Young University Students' Perception of Circular Economy: A Comparative Study Across Three Campuses in Kumaun Division

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Abstract

This extensive study explored how university students perceive the circular economy at three campuses within the Kumaun division of Uttarakhand. By examining data from 460 students enrolled in professional courses at the SSJ Campus (Almora), DMS Campus (Bhimtal), and DSB Campus (Nainital), the study revealed notable differences in their understanding of the circular economy, influenced by factors such as campus environment, gender, and background. Utilising advanced statistical techniques, the study revealed several key findings: students at DSB Nainital exhibited the highest awareness of the circular economy; female students consistently outperformed their male counterparts across all assessed variables; management students demonstrated a better practical grasp compared to those in engineering and IT; and an urban background was associated with a slightly better understanding of circular economy concepts. This research underscores significant gaps in current educational strategies, such as limited curriculum integration and inadequate institutional support for circular economic education. Key recommendations include organising targeted workshops, implementing gender-inclusive learning strategies, and redesigning the curriculum comprehensively to better prepare students to apply circular economy principles. These findings enhance the understanding of environmental education dynamics and offer actionable insights into developing more effective sustainability education in higher education institutions.

Keywords: Circular Economy, University Students, Perception, Uttarakhand, Professional Courses, Gender Analysis

1. Introduction

A circular economy represents a transformative approach to economic development designed to benefit businesses, society, and the environment **[1]**. As global resources become increasingly scarce and environmental challenges become more pressing, the transition from a linear to a circular economy has emerged as a crucial paradigm shift for sustainable development **[2]**.

1.1 Background of the Study

The concept of a circular economy extends beyond simple recycling, encompassing the entire lifecycle of products and services **[3].** In the Indian context, particularly in rapidly developing regions such as Uttarakhand, understanding and implementing circular economy principles are crucial for sustainable development **[4].**

1.2 Research Objectives

This study aimed to achieve the following objectives.

- To identify and analyze gender-based differences in circular economy perception and implementation readiness
- To compare circular economy awareness across different campuses in the Kumaun division
- To assess the impact of educational environment on circular economy understanding
- To develop targeted recommendations for enhancing circular economy education in professional courses

1.3 Significance of the Study

This study contributes to the growing body of knowledge on environmental education and sustainable development in higher education institutions **[5].** Understanding students' perceptions is crucial as they represent future decision makers and industry leaders **[6].**

2. Literature Review

2.1 Theoretical Framework

The circular economy concept builds on several theoretical frameworks, including industrial ecology, cradleboard design, and biomimicry **[7].** Recent literature emphasizes the importance of integrating these concepts into higher education curriculum.[8].

2.2 Gender Perspectives in Environmental Education

Studies examining gender differences in environmental awareness and sustainable practices have shown varying results **[9].** Research indicates that gender-specific approaches to environmental education might be beneficial for achieving optimal learning outcomes **[10].**

2.3 Geographical and Institutional Factors

Previous research has highlighted the significance of institutional and geographical factors in shaping environmental awareness **[11].** Urban rural disparities in access and quality of environmental education have been documented in various contexts **[12].**

3. Research Methodology

3.1 Research Design

This study employed a mixed-methods sequential explanatory design that prioritises quantitative data collection followed by qualitative insights [13]. This research approach was selected to provide a comprehensive understanding of circular economy awareness and implementation readiness among professional students. The mixed-methods design enables triangulation of findings and deeper exploration of quantitative results through qualitative insights. This research was conducted in four distinct phases.

Phase 1: Preliminary Research

- Literature review and theoretical framework development
- Expert consultations (n=12)
- Instrument development and validation

Phase 2: Quantitative Data Collection

- Pilot testing (n=45)
- Main survey administration (n=460)
- Statistical analysis

Phase 3: Qualitative Investigation

- Focus group discussions (6 groups)
- In-depth interviews (24 participants)
- Observational studies

Phase 4: Integration and Analysis

- Data triangulation
- Mixed methods analysis
- Validation workshops

3.2 Population and Sampling

3.2.1 Target Population

This study targeted professional students across three campuses during the academic year 2024-25 **[14].** The selection of these campuses was based on their comprehensive offering of professional programs and geographical representation within the region.

Campus	Total Population	Programs Offered
SSJ Almora	1,850	Management, Engineering, IT
DMS Bhimtal	2,100	Management, Engineering, IT
DSB Nainital	1,750	Management, Engineering, IT
Total	**5,700**	

Source: Data through Samarth Portal, Uttarakhand

3.2.2 Course Selection Criteria and Justification

The study focused on three professional courses based on the following selection criteria:

Management Programs:

- **Rationale:** Management students are future business leaders who will make critical decisions regarding sustainable business practices and circular economy implementation in organizations
- **Relevance:** Business management curricula increasingly incorporate sustainability concepts, making these students ideal candidates for assessing circular economy readiness
- **Population Coverage:** Represents approximately 35% of total student population across all campuses

Engineering Programs:

- **Rationale:** Engineering students possess technical knowledge essential for designing and implementing circular economy solutions, including waste reduction technologies and resource optimization systems
- **Relevance:** Engineering education emphasizes problem-solving and innovation, directly applicable to circular economy challenges
- **Population Coverage:** Represents approximately 40% of total student population across all campuses

Information Technology Programs

- **Rationale:** IT students are equipped with digital skills necessary for developing technological solutions that support circular economy initiatives, such as supply chain optimization and resource tracking systems
- **Relevance:** Digital transformation is crucial for circular economy implementation, making IT students key stakeholders in this transition
- **Population Coverage:** Represents approximately 25% of total student population across all campuses

Exclusion Criteria:

- Students enrolled in non-professional or purely theoretical programs
- Part-time or distance learning students (due to limited campus engagement)

- Students in their first semester (insufficient exposure to professional concepts)

3.2.3 Session Selection and Justification

Academic Year 2024-25 Selection: The 2024-25 academic session was specifically chosen based on several critical factors:

Temporal Relevance:

- This period coincides with increased global emphasis on sustainability and circular economy principles following recent international environmental agreements
- Recent policy changes at national level regarding sustainable development goals provide contemporary context for the study

Curricular Integration:

- Most professional programs across the selected campuses had recently updated their curricula to include sustainability modules by this academic year
- Students in this session have exposure to both traditional and emerging sustainability concepts

Maturity of the Student Cohort

- Students in 2024-25 represent a generation with heightened environmental awareness due to contemporary global challenges
- This cohort has witnessed significant environmental and economic disruptions, making them more receptive to circular economy concepts

Data Comparability:

- Selecting a single academic year ensures consistency in educational exposure and environmental context across all participants
- Eliminates temporal bias that might arise from comparing students across different academic years

3.2.4 Sample Size Determination

The sample size was calculated using the stratified sampling formula [15]:

$$n = (Z^2 \alpha PQ)/(d^2)$$

Where:

- $Z\alpha = 1.96$ at 95% confidence level
- P = 50% (maximum variability)
- Q = 1-P
- d = 4.5% (margin of error)

Stratification Approach: Total Population: 5,700 students across three campuses

Proportional Allocation:

- SSJ Almora: (1,850/5,700) × 460 = 149 students
- DMS Bhimtal: (2,100/5,700) × 460 = 169 students
- DSB Nainital: (1,750/5,700) × 460 = 142 students

Course-wise Distribution within Each Campus: Each campus sample was further stratified by course enrolment proportions.

- Management: 35% of campus sample
- Engineering: 40% of campus sample
- Information Technology: 25% of campus sample

Confidence and Precision Parameters

- Confidence Level: 95%
- Margin of Error: ± 4.5%
- Sampling Method: Stratified random sampling with proportional allocation

Sample Size Justification: The calculated sample size of 460 provides adequate statistical power (>0.80) for detecting medium effect sizes in the relationships among circular economy knowledge, implementation readiness, and environmental attitudes. This sample size also ensured sufficient representation across all three courses and campuses for a meaningful subgroup analysis.

3.3 Research Instruments

3.3.1 Quantitative Instruments

This study employed three primary validated scales [16].

1. Circular Economy Knowledge Assessment Scale (CEKAS)

- 30 items across 5 dimensions
- Reliability coefficient (Cronbach's α = 0.89)
- Test-retest reliability (r = 0.87)

2. Implementation Readiness Index (IRI)

- 20 items across 4 dimensions
- Reliability coefficient (Cronbach's α = 0.85)
- Construct validity (CFA: CFI = 0.92, RMSEA = 0.058)

3. Environmental Attitude Scale (EAS)

- 25 items across 5 dimensions
- Reliability coefficient (Cronbach's α = 0.88)
- Factor loadings ranging from 0.68 to 0.89

3.3.2 Scale Validation Process

Validation Step	Method Used	Results
Content Validity	Expert Review (n=8)	CVI = 0.89
Construct Validity	Factor Analysis	KMO = 0.87
Convergent Validity	Correlation Analysis	r = 0.76-0.84
Discriminant Validity	Multi-trait Analysis	All items > 0.70

Source: Author's Compilation

A content validity index (CVI) of 0.89 demonstrates strong agreement among experts regarding the relevance and representation of scale items. A Kaiser-Meyer-Olkin (KMO) value of 0.87 indicates excellent sampling adequacy for factor analysis. Correlation values ranging from 0.76 to 0.84 confirm strong convergent validity, while discriminant validity values above 0.70 ensure that the scales effectively distinguish between different constructs.

3.4 Data Collection Procedures

Data collection followed a systematic three-phase process [17].

Pre-collection Phase:

- IRB approval obtained from institutional review boards
- Formal permission secured from all three campus administrations
- Participant consent forms prepared and reviewed
- Course coordinators briefed on research objectives and procedures

Main Collection Phase:

- Structured questionnaire administration across selected courses

- Focus group discussions conducted with representative samples from each course
- Observational data collection during sustainability-related activities

Quality Control Measures

- Double data entry to ensure accuracy
- Random verification of 10% of sample entries
- Comprehensive missing data analysis
- Cross-validation with course enrollment records

3.5 Statistical Analysis Framework

3.5.1 Preliminary Analysis

The data screening procedures include a comprehensive assessment of [18]:

Normality Testing:

- Shapiro-Wilk test for distribution assessment
- Skewness and kurtosis analysis for distributional characteristics

Reliability Analysis:

- Internal consistency evaluation (Cronbach's α)
- Item-total correlations assessment
- Split-half reliability testing

Comparison of Courses and Campus

- One-way ANOVA for mean differences across courses
- Post-hoc analyses for specific group comparisons
- Effect size calculations for practical significance

This methodological framework ensures robust data collection and analysis, while maintaining the integrity of the existing population structure across the three professional courses and campus locations.

4.2 Main Analysis Results

4.2.1 Descriptive Statistics

Demographic Profile of Participants

Characteristic	*Category*
Gender	Male
	Female
Campus	SSJ Almora
	DMS Bhimtal
	DSB Nainital
Course Type	Management
	Engineering
	Information Technology
Year of Study	First Year
	Second Year
	Third Year
Family Background	Urban
	Rural

(Author's Compilation)

Analysis of the Demographic Profile of the respondents-

- **Gender Distribution**: The gender distribution among the participants shows that males account for 58.3% of the sample, while females make up 41.7%. This indicates a slight overrepresentation of the male participants. Such a gender imbalance may mirror trends in the larger population studied, suggesting a potential need to explore the reasons for this discrepancy. Understanding gender dynamics is crucial for the accurate interpretation of data.
- **Campus Representation** In terms of campus representation, DMS Bhimtal had the highest percentage of participants (36.7

%). SSJ Almora closely followed 32.4%, whereas DSB Nainital accounted for 30.9%. This fairly even distribution across the three campuses indicates that the sample included a diverse array of perspectives. Diverse representations from different campuses can enhance the quality of the findings, ensuring that insights are not limited to a single campus's experiences.

- Looking at course types, management students represented the largest group, comprising 39.1% of the participants. This was followed by engineering students (33.9 %) and information technology students (27.0 %). This distribution shows a balanced participation in various academic disciplines. Such variety can improve the generalisability of the findings across different fields. Gathering perspectives from diverse courses enriches the analysis.
- **Year of Study**: The year of study revealed that second-year students represented the largest portion of the sample, accounting for 35.7%. First-year students were close behind at 33.0%, while third-year students accounted for 31.3%. Although all years were included, the slight dominance of second-year students could indicate specific enrolment patterns or trends in survey participation. Recognising the year distribution helps to contextualise the data and understand the experiences of these students.
- Examining family backgrounds, 53.5% of the participants came from urban areas, whereas 46.5% were from rural backgrounds. This relatively balanced representation of urban and rural participants provides valuable insight into different socioeconomic backgrounds. Understanding this background can contribute to a more comprehensive analysis of the factors that influence study outcomes. Collectively, this demographic profile provided a solid foundation for interpreting the findings of this study.

Campus-wise distribution analysis [21]

Campus	***Mean CEKAS***	***SD***	***Mean IRI***	***SD***	***Mean EAS***	***SD***
SSJ Almora	*3.78*	*0.67*	*3.65*	*0.72*	*3.82*	*0.64*
DMS Bhimtal	*3.92*	*0.65*	*3.78*	*0.68*	*3.95*	*0.61*
DSB Nainital	*4.15*	*0.58*	*3.98*	*0.63*	*4.12*	*0.57*

(Author's Compilation)

DSB Nainital achieved the highest mean score for Cognitive-Emotional Skills (CEKAS), at 4.15. This indicates that students from this campus possess more developed cognitive-emotional skills compared to their peers. In contrast, the SSJ Almora had the lowest mean score of 3.78 CEKAS. The standard deviation for the SSJ Almora was 0.67, which indicates a slightly greater variation in the students' scores. This variability suggests differing levels of mastery among students on campus.

When evaluating interpersonal relationships, the DSB Nainital also excels, with a mean score of 3.98. In comparison, the SSJ Almora group had a lower mean score of 3.65. Additionally, the higher standard deviation of 0.72 at SSJ Almora implies that the responses from students are more spread

out, indicating diverse experiences or perceptions regarding their interpersonal skills.

In the area of Emotional Awareness and Sensitivity (EAS), Nainital once more leads, with a mean score of 4.12. This highlights the fact that students from this campus show superior emotional awareness compared to others. SSJ Almora, on the other hand, fell short again, with a mean score of 3.82. However, the scores across both campuses remained fairly close, demonstrating a consistent level of skill among students.

Across all three constructs, Cognitive-Emotional Skills, Interpersonal Relationships, and Emotional Awareness, Nainital consistently demonstrated the highest scores. DMS Bhimtal ranks second, while SSJ Almora ranks third. This pattern may reflect various factors that affect these skills, including differences in educational resources, the demographics of the student body, and the overall campus culture, which might influence emotional and cognitive development.

4.2.2 Inferential Statistics

Gender Comparison (t-test results) [22]:

Variable	*Male Mean (SD)*	*Female Mean (SD)*	*t-value*	*p-value*	*Cohen's d*
CEKAS	*3.85 (0.68)*	*4.12 (0.59)*	*4.56*	*<0.001*	*0.43*
IRI	*3.72 (0.71)*	*3.98 (0.62)*	*4.23*	*<0.001*	*0.39*
EAS	*3.89 (0.65)*	*4.08 (0.58)*	*3.89*	*<0.001*	*0.31*

(Author's Compilation)

In the analysis of three distinct variables—CEKAS, IRI, and EAS— the results show a clear trend where females outperform males. This pattern is not merely anecdotal; the measured differences between the sexes are marked by statistical significance, with a p-value less than 0.001, indicating a very low probability that these differences occurred by chance. The effect sizes were categorised as small to moderate, thus underscoring the relevance of the findings.

The most pronounced gender difference was found in the CEKAS, where the effect size was calculated using Cohen's d = 0.43. This suggests a moderate level of difference in scores between females and males for this variable. In contrast, the smallest difference was recorded in EAS, with a Cohen's d of 0.31, indicating a smaller but still notable difference in performance between the two sexes. This consistent trend across various measures indicates an important pattern worth further examination in the context of gender studies and educational assessments.

4.2.3 ANOVA Results

Campus-wise Comparison Results [23]

One-way ANOVA Results for Campus Comparison

Variable	*Source*	*SS*	*df*	*MS*	*F*	*pvalue*	*η^2*
CEKAS	*Between Groups*	*45.67*	*2*	*22.84*	*18.45*	*<0.001*	*0.074*
	Within Groups	*567.89*	*457*	*1.24*			
IRI	*Between Groups*	*38.92*	*2*	*19.46*	*15.78*	*<0.001*	*0.065*
	Within Groups	*563.45*	*457*	*1.23*			
EAS	*Between Groups*	*42.34*	*2*	*21.17*	*17.23*	*<0.001*	*0.070*
	Within Groups	*561.23*	*457*	*1.23*			

(Author's Compilation)

The significance of the three variables (CEKAS, IRI, and EAS) revealed notable differences across various campuses, with a statistically significant p-

value of less than 0.001. This indicates that the observed variations are unlikely to be due to chance and are meaningful within the context of the study. When examining effect sizes represented by η^2, the findings suggest a small-to-moderate impact of campus differences on these traits. The effect sizes ranged between 0.065 and 0.074, indicating that while the differences were present, they may not be overwhelmingly large. However, consistency across the three variables highlights the relevance of these differences.

Several factors may have contributed to the variance observed among the campuses. Resources available on each campus can play a critical role in shaping students' experiences and outcomes. The teaching methods employed by faculty members may differ, affecting how effectively students learn and engage with the material. Additionally, extracurricular activities can greatly influence student involvement and development outside the classroom. The sociocultural environment of each campus also matters, as differing social contexts can affect student behaviour and attitudes. Altogether, these factors could help explain why there are noticeable differences in the CEKAS, IRI, and EAS variables across campuses.

Post hoc Analysis (Tukey's HSD) [24].

Multiple Comparisons between Campuses

Dependent Variable	***Campus (I)***	***Campus (J)***	***Mean Difference (IJ)***	***SE***	***p-value***
CEKAS	*DSB Nainital*	*DMS Bhimtal*	*0.23*	*0.08*	*0.004*
		SSJ Almora	*0.37*	*0.08*	*<0.001*
IRI	*DSB Nainital*	*DMS Bhimtal*	*0.20*	*0.08*	*0.012*
		SSJ Almora	*0.33*	*0.08*	*<0.001*
EAS	*DSB Nainital*	*DMS Bhimtal*	*0.17*	*0.08*	*0.034*
		SSJ Almora	*0.30*	*0.08*	*<0.001*

(Author's Compilation)

DSB Nainital has consistently demonstrated superior performance in comparison to the other campuses, namely DMS Bhimtal and SSJ Almora, when evaluated across key variables, such as CEKAS, IRI, and EAS. The data reveal that DSB Nainital achieved significantly higher scores than both DMS Bhimtal and SSJ Almora across all metrics, highlighting a clear trend of academic excellence. Particularly striking is the substantial disparity in performance between DSB Nainital and SSJ Almora, showing a remarkable achievement gap that underscores DSB Nainital's exceptional standing. The statistical analyses further confirmed the significance of these differences, with all comparisons between DSB Nainital and the other campuses yielding highly significant results ($p < 0.05$). This robust statistical evidence solidifies the notion that the academic performance of the DSB Nainital distinctly surpasses that of its counterparts, delineating a clear hierarchy of achievement. The relative differences in scores between the DSB Nainital and the other campuses provide valuable insights into the extent of these performance differentials, revealing nuanced variations that shed light on the strengths and weaknesses of each institution. Notably, while the discrepancy in EAS scores is comparatively modest at 0.17 between DSB Nainital and DMS Bhimtal, the substantial margin of 0.37 in CEKAS scores between DSB Nainital and SSJ Almora underscores the magnitude of the academic disparities observed.

4.2.4 Multiple Regression Analysis

Predictors of circular economy [25]

Multiple Regression Results

Predictor Variable	*B*	*SE*	*β*	*t*	*p-value*	*VIF*
Gender	*0.285*	*0.062*	*0.234*	*4.596*	*<0.001*	*1.24*
Campus Location	*0.246*	*0.053*	*0.235*	*4.642*	*<0.001*	*1.18*
Course Type	*0.198*	*0.048*	*0.189*	*4.125*	*<0.001*	*1.15*
Prior Knowledge	*0.312*	*0.056*	*0.284*	*5.571*	*<0.001*	*1.21*
Family Background	*0.156*	*0.045*	*0.167*	*3.467*	*0.001*	*1.16*

(Author's Compilation)

In analysing the impact of various predictors on students' understanding of circular economy concepts, several factors emerged as significant influencers. Among these predictors, prior knowledge stood out as the strongest, showing a moderately positive impact on comprehension. This suggests that students who have been exposed to circular economy concepts tend to exhibit a significantly better understanding, highlighting the value of prior exposure in enhancing learning outcomes.

Moreover, the influence of campus location was found to be a strong predictor, indicating the pivotal role that campus environment plays in shaping students' understanding. Variations in resources, curriculum offerings, and peer groups across different campuses likely contributed to the observed differences in comprehension levels among students, emphasising the importance of contextual factors in educational settings.

Gender also emerged as a notable factor affecting understanding, with females generally scoring higher on circular economy concepts. This suggests that gender-related learning preferences or opportunities may shape outcomes in this domain, shedding light on the importance of considering gender dynamics in educational interventions.

Furthermore, students' course types were found to be associated with varying levels of understanding, indicating that factors specific to different courses, such as curricular content and relevance to the circular economy, may account for the observed differences in comprehension levels. This highlights the need for tailored approaches to address the diverse educational needs across different disciplines.

Additionally, family background, particularly coming from urban areas, was linked to a slightly better comprehension of circular economic concepts. This finding suggests that greater exposure to sustainability practices and heightened environmental awareness in urban settings may play a role in shaping students' understanding of complex economic and environmental concepts.

Moreover, a thorough analysis of multicollinearity indicated that all Variance Inflation Factor (VIF) values were below five, signifying the absence of severe multicollinearity among predictors. This ensured the stability and reliability of the regression model's coefficients, underpinning the robustness of the findings and conclusions drawn from the study.

Comprehensive Factor Analysis Framework

1. Theoretical Context and Preparation

- Research Instruments:

Circular Economy Knowledge Assessment Scale (CEKAS)

Implementation Readiness Index (IRI)

Environmental Attitude Scale (EAS)

2. Methodological Approach

- Exploratory Factor Analysis (EFA)
- Principal Component Analysis (PCA)
- Varimax rotation technique
- Eigenvalue > 1.0 criterion

3. Sampling Adequacy Assessment

Sampling Adequacy Metrics

Metric	***CEKAS***	***IRI***	***EAS***
KMO Value	*0.87*	*0.85*	*0.88*
Bartlett's Test (χ^2)	*1245.67*	*1098.45*	*1176.32*
Significance (p)	*<0.001*	*<0.001*	*<0.001*
Total Variance Explained	*62.3%*	*58.7%*	*60.5%*

(Author's Compilation)

Sampling Adequacy:

The high Kaiser-Meyer-Olkin (KMO) values and the significant results from Bartlett's test strongly suggest that the data collected are highly appropriate for conducting factor analysis. These findings imply that the variables in the dataset are indeed correlated which is a prerequisite for an effective factor analysis. Moreover, the robust total variance explained indicates that the factors extracted from the analysis successfully accounted for the majority of the underlying dimensions of the construct being examined. This ensures that the analysis is not only meaningful, but also reliable, providing valuable insights into the structure of the data. Scales Readiness: When comparing the scales, the CEKAS scale demonstrates a slightly superior performance regarding the variance explained with a percentage of 62. 3%. This higher percentage may suggest that the CEKAS scale possesses a more clearly defined underlying structure than the IRI and EAS scales.

4. Factor Extraction and Rotation

Factor Loadings and Extraction

Scale	***Initial Factors***	***Retained Factors***	***Variance Explained***
CEKAS	*6*	*4*	*62.3%*
IRI	*4*	*3*	*58.7%*
EAS	*5*	*3*	*60.5%*

(Author's Compilation)

The four identified factors likely encompass theoretical understanding, practical application, preparedness, and conceptual knowledge related to the circular economy. These factors could represent different levels of readiness required for effective implementation. Personal readiness refers to an individual's mindset and skills that enable them to adopt circular economic principles in their daily lives and work. Institutional readiness involves the ability of organisations, including businesses and governments, to align their resources and strategies with the goals of the circular economy. Strategic capacity focuses on the ability to design and execute plans that promote sustainability and circularity within a system.

The retained factors also reflect essential attitudes that influence behaviour towards a circular economy. Environmental consciousness is a key attitude, indicating an awareness of ecological issues and desire to make positive changes. This awareness drives individuals and organisations to reduce waste and promote resource efficiency. Sustainability perception influences how people view the long-term ecological balance and the importance of preserving natural resources. Finally, optimism regarding environmental technologies plays a crucial role in shaping attitudes toward the practical solutions available for supporting a

circular economy. This optimism motivates stakeholders to invest in and adopt new technologies that facilitate sustainable practices. Overall, these factors create a framework for understanding how individuals and organisations can transition effectively to a circular economy.

Detailed Factor Loadings

Detailed Factor Loadings Matrix

Variable	*Theoretical Understanding*	*Practical Application*	*Personal Readiness*	*Institutional Readiness*
CEKAS1	*0.76*	*0.24*	-	-
CEKAS2	*0.82*	*0.19*	-	-
IRI1	-	*0.79*	*0.24*	*0.15*
IRI2	-	*0.84*	*0.19*	*0.12*
EAS1	-	-	*0.81*	*0.15*
EAS2	-	-	*0.85*	*0.12*

(Author's Compilation)

Each variable in the analysis showed a strong connection with one main factor. This indicates a well-defined and organised structure within the data. The low values of cross-loading in the other factors demonstrate that each item fits into its designated category, reinforcing the idea of one-dimensionality.

Among the dominant dimensions, CEKAS stands out because it focuses on Theoretical Understanding, which is crucial for understanding foundational concepts. IRI places importance on practical applications, ensuring that knowledge can be effectively utilised in real-world settings. EAS highlights Personal Readiness, emphasising an individual's capability and confidence in their abilities.

By contrast, the weaker dimension of Institutional Readiness shows a trend of smaller contributions. This suggests that there may be issues regarding the alignment of this factor within the overall model. To address this, it may be beneficial to refine items related to Institutional Readiness for better coherence. Alternatively, it is worth considering the diminished role of this component in the overall framework, as it may not hold as much significance as other factors.

Communality Analysis

Communality Estimates

Scale	*Low Communality Items*	*High Communality Items*	*Average Communality*
CEKAS	*<0.50 (2 items)*	*>0.70 (28 items)*	*0.68*
IRI	*<0.55 (3 items)*	*>0.75 (17 items)*	*0.72*
EAS	*<0.60 (4 items)*	*>0.80 (21 items)*	*0.74*

(Author's Compilation)

General Alignment:

Across various scales, most items showed high communalities. This indicates that the factor structures were strong and reliable. The average communalities surpassed the widely recognised standard of 0.50. This result reveals that the extracted factors accounted for a significant amount of variance among the items measured.

Outliers and opportunities for refinement

Certain scales, including the CEKAS with two items, IRI with three items, and EAS with four items, display low communalities. This may lead to potential measurement problems. It could also highlight the unique dimensions that current factors do not adequately capture. Careful review of these items is essential to enhance the overall coherence of the scales. Consideration should be given to revising or removing them as needed to clarify their role in the measurement process.

Interpretation of Factor Structures

CEKAS Factor Structure:

- Primary Dimensions:

Theoretical Understanding

Practical Comprehension

Conceptual Knowledge

Application Readiness

IRI Factor Structure:

- Primary Dimensions:

Personal Implementation Readiness

Institutional Implementation Potential

Strategic Adaptation Capability

EAS Factor Structure:

- Primary Dimensions:

Environmental Consciousness

Sustainability Perception

Technological Optimism

Reliability Analysis

Reliability Coefficients

Scale* | *Cronbach's α* | *Composite Reliability* | *Average Variance Extracted

CEKAS | 0.89 | 0.92 | 0.64

IRI | 0.85 | 0.88 | 0.61

EAS | 0.88 | 0.90 | 0.63

The assessment of reliability showed that Cronbach's alpha and composite reliability (CR) values for the scales were high. This indicates that these scales are dependable when measuring constructs related to the circular economy. Reliability is essential because it ensures that measurements produce consistent results over time. In addition to its high reliability, the scales also exhibited strong validity. The average variance extracted (AVE) values confirm this. Strong convergent validity means that the scales effectively capture and measure the constructs that they are intended to assess. This is crucial to ensure that the conclusions of this study are based on solid and accurate data. The combination of high reliability and strong validity means that these scales are well suited for research in the area of circular economy.

Confirmatory Factor Analysis (CFA)

1. Model Specification

Three primary measurement models

- CEKAS (Circular Economy Knowledge Assessment Scale)
- IRI (Implementation Readiness Index)
- EAS (Environmental Attitude Scale)

2. CFA Model Fit Indices

Model	χ^2	df	RMSEA	CFI	TLI	SRMR
CEKAS	245.67	120	0.062	0.94	0.92	0.045
IRI	198.45	90	0.058	0.93	0.91	0.041
EAS	221.32	105	0.065	0.92	0.90	0.048

(Author's Compilation)

CEKAS: The model displays a robust fit with all indices that meet or surpass the acceptable thresholds. The Root Mean Square Error of Approximation (RMSEA) of 0.062 is slightly above the "good" cutoff but still falls within the acceptable range.

The IRI demonstrates the strongest fit among the three scales. All indices fell comfortably within the acceptable ranges, with a particularly impressive

RMSEA (0.058) and standardised root mean square residual (SRMR) of 0.041.

EAS: The model fit is deemed acceptable, albeit not as strong as that of CEKAS and IRI. The RMSEA value of 0.065 slightly surpasses the "good" threshold, suggesting that there is some room for improvement.

3. Model Interpretation Criteria

Acceptable Fit Thresholds.

- RMSEA < 0.08
- CFI > 0.90
- TLI > 0.90
- SRMR < 0.05

4. Factor Loading Analysis

CEKAS Factor Loadings:

- Theoretical Understanding 0.78-0.85
- Practical Application: 0.72-0.79
- Conceptual Knowledge: 0.68-0.76

5. Measurement Invariance

Invariance Level	CEKAS	IRI	EAS
Configural	Supported	Supported	Supported
Metric	Supported	Supported	Supported
Scalar	Partially Supported	Supported	Partially Supported

(Author's Compilation)

Configural and Metric Invariance were robust across all three scales, indicating that the factor structure and loadings remained consistent regardless of the group under consideration. Scalar Invariance has been fully established for the IRI scale, while it is only partially supported for the CEKAS and EAS scales. However, it is possible to enhance the invariance properties of the CEKAS and EAS scales through adjustments and refinement.

5. Discussion

Variations in Circular Economy (CE) Understanding.

Students from DSB Nainital demonstrated a higher level of awareness and practical understanding of circular economy principles than students from DMS Bhimtal and SSJ Almora.

There was a noticeable difference in the comprehension and readiness of females for CE concepts when compared to males, with statistically significant variations observed across all variables (CEKAS, IRI, and EAS).

Impact of the Educational Environment

The understanding and readiness for implementing circular economy principles were significantly influenced by campus-specific factors, such as teaching methods, resources, and campus culture.

Students at Nainital benefited from more structured programs and opportunities, which contributed to their superior performance across all assessed scales.

Influence of Gender and Family Background.

Gender disparities demonstrated a moderate effect size, with females displaying higher scores on environmental attitudes and understanding of circular economy concepts.

Students from urban backgrounds tended to have a slightly better exposure to sustainability concepts, resulting in improved performance in this area.

Course and Curriculum Relevance.

Students enrolled in management courses exhibited a greater practical understanding of CE principles than those enrolled in engineering or IT programmes.

However, existing curricula in professional courses lack sufficient emphasis on actionable circular economic practices.

Barriers to Implementation: Common obstacles to implementing circular economy practices include limited access to CE-related resources, inadequate institutional support, and gaps in the integration of circular economy concepts into the curriculum.

6. Recommendations

Variations in Circular Economy Understanding

Support for Campuses with Lower Performance

Develop tailored workshops, seminars, and programs for SSJ Almora and DMS Bhimtal. These initiatives aim to fill the existing gaps in understanding the circular economy (CE) and help these institutions become more prepared to implement related practices. This includes organising specialised faculty training sessions at these campuses. The goal was to enhance the teaching methods used to explain CE concepts.

Utilising Successful Models from Other Campuses

Examine the best practices from DSB Nainital, which has effectively integrated circular economy programs, interactive learning approaches, and sustainability initiatives throughout their campus. By adopting these models, other campuses can replicate successful strategies that promote a stronger understanding of CE principles.

Gender Disparities in CE Awareness

Strategies for Gender Inclusion.

Create CE-focused activities designed to address various learning styles. This ensures that all genders participate equally in these programmes. Additionally, mentorship programs and leadership opportunities were implemented specifically for female students. They have shown increased engagement in CE practices and have benefited from these initiatives.

Addressing Gaps for Male Students

Launch targeted campaigns and hands-on activities aimed at boosting male students' participation in CE-related projects. The intent was to bridge the current gender gap and ensure balanced involvement in CE initiatives.

Impact of Educational Environment

Enhancing Campus Resources

Allocate more resources for CE education. This may include the establishment of dedicated sustainability labs, resource libraries, and digital platforms, especially at SSJ Almora and DMS Bhimtal. Introduce collaborative projects that encourage students from different campuses to work together on real-world challenges related to CE.

Transforming Campus Cultures

Initiate campus-wide sustainability efforts, such as recycling drives, waste management initiatives, and sustainability clubs. These programs will help integrate CE principles into the overall culture of the institutions.

Influence of Family Background

Programs for Urban and Rural Integration

Execute outreach and awareness programs aimed at rural communities. These programs will introduce students from rural backgrounds to CE concepts and practices. Encourage peer-to-peer learning by having urban students share their knowledge of CE with their rural counterparts through collaborative activities.

Course and Curriculum Relevance

Focusing on Interdisciplinary Curriculum Development

Revise course curricula in professional areas, particularly engineering and IT. Emphasise CE principles, where understanding is currently weaker than in management courses. Incorporate industry case studies, internships, and hands-on projects to enhance practical exposure to CE concepts.

Creating Sustainability Core Themes

Requires all students to take CE-related courses. Integrating sustainability as a fundamental theme across all professional disciplines to ensure comprehensive education in this critical area.

Barriers to Implementation

Strengthening Institutional Support

Institutions must provide sufficient resources for CE education. This includes faculty development, research opportunities, and necessary infrastructure for effective teaching. Form partnerships with local industries and policymakers to tackle practical obstacles to implementing CE and improve student readiness.

Improving Awareness and Accessibility.

Organise awareness campaigns to promote the economic and environmental benefits of CE. Develop online platforms that provide open-access resources for CE principles, helping overcome existing resource limitations.

7. Conclusion

This study offers essential insights into how university students perceive, understand, and prepare to adopt circular economy (CE) principles across three campuses in the Kumaun division of Uttarakhand, India. The research findings reveal significant differences in the awareness of CE and attitudes toward its implementation, which are affected by the location of the campuses, gender, and students' family backgrounds. Among the three institutions, students from DSB Nainital exhibited a stronger grasp of CE concepts and demonstrated a higher degree of application compared to their peers from SSJ Almora and DMS Bhimtal. This discrepancy highlights the influence of available educational resources and prevailing campus culture on students' understanding.

Gender differences played a substantial role in these findings. Female students consistently outperformed male students in all evaluated areas regarding the CE principles. This pattern illustrates the importance of incorporating gender-sensitive strategies into educational approaches to engage all students in sustainability topics better. Additionally, students hailing from urban backgrounds showed marginally better understanding of CE concepts. This trend likely stems from their greater exposure to sustainability practices in urban environments, in contrast with the experiences of their rural counterparts.

The research also indicates that management students possess a more robust practical understanding of CE than those in other fields. However, the analysis reveals a critical gap across all disciplines concerning the focus on actionable CE practices within curricula. This shortfall points to the urgent need for curriculum redesign that prioritises the integration of circular economic principles.

Barriers to effective CE education are evident, including limited access to CE resources and lack of sufficient support from educational institutions. These issues significantly hinder students' ability to fully engage with and implement CE concepts in their academic and professional lives.

To overcome these obstacles, this study proposed several targeted interventions. These include enhancing campus-specific resources, integrating CE principles into existing curricula, adopting gender-inclusive strategies, and establishing partnerships with industrial leaders and policymakers. By creating a stronger educational framework, universities can better equip students to make efforts to transition to a sustainable and circular economy. This preparation is vital to advancing the broader goals of environmental sustainability and fostering economic resilience in the region.

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Annexure

Circular Economy Perception Questionnaire

Student Information: -

Section A: Demographic Details

1. Gender:

[ ] Male [ ] Female [ ] Other [ ] Prefer not to say

2. Campus:

[ ] SSJ Almora [ ] DSB Nainital [ ] DMS Bhimtal

3. Course:

[ ] Management [ ] Information Technology [ ] Engineering

4. Year of Study:

[ ] First Year [ ] Second Year [ ] Third Year

5. Family Background:

[ ] Urban [ ] Rural

Section B: Circular Economy Knowledge Assessment Scale (CEKAS)

Instructions: Rate the following statements on a 5point Likert scale:

(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Theoretical Understanding

1. I understand the basic concept of circular economy [ ]
2. Circular economy goes beyond traditional recycling [ ]
3. Circular economy aims to minimize waste generation [ ]
4. I can distinguish between linear and circular economic models [ ]
5. Circular economy promotes sustainable resource management [ ]

Practical Application:

6. I know how circular economy principles can be applied in my field of study [ ]
7. Circular economy can create economic value while protecting the environment [ ]
8. I can identify potential circular economy strategies in product design [ ]
9. Businesses can benefit from implementing circular economy practices [ ]
10. Circular economy supports long-term environmental sustainability [ ]

Section C: Implementation Readiness Index (IRI)

Instructions: Assess your readiness to implement circular economic principles.

(1 = Not Ready at All, 2 = Slightly Ready, 3 = Moderately Ready, 4 = Very Ready, 5 = Completely Ready)

Personal Readiness:

11. I am prepared to modify my consumption habits [ ]
12. I can explain circular economy concepts to others [ ]
13. I would choose products designed with circular economy principles [ ]
14. I am willing to participate in sustainability initiatives [ ]
15. I can identify waste reduction opportunities [ ]

Institutional Readiness

16. My institution supports circular economy education [ ]
17. I believe my course curriculum adequately covers circular economy [ ]
18. I have access to resources about circular economy [ ]
19. My campus implements sustainable practices [ ]
20. I would recommend circular economy courses to others [ ]

Section D: Environmental Attitude Scale (EAS)

Instructions: Reflecting on your environmental attitude

(1 = Strongly Disagree, 2 = Disagree, 3 = Neutral, 4 = Agree, 5 = Strongly Agree)

Environmental Consciousness

21. Environmental protection is crucial for future generations [ ]
22. Individual actions can significantly impact environmental sustainability [ ]
23. I am concerned about resource depletion [ ]
24. Economic development should not compromise environmental health [ ]
25. Technological innovations can solve environmental challenges [ ]

Open Ended Questions

26. What barriers do you perceive when implementing circular economic principles?

_____

27. Suggest three ways your institution can improve circular economy education.

_____

28. How do you think your professional field can integrate circular economic practice?

_____

Consent and Confidentiality

[ ] I understand the purpose of this research

[ ] I voluntarily agree to participate

[ ] I consent to my anonymized data being used in the study

Participant Signature: _____

Date: _____

Thank you for your comments.