

Insight to Action: The Role of Knowledge and Attitude in Unlocking Sustainability Practices in Manufacturing Firms

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Abstract: Broadening the scale and scope of manufacturing industries to meet growing consumer demand has led to substantial economic growth, but it has also posed serious challenges to environmental sustainability. Gaining insight into the sustainability-related knowledge, attitudes, and practices of various manufacturing firms is therefore essential for a successful transition towards sustainability. Employing the KAP (Knowledge, Attitudes, and Practices) model, the study analyses the linkages between knowledge and attitudes regarding sustainability and the adoption of sustainable practices in manufacturing units in Kerala, India. A quantitative approach was followed, with data collected from 91 managers through a structured questionnaire, which was then analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). A disjoint two-stage approach was used to analyse the data as the model included a higher-order construct. Findings reveal a strong positive relationship between knowledge and sustainability practices ($\beta = 0.413$, $p < 0.001$), with an even stronger influence of attitudes on the adoption of these practices ($\beta = 0.428$, $p < 0.001$). The study highlights that while knowledge is essential, fostering a favourable attitude towards sustainability is crucial for effectively implementing sustainability practices.

Keywords: Sustainability Practices; KAP Model, Manufacturing Industry, PLS-SEM, Sustainable Development

JEL Classification: L60, Q56, M14

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1. Introduction

The growing demand for consumer goods, driven by population growth and rising income levels, has broadened the scale and scope of manufacturing industries globally (Ahmad & Wong, 2018). The manufacturing sector plays a pivotal role in fostering economic growth; directly through its substantial contribution to output and employment, and indirectly through its linkages with other sectors. For instance, manufacturing value-added accounted for 16.8% of global GDP in 2022, while the industry contributed 13.6% of total employment worldwide in 2021 (UNIDO, 2023).

However, industrialisation has led to rapid environmental degradation through greenhouse gas emissions, and raised concerns among researchers and policymakers (Chuah et al., 2025). In South Asia, methane and carbon dioxide emissions are rising, particularly in India and Sri Lanka (Alaganthiran et al., 2025). Manufacturing activities cause environmental pollution directly through the conversion of raw materials into finished goods, or indirectly through the energy required to power these activities (Salonitis & Ball, 2013). Historically, many corporate organisations solely focused on expansion and profitability over sustainability, neglecting long-term social and environmental security. To address these problems, manufacturers need to pursue environmentally friendly activities and integrate sustainability into their manufacturing processes and decision-making (Khan et al., 2021).

Although research in the area of sustainability has gained more attention, a critical question remains: to what extent have manufacturing units or businesses successfully adopted sustainability practices? Evidence suggests that industrial sectors make only minimal engagement in sustainability initiatives (Chen et al., 2024), and business organisations are not revising their production processes and marketing activities to make them more environmentally friendly (Kaur et al., 2022). Understanding how manufacturing units embrace sustainability is therefore essential for evaluating the effectiveness of current initiatives and designing future interventions.

Knowledge and attitude are key predictors of behaviour (Chen et al., 2025; Wang et al., 2023), and they help achieve the psychological preparedness, the foundation of any successful behaviour change intervention (Green & Kreuter, 1991). Therefore, applying the KAP (Knowledge, Attitudes, and Practices) model can capture valuable insights

about the sustainability behaviour of manufacturing firms. Even though KAP studies are conducted in several fields, they are rarely employed in sustainability research (Salas-Zapata et al., 2018). Moreover, prior scholarly works often examined either knowledge or attitude as a predictor of behaviour (Cayolla et al., 2023; Dong et al., 2020; Ojstersek et al., 2022), or followed the classical linear pathway ($K \rightarrow A \rightarrow P$), where knowledge shapes attitude, which in turn influences behaviour (Wang & Zhang, 2021). This leaves an important gap in understanding the individual effect of knowledge and attitude on the adoption of sustainable practices among manufacturing units.

Employing a modified KAP model to address the gap, this study provides a novel perspective on sustainability research and advances understanding of how knowledge and attitudes towards sustainability translate into sustainable organisational practices. The primary objective is to examine the influence of sustainability-related knowledge and attitude on the adoption of sustainability practices in manufacturing units. The study focuses on manufacturing units in Kerala, one of India's states with the highest literacy rate (Gohain, 2025). This context provides valuable insights for designing focused knowledge and attitude-oriented interventions to promote sustainable industrial practices.

2. Literature Review and Hypothesis Development

2.1 KAP model and sustainability practices

Despite being the core of a nation's economy, the growing manufacturing sector is exacerbating issues related to energy, wastewater, gas emissions, and residues (Bour et al., 2023). In developing nations, sustainable strategies of restructuring conventional business models and green innovations can balance economic growth with social and environmental responsibility (Snihur & Bocken, 2022). Sustainability practices can help manufacturing units support sustainable development goals, establish a good reputation, adhere to ethical trade norms, and develop long-term stakeholder relationships (Aziz Khan et al., 2024). Regulatory support (Liu et al., 2025) and financial assistance through low-interest loans, grants, and green subsidies can motivate firms to pursue eco-innovation (Han et al., 2023; Wu et al., 2024).

However, transition toward sustainability requires drastic and systemic changes in deeply held ideas and values, social behaviour patterns, and multi-level systems of management and governance (Westley et al., 2011). Understanding the sustainability-related knowledge, attitudes, and practices among various populations is essential for the success of any such transition. Therefore, it is necessary to examine at least three elements: knowledge or beliefs, attitudes or value systems, and actions to comprehend how transitions towards sustainability occur in a given group of people (Salas-Zapata et al., 2018).

Knowledge refers to the ability to comprehend information, which entails being conscious of and interpreting meaning beyond symbolic representation (Liao et al., 2022). There are four types: scientific and socially scientific knowledge, local knowledge, tacit knowledge, and self-reflective knowledge (Hulme, 2018). Attitude represents the favourable or unfavourable evaluations of a thing or concept (Ajzen & Fishbein, 2000). Regular actions shaped by widely held social norms and ideas are referred to as practices (Schirato & Roberts, 2020). Knowledge, attitudes, and practices are widely recognised as key components of behavioural change models.

The KAP model, which originated in the 1950s in family planning and population studies, is now a popularly used survey instrument in social science research (Vandamme, 2009). The KAP model employs a standardised questionnaire to measure and analyse what people know (knowledge), believe (attitudes), and do (practices) about a certain issue (Andrade et al., 2020; Nguyen et al., 2019). It is considered the most relevant and straightforward method to comprehend the connection between knowledge, attitude, and practices (Liao et al., 2022). The model is supported by social learning theory (Bandura, 1971) and diffusion of innovation theory (Roger, 1995), and is well-suited for examining behavioural change in social systems such as farming and industry. The Theory of Planned Behaviour (TPB) emphasises how attitudes, subjective norms, and perceived behavioural control shape behavioural intention (Ajzen, 1991), whereas the KAP model assesses real-world behavioural adoption (Liao et al., 2022).

Prior research tested the sequential relationship using the KAP model; however, the relationship was not present in every context. For instance, Ainul et al. (2025) found no significant association between sustainability-related knowledge and attitude among university students: although students were knowledgeable, it did not translate into positive attitudes. These

highlight the need to study the independent effects of knowledge and attitude on the adoption of sustainability practices in manufacturing units, rather than assuming a sequential relationship.

2.2 Knowledge-sustainability practices linkage

Sustainability knowledge encompasses comprehending specific ecosystems or resources, their preservation, and related environmental issues (Salas-Zapata et al., 2018). Business strategies now heavily emphasise sustainability, though sustainability and marketing are often viewed as opposing concepts. Marketing is concerned with increasing product sales and is often associated with aggressive commercial tactics, financial success, and encouraging consumer choices that provide immediate gratification. In contrast, sustainability focuses on reducing product consumption (Jung & Kim, 2023).

As organisations gain knowledge, they can identify the key skills needed to become more innovative, helping them put sustainability principles into action (Robinson et al., 2006). Absorptive capacity, the ability of a company to acquire new information, absorb it, and utilise it for business purposes, helping to maintain an edge over others (Cohen & Levinthal, 1990; Lane & Lubatkin, 1998; Zahra & George, 2002). According to the absorptive capacity theory, suppliers' knowledge bases, including their access to external knowledge and prior relevant expertise, benefit their adoption of sustainable practices. Knowledge about technologies and techniques for sustainability management is essential for embracing sustainability practices (Liu et al., 2019). Moreover, one of the major barriers to adopting sustainability practices is the lack of knowledge on how to adopt sustainable manufacturing practices (Bhanot et al., 2015). Grounded in these theoretical underpinnings, this study proposes the following hypothesis:

- H₁ Knowledge about sustainability positively influences the adoption of sustainability practices.

2.3 Attitude-sustainability practices linkage

There is broad agreement in the literature that sustainable development cannot occur without a shift in the nation's and people's perceptions of

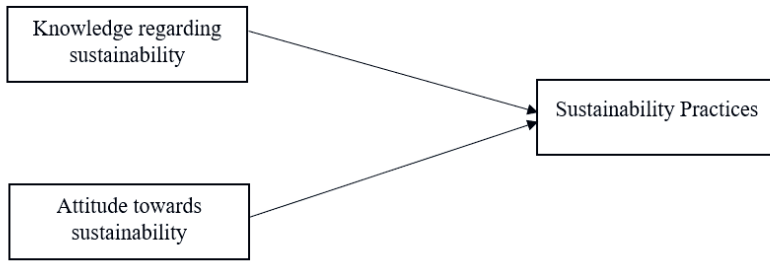
sustainability (Kalsoom, 2018). People's behaviours and interactions with the environment are predicted by their attitudes, and large-scale sustainability initiatives require a shift in attitudes. Sustainability, like charity, begins at home and is an inside-out process that must begin at a person's or a company's core. The shift towards sustainability involves changing not only the way we do things but also the way we think. Research in the field of environmental psychology indicates that pro-environmental behaviours are more common among those with a favourable attitude toward the environment (Kollmuss & Agyeman, 2002).

Business organisations can significantly contribute to combating global warming and preserving the ecological balance of nature. However, the attitudes of business professionals toward sustainability greatly determine the success of these efforts. The attitudes of professionals and corporate executives towards sustainable business practices will determine how well sustainable business development proceeds (Chang & Slaubaugh, 2016). The pace of the sustainability movement will quicken and become ingrained in the day-to-day operations of businesses if business professionals broadly embrace the idea and values of sustainability. The attitude towards sustainability compels marketers to re-evaluate and frame their tactics in an environmentally friendly manner (Utkal & Yadav, 2014). Thus, it is essential to determine whether manufacturing units have adopted a more sustainable attitude and have truly integrated sustainability into their day-to-day operations. As suggested by the existing literature, the study formulates the following hypothesis:

- H₂ Attitude towards sustainability positively influences the adoption of sustainability practices

A conceptual framework (Figure 1) was developed, adapting the classical KAP model, with modifications to the linear sequence, to examine knowledge and attitude as independent predictors of sustainability practices.

Figure 1: Conceptual framework



3. Methodology

A quantitative research approach was adopted for the study. Data were collected using a structured questionnaire from top or middle-level managers responsible for policy formulation and execution, with one respondent per firm. The questionnaire was distributed via email, WhatsApp, and in-person meetings. Purposive sampling was employed because a comprehensive list of potential respondents was unavailable.

A pre-test was administered among 30 managers to ascertain that the questionnaire items were clearly understood and accurately interpreted by the respondents. Based on feedback from pilot participants, the questionnaire items were simplified and reworded. Of the 120 questionnaires distributed, 102 were returned, of which 91 were considered valid for analysis. The remaining 11 were excluded due to substantial missing data, with more than 15% of items left unanswered. Non-response bias was not analysed, as the non-response rate was low (11%) and non-respondents shared similar profiles with respondents, impacting the study's results negligibly.

The sample size exceeded the threshold established by the widely recognised “10-times rule” for Partial Least Squares Structural Equation Modelling (PLS-SEM) suggested by Hair et al. (2019). This rule stipulates that the required minimum sample should be at least ten times the maximum number of structural paths directed at endogenous constructs in the model.

Face validity reflects the extent to which an instrument appears to measure the intended construct (Gravetter & Forzano, 2012) and whether its items are understandable to the target respondents (Norman & Cairney, 2015). To establish face validity, five academicians with theoretical knowledge and practical expertise in sustainability practices reviewed the survey instrument for phrasing, readability, and clarity. Multivariate outliers

were examined using Mahalanobis distance (Hair et al., 2019), and no extreme cases were detected, confirming the suitability for further analysis.

3.1 Variables and measurement

The study assessed three latent variables: knowledge, attitudes, and sustainability practices using 22 items adapted from prior studies (Appendix 1). Knowledge regarding sustainability (KW) was measured using seven items adapted from Oriade et al. (2021) and Attitude (AT) towards sustainability, with seven items from Chang & Slaubaugh (2016). Sustainability practices (SP) were measured as a higher-order reflective construct consisting of two dimensions: sustainable manufacturing practices (SPSMP) with three items and sustainable supply chain management practices (SPSCM) with five items adapted from Ibrahim et al. (2020). All items were measured on a 5-point Likert scale ranging from ‘strongly disagree’ (1) to ‘strongly agree’ (5).

4. Data Analysis and Discussion

Data analysis was conducted using PLS-SEM via SmartPLS 4. PLS-SEM, a variance-based estimation method, assesses the reliability and validity of constructs and their interrelationships (Reinartz et al., 2009) and is widely applied in social sciences, marketing, and business strategy research (Hair et al., 2017). Its flexibility and relaxed assumptions make it appropriate for studies with smaller sample sizes (Dhakal et al., 2024). Several methods are available to estimate higher-order constructs in PLS-SEM, with the two-stage and (extended) repeated indicator approaches being the most widely used (Ringle et al., 2012). The repeated indicator approach may introduce biases in the measurement model, whereas the two-stage method provides superior parameter recovery in the structural model (Sarstedt et al., 2019).

The disjoint two-stage approach was employed to estimate the higher-order construct, SP. In stage one, the lower-order components of SP were modelled by linking them to exogenous variables, and their reliability, validity, and factor loadings were assessed. Latent variable scores derived from this stage were then used as indicators of the higher-order construct in stage two, where the measurement model was re-evaluated and hypotheses were tested (Sarstedt et al., 2019).

4.1 Profile of respondents

Table 1 presents a brief profile of respondents' business categories, job positions, and experience. The respondents came from various industries, with the highest representation in food and beverage (23.1%), followed by electronics (16.5%) and textiles (14.3%). Job position-wise, most participants were managers (74.7%), followed by executives (13.2%) and senior managers (12.1%). The respondents' experience ranges from one to fifteen years, with the most common durations being two, four, and five years, each representing 14.3%.

Table 1: Profile of respondents

Category	Items	Frequency	Percentage
Business Activity	Food & Beverage	21	23.1
	Textiles	13	14.3
	Tires	5	5.5
	Paper	7	7.7
	Cement	11	12.1
	Furniture	6	6.6
	Chemicals & Related Products	9	9.9
	Electronics	15	16.5
	Handcrafts	4	4.4
Position	Senior Manager	11	12.1
	Executive	12	13.2
	Manager	68	74.7
Experience	1	4	4.4
	2	13	14.3
	3	7	7.7
	4	13	14.3
	5	13	14.3
	6	6	6.6
	7	6	6.6
	8	7	7.7
	9	10	11.0
	10	3	3.3
	11	2	2.2
	12	3	3.3
	13	2	2.2
	14	1	1.1
	15	1	1.1

4.1.1 Shapiro–Wilk and kolmogorov–Smirnov test

Normality was assessed using the Shapiro-Wilk and Kolmogorov-Smirnov tests (Table 2); both yielded significance values below 0.050, indicating non-normal distributions across all constructs. However, the normality violation does not compromise the analysis, as PLS SEM is a variance-based estimation and does not require normality assumptions (Hair et al., 2019).

Table 2: Result of the normality test

Variable	Kolmogorov-Smirnov		Shapiro-Wilk	
	Statistic	Sig.	Statistic	Sig.
Knowledge	.176	.000	.937	.000
Attitude	.125	.001	.957	.004
SPSMP	.131	.000	.958	.004
SPSCP	.145	.000	.937	.000

4.1.2 Exploratory Factor Analysis (EFA)

Language, cultural, or sectoral differences may cause even a well-established instrument to behave differently in different circumstances (Hair et al., 2010). Therefore, EFA was conducted to establish the empirical validity and contextual relevance of the items used in the study. Using maximum likelihood estimation with varimax rotation and Kaiser normalisation, loadings above 0.50 were retained. All items loaded significantly on their intended constructs, with eigenvalues exceeding 1, and the extracted factors accounted for 60.40% of the total variance (Malhotra, 2010). The value of Kaiser-Meyer-Olkin (0.922), more than 0.70 and Bartlett’s Test of Sphericity (χ^2 , $p < 0.001$), as shown in Table 3, confirmed the sampling adequacy and suitability for factor analysis. (Mia et al., 2022).

Table 3: KMO and Bartlett’s test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.922
Bartlett’s Test of Sphericity	Approx. Chi-Square	1428.777
	df	231
	Sig.	.000

Principal Component Analysis (PCA) was conducted to reduce dimensionality and identify which items correspond to which factors. An item was considered loaded onto a specific factor if its factor loading was 0.50 or higher for that factor and less than 0.50 for the remaining factors (Sigudla & Maritz, 2023). The PCA results supported the 22 items loaded onto three pre-specified factors: knowledge (KW1 through KW7), attitude (AT1 through AT7), and sustainability practices (SPSMP1 through SPSMP3; SPSCM1 through SPSCM5, with all items loading strongly on their respective constructs (Table 4).

Table 4: Rotated Component Matrix

Items	Component		
	1	2	3
KW1		.734	
KW2		.656	
KW3		.731	
KW4		.704	
KW5		.700	
KW6		.717	
KW7		.656	
AT1			.652
AT2			.538
AT3			.530
AT4			.757
AT5			.659
AT6			.709
AT7			.717
SPSMP_1	.690		
SPSMP_2	.762		
SPSMP_3	.733		
SPSCM_1	.683		
SPSCM_2	.726		
SPSCM_3	.672		
SPSCM_4	.624		
SPSCM_5	.710		

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalisation.

4.2 Lower-order measurement model

Validating higher-order constructs in PLS-SEM requires adherence to the general model evaluation criteria applicable for all PLS-SEM analyses (Sarstedt et al., 2022). This involves assessing two measurement models: the lower-order constructs (LOCs) model (Figure 2) to evaluate reliability and validity (convergent and discriminant), and the higher-order construct (HOC) model to examine the relationships between the LOCs and HOC, and to assess validity.

Table 5 shows the construct reliability and convergent validity. Composite reliability (CR) was used to assess internal consistency of the scale categories (Hair et al., 2017). All LOCs achieved CR values between 0.880 and 0.920, exceeding the recommended 0.70 threshold (Rahman & Mia, 2020). Cronbach’s alpha values ranged from 0.876 to 0.911, also exceeding the recommended minimum of 0.70 (Hair et al., 2016). Standardised factor loadings for all items were above 0.70, confirming indicator reliability (Khan et al., 2022). Convergent validity was confirmed with Average Variance Extracted (AVE) values between 0.583 and 0.801, all above the 0.50 threshold (Hult et al., 2018).

Figure 2: Lower-order measurement model

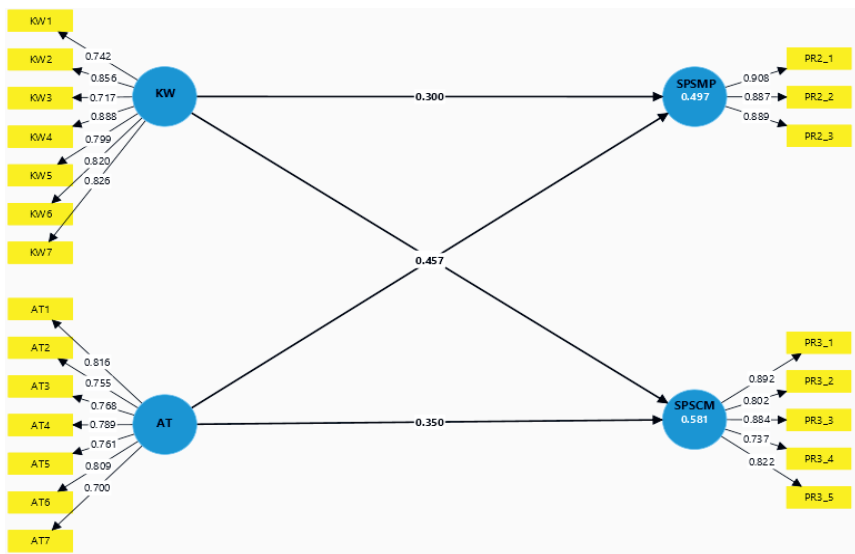


Table 5: Construct reliability and convergent validity

	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
AT	0.887	0.89	0.912	0.596
KW	0.911	0.92	0.93	0.654
SPSCM	0.885	0.901	0.916	0.688
SPSMP	0.876	0.88	0.923	0.801

4.2.1 Discriminant validity

Discriminant validity, which confirms that the constructs are empirically distinct, was then assessed using cross-loadings, the Fornell–Larcker criterion, and the heterotrait–monotrait ratio (HTMT) (Habib et al., 2021). For cross-loading evaluation, each measurement item's outer loading on its intended construct must exceed its loadings on all other constructs (Khan et al., 2022). Consistent with this requirement, the cross-loading matrix (Table 6) results showed that all items loaded more strongly on their targeted constructs. The Fornell–Larcker criterion was also satisfied, as the square root of each construct's AVE exceeded its correlations with other constructs (Fornell & Larcker, 1981) (Table 7). Finally, HTMT values (Table 8) were well below the 0.90 threshold, further supporting discriminant validity (Khan et al., 2022). Collectively, these results establish the LOC measurement model's reliability as well as its convergent and discriminant validity.

To control the potential common method bias, the procedural remedies suggested by Podsakoff et. al. (2003) and statistical tests were employed. Procedurally, respondent confidentiality was assured, and questionnaire items were randomised to reduce the chance of inferring causal relationships between constructs and variables. Statistically, inner variance inflation factor (VIF) values were examined to detect multicollinearity among predictor constructs, as recommended by Hair et al. (2017). The results showed that all VIF values were below the 3.3 threshold, indicating that common method bias was not a concern.

Table 6: Cross loadings

	AT	KW	SPSMP	SPSCM
AT1	0.816	0.593	0.598	0.597
AT2	0.755	0.596	0.529	0.54
AT3	0.768	0.579	0.554	0.56
AT4	0.789	0.541	0.443	0.497
AT5	0.761	0.592	0.452	0.49
AT6	0.809	0.602	0.547	0.569
AT7	0.7	0.405	0.495	0.457
KW1	0.462	0.742	0.427	0.522
KW2	0.647	0.856	0.586	0.647
KW3	0.491	0.717	0.371	0.444
KW4	0.671	0.888	0.586	0.648
KW5	0.586	0.799	0.484	0.595
KW6	0.576	0.82	0.506	0.59
KW7	0.641	0.826	0.566	0.614
SPSMP_1	0.619	0.563	0.908	0.652
SPSMP_2	0.553	0.517	0.887	0.644
SPSMP_3	0.632	0.608	0.889	0.737
SPSCM_1	0.665	0.672	0.694	0.892
SPSCM_2	0.512	0.511	0.641	0.802
SPSCM_3	0.654	0.672	0.666	0.884
SPSCM_4	0.471	0.453	0.472	0.737
SPSCM_5	0.529	0.649	0.652	0.822

Table 7: Discriminant validity—Fornell–Larcker criterion

	AT	KW	SPSCM	SPSMP
AT	0.772			
KW	0.726	0.809		
SPSCM	0.691	0.723	0.829	
SPSMP	0.674	0.631	0.759	0.895

Table 8: HTMT ratio of correlations

	AT	KW	SPSCM
AT			
KW	0.799		
SPSCM	0.768	0.789	
SPSMP	0.757	0.695	0.854

4.3 Higher-order measurement model

The higher-order construct SP was measured reflectively and represented by two lower-order constructs: SPCM and SPSMP. Loading, reliability, and validity statistics of the higher-order component were displayed in Table 9. The outer loadings exceeded the minimum threshold of 0.50 and were statistically significant, indicating that the indicators effectively captured the variance of their respective constructs (Dhakal et al., 2024). Both Cronbach’s alpha (0.863) and composite reliability (0.936) values for SP were above the recommended threshold of 0.70 (Hair et al., 2011), demonstrating strong internal consistency. Convergent validity was also established, with an AVE value of 0.879, higher than the minimum criterion of 0.50. Overall, these results provide strong evidence for the reliability and validity of the higher-order measurement model, confirming that SP is adequately represented by its two dimensions.

The HTMT ratios of the higher-order construct model ranged from 0.799 to 0.827, falling below the threshold value of 0.9, ensuring the discriminant validity (Table 10). Thus, the three constructs AT, KW, and SP are distinct, and each captures a unique dimension.

The VIF values for AT (2.115) and KW (2.115) were below the recommended threshold value of 3.3, confirming no issues of collinearity (Table 11). Hence, AT and KW can be included in the model as predictors of SP.

Table 9: Loading, reliability, and validity statistics of the higher-order component

	Loading	Cronbach’s alpha	Composite reliability	Average Variance Extracted
Sustainability Practices		0.863	0.936	0.879
SPSCM	0.943			
SPSMP	0.933			

Table 10: Discriminant validity assessment of higher-order constructs using the HTMT criterion

	AT	KW
AT		
KW	0.799	
SP	0.827	0.806

Table 11: Collinearity statistics (VIF) - Inner model

Predictand	Predictors	VIF
SP	AT	2.115
	KW	2.115

4.4 Structural model

Based on the theoretical framework, a structural model was developed to test the hypothesised relationships among latent constructs (Figure 3). Initially, 5000 bootstrapping samples were used to assess the significance of the path coefficients in direct path analysis using predetermined variables (Khan et al., 2022). Model evaluation considered explanatory power (R^2), effect size (f^2), and predictive relevance (Q^2). The R^2 value reflects the model’s explanatory power (Dhakal et al., 2024), and a value of 0.611 indicates that AT and KW together explain 61.1% of the variance in SP. According to the R^2 criterion, values of 0.67, 0.33, and 0.19 are classified as significant, moderate, and weak, respectively. Changes in the R^2 value can help determine whether the exogenous latent variable influences the endogenous latent variable significantly (Khan et al., 2022). The minimal difference between R^2 and adjusted R^2 indicates good model stability. The f-square sizes of exogenous latent variables, categorised as weak, moderate, and strong structural influences, are 0.02, 0.15, and 0.35, respectively (Agus Purwanto & Yuli Sudargini, 2021; Cohen, 1988; Geffen & Rothenberg, 2000). In this study, all f^2 values exceeded 0.020, indicating a substantial impact on the model’s validity (Khan et al., 2022). Furthermore, the model shows predictive relevance, as the Q^2 values exceed zero (Henseler et al., 2009). Collectively, the R^2 , Q^2 values (Table 12), and f^2 (Table 13) values provide strong evidence for the explanatory and predictive adequacy of the structural model.

Figure 3: Higher-order measurement model

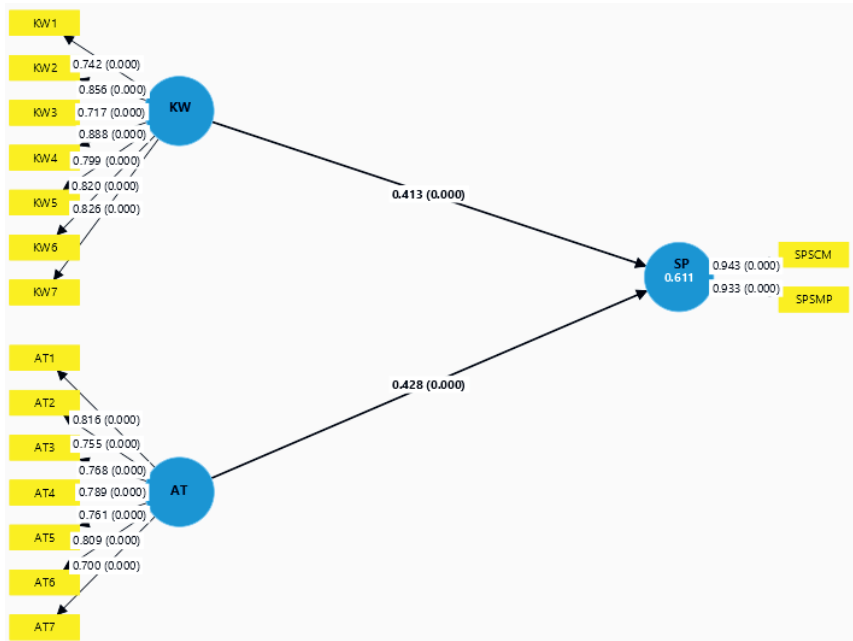


Table 12: R-square and Q-square

	R-square	R-square adjusted	Q-square
SP	0.611	0.602	0.601

The structural model results (Table 13) provide strong empirical evidence supporting both hypotheses. The path coefficient KW to SP was positive and significant ($\beta = 0.413$, $p < 0.001$), supporting H1. This implies that greater knowledge regarding suitability can increase the likelihood of the adoption of sustainability practices. Similarly, the attitude towards sustainability also exerted a significant positive influence on SP ($\beta = 0.428$, $p < 0.001$), thereby supporting H2. Together, the results proved that both knowledge and attitude can be significant predictors of sustainability practice adoption.

Table 13: Bootstrapping results for structural model evaluation

Path coefficient	Coefficient	Mean	SD	f ²	t statistics	P values
KW → SP	0.413	0.415	0.104	0.222	3.989	0.000
AT → SP	0.428	0.431	0.108	0.208	3.969	0.000

Notably, attitude exerted a slightly greater influence than knowledge on the adoption of sustainability practices. In line with the work of Thomas & Lamm (2012), this study reaffirms that a significant shift in the moral attitudes of organisational actors, namely, managers and top executives who make strategic decisions, is necessary for genuine progress in adopting strong sustainability practices.

5. Discussion

Manufacturing has been a significant contributor to economic development, facilitating employment, revenue generation, and resource utilisation for human satisfaction (Fortuny-Santos et al., 2024; Opoku & Li, 2025). However, its detrimental ecological effects have become widespread and severe, particularly in developing economies (Opoku & Li, 2025). As a result, researchers and practitioners are focusing on sustainability practices to help manufacturing firms address the environmental problems they cause (Opoku, 2024). The present study empirically examines how knowledge and attitude shape the adoption of sustainable practices in manufacturing firms.

The study found that both knowledge and attitude exert a significant positive influence on the adoption of sustainability practices. This finding is consistent with previous studies in related contexts. For instance, Ahmad et al. (2020) reported that knowledge and attitude influence the adoption of green fashion innovation. Koliby et al. (2025) found that knowledge management enhances sustainable performance, while Liu et al. (2019) concluded that a strong knowledge base is essential for adopting sustainable practices. Furthermore, employees' attitudes towards the environment influence the adoption of sustainability practices (Sharma, 2014). Liem & Hien (2024) observed that managers with positive environmental attitudes are more likely to choose green production strategies. Collectively, these studies support the importance of knowledge and attitude in facilitating the adoption of sustainability practices, as highlighted by the present study.

The KAP model depicts a linear relationship in which knowledge influences attitude, which in turn leads to the adoption of a practice. However, the study findings showed that both knowledge and attitude can act as independent predictors of the adoption of practices, with attitude exerting a slightly greater influence. This implies that the KAP model's conventional sequential flow may not be applicable in all settings, particularly in the

context of sustainability practice adoption.

Durán Gabela et al. (2022) found a weak positive correlation between knowledge and attitude in sustainable agriculture, hinting that they may function independently. Thus, this study supports our model, which considers knowledge and attitude as independent variables to better comprehend their individual contributions to the adoption of sustainable practices. Similarly, the present study's findings corroborate with Ovais (2023), who found that sustainability knowledge and attitude influence students' sustainability behaviour, with attitude having a more significant impact on behaviour. These insights reinforce the argument that, even though knowledge and attitude are conceptually linked, they can contribute independently to sustainability practice adoption.

The stronger effect of attitude highlights the importance of personal agency in adopting sustainability practices. While knowledge provides awareness, it remains insufficient unless coupled with a strong belief that one's action can change the particular situation. Without such a sense of personal agency, knowledgeable people would be unable to adopt practices (Ovais, 2023). In this regard, green self-efficacy, the belief that one can contribute to solving environmental problems, becomes essential. Managers and employees with a strong sense of personal agency, such as green self-efficacy, can translate their positive attitude into tangible practices or behaviour.

Beyond individual factors, external enablers such as regulatory frameworks, institutional supports, and market incentives can further amplify the influence of knowledge and attitude on sustainability practices. For instance, the Government of Kerala has introduced a sustainable industry incentive scheme, which ensures 25% reimbursement of expenses incurred in connection with sustainability initiatives (Kerala State Industrial Development Corporation, 2023). Therefore, organisations with a strong knowledge base and a positive sustainability attitude are better equipped to adapt to regulatory and policy pressures smoothly.

6. Conclusion

Environmental degradation resulting from human actions has always been a concern. Specifically, manufacturing units are primarily responsible for environmental problems; therefore, they need to perform their operations

more sustainably (López-Cózar-Navarro et al., 2024). Comprehending knowledge, attitudes, and sustainability practices is required for effective transitions toward sustainability. (Salas-Zapata et al., 2018). This study delineates the cognitive and attitudinal factors that facilitate the transition to sustainability through the adoption of sustainable practices. Prior research that adopted the KAP model tested the linear relationship—Knowledge → Attitude → Practice—in different contexts. However, a modified KAP model, treating knowledge and attitude as independent predictors of practice, was used in this study. PLS-SEM was used to assess the reliability and validity of the constructs and their interrelationships.

Corroborating the findings of Birou et al. (2019), the significant relationship between knowledge and the adoption of sustainable practices as revealed by the study suggests that enhancing sustainability awareness within organisations can lead to better adoption of sustainable practices. Furthermore, the study reveals that attitudes toward sustainability have a positive influence on sustainability practices. In line with the work of Thomas & Lamm (2012), this study reaffirms that a significant shift in the attitudes of organisational actors—namely, managers and top executives who make strategic decisions—is necessary for genuine progress in adopting robust sustainability practices. However, the analysis also found that attitude has more influence on the adoption of sustainability practices. This means that the adoption of sustainability practices can't be considered as a sequential process. Sustainability-related knowledge enhances people's capacity to deal with environmental issues. But knowing about sustainability is not enough; one's attitude must also reflect it (Ovais, 2023). Even if employees are knowledgeable about sustainability aspects and environmental issues, the adoption of sustainability practices is not always evident. Attitude encompasses both rational and emotional responses, in contrast to the rational nature of knowledge. Engaging emotionally can make people feel more passionate or morally bound to act, which can lead to deeper commitments to sustainability initiatives (Bamberg & Moser, 2007). The study emphasises the need to move beyond awareness classes. Incorporating sustainability practices into manufacturing culture requires more attitudinal changes. The study's results help manufacturing units concentrate more on attitudinal shifts rather than simply providing awareness sessions.

7. Managerial Implications

Progress toward building a sustainable society has not progressed as quickly as anticipated, leaving us in a worse situation than a decade ago (Baumgartner & Rauter, 2017). This study provides actionable insights for manufacturing units to strengthen their environmental commitment. Like Ajzen (1991) and Gifford (2011), the findings confirm that both knowledge and attitude influence sustainability adoption, though attitude exerts a slightly stronger effect.

As study findings suggest, managers must first focus on knowledge enhancement, moving beyond generic awareness sessions towards targeted programs that address specific gaps. The need to conduct advanced training, such as dynamic lifecycle assessment, to equip employees with practical tools to effectively evaluate the environmental impacts of operations. Secondly, managers must take measures to shape sustainability-oriented attitudes within the organisations. Recruitment processes should include the assessment of pro-environmental behaviour along with the technical expertise. Managers can reinforce positive attitudes by rewarding employees who exhibit strong sustainability commitments, encouraging participation in green initiatives, and promoting the use of eco-friendly products. Establishing environmental committees with clear performance metrics can institutionalise accountability. Manufacturing units should also collaborate with industry partners to organise sustainability conferences, thereby showcasing initiatives and cultivating a shared sustainability culture. Finally, integrating sustainability into the company's mission, vision, and daily operations, rather than treating it as a promotional tool, but as a core value, will encourage long-term dedication and behavioural consistency.

8. Limitations and Future Research Directions

The analysis is limited to data collected from manufacturing units in Kerala, thereby restricting the geographical scope of inference. Although the study findings make valid contributions to the literature, the relatively smaller sample size and use of a non-random sampling technique limit the generalisability of the findings. The adoption of sustainability practices was examined using a single KAP model, with only knowledge and attitude as determinants, leaving other influential behavioural factors as predictors

or control variables. The influence of potential mediating and moderating variables was also not examined.

Future research can enhance the external validity of findings by broadening the geographical scope and employing a randomly selected larger sample. Integrating the KAP model with the Theory of Planned Behaviour would provide an alternative perspective on sustainability adoption. Finally, including leadership style, regulatory pressures, organisational culture, firm size as mediators and moderators would better explain dynamics underlying the knowledge–attitude–practice relationship.

CRedit author statement

Arya Thomson: Conceptualisation, data collection/curation, and formal analysis. **Rajeev Kumar A.D.:** Design of methodology, original draft preparation, and editing.

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Appendix 1: Variables and Sources

Variable Code	Items	Adapted from
<i>Knowledge regarding sustainability</i>		
KW1	I am very knowledgeable about environmental/sustainability issues.	Oriade et al. (2021)
KW2	I understand the Corporate Social Responsibility (CSR) concept	
KW3	I understand that sustainability is mainly about the physical environment	
KW4	I know that contribution to the community is part of corporate social responsibility.	
KW5	I understand the industry practices of sustainability.	
KW6	I understand environmental phrases and symbols on product packages.	
KW7	I understand how to source and procure sustainable products.	
<i>Attitude towards sustainability</i>		
AT1	A business should be concerned with sustainable business practices.	Chang & Slaubaugh (2016)
AT2	Sustainable business practices impose unreasonable costs on businesses,	
AT3	Sustainable business practices reduce the competitiveness of enterprises.	
AT4	Sustainable business practices can be a smart business strategy in a world of increasing ecological awareness.	
AT5	More and more consumers are willing to pay for products or services provided by an eco-friendly company.	
AT6	Ignoring sustainable business practices will cost companies in the long run.	
AT 7	Ignoring environmental sustainability will result in irreversible harm to the earth.	
<i>Sustainable Manufacturing Practices (SPSMP)</i>		
SPSMP1	We adopted measures to save energy during the manufacturing process	Ibrahim et al. (2020)
SPSMP2	We reduce emissions during the manufacturing process	
SPSMP3	We commit to sustainable programs, standards, or regulations	
<i>Sustainable supply chain practices (SPSCM)</i>		
SPSCM1	We choose sustainable suppliers	Ibrahim et al. (2020)
SPSCM2	We make sustainable collaborations with suppliers	
SPSCM3	We impact customers to accept sustainable practices, services, or products	
SPSCM4	We use less or reusable packaging	
SPSCM5	We use energy-efficient transportation	