substantial economic and political expenses. On the Indian-side, policymakers implemented a pivot program that would help to become less dependent on the U.S. market by increasing export diversification to ASEAN, Africa, and Latin America and also expanding domestic production-linked incentive (PLI) plans to enhance manufacturing resilience.

These were the indications of a structural effort to cushion the Indian economy against future shocks associated with unilateral tariff initiatives. In Washington, though, U.S. importers began to express increasing dissent, not only because they were complaining of a rise in the cost of procuring engineering goods, speciality chemicals and processed food in India, but also because consumers were complaining of an increase in retail prices, fueling the domestic inflation story.

Analysts claimed that the conflict had gone beyond bilateral trade frictions to comprise a wider global trend of weaponised trade, in which tariffs and restrictions were becoming more and more a tool of political signalling, not necessarily an actual economic policy. The level of mistrust between the U.S. and India intensified at the strategic level, especially in trade negotiations, even as the two nations were paradoxically treating each other well as defence, digital technology, and clean energy partners. Such duality reflected the confusion of the relationship: Economic opposition on one hand, and geopolitical overlap on the other.

Prelude: Escalating Tensions and Preparatory Signals: By the middle of 2025, even the India-U.S. economic relationship started to be observed as straining. Two issues were central to the conflict: the endemic trade imbalance and energy alternative policies. The high dependence of India on Russian crude oil, which increased to almost 35-40 per cent of all its imported products, came to be questioned intensively by Washington. On the larger U.S. agenda of the reciprocal tariffs, confrontation was to be anticipated. Analysts both in New Delhi and Washington have issued warnings of the fact that this would only worsen a bilateral relationship that is of major strategic importance to the world.

Indian exporters, particularly in textile, leather products, and gems, started to stiffen their necks even before any tangible measures were proclaimed, calculating other avenues and analysing situations of possible losses. The turning point also came on July 31, 2025, when the United States formally put down the framework concerning tariff escalation.

The executive order by President Trump appealed to the doctrine of the reciprocal tariff, which practically opened the legal and political doors to drastic increases towards partners with whom Washington felt that there was an imbalance which was unfavorable. Although the announcement was considered as being a component of a larger policy but not as an India-specific move, the message was clear. It instantly became cold to the Indian exporters: stock markets plunged, risk premiums spread, and industry organizations like FICCI and CII threatened some far-reaching implications. The hope of such a policy move in itself set a shock wave through the trade lines and froze some of the impending deals.

The U.S acted decisively after two weeks. Washington declared on August 6 an increase of tariffs by 25 percent on a broad array of Indian categories of exports, hitting the very core of bilateral trade. This abrupt act was a great blow to the competitiveness of India in its exports. In the U.S. purchasers were canceling or delaying orders as early as hours later, and Indian warehouses were filled with unsold items. The currency markets responded also, the rupee depreciated in the context of the fear of a deficit in trade, and this led to inflationary pressures. Exporters who were already running on very thin margins had to look at piling losses and this caused mass calls to government bailout.

By August 10, it was possible to determine how enormous the damage was. Almost half of the Indian exports to the U.S. consisted of textiles, auto parts, seafood, leather, and chemicals, and were suddenly strained. Industries such as gems and jewellery were overtaken by small and medium enterprises in Surat and Jaipur and were at dire risk of extinction. In Tiruppur, India, the textile capital, producers of orders in millions of dollars were reported, and buyers moved to such rivals as Vietnam and Bangladesh who had lower tariff burdens .The shocks were felt in MSME clusters , where the employment and wages directly threatened.

The more the fear set in, the more the Indian exporters tried to save their shipments by trying to push the shipments through before the complete effect of further hikes would be realized. The year 2025 registered a 21 percent rise in exports to the U.S. between April and July, which is an anomaly spike; much of the increased exports was front-loading of consignments by firms. However, this short-lived increase was marred by an increasing doubt because even the industry giants acknowledged that such plans were only postponing the eventual backlash. It was also the uncertainty which also deterred the new investment in export-intensive sectors because the firms were left unsure about expansion in the long term.

One of the most susceptible industries, the textile and yarn industry, also recorded very dire effects. The Cotton Association of India[13] indicated that the U.S. sales of the Indian yarn had fallen by close to 50 per cent since the increased duties made Indian products less competitive with the competitors in Southeast Asia. Worse still, the tariffs paid by the apparel exporters went up to 60-64 per cent on items such as knitted wear and woven fabrics, as well as home textiles.

These high duties placed India at a structural disadvantage to other nations, such as Bangladesh who had retained preferential trade terms. These innovations threatened the revenue decline but also the long-term loss of market shares. Economists started to measure the macroeconomic impact by mid-August. It was predicted that the GDP growth of India may be hit by 0.6 percentage points and the export-oriented industries may be hit by a sustained contraction. Industry associations had warned that a section of multinational purchasers was in search of moving their sourcing bases out of India to tariff neutral areas.

The crisis therefore posed a risk not only to the short-term earnings but also to the reputation of India as a reliable export market. The threat of capital flight was imminent as companies thought about taking their part of the production to Southeast Asia to avoid U.S. taxes. However, the financial markets began to indicate resiliency by mid-August despite the turmoil. Rupee that had gone down drastically, consolidated to about Rs. 87.2/ U.S. dollar. The decision to reduce political risk, anticipation of tax cuts, and the robust domestic consumption in India, to name a few, contributed towards boosting investor confidence. Rating agencies such as S&P and Moody's held their stable positions with both saying that the external trade had been hit, but the services sector of India and domestic demand cushioned them.

This pessimistic optimism implied that the tariffs were harmful, but the larger growth process in India still had some strength. The BJP and political leadership created an image of resiliency, with emphasis being laid on the nature of the crisis. Ministers pointed to a great domestic market in India and said the tariffs could not stop the overall growth momentum. Nevertheless, official reports were more bleak: almost 48.2 billion dollars in the form of exports was directly exposed to the U.S. tariffs. The difference in political assurance and economic statistics highlighted the issue of how to not only handle economic shocks but also how to handle the media and investor trust. India is now starting to reformulate its trade policy as the crisis continues to linger on. New policies were implemented to assist exporters through credit easing and subsidies.

Meanwhile, New Delhi rejuvenated its free trade agreement (FTA) talks with the European Union, the United Kingdom and ASEAN members as a means of diversification out of the U.S. market. Another policy that the crisis brought back is Atmanirbhar Bharat (self-reliance) with a focus on local production and supply chain diversification. In the field of economics, but even more so, the tariff war echoed into the field of geopolitics: the lack of trust increased in such areas as technology collaboration and security alliances. Unless it is resolved, analysts cautioned that the dispute may result in the commencement of the long-term re-calibration of the India-U.S. strategic equation.

The Strains at Their Peak: As at late August 2025, the tariff dispute between the United States and India was on the verge of its most dangerous stage. What started as a normal announcement of policy in late July had quickly moved into a full scale economic confrontation and had destabilized bilateral trust and caused ripple effects in the areas of trade, currency and diplomacy. The exporters of the core sectors like textiles, pharmaceuticals, gems and jewellery and auto parts became caught up in a vicious cycle of crashing orders and skyrocketing landed costs in the U.S and dwindling profit margins.

It was reported that small and medium size textile companies located in Tiruppur and Surat had to cease production lines, because millions of dollars worth of shipments lost their competitiveness in the U.S. market (turn0news15). Even the Cotton Association of India[13] pointed out that the

U.S. had dropped its purchases of cotton yarn by close to 50% an all-time low which made the industry take note of it. Business lobbies threatened that thousands of jobs in the hubs that rely on exports would be lost unless immediate relief measures are implemented. Macroeconomically, the tariffs worsened the already limited external account pressures in India. The deficit on trade was increasing in 2024 but the abrupt decline in the U.S. demand, which usually takes up approximately 55 percent of the large export base in India, posed a risk to cut merchandise incomes by up to 48.2 billion dollars (turn0news16).

The independent think tanks estimated the tariff shock to wipe off 0.5-0.6 percentage points off the GDP growth of India in FY2025-26 (turn0news19). Even though the rupee had temporarily recovered to the Rs.87.2/$ level in early summer (turn0news14), there was a massive threat of fresh depreciation should export inflows continue to be unstable. Diplomatically, the state of affairs broke towards mid-August. Negotiators of Indian trade openly requested that what they referred to as discriminatory tariffs be withdrawn as a breach of the spirit of WTO reciprocity. Washington, in its turn, justified the actions by a larger plan of mutual tariff alignment aimed at equalising the deficits, bilaterally. This solidified rhetoric increased distrust and the Ministry of Commerce in India publicly stated that they were considering retaliatory tariffs on American agricultural exports, technology equipment and spirits.

These actions were feared by analysts as they could lead to a full-scale trade war between the two countries. These growing fears started to be found in financial markets. The Bombay Stock Exchange textile index dropped drastically in mid-August and pulled the mood in other related sectors like chemicals and packaging. Foreign institutional investors (FIIs) moved into a wait-and-watch approach and reduced the rate at which they were pouring in funds in the manufacturing sector in India. Even credit rating agencies like S&P and Moody, which were nonetheless overall constructive on the growth potential of India in the long-term, sounded cautionary bells that the continued tariff disruptions might harm investor confidence in the Indian export-driven manufacturing narrative (turn0news18; turn0news 27).

The intense pressures, however, were the labour market ones, which were the most urgent. Cancelled contracts were easily translated into layoffs and wage cuts as the MSME sector in India comprised almost 30% of the exports. Textile clusters, diamond-polishing workshops and seafood processing factories were some of the worst affected workers. The issue was presented as not only an economic challenge but a possible social crisis, and trade unions threatened to develop a growing industrial unrest in case the relief measures were not implemented. The spectre of unemployment was approaching to destroy the fragile political economy of export-driven states. The war of tariff also led to a deeper breach of bilateral trust, as well as the direct economics. India and the U.S. had recently entered into an alliance in the midst of Indo-Pacific Strategic Partnership as a foundation of their long-term geopolitical agreement.

But by August 2025 the punitive tariff regime was increasingly being regarded in New Delhi as a form of economic coercion, in order to punish India by virtue of the diversification of its oil imports and by the fact that it sought a more advanced degree of strategic autonomy. This led to clumsy policy dilemmas: can India significantly deepen the interconnection between its defence and technology ties with Washington and simultaneously absorb economic earthquakes which would be delivered by the same partner? The tariff war between India and the U.S. had become a multi-dimensional crisis in the third week of August.

The export business was declining drastically in terms of the economy. Workers and MSMEs were socially weak as never before. Politically, the war was causing internal tension to the Indian government. Strategically, the two democracies had the lowest level of trust for more than ten years. It was as far as it was possible to go, to the extent where both nations were to lose everything unless corrective diplomacy and well-planned counter measures were immediately put into force.

Strategic Quandary: The Indian strategic dilemma concerning the U.S. tariffs is based on the aspect of short-term relief and long-term positioning. The policymakers have to consider the short-term requirements of the industries that rely on exports and the long-term effects on geopolitical alignment and political credibility at home. It is also not a one-dimensional issue but rather a strategic one since India has a tricky relationship with an ally and rival at the same time. The retaliatory tariffs on the American goods could be one of the possible answers. This would offer direct bargaining power and would be attractive to the domestic political feeling by indicating power. In economic terms, it may save weak areas and compel negotiators of the United States to think in terms of harsh treatment.

The risks are however, immense. Due to the possible transformation into a full-scale trade war, the export flows of India might be weakened, the relations in the defence and technology might be endangered, and the investors all over the world would suffer as they rely on the predictability of the trade relations. The other avenue is an option of an agreed settlement by making selective concessions. This would stabilize trade flows, minimize economic uncertainty and investor confidence would be reinstated. Politically, it presents India as a practical actor in the world by diplomacy, which has the ability to control conflicts. However, it has domestic risks: concessions may be seen as a sign of surrender, and the support of the population will reduce, and India will lose its bargaining power in the future in case of trade negotiations.

Alternatively, one can export diversification in the ASEAN, Africa, and Latin America. This would be a long-term solution to minimize the dependence on the U.S. market and increase the economic stability of India under the Atmanirbhar Bharat framework. In the political front, it strengthens the position of India as a market leader in South-South trade relations. However, economically this direction

is costly in terms of adjustments, which takes years to introduce new supply chains, create access points to markets and compete with experienced market participants, such as Vietnam and Bangladesh. Under this option, temporary remedy to ailing MSMEs is limited.

Direct cushioning of exporters is provided through domestic policy assistance such as subsidies, Production-Linked Incentive (PLI) schemes and credit relief to maintain employment in such weak industries as the textile industry and engineering goods. Politically, these actions show the efforts of the government to protect the livelihoods and the stability of industries. The risks are more fiscal in nature. Long term subsidies can put a strain on the finances of the government, be subject to WTO review as trade distorting, and are inefficient or poorly distributed. Lastly, India may practice a wait-and-watch policy and not confront but maintain the diplomatic lines open.

This approach conserves the flexibility and avoids unwarranted heightening, and allows time to evaluate U.S. intentions. However, it runs the risk of failing to alleviate the exporters in time, plunging the exporters into a sense of passive action, and Washington might even be encouraged to take even tougher action on trade. Overall, both of these tracks entail a sensitive equilibrium between any political indicators and the economic influence. Each of them presents its own set of risks which should be weighed, because India wants to safeguard its own short-term economic interests and not to lose the strategic plausibility in the unstable international trade arena.

CONCLUSION

The India-U.S. 2024-2025 tariff-face off reveals the expertise weakness of asymmetric trade relations and deep home exposure that emerging economies face in the wake of a sudden change of policy. The intensification, which was based on protectionist pressures, trade imbalances, and industry-specific lobbying, gave rise to extensive economic, political, and strategic implications to India. The short-term impact included the merchandise export business, currency fluctuations, inflation rates, and extreme stress on MSMEs in labour intensive industries like textiles, engineering products, chemicals, and processed foods. In addition to macroeconomic instability, the crisis revealed weaknesses in the institutional readiness of India to external shocks and it was also necessary to diversify the export markets, enhance domestic value chains, and reduce over-dependence on one trading partner.

The extended standoff also highlighted the vulnerability of strategic trust between the United States and India thus impacting on the wider collaboration in defence, technology and world governance. Finally, the tariff dispute shows that India should implement a more sustainable external economic policy, which includes trade diplomacy, diversification of supply chains, predictability of the policies, and a more competitive manufacturing sector so as to reduce the effects of future shocks. With global protectionism growing clearer, it will be the capability of India to strike the right balance between aggressive negotiations and the realization of lasting economic changes which will define its success amidst the growing turbulent environment in the trade arena.

Conflict of Interest: There is no conflict of interest from any of the authors associated with this research work.

Data Availability: All data are available with the corresponding author on reasonable request

REFERENCES

1. Ministry of Commerce and Industry (India). India–U.S. Bilateral Trade Statistics 2024. New Delhi: Government of India; 2024.Available from: https://commerce.gov.in/
2. Office of the United States Trade Representative (USTR). National Trade Estimate Report on Foreign Trade Barriers. Washington (DC): USTR; 2024. https://ustr.gov/about-us/policy-offices/press-office/reports-and-publications/2024-national-trade-estimate-report
3. World Bank. India Agricultural Support and Export Subsidy Assessment Report. Washington (DC): World Bank; 2024. https://www.worldbank.org/en/country/india/publication
4. Kumar A, Gupta R. U.S.–India disputes in IT and pharmaceutical trade: Labour and regulatory perspectives. New Delhi: Centre for Trade Studies; 2024 https://cts.org.in/
5. NASSCOM. India IT Exports Report 2024. New Delhi: National Association of Software and Service Companies; 2024. https://nasscom.in/knowledge-center/publications
6. EXIM Bank of India. Export Sector Review 2024. Mumbai: EXIM Bank; 2024. https://www.eximbankindia.in/research-reports
7. Reserve Bank of India. Annual Report on India's External Sector. Mumbai: RBI; 2024. https://www.rbi.org.in/Scripts/AnnualReportPublications.aspx
8. Global Trade Review. U.S. Sugar Alliance and allegations on Indian subsidies: Sectoral analysis. London: GTR; 2024. https://www.gtreview.com/
9. American Sugar Alliance. Policy position on Indian sugar exports and global price distortion. Washington (DC): ASA; 2024. https://sugaralliance.org/
10. Bhattacharya S. India's export dependency and macroeconomic stability: A policy dilemma. Kolkata: Institute of Economic Studies; 2024. https://ies.org.in/
11. Federation of Indian Chambers of Commerce and Industry (FICCI). Industry concerns on U.S. tariff hikes: Policy brief. New Delhi: FICCI; 2024. https://www.cii.in/PolicyAdvocacy.aspx
12. Confederation of Indian Industry (CII). Trade disruptions and MSME vulnerability report. New Delhi: CII; 2024. https://www.cii.in/PolicyAdvocacy.aspx
13. Cotton Association of India. Impact of U.S. tariff revisions on Indian textile and yarn exports. Mumbai: CAI; 2025. https://cottonassociation.in/

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Assessing Financial Literacy among Graduate Students in Jaipur, India

Anind Goswami*[1] and Pulock Bhattacharjee[2]

[1]Research Scholar, Department of Management & Commerce, S uresh Gyan Vihar University, Jaipur, India.

[2]CEO, American Academy for Financial Management, India Chapter, New Delhi, India.

ABSTRACT

Financial literacy has emerged as a critical determinant of economic stability, personal well-being, and long-term financial security, particularly among young adults transitioning from academic life to financial independence. Graduate students represent a pivotal group whose financial decisions influence future workforce productivity and societal economic resilience. This study aimed to assess the knowledge, attitude, and financial practices (KAP) related to financial literacy among graduate students in the Jaipur region, India, and to analyse differences across academic streams and gender. A cross-sectional questionnaire-based study was conducted among graduate students from arts, science, commerce, and professional programs between June and Oct 2025. A validated self-administered questionnaire assessing financial knowledge, financial attitude, and financial practices was distributed electronically. Data were analysed using descriptive statistics and chi-square tests. Students from commerce and professional programs demonstrated significantly higher financial knowledge and financial practice scores ($p < 0.001$). Financial attitude showed no independent statistically significant association with overall financial literacy. Female students scored significantly higher than males across all three domains ($p < 0.001$). The findings reveal substantial gaps in financial literacy among non-commerce graduate students. Integrating structured financial education into undergraduate curricula is essential to enhance responsible financial behaviour and preparedness for economic independence.

KEY WORDS: FINANCIAL LITERACY, KNOWLEDGE–ATTITUDE–PRACTICE, GRADUATE STUDENTS, JAIPUR, INDIA, CROSS-SECTIONAL STUDY.

INTRODUCTION

Financial literacy has increasingly been recognised as a core life competency that enables individuals to make informed decisions regarding income management, savings, credit utilisation, investments, and long-term financial planning [1,2]. In the contemporary economic environment—characterised by digital banking, easy access to consumer credit, rising education costs, and increasingly complex financial products—young adults are required to assume financial responsibility at an early stage of life [3]. Graduate students, in particular, represent a critical transitional group as they move from financial dependence to financial autonomy, often confronting decisions related to student loans, consumption patterns, and early career financial planning. Inadequate financial literacy during

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this phase may have long-term implications for individual financial stability and overall well-being.

Empirical evidence from different regions consistently demonstrates low to moderate levels of financial literacy among young adults. Studies from the United States and Europe indicate that many college graduates lack basic understanding of interest rates, inflation, and risk diversification despite higher educational attainment [4,5]. Similar trends have been observed in Asian economies, where financial knowledge gaps persist among university students [6]. In the Indian context, several studies report significant variation in financial literacy among graduate students across academic disciplines, with students from commerce and management backgrounds generally outperforming those from arts and science streams [7,8]. These findings suggest that formal education alone does not necessarily ensure adequate financial preparedness.

The consequences of financial illiteracy extend beyond individual outcomes and pose broader societal and economic challenges. Poor financial knowledge and practices among young adults have been associated with excessive indebtedness, insufficient savings, vulnerability to financial fraud, and inadequate retirement preparedness [9]. At the societal level, widespread financial illiteracy may contribute to economic instability, increased dependence on social welfare systems, and widening income inequalities [10]. Conversely, financially literate individuals are more likely to demonstrate responsible financial behavior, support household financial stability, and contribute to sustainable economic growth [11]. As a result, financial literacy has emerged as an important public policy and educational priority worldwide.

Despite growing scholarly attention, notable gaps remain in the existing literature. Many studies focus primarily on financial knowledge while giving limited consideration to financial attitudes and actual financial practices, thereby failing to capture the behavioral dimension of financial literacy [2,12]. Furthermore, the application of a comprehensive Knowledge–Attitude–Practice (KAP) framework among graduate students remains limited, particularly in the Indian context. Most Indian studies are concentrated in metropolitan areas or restricted to commerce and management students, leaving non-commerce graduate populations underexplored [7]. There is also a scarcity of region-specific evidence from tier-2 educational hubs such as Jaipur, which limits the development of targeted financial literacy interventions.

In light of these gaps, the present study aims to assess financial knowledge, attitudes, and practices related to financial literacy among graduate students in the Jaipur region using a structured KAP framework. The specific objectives are to evaluate levels of financial knowledge, examine attitudes toward money management and financial planning, and analyse financial practices such as budgeting, saving, and credit use. The study further seeks to compare financial literacy across academic streams and gender. By generating empirical evidence from an underrepresented population, this research contributes to the existing literature and provides insights for educators, policymakers, and curriculum designers. The study tests the hypotheses that financial knowledge and financial practices are significantly associated with overall financial literacy, whereas financial attitude alone may not independently predict financially responsible behaviour.

MATERIALS AND METHODS

A cross-sectional, questionnaire-based study was conducted between June 2025 and October 2025 to assess financial literacy among graduate students in the Jaipur region of Rajasthan, India. The study included students enrolled in diverse academic disciplines, namely arts, science, commerce, and professional programs such as management, engineering, and computer applications. The primary objective was to evaluate differences in financial knowledge, attitudes toward money management, and financial practices across student groups stratified by gender and academic stream.

Based on institutional enrollment records, the average annual intake across the selected colleges ranged from 70 to 80 students per discipline. The total eligible population comprised 520 graduate students, of whom 468 responded to the questionnaire. After exclusion of incomplete responses, 442 fully completed questionnaires were included in the final analysis, yielding an overall response rate of approximately 85%.

Participation in the study was entirely voluntary. The inclusion criteria consisted of undergraduate students enrolled in the final or pre-final year of graduate programs who provided informed consent. Exclusion criteria included postgraduate students, students possessing formal professional financial certifications, and respondents who either declined consent or submitted incomplete questionnaires. At the time of the study, none of the participating institutions had a mandatory or structured financial literacy course integrated into the undergraduate curriculum for non-commerce disciplines.

All eligible students across the selected disciplines were approached, as they were expected to enter the workforce or pursue higher education in the near future and would therefore be required to make independent financial decisions. Assessing financial literacy at this transitional stage was considered appropriate for evaluating preparedness for financial independence. The study protocol was reviewed and approved by the Institutional Ethics/ Research Review Committee, and confidentiality and anonymity of participant responses were strictly maintained.

The study employed a validated, self-administered questionnaire adapted from previously published financial literacy and Knowledge–Attitude–Practice (KAP)-based instruments [1–4]. The questionnaire comprised four sections: demographic characteristics, financial knowledge, financial attitude, and financial practices. Demographic variables included age, gender, academic stream, prior exposure to finance-related subjects, and family income category.

The instrument consisted of a total of 34 items, systematically organized into four sections. Items 1–8 captured the general demographic characteristics of the respondents, including age, gender, academic stream, and prior exposure to finance-related subjects.

Table 1. Questionnaire assessing knowledge, attitude, and financial practices related to financial literacy

Financial Knowledge

- Have you heard of the term "financial literacy"?
- Do you understand the concept of budgeting and expense tracking?
- Do you know how simple and compound interest work?
- Are you aware of the impact of inflation on purchasing power?
- Do you understand the difference between saving and investment?
- Are you aware of basic investment options such as fixed deposits, mutual funds, or equities?
- Do you understand credit scores and their importance?
- Do you know the consequences of excessive debt and late repayments?

Financial Attitude

- Do you believe financial planning is important at a young age?
- Do you agree that saving regularly is essential for financial security?
- Do you believe borrowing should be avoided unless absolutely necessary?
- Do you feel confident in making financial decisions independently?
- Do you consider long-term financial goals while spending money?
- Do you believe financial literacy should be a compulsory part of higher education?
- Do you feel that financial risks should be carefully evaluated before investing?
- Do you believe financial discipline contributes to a better quality of life?

Financial Practices

- Do you prepare a monthly budget for your expenses?
- Do you regularly save a portion of your income or allowance?
- Do you track your spending habits?
- Do you use digital payment platforms responsibly?
- Have you ever invested or planned to invest in financial instruments?
- Do you avoid unnecessary borrowing or credit card use?
- Do you discuss financial decisions with family members?
- Do you plan financially for future goals such as higher education or career development?

Questions 9 to 18 were designed to assess financial knowledge, focusing on core concepts such as budgeting, interest rates, inflation, savings, investments, credit, and debt management. Questions 19 to 26 evaluated financial attitudes, examining respondents' perceptions and beliefs regarding money management, saving behaviour, financial planning, risk-taking, and the perceived importance of financial literacy. Finally, Questions 27 to 34 assessed financial practices, capturing self-reported behaviours related to budgeting, saving, spending discipline, use of digital financial services, borrowing habits, and future financial planning.

The financial knowledge items were of a nominal nature with response options including Yes, No, and Don't Know. The financial attitude and financial practice items were measured using a five-point Likert scale ranging from Strongly Agree to Strongly Disagree. Higher scores indicated better financial knowledge, a more positive financial attitude, and healthier financial practices. Scores equal to or above 50% of the maximum attainable score were categorised as high, while scores below 50% were categorised as low.

The questionnaire was distributed electronically using an online survey platform. Participants were instructed to complete the questionnaire independently without discussion. Collected data were entered into Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY, USA). Categorical variables were analysed using descriptive statistics, and associations between variables were tested using the Chi-square test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Out of the 520 graduate students who were approached to participate in the study, 468 students responded to the questionnaire. After excluding incomplete responses, 442 questionnaires were found to be complete and suitable for

analysis, resulting in a response rate of 85% . The study population consisted of 234 male students (52.9%) and 208 female students (47.1%). The baseline demographic characteristics of the respondents are summarized in Table 2.

Table 2. Demographic characteristics of graduate students participating in the financial literacy study (n = 442)

Category	n (%)
Age (years)	
< 20	96 (21.7%)
20–22	214 (48.4%)
23–25	132 (29.9%)
>25	0 (0%)
Gender	
Male	234 (52.9%)
Female	208 (47.1%)
Academic Stream	
Arts	106 (24.0%)
Science	93 (21.0%)
Commerce	115 (26.0%)
Professional Courses (Management, Engineering, MCA, etc.)	128 (29.0%)
Marital Status	
Single	397 (89.8%)
Married	45 (10.2%)
Number of Dependent Family Members	
≤2	142 (32.1%)
3–4	176 (39.8%)
5–6	92 (20.8%)
>6	32 (7.3%)
Prior Exposure to Finance-related Subjects	
Yes	171 (38.7%)
No	271 (61.3%)

Table 3. Stream-wise comparison of knowledge, attitude, and financial practice scores among graduate students in Jaipur (n = 442)

Financial Knowledge	Low Score(<50% of maximum score) n (%)	High Score (≥50% of maximum score) n (%)	p value
Arts	74 (69.8%)	32 (30.2%)	
Science	59 (63.4%)	34 (36.6%)	
Commerce	29 (25.2%)	86 (74.8%)	0.001**
Professional Courses	34 (26.6%)	94 (73.4%)	0.001**
Financial Attitude			
Arts	66 (62.3%)	40 (37.7%)	
Science	58 (62.4%)	35 (37.6%)	
Commerce	42 (36.5%)	73 (63.5%)	0.001**
Professional Courses	41 (32.0%)	87 (68.0%)	0.001**
Financial Practices			
Arts	79 (74.5%)	27 (25.5%)	
Science	66 (71.0%)	27 (29.0%)	
Commerce	31 (27.0%)	84 (73.0%)	0.001**
Professional Courses	38 (29.7%)	90 (70.3%)	0.001**

The demographic profile indicates that the majority of participants were young adults aged between 20 and 25 years, reflecting the typical age distribution of graduate students in the Jaipur region. A nearly balanced gender distribution was observed. With respect to the academic stream, students from commerce and professional courses together constituted more than half of the study population, while arts and science students formed a substantial proportion.

Preliminary analysis revealed that financial knowledge and financial practice scores were significantly higher among commerce and professional-course students compared to arts and science students ($p < 0.001$). Female students demonstrated comparatively higher scores across the domains of financial knowledge, attitude, and practices than their male counterparts ($p < 0.001$). These variations underscore the influence of academic exposure and demographic factors on financial literacy levels among graduate students.

The analysis revealed that financial knowledge scores were significantly higher among commerce and professional-course students, whereas students from arts and science streams demonstrated uniformly lower knowledge levels ($p = 0.001$). A similar trend was observed for financial practices, where commerce and professional students exhibited significantly better budgeting, saving, and spending behaviours compared to their counterparts ($p = 0.001$). Although financial attitude scores were relatively positive across all streams, they were still significantly higher among commerce and professional students, indicating that academic exposure to finance positively influences financial outlook and behaviour.

Table 4. Gender-wise comparison of knowledge, attitude, and financial practice scores among graduate students (n = 442)

Financial Knowledge	Low Score(<50% of maximum score) n (%)	High Score (≥50% of maximum score) n (%)	p value
Male (n = 234)	146 (62.4%)	88 (37.6%)	
Female (n = 208)	50 (24.0%)	158 (76.0%)	0.001*
Financial Attitude			
Male (n = 234)	142 (60.7%)	92 (39.3%)	
Female (n = 208)	65 (31.3%)	143 (68.7%)	0.001*
Financial Practices			
Male(n =234)	159 (67.9%)	75 (32.1%)	
Female(n=208)	54 (26.0%)	154 (74.0%)	0.001*

On evaluating financial literacy across gender, it was observed that female graduate students scored significantly higher than males across all three domains—financial knowledge, financial attitude, and financial practices. These differences were found to be statistically significant ($p < 0.001$)(Table 4). The higher scores among female students may reflect greater financial caution, disciplined spending behaviour, and stronger orientation toward saving and long-term financial planning.

DISCUSSION

The present study provides a comprehensive assessment of financial literacy among graduate students in Jaipur using a Knowledge–Attitude–Practice (KAP) framework. The findings indicate that financial literacy is significantly influenced by academic stream and gender, with students enrolled in commerce and professional courses demonstrating higher financial knowledge, more positive financial attitudes, and healthier financial practices than their counterparts from arts and science streams. Female students consistently outperformed male students across all three domains. These results suggest that financial literacy among graduate students is heterogeneous and shaped by both educational exposure and demographic factors.

The significantly higher financial knowledge scores observed among commerce and professional-course students are consistent with findings from previous international and Indian studies, which demonstrate that formal exposure to finance-related subjects enhances understanding of core financial concepts such as interest rates, inflation, and investment diversification [1–3].

Similar patterns have been reported among university students in the United States and Europe, where those enrolled in business or economics programs consistently exhibit superior financial knowledge compared with non-commerce peers [4]. The lower knowledge levels among arts and science students observed in the present study likely reflect the absence of structured financial education within their curricula.

In parallel with financial knowledge, financial practices such as budgeting, saving, and controlled spending were significantly better among commerce and professional students. This finding supports earlier evidence indicating that financial knowledge is more likely to translate into responsible financial behaviour when reinforced through education and practical exposure [5,6]. However, studies from developing economies have reported weaker

associations between financial knowledge and practice due to contextual constraints such as low income levels or limited access to financial instruments [7].

The stronger association observed in the present study may be attributed to increasing digital financial inclusion and greater exposure to banking and digital payment platforms among urban graduate students in Jaipur. Although financial attitude scores were generally positive across all academic streams, commerce and professional students demonstrated significantly higher scores. This observation aligns partially with prior studies suggesting that attitudes toward saving and financial planning are shaped not only by education but also by family environment, peer influence, and socio-cultural norms [8,9].

Importantly, the findings support earlier evidence that positive financial attitudes alone do not necessarily translate into sound financial practices, underscoring the critical role of applied financial knowledge [10,5].A notable finding of this study is the consistently higher financial literacy scores among female students across all domains. This result is consistent with several Indian and international studies reporting greater financial caution, saving orientation, and long-term planning tendencies among women [2,11]. In contrast, some global studies have reported higher financial knowledge levels among men [1], highlighting contextual variability. The higher performance of female students in the present study may reflect evolving socio-economic roles, increasing financial awareness, and greater risk aversion among young women in urban Indian settings.

The findings have important implications at both individual and societal levels. Inadequate financial literacy among arts and science graduates may predispose them to poor financial decision-making, excessive debt, and long-term financial vulnerability, cumulatively affecting household stability and economic resilience [12]. Given that graduate students constitute the future workforce, integrating financial literacy education across all academic disciplines could enhance personal financial well-being and promote informed engagement with the formal financial system. These results reinforce the growing consensus that financial literacy should be regarded as a core life skill rather than a discipline-specific competency.

Despite its strengths, the study has certain limitations. The cross-sectional design restricts causal inference, and reliance on self-reported data may introduce response bias. Additionally, the study's focus on a single urban region limits generalizability to rural or socio-economically diverse populations. Future studies should adopt longitudinal designs to examine changes in financial literacy over time and evaluate the impact of targeted financial education interventions. Expanding research across multiple regions and incorporating qualitative methods could provide deeper insights into behavioural and contextual determinants of financial literacy among young adults.

CONCLUSION

This study demonstrates that financial literacy among graduate students in the Jaipur region varies significantly by academic stream and gender, with commerce and professional-course students exhibiting higher financial knowledge, more positive attitudes, and healthier financial practices than arts and science students. While attitudes toward financial planning were generally favourable, they did not consistently translate into sound financial behaviour in the absence of structured financial education. Female students outperformed males across all domains, highlighting the influence of demographic factors on financial decision-making. Overall, the findings underscore the need to integrate financial literacy as a core component of undergraduate education across disciplines to enhance financial preparedness, promote responsible financial behaviour, and support long-term economic well-being.

Data Availability: The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest: The authors declare that they have no conflicts of interest.

REFERENCES

1. Remund DL. Financial literacy explicated: The case for a clearer definition in an increasingly complex economy. J Consum Aff. 2010;44(2):276-295. doi:10.1111/j.1745-6606.2010.01169.x
2. Huston SJ. Measuring financial literacy. J Consum Aff. 2009;44(2):296-316. doi:10.1111/j.1745-6606.2010.01170.x
3. Lusardi A. Financial literacy and the need for financial education: Evidence and implications. Swiss J Econ Stat. 2019;155(1):1-8. doi:10.1186/s41937-019-0027-5
4. Lusardi A, Mitchell OS. The economic importance of financial literacy: Theory and evidence. J Econ Lit. 2014;52(1):5-44. doi:10.1257/jel.52.1.5
5. Van Rooij M, Lusardi A, Alessie R. Financial literacy, retirement planning and household wealth. Econ J. 2012;122(560):449-478. doi:10.1111/j.1468-0297.2012.02501.x
6. Kadoya Y, Khan MSR, Oba H, Narumoto J. Financial literacy and anxiety about life in old age: Evidence from Japan. J Risk Res. 2017;21(10):1-18. doi:10.1080/13669877.2017.1313760
7. Bhushan P, Medury Y. An empirical analysis of inter linkages between financial attitudes, financial behavior and financial knowledge of salaried individuals. Indian J Commer Manag Stud. 2014;5(3):58-64.
8. Agarwalla SK, Barua SK, Jacob J, Varma JR. Financial literacy among working young in urban

India. World Dev. 2015;67:101-109. doi:10.1016/j.worlddev.2014.10.004
9. Lusardi A, Tufano P. Debt literacy, financial experiences, and overindebtedness. J Pension Econ Finance. 2015;14(4):332-368. doi:10.1017/S1474747215000232
10. OECD. OECD/INFE international survey of adult financial literacy competencies. Paris: Organisation for Economic Co-operation and Development; 2016.
11. OECD. G20/OECD INFE report on adult financial literacy in G20 countries. Paris: Organisation for Economic Co-operation and Development; 2017.
12. Sabri MF, Lee SY. Financial literacy, behavior and vulnerability among Malaysian households: Does gender matter? Int J Econ Manag. 2017;11(1):1-18.

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Environmental Management Systems and Microplastic Pollution: Bridging Science, Policy, and Practice

Darakhshan Khan
Department of Biotechnology, Sant Hirdaram Girls College, Bhopal, 462030 (MP) India.

ABSTRACT
Microplastic pollution has become a major environmental concern due to its persistence, ubiquity, and complex impacts. Defined as plastic particles smaller than 5 mm, microplastics originate from primary sources such as microbeads and synthetic fibres, and secondary fragmentation of larger plastics. Their widespread presence in water, soil, and air raises serious risks for ecosystems, food safety, and human health. Traditional Environmental Management Systems (EMS), including ISO 14001, were not designed to address pollutants of such microscopic scale and diverse composition. This review synthesises current knowledge on microplastic sources, pathways, and impacts, while exploring how EMS can evolve to integrate microplastic specific strategies. Embedding microplastic management into EMS aligns with sustainability agendas such as circular economy practices and extended producer responsibility. Achieving this requires technological innovation, improved recycling, biodegradable alternatives, and governance mechanisms that harmonise standards. Interdisciplinary collaboration is essential to strengthening EMS frameworks and mitigating microplastic pollution effectively.

KEY WORDS: MICROPLASTICS, ENVIRONMENTAL MANAGEMENT SYSTEMS, POLLUTION MITIGATION, SUSTAINABILITY, HUMAN HEALTH.

INTRODUCTION

Plastic pollution has emerged as one of the most pressing environmental challenges of the 21st century, with microplastics, i.e., plastic particles smaller than 5 mm, representing a particularly insidious form of contamination [1]. Unlike larger plastic debris, microplastics are pervasive, persistent, and capable of infiltrating nearly every environmental compartment, including marine and freshwater systems, soils, and the atmosphere [2,3]. Their ubiquity is driven by both primary sources (manufactured microbeads, industrial abrasives, synthetic fibres) and secondary sources (fragmentation of larger plastic items through weathering, mechanical abrasion, and photodegradation). As a result, microplastics are now recognised as an emerging pollutant with global relevance, raising concerns for ecological integrity, food safety, and human health [4].

The environmental management of microplastics presents unique challenges. Traditional Environmental Management Systems (EMS), such as those guided by ISO 14001 standards, were designed to address broader categories of pollution and resource use. However, the microscopic scale, diverse polymer composition, and complex environmental behaviour of microplastics complicate monitoring, risk assessment, and mitigation within existing EMS frameworks, [5,6]. Unlike conventional pollutants, microplastics are not easily captured by standard treatment technologies, nor are

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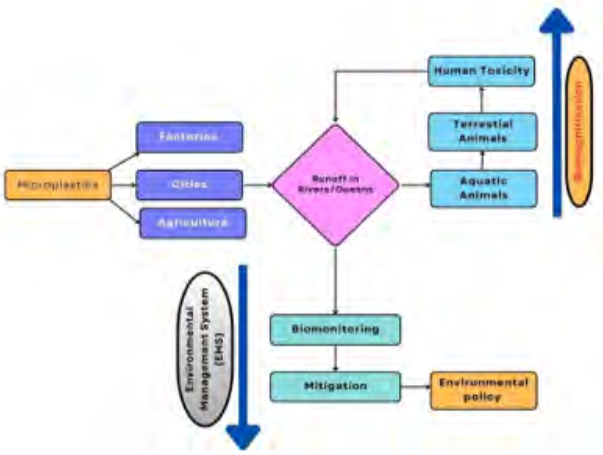
they consistently regulated across jurisdictions. This gap underscores the need to integrate microplastic-specific strategies into EMS, aligning scientific advances with policy and industry practices [7].

Microplastics also pose multifaceted risks. Ecologically, they can disrupt food webs, reduce biodiversity, and alter ecosystem functions. Chemically, they act as vectors for additives and persistent organic pollutants, potentially amplifying toxicity. Biologically, laboratory studies suggest that microplastics may induce oxidative stress, inflammation, and endocrine disruption in organisms, though human health implications remain under investigation [8,9]. These uncertainties demand precautionary approaches, particularly in regions such as Asia, where rapid industrialisation, high population density, and inadequate waste management systems exacerbate plastic leakage into the environment [10,11].

Figure 1: ***schematic overview of microplastic pathways, biomagnification and management strategies.***



At the same time, microplastic pollution intersects with broader sustainability agendas, including the circular economy, extended producer responsibility, and corporate environmental accountability. Embedding microplastic management into EMS offers a pathway to operationalise these agendas, enabling organisations to systematically identify, monitor, and reduce microplastic emissions [12,13]. This integration requires not only technological innovation such as advanced filtration, biodegradable materials, and improved recycling but also governance mechanisms that harmonise standards, foster transparency, and encourage stakeholder participation (fig.1).

This review therefore aims to synthesise current knowledge on microplastic pollution and critically examine how Environmental Management Systems can evolve to address this emerging challenge. By exploring sources, pathways, impacts, and management responses, it highlights both the scientific complexities and the institutional opportunities for embedding microplastic risk into EMS frameworks. Ultimately, the paper seeks to chart future directions for research, policy, and practice, emphasising the importance of interdisciplinary collaboration in mitigating microplastic pollution and safeguarding environmental and human health.

Sources and Pathways of Microplastics: Microplastics are divided into two types: primary and secondary microplastics. Primary microplastic is synthetic microbeads developed for domestic and industrial purposes. Microbeads are used as raw materials in the plastic industry for cosmetics, detergents, and other hygiene and personal care products [14]. About 93% of the microplastics used as microbeads in personal-care products and cosmetics were composed of microplastics. These tiny microbeads can be transported to wastewater treatment plants, released into rivers from water treatment plants, and enter into the oxidation ponds and sewage sludge or eventually into the sea on a global scale [15,16]. These microplastic particles can also pass-through filtration systems into the water bodies and affect aquatic habitats [17].

Secondary microplastics are plastic particles which get fragmented by photo-degradation, mechanical abrasions, and physical and biochemical reactions. It includes fishing nets, industrial resin pellets, domestic items, and other discarded plastic debris [18]. Other sources of secondary microplastic include effluent treatment plants, landfills, irrigation, industrial wastewater and domestic usage [19]. Microplastics in the environment appear in different shapes and sizes in the form of spheres, beads, pellets, foam, fibres, fragments, films, and flakes.

The morphology and texture of microplastic particles depend on the type of polymer used to make its original form as the manufacturers aim to develop plastics with certain features (e.g., flexibility, roughness, resistance, and durability) [20]. For example, polyurethane (PU) is a polymer used to make flexible foams. Polyethene terephthalate (PET) in textile fibres and drink bottles, and Polystyrene (PS) in packaging and building insulation. However, these polymers are composed of diverse monomers, which might be detrimental to the environment [21]. The shape of secondary microplastic particles is also influenced by the fragmentation process and the retention time in the environment [22].

The colour of microplastic particles helps identify the sources of plastic fragments and potential pollutants during sample preparation [23]. Colour can also enable the separation of distributed microplastic among large quantities from other debris. In previous studies, microplastics have been evident in different colours including red, orange, yellow, brown, tan, off-white, white, grey, blue, green, and so on [24].

The animals always tend to ingest MPs similar in colour to their prey. The colour can also affect the intake of microplastics by aquatic organisms. In a study, Schuyler et al. reported that sea turtles often die due to the accidental intake of transparent and white plastic fragments [25,26]. These diverse types of microplastics in the environment,

which differ in shape, colour, and size, have different likelihoods of ingestion by aquatic biota has become the growing problem of plastic pollution [27].

Environmental Distribution and Impacts

Microplastics in aquatic ecosystems: Aquatic ecosystems are major sinks for global plastic pollution, with microplastics now pervasive in marine and freshwater systems. Their persistence and interactions with biota make them key targets for environmental management. Understanding their sources, distribution, and impacts is vital for effective monitoring and mitigation [28,29]. Over the past two decades, research has documented microplastics as widespread and ecologically significant. Rivers and coastal runoff are primary sources, fragmenting into microplastics that accumulate in ocean gyres and sediments [30,31]. Fishing gear, aquaculture, and shipping further contribute to marine microplastic loads. Biofouling and vertical transport facilitate sinking, contaminating benthic habitats and sediments [32]. Marine studies show plankton ingest microplastics, reducing feeding efficiency and disrupting energy transfer [33,34]. Microplastics also affect microbial communities, potentially altering nutrient cycling and ecosystem resilience [35,36,37]

Freshwater systems have received less attention, but recent research highlights rivers as key pathways transporting microplastics from land to sea. Major sources include urban wastewater, stormwater runoff, and industrial discharges, with inadequate treatment in many Asian cities worsening contamination [38,39]

Freshwater studies report microplastic ingestion by zooplankton, invertebrates, and fish, impacting growth and survival. Microplastics can carry heavy metals and pollutants, increase chemical risks, and alter sediment quality, potentially disrupting ecological processes [40,41]. Marine systems show greater diversity of microplastics due to multiple sources and currents, while freshwater systems reflect localized urban and industrial inputs. Various Asian studies report high microplastic concentrations in rivers and coasts, linked to poor waste management and industry [42,43]. Aquaculture faces increasing risks, and monsoons accelerate plastic transport, compounding management challenges [44,45] The significant gaps remain, including inconsistent methods and limited understanding of long-term ecological impacts. Translating laboratory findings to natural populations is challenging [46]. The literature calls for standardized monitoring, interdisciplinary research, and integration of microplastic indicators into environmental management Systems.

Microplastics in Terrestrial Environments and their Contamination: Microplastic contamination in terrestrial environments has received increasing scholarly attention, as soils and land-based systems are now recognized as significant reservoirs and pathways for plastic pollution. Although initial research focused on marine ecosystems, subsequent studies have shown that terrestrial environments may contain higher concentrations of microplastics, primarily due to direct inputs from agriculture, waste management, and urban activities [47,48].

Several studies have documented the presence of microplastics in agricultural soils, especially in regions where plastic mulch films are widely used. These films, used to conserve moisture and control weeds, degrade over time and fragment into microplastic particles that are found in soil matrices [49,50]. The application of sewage sludge as fertiliser constitutes another major source, introducing microplastics originating from wastewater effluents and household products. Evidence indicates that microplastics in soils can alter soil structure, reduce porosity, and impact microbial communities, with potential consequences for nutrient cycling and crop productivity [51,52] Experimental studies further suggest that microplastics may indirectly influence plant growth by modifying soil physicochemical properties, although findings remain inconsistent across species and soil types [53].

Landfills and open dumping sites are critical sources of terrestrial microplastic contamination. Inadequately managed landfills permit plastics to fragment under mechanical stress and ultraviolet exposure, releasing microplastics into adjacent soils and leachates. These particles may migrate into groundwater or be transported by surface runoff into rivers and lakes. Research in Asia demonstrates that informal waste disposal practices, such as open burning and unregulated dumping, intensify microplastic leakage into terrestrial systems [54,55]. The absence of engineered control structures in many developing regions further elevates the risk of widespread contamination.

Urban dust, tire wear particles, and synthetic textile fibres contribute substantially to terrestrial microplastic loads. Road runoff and atmospheric deposition introduce microplastics into soils, primarily in densely populated and industrialized areas. Industrial zones, including plastic manufacturing and recycling facilities, have been identified as hotspots for soil contamination, with elevated concentrations of microplastics detected in surrounding areas [56,57]. These observations emphasize the role of urbanization and industrial activity in molding terrestrial microplastic profiles.

Microplastics in soils interact with biota at various levels. Earthworms and other soil invertebrates ingest microplastics, which can disrupt growth, reproduction, and survival [58]. Reported alterations in soil microbial communities raise concerns regarding long-term impacts on soil fertility and ecosystem services. Additionally, microplastics can adsorb heavy metals and organic pollutants, serving as vectors for chemical co-contaminants [59]. This dual role as both physical and chemical stressors complicates risk assessment and management strategies.

The combination of intensive agriculture, widespread use of plastic mulching, and inadequate waste management infrastructure renders terrestrial microplastic contamination particularly acute in Asian countries. Studies conducted in

China, India, and Southeast Asia have documented high concentrations of microplastics in agricultural soils, often linked to sludge application and the use of plastic film [60,61,62]. Informal recycling and landfill practices have contributed to extensive contamination. Seasonal monsoons and flooding events further facilitate the transport of microplastics from terrestrial to aquatic systems, reinforcing the connection between environmental compartments.

Although evidence is increasing, research on terrestrial microplastics remains less developed than studies focused on aquatic environments. Variations in sampling and extraction methodologies hinder comparability across studies. Long-term ecological impacts on soil health and crop yields are poorly understood, and few studies have examined human exposure pathways via terrestrial contamination (e.g., crops grown in contaminated soils). The literature emphasizes the need for standardized protocols, interdisciplinary approaches, and integration of terrestrial monitoring into environmental management systems.

Human Health Implications: Microplastics have been detected across multiple trophic levels, raising concerns about their transfer through food chains and eventual human exposure. The literature consistently highlights ingestion of microplastics by aquatic organisms, accumulation in edible tissues, and the potential for biomagnification, though the extent of human health risks remains under investigation [63,64]. Early studies demonstrated that plankton readily ingest microplastics, mistaking them for food particles. This ingestion reduces feeding efficiency and alters energy assimilation, weakening the base of aquatic food webs [14]. Subsequent research confirmed that fish and shellfish accumulate microplastics in gastrointestinal tracts, with evidence of trophic transfer to higher predators [65].

Microplastics have been detected in commercially important seafood species, including fish, bivalves, and crustaceans, raising concerns about dietary exposure [66]. Studies report microplastics in table salt, bottled water, and even staple foods, suggesting that ingestion is not limited to seafood consumption [67]. Human stool samples analysed in pilot studies have confirmed the presence of microplastics, providing direct evidence of exposure [68]. While the toxicological implications remain uncertain, ingestion of microplastics and associated chemicals (e.g., additives, persistent organic pollutants) is considered a plausible risk factor for gastrointestinal and systemic health effects.

In addition to ingestion, inhalation of airborne microplastics represents another exposure route. Indoor environments, particularly those with synthetic textiles, show elevated concentrations of airborne fibres [69]. Occupational studies in textile and plastic industries report respiratory symptoms linked to microplastic exposure, though general population data remain limited. Dermal exposure through personal care products containing microbeads has been suggested, but current evidence indicates this pathway is less significant compared to ingestion and inhalation. Microplastics may interact with skin microbiota or penetrate through wounds, though these pathways remain poorly studied [70]

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Experimental studies demonstrate that small microplastics and nano plastics can cross biological barriers under certain conditions, potentially reaching systemic circulation. In vitro research shows cytotoxicity, genotoxicity, and endocrine-disrupting effects, raising concerns about long-term systemic impacts [71]. The role of microplastics as vectors for chemical additives and sorbed pollutants further complicates risk assessment, as these compounds may contribute to endocrine, metabolic, or carcinogenic outcomes independent of the particle itself.

The dependence on seafood and aquaculture in Asian countries increases dietary exposure risks. Research conducted in China, India, and Southeast Asia has identified microplastics in fish and shellfish available in local markets, frequently associated with polluted rivers and coastal waters [72,73]. Additionally, the extensive consumption of bottled water and salt derived from contaminated sources further elevates exposure. Informal recycling practices and the open burning of plastics intensify atmospheric contamination, thereby raising inhalation risks among urban populations. However, only a few studies have actually quantified human intake levels or assess long-term health outcomes which emphasises the need for standardised exposure assessment, longitudinal epidemiological studies, and integration of human biomonitoring into environmental management systems.

Environmental Management Systems (EMS) Framework
Environmental Management Systems (EMS) provide structured approaches for organizations to monitor, evaluate, and mitigate environmental impacts. Traditionally guided by frameworks such as ISO 14001, EMS have been applied to issues including air pollution, wastewater management, and resource efficiency [5]. However, the emergence of microplastics as a pervasive pollutant has prompted scholars and policymakers to consider how EMS can adapt to address this new challenge.

Recent literature suggests that EMS can incorporate microplastic indicators into water quality assessments, waste audits, and product life-cycle analyses. For example, wastewater treatment plants could integrate microplastic monitoring into EMS reporting, enabling organizations to track emissions and evaluate treatment efficiency [74]. Similarly, industries dependent on synthetic textiles or plastics could adopt EMS-based monitoring of fiber release during production and use [75].

EMS frameworks align closely with circular economy principles, which aim to minimize waste and maximize resource efficiency. Scholars argue that integrating microplastic management into EMS can support extended producer responsibility (EPR), encouraging industries to design products that shed fewer fibres or use biodegradable alternatives [76]. This integration also facilitates compliance with emerging regulations targeting single-use plastics and microplastic emissions. It also have been reported that EMS can serve as a bridge between scientific evidence and policy implementation, translating microplastic research into actionable management practices [77]. Regional studies in Asia highlight the need for harmonized standards and

intergovernmental cooperation, given the transboundary nature of plastic pollution. Incorporating microplastic indicators into EMS audits could strengthen accountability and foster regional collaboration [78,79].

Microplastic pollution has emerged as a global governance challenge, requiring coordinated policy responses across local, national, and international levels. The literature highlights the complexity of regulating microplastics due to their diverse sources, microscopic size, and transboundary movement, while also emphasizing the role of environmental management systems (EMS) in operationalizing policy frameworks [80,81].

Global institutions have increasingly recognized microplastics as a priority pollutant. The United Nations Environment Programme (UNEP) has called for urgent action to address marine litter and microplastics, framing them as threats to ecosystems, food security, and human health [77]. The Basel Convention has expanded its scope to include plastic waste, promoting transboundary control and environmentally sound management [82]. Regional initiatives, particularly in the European Union (EU), have advanced regulatory frameworks targeting microplastics. The EU has restricted the use of microbeads in cosmetics and proposed measures to reduce microplastic emissions from textiles, tires, and paints [83]

In Asia, national responses vary: China has banned microbeads in personal care products, while India and Southeast Asian countries are strengthening plastic waste management policies. However, enforcement challenges and infrastructural limitations hinder effective implementation in many developing economies [84].

These evidences emphasizing several governance challenges, such as lack of harmonized definitions and monitoring protocols complicates regulation and compliance; Rivers and ocean currents transport microplastics across borders, requiring regional cooperation; Extended producer responsibility (EPR) frameworks are unevenly applied, limiting incentives for product redesign; Limited risk communication hampers consumer engagement and behavioural change.

Preventive Strategies & Innovations: The growing recognition of microplastics as an emerging pollutant has prompted research into technological innovations and management strategies aimed at reducing emissions, enhancing removal, and preventing environmental leakage. Studies consistently identify inadequate waste management as a major driver of microplastic pollution. Mechanical and chemical recycling technologies have advanced, though challenges remain in maintaining polymer quality and preventing secondary microplastic generation [85,86]. Biodegradation approaches, including microbial and enzymatic breakdown of plastics, are being explored as sustainable alternatives, though scalability and efficiency are still limited [87].

Asia faces unique challenges due to rapid industrialisation, high plastic consumption, and limited waste infrastructure. Industrial sectors such as textiles, packaging, and fisheries are significant contributors to microplastic emissions. Previous literature have been suggested that adopting best practices—such as reducing microfibre shedding in textiles, redesigning packaging to minimise fragmentation, and implementing gear recovery programs in fisheries—can substantially reduce emissions [88]. The research also highlights innovations in biodegradable polymers, green chemistry, and product redesign to minimise fragmentation and fibre release [89].

Consumer-level interventions, such as washing machine filters to capture textile fibres, also contribute to emission reduction. EMS frameworks can support preventive strategies by embedding microplastic indicators into product audits and sustainability reporting. Studies have been showed the importance of scaling up waste management innovations, improving wastewater treatment capacity, and promoting industry accountability in textile and packaging sectors [90,91].

Also, wastewater treatment plants (WWTPs) are recognized as critical nodes for microplastic removal. Advanced technologies, including membrane bioreactors, rapid sand filtration, and dissolved air flotation, have demonstrated improved removal efficiencies. Integration of microplastic monitoring into WWTP EMS frameworks is recommended to track performance and guide upgrades [92].

However, Few studies evaluate the long-term effectiveness and scalability of technologies in diverse contexts. Economic feasibility and social acceptance of interventions remain underexplored. The integration of microplastic management into EMS frameworks is still nascent, requiring interdisciplinary research to operationalize monitoring, reporting, and continuous improvement.

Future Perspectives: The significant advances in understanding microplastic pollution, the literature consistently underscore that research remains fragmented and incomplete. Current studies provide strong evidence of microplastic ubiquity and plausible ecological and health risks, yet translating these findings into comprehensive management strategies and policy frameworks is still a work in progress [93,94].

One of the most frequently cited limitations is the lack of standardised methodologies for sampling, extraction, and identification of microplastics. Studies vary widely in particle size thresholds, polymer identification techniques, and contamination control measures, making cross-comparison difficult [95]. The absence of harmonized protocols hampers meta-analyses and global assessments, underscoring the need for international consensus on methodological standards.

While biomonitoring studies have detected microplastics in human stool, blood, and respiratory samples, quantitative exposure data remain scarce. Few studies have established dose–response relationships or long-term health outcomes in humans [68,71]. Risk assessment frameworks are challenged by the dual role of microplastics as physical

particles and chemical vectors, complicating toxicological evaluations. Future research must integrate particle characteristics, co-contaminants, and biological responses to develop robust risk models.

Most ecological studies focus on individual organisms or laboratory exposures, with limited data on population-level or ecosystem-scale consequences [96]. Long-term monitoring of biodiversity, food webs, and ecosystem services is needed to assess cumulative impacts. This also highlights the importance interdisciplinary approaches that link ecotoxicology, ecology, and socioeconomics to evaluate microplastic pollution alters ecosystem functioning and service provision. Also, Collaborative networks across Asian countries could harmonise methodologies, share data, and foster coordinated policy responses to microplastic pollution.

CONCLUSION

Microplastics have emerged as ubiquitous and persistent contaminants across environmental compartments, posing significant ecological and human health risks through multiple exposure pathways. While policy initiatives and technological interventions are advancing, their impact is limited by enforcement gaps, lack of standardized methodologies, and insufficient integration into Environmental Management Systems (EMS). The literature underscores the need for harmonized monitoring, long-term ecological and health studies, and interdisciplinary collaboration. Embedding microplastic indicators within EMS, strengthening extended producer responsibility, and enhancing regional cooperation, particularly in Asia, where rapid industrialisation and inadequate waste infrastructure intensify risks.

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REFERENCES

1. Lin X, Gowen AA, Pu H, Xu JL. Microplastic contamination in fish: Critical review and assessment of data quality. Food Control. 2023.153,109939.
2. Miraj SS, Parveen N, Zedan HS. Plastic microbeads: small yet mighty concerning. International Journal of Environmental Health Research. 2021, 31(7):788-804.
3. Khan D, Husain T, Kassab G, Ali SA. Microplastics as potential source for environmental pollution: an updated review on Indian scenario post Covid-19.World Journal of Biology Pharmacy and Health Sciences, 2022, 12(03), 094–106.
4. Igiebor FA, Amengialue OO, Ngwoke UN, Edogun PI, Ogboye PO, Obueh HO, Egharevba PA, Iyoha AI, Ochoyama H, Uwuigiaren NJ. Role of Microplastics in the Global Plastics Pollution Crisis with Respect to One Health in the Post-COVID-19 Era. InEmerging Contaminants and One Health Approach 2025 ,103-124.
5. Bhateria R. Environmental Management System (EMS). In Environmental Impact Assessment: A Journey to Sustainable Development, 2024, 101-124.
6. Alam MJ, Rahman MM. Various conventional and advanced management techniques and policies adopted at the global level for microplastics. InMicroplastics. 2025, 429-440.
7. Emami SK, Saadat AM, Hamidifar H. Microplastic Pollution: Analytical Techniques, Policy Landscape, and Integrated Strategies for Sustainable Environmental Stewardship. InWater Crises and Sustainable Management in the Global South 2024, 341-369.
8. Beiras R, Verdejo E, Campoy-Lopez P, Vidal-Liñán L. Aquatic toxicity of chemically defined microplastics can be explained by functional additives. Journal of Hazardous Materials. 2021, 406,124338.
9. Saeedi M. How microplastics interact with food chain: a short overview of fate and impacts. Journal of Food Science and Technology. 2024, 61(3), 403-13.
10. Nitivattananon V, Krainara C. Smart Cities Enable Urban Environmental Management in Asia and The Pacific Region: Problems, Challenges, and Prospects. Smart City, Village, and Region Innovation: Innovation and Praxis in Several Countries. 2025, 103.
11. Sarker B, Keya KN, Mahir FI, Nahiun KM, Shahida S, Khan RA. Surface and ground water pollution: causes and effects of urbanization and industrialization in South Asia. Scientific Review. 2021, 7(3), 32-41.
12. Fadeeva Z, Van Berkel R. Unlocking circular economy for prevention of marine plastic pollution: An exploration of G20 policy and initiatives. Journal of Environmental Management. 2021, 277, 111457.
13. Bokor B. Corporate engagement in mitigating plastic pollution: examining voluntary initiatives and EU regulations. Frontiers in Sustainability. 2024, 5, 1420041.
14. Cole M, Lindeque PK, Fileman E, Clark J, Lewis C, Halsband C, Galloway TS. Microplastics alter the properties and sinking rates of zooplankton faecal

pellets. Environmental science & technology. 2016, 50(6), 3239-46.
15. UNEP, (2015). Plastic in Cosmetics, ISBN: 978-92-807-3466-9 pp. 33.
16. GESAMP, 2016. Sources, fate and effects of microplastics in the marine environment (part 2). Available: http://www.gesamp.org/publications/microplastics-in-the-marine-
17. Wang F, Wong CS, Chen D, Lu X, Wang F, Zeng EY. Interaction of toxic chemicals with microplastics: a critical review. Water research. 2018, 139, 208-219.
18. Gewert B, Ogonowski M, Barth A, MacLeod M. Abundance and composition of near surface microplastics and plastic debris in the Stockholm Archipelago, Baltic Sea. Marine pollution bulletin. 2017. 120 (1-2), 292-302.
19. Corradini F, Meza P, Eguiluz R, Casado F, Huerta-Lwanga E, Geissen V. Evidence of microplastic accumulation in agricultural soils from sewage sludge disposal. Science of the total environment.2018, 671, 411-420.
20. Espí E, Salmerón A, Fontecha A, García-Alonso Y, Real AI. Journal of Plastic Film and. Journal of plastic film & sheeting. 2018, 22, 59.
21. Lithner D, Larsson Å, Dave G. Environmental and health hazard ranking and assessment of plastic polymers based on chemical composition. Science of the total environment. 2018, 409(18), 3309-3324.
22. Zhou Z, Zhou J, Fan H. (2017). Plastic analyses of thin-walled steel honeycombs with re-entrant deformation style. Materials Science and Engineering: A, 688, 123-133.
23. Silva-Cavalcanti JS, Silva JDB, de França EJ, de Araújo MCB, Gusmao F. Microplastics ingestion by a common tropical freshwater fishing resource. Environmental pollution. 2017, 221, 218-226.
24. Rochman CM, Brookson C, Bikker J, Djuric N, Earn A, Bucci K, Athey S, Huntington A, McIlwraith H, Munno K, De Frond H. Rethinking microplastics as a diverse contaminant suite. Environmental toxicology and chemistry. 2019, 38(4), 703-711.
25. Schuyler Q, Wilcox C, Townsend K, Wedemeyer-Strombel KR, Balazs G, van Sebille E, Hardesty BD. Risk analysis reveals global hotspots for marine debris ingestion by sea turtles. Global change biology. 2015, 22(2), 567–576.
26. Novotna K, Cermakova L, Pivokonska L, Cajthaml T, Pivokonsky M. Microplastics in drinking water treatment–current knowledge and research needs. Science of the total environment. 2019, 667, 730-740.
27. Amelia D, Karamah EF, Mahardika M, Syafri E, Rangappa S M, Siengchin S, Asrofi M. Effect of advanced oxidation process for chemical structure changes of polyethylene microplastics. Materials today: proceedings, 2022, 52, 2501-2504.
28. Ali N, Khan MH, Ali M, Ahmad S, Khan A, Nabi G, Ali F, Bououdina M, Kyzas GZ. Insight into microplastics in the aquatic ecosystem: Properties, sources, threats and mitigation strategies. Science of the Total Environment. 2024, 25, 913, 169489.
29. Das BK, Das S, Kumar V, Roy S, Mitra A, Mandal B. Microplastics in ecosystems: ecotoxicological threats and strategies for mitigation and governance. Frontiers in Marine Science. 2025, 12,1672484.
30. Zhang, H. Transport of microplastics in coastal seas. Estuarine, Coastal and Shelf Science. 2017, 199, 74-86.
31. Hale RC, Seeley ME, La Guardia MJ, Mai L, Zeng EY. A global perspective on microplastics. Journal of Geophysical Research: Oceans. 2020, 125(1), e2018JC014719.
32. Joern GM, Pedrosa-Pàmies R, Jiang X, Liu Z, Bochdansky AB. Characterization of microbial biofilms on marine plastics: community development and density implications for vertical transport dynamics. Frontiers in Marine Science. 2025, 20, 12, 1581727.
33. Setälä O, Fleming-Lehtinen V, Lehtiniemi M. Ingestion and transfer of microplastics in the planktonic food web. Environmental pollution. 2014, 185, 77-83.
34. Rodríguez-Torres R, Rist S, Almeda R, Nielsen TG, Pedrotti ML, Hartmann NB. Research trends in nano- and microplastic ingestion in marine planktonic food webs. Environmental Pollution. 2024, 363, 125136.
35. Wu C, Ma Y, Shan Y, Song X, Wang D, Ren X, Hu H, Cui J, Ma Y. Exploring the potential of biochar for the remediation of microbial communities and element cycling in microplastic-contaminated soil. Chemosphere. 2024, 362,142698.
36. Seeley ME, Song B, Passie R, Hale RC. Microplastics affect sedimentary microbial communities and nitrogen cycling. Nature communications. 2020, 11(1), 2372.
37. Shi J, Wang Z, Peng Y, Zhang Z, Fan Z, Wang J, Wang X. Microbes drive metabolism, community diversity, and interactions in response to microplastic-induced nutrient imbalance. Science of the Total Environment. 2023, 877, 162885.
38. Schellenberg T, Subramanian V, Ganeshan G, Tompkins D, Pradeep R. Wastewater discharge standards in the evolving context of urban sustainability–The case of India. Frontiers in Environmental Science. 2020, 8, 30.
39. Tella TA, Festus B, Olaoluwa TD, Oladapo AS. Water and wastewater treatment in developed and developing countries: Present experience and future plans. InSmart Nanomaterials for Environmental Applications. 2025, 351-385.
40. Bellasi A, Binda G, Pozzi A, Galafassi S, Volta P,

Bettinetti R. Microplastic contamination in freshwater environments: A review, focusing on interactions with sediments and benthic organisms. Environments. 2020, 7(4), 30.

41. Lawrence, J., Santolini, C., Binda, G., Carnati, S., Boldrocchi, G., Pozzi, A., & Bettinetti, R. Freshwater lacustrine zooplankton and microplastic: An issue to be still explored. Toxics. 2023, 11(12), 1017.
42. Wei N, Lu J, Jiao M, Zong C, Zhang F, Jiang C, Zhu L, Liu K, Cui T, Li D. Estuarine plastic dynamics: Analyzing export patterns from a typical semi-enclosed bay in Asia. Journal of Hazardous Materials. 2025, 492, 138214.
43. Sin LT, Balakrishnan V, Bee ST, Bee SL. A review of the current state of microplastic pollution in South Asian countries. Sustainability. 2023, 15(8), 6813.
44. Van Emmerik TH. The impact of floods on plastic pollution. Global Sustainability. 2024, 7, e17.
45. Ravishankar GC, Chandrasekaran LN, Sekar S. Impact of the 2023 floods on microplastic contamination in coastal groundwater: a comparative analysis of chennai's pre-and post-flood conditions. Journal of Coastal Conservation. 2025, 29(5), 53.
46. Shruti VC, Kutralam-Muniasamy G. The Human Plastiphere: A Bioparticulate System Challenging Microplastic Risk Assessment and Governance. Environmental Science & Technology. 2025. 59, 24131−24150
47. de Souza Machado, A. A., Kloas, W., Zarfl, C., Hempel, S., & Rillig, M. C. (2018). Microplastics as an emerging threat to terrestrial ecosystems. Global change biology. 2018, 24(4), 1405-1416.
48. Naqash N, Yadav KK, Shaik AS, Alam MW, Djajadi D, Sunarto DA, Marjani M, Sujak S, Rochman F, Rachmawati D, Riajaya PD. Microplastic Pollution in Terrestrial Systems: Sources and Implications for Soil Functioning and Plant Performance. Water, Air, & Soil Pollution. 2025, 236 (3), 172.
49. Li W, Wufuer R, Duo J, Wang S, Luo Y, Zhang D, Pan X. Microplastics in agricultural soils: Extraction and characterization after different periods of polythene film mulching in an arid region. Science of the Total Environment. 2020, 749, 141420.
50. Qi R, Tang Y, Jones DL, He W, Yan C. Occurrence and characteristics of microplastics in soils from greenhouse and open-field cultivation using plastic mulch film. Science of the Total Environment. 2023, 905, 166935.
51. Han L, Chen L, Feng Y, Kuzyakov Y, Chen QA, Zhang S, Chao L, Cai Y, Ma C, Sun K, Rillig MC. Microplastics alter soil structure and microbial community composition. Environment International. 2024, 185, 108508.
52. Hasan MM, Tarannum MN. Adverse impacts of microplastics on soil physicochemical properties and crop health in agricultural systems. Journal of Hazardous Materials Advances. 2025, 17, 100528.
53. Shah T, Ali A, Haider G, Asad M, Munsif F. Microplastics alter soil enzyme activities and microbial community structure without negatively affecting plant growth in an agroecosystem. Chemosphere. 2023, 322, 138188.
54. Velis CA, Cook E. Mismanagement of plastic waste through open burning with emphasis on the global south: a systematic review of risks to occupational and public health. Environmental Science & Technology. 2021, 55(11), 7186-207.
55. Ma J, Ma M, Li J, Yang Q, Wan Y, Zhao K, Zhang Y, Liu L, Fei X. Distribution and characteristics of Microplastics in leachate and underneath soil of two informal landfills. Waste Management. 2025, 195, 155-66.
56. Lindfors S, Österlund H, Lorenz C, Vianello A, Nordqvist K, Gopinath K, Lykkemark J, Lundy L, Vollertsen J, Viklander M. Microplastics and tyre wear particles in urban runoff from different urban surfaces. Science of the Total Environment. 2025, 980, 179527.
57. Ziajahromi S, Lu HC, Drapper D, Hornbuckle A, Leusch FD. Microplastics and tire wear particles in urban stormwater: abundance, characteristics, and potential mitigation strategies. Environmental Science & Technology. 2023, 57(34), 12829-37.
58. Kwak JI, An YJ. Microplastic digestion generates fragmented nanoplastics in soils and damages earthworm spermatogenesis and coelomocyte viability. Journal of Hazardous Materials. 2021, 402, 124034.
59. Alowaisy A, Allouzi MMA, Chia WY, Mayol AP, Sriariyanun M, Show PL. Interactions between phytoplankton species and micro/nano-plastics and heavy metal contamination. Biological Reviews. 2025.
60. Zhang GS, Liu YF. The distribution of microplastics in soil aggregate fractions in southwestern China. Science of the Total Environment. 2018, 642, 12-20.
61. Sin LT, Balakrishnan V, Bee ST, Bee SL. A review of the current state of microplastic pollution in South Asian countries. Sustainability. 2023, 15(8), 6813.
62. Singh S, Chakma S, Alawa B, Kalyanasundaram M, Diwan V. Assessment of microplastic pollution in agricultural soil of Bhopal, Central India. Journal of Material Cycles and Waste Management. 2024, 26(2), 708-22.
63. Akhbarizadeh R, Moore F, Keshavarzi B. Investigating microplastics bioaccumulation and biomagnification in seafood from the Persian Gulf: a threat to human health? Food Additives & Contaminants: Part A. 2019, 36(11), 1696-708.
64. Nath J, Parvin F, Tareq SM. Bioaccumulation of

microplastics in the edible tissues of fish collected from urban lakes of Bangladesh: a potential exposure to public health. Environmental Science and Pollution Research. 2024, 31(2), 2067-78.
65. Farrell P, Nelson K. Trophic level transfer of microplastic: Mytilus edulis (L.) to Carcinus maenas (L.). Environmental Pollution. 2013, 177, 1-3.
66. Huvet A, Paul-Pont I, Fabioux C, Lambert C, Suquet M, Thomas Y, Robbens J, Soudant P, Sussarellu R. Reply to Lenz et al.: quantifying the smallest microplastics is the challenge for a comprehensive view of their environmental impacts. Proceedings of the National Academy of Sciences of the United States of America. 2016, 113(29), E4123-4.
67. Karami A, Golieskardi A, Choo CK, Romano N, Ho YB, Salamatinia B. A high-performance protocol for extraction of microplastics in fish. Science of the Total Environment. 2017, 578, 485-94.
68. Schwabl P, Köppel S, Königshofer P, Bucsics T, Trauner M, Reiberger T, Liebmann B. Detection of various microplastics in human stool: a prospective case series. Annals of Internal Medicine. 2019, 171(7), 453-7.
69. Prata JC, Da Costa JP, Lopes I, Duarte AC, Rocha-Santos T. Effects of microplastics on microalgae populations: a critical review. Science of the Total Environment. 2019, 665, 400-5.
70. Ribeiro F, O'Brien JW, Galloway T, Thomas KV. Accumulation and fate of nano- and micro-plastics and associated contaminants in organisms. Trends in Analytical Chemistry. 2019, 111, 139-47.
71. Yong CQY, Valiyaveettil S, Tang BL. Toxicity of microplastics and nanoplastics in mammalian systems. International Journal of Environmental Research and Public Health. 2020, 17(5), 1509.
72. Gao P, Mohd Noor NQI, Md Shaarani S. Current status of food safety hazards and health risks connected with aquatic food products from Southeast Asian region. Critical Reviews in Food Science and Nutrition. 2022, 62(13), 3471-89.
73. Li J, Green C, Reynolds A, Shi H, Rotchell JM. Microplastics in mussels sampled from coastal waters and supermarkets in the United Kingdom. Environmental Pollution. 2018, 241, 35-44.
74. Abusafia AYA. Developing monitoring strategies for quantifying and examining the fate of microplastic emissions in urban wastewater drainage systems. Rheinland-Pfälzische Technische Universität Kaiserslautern-Landau. 2024.
75. Abu Jadayil W, Qureshi MRNM, Ajaj R, Aqil E, Shawahin G, Anver H, Aljeawi S. An empirical investigation on plastic waste issues and plastic disposal strategies to protect the environment: A UAE perspective. Sustainability. 2022, 14(24), 16719.
76. Chaudhary N. Extended producer responsibility (EPR) in Nepal: A transformative policy strategy for sustainable waste management. Tribhuvan University Journal. 2024, 39(2), 188-204.
77. United Nations Environment Programme (UNEP). Emissions Gap Report 21. Nairobi: UNEP; 2021. Available from: https://www.unep.org/resources/emissions-gap-report-2021
78. Maruf M, Chang YC, Yang L. Managing institutional interlinkages for the protection of marine environment in the East Asian seas region and beyond: The case of marine plastic pollution. Ocean & Coastal Management. 2024, 255, 107232.
79. Li JM, Yu MF, Kao CM, Surampalli RY, Zhang TC. Global strategies/policies and citizen science for microplastic management. In: Microplastics in the Environment: Fate, Impacts, Removal, and Management. 2025, 577-97.
80. Vũ A. Multistakeholder partnerships to address plastic waste pollution through a circular economy framework in Vietnam: A meta-governance approach. 2024.
81. Munhoz DR, Harkes P, Beriot N, Larreta J, Basurko OC. Microplastics: a review of policies and responses. Microplastics. 2022, 2(1), 1-26.
82. Wingfield S, Lim M. The United Nations Basel convention's global plastic waste partnership: history, evolution and progress. In: Microplastic in the Environment: Pattern and Process. 2022, 323-31.
83. European Chemicals Agency. Report-Proposal for a restriction: Intentionally added microplastics. 2019.
84. Xanthos D, Walker TR. International policies to reduce plastic marine pollution from single-use plastics (plastic bags and microbeads): a review. Marine Pollution Bulletin. 2017, 118(1-2), 17-26.
85. Geyer R, Jambeck JR, Law KL. Production, use, and fate of all plastics ever made. Science Advances. 2017, 3(7), e1700782.
86. Schyns ZO, Shaver MP. Mechanical recycling of packaging plastics: a review. Macromolecular Rapid Communications. 2021, 42(3), 2000415.
87. Choi SY, Lee Y, Yu HE, Cho IJ, Kang M, Lee SY. Sustainable production and degradation of plastics using microbes. Nature Microbiology. 2023, 8(12), 2253-67.
88. Henry B, Laitala K, Klepp IG. Microfibres from apparel and home textiles: prospects for including microplastics in environmental sustainability assessment. Science of the Total Environment. 2019, 652, 483-94.
89. Henderson L, Green C. Making sense of microplastics? Public understandings of plastic pollution. Marine Pollution Bulletin. 2020, 152, 110908.
90. Liang Y, Tan Q, Song Q, Li J. An analysis of the

plastic waste trade and management in Asia. Waste Management. 2021, 119, 242-53.
91. Gomes K, Caucci S, Morris J, Guenther E, Miggelbrink J. Sustainability transformation in the textile industry—the case of wastewater management. Business Strategy and Development. 2024, 7(1), e324.
92. Braine M. A national risk management framework for biosolids [doctoral dissertation]. Sydney: UNSW Sydney, 2025.
93. Gouin T, Becker RA, Collot AG, Davis JW, Howard B, Inawaka K, Lampi M, Ramon BS, Shi J, Hopp PW. Toward the development and application of an environmental risk assessment framework for microplastic. Environmental Toxicology and Chemistry. 2019, 38(10), 2087-100.
94. Ihenetu SC, Enyoh CE, Wang C, Li G. Sustainable urbanization and microplastic management: Implications for human health and the environment. Urban Science. 2024, 8(4), 252.
95. He D, Luo Y, Lu S, Liu M, Song Y, Lei L. Microplastics in soils: Analytical methods, pollution characteristics and ecological risks. Trends in Analytical Chemistry. 2018, 109, 163-72.
96. Koelmans AA, Redondo-Hasselerharm PE, Nor NHM, Gouin T. On the probability of ecological risks from microplastics in the Laurentian Great Lakes. Environmental Pollution. 2023, 325, 121445.

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