Journal of Natural Resources and Environmental Management
http://dx.doi.org/10.29244/jpsl.16.3.348

RESEARCH ARTICLE

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Does Visitor Knowledge of Forest-based Ecosystem Services Reflect Distinct Behavioral Profiles? A Visitor Segmentation Analysis in Gunung Ciremai National Park, Indonesia

Candra Wigati Hayuningsih, Prasetyo Nugroho

Bachelor of Applied Science in Forest Management, Department of Bioresources and Veterinary, School of Applied Sciences Universitas Gadjah Mada, Yogyakarta, 55281, Indonesia

Article History
Received
4 September 2025
Revised 9 April 2026
Accepted 14 April 2026

Keywords
forest conservation, forest-based ecosystem services, forest management, protected areas

ABSTRACT

National parks (NPs) provide multiple forest-based ecosystem services (FbES yet increasing visitation may also intensify ecological pressures, making visitor behavior important for conservation outcomes. Limited evidence has explicitly linked visitors' FbES knowledge to distinct behavioral segments in tropical NPs. This study aimed to determine whether visitors' knowledge of FbES is consistent with various profiles of conservation-related attitudes and self-reported environmental behavior in Gunung Ciremai National Park (GCNP), Indonesia. Data were gathered through face-to-face surveys with 452 visitors using five-point Likert-scale items measuring knowledge of provisioning, regulating and supporting, and cultural services, together with attitudes toward conservation behavior and self-reported environmental behavior. Guided by the Knowledge-Attitude-Behavior framework, we utilized k-means clustering analysis, followed by independent-samples t-tests and correlation analysis. Two visitor segments were identified: conservation advocates/CA (n = 243) and conservation supporters/CS (n = 209). CA scored significantly higher than CS across all variables, including provisioning knowledge (4.17 and 3.34, respectively; d = 1.69), regulating and supporting knowledge (4.22 and 3.50; d = 1.67), cultural knowledge (4.31 and. 3.67, respectively; d = 1.45), attitude toward behavior (4.47 and 3.89, respectively; d = 1.05), and environmental behavior (4.21 and 3.66, respectively; d = 1.26). All differences between clusters were statistically significant ($p < 0.001$). The study contributes analytically by showing that FbES knowledge provides a meaningful basis for behavioral segmentation in a tropical NPs context. The findings advocate for more focused communication, environmental education, and visitor management measures specifically designed for various tourist segments in GCNP management.

Introduction

Forests generate multiple ecosystem services that sustain biodiversity, mitigate climate risks, and enhance human well-being. In protected areas, particularly national parks (NPs), these services cover provisioning, regulating, supporting, and cultural benefits that ensure ecological integrity while facilitating recreation and education [1–5]. Given its exceptional potential, NPs have become a popular spot for nature-based tourism worldwide [6–8]. As nature-based tourism expands, increased visitation may increase challenges on habitats and management capabilities, an issue that is particularly pronounced in developing countries where ecological diversity aligns with constrained resources [8–10]. These conditions make visitor management increasingly important, not only in terms of controlling visitor numbers but also in understanding how visitors interact with NPs environments [11,12].

Visitors to NPs are not merely recreational users but also participants whose knowledge, attitudes, and activities can influence conservation outcomes. Variations in visitors' understanding of forest-based

Corresponding Author: Prasetyo Nugroho prasetyonugroho@ugm.ac.id Bachelor of Applied Science in Forest Management, Department of Bioresources and Veterinary, Vocational College of Universitas Gadjah Mada, Yogyakarta, Indonesia.

ecosystem services may affect their valuation of ecological conservation, interpretation of park laws, and reactions to management strategies. This is significant as conservation-related attitudes frequently manifest in the daily behaviors of visitors, including adherence to site regulations, appropriate waste management, and the avoidance of activities that disrupt wildlife or harm natural attributes [13–16]. Nevertheless, research on visitors in protected areas has predominantly focused on demographic or motivational classifications, whereas the influence of ecosystem-service knowledge on conservation-related attitudes and behaviors is still inadequately comprehended, particularly in tropical protected areas [17–20]. Consequently, a deeper comprehension of the relationship between visitors' knowledge, attitudes, and self-reported behaviors is essential to enhance evidence-based visitor management in national parks.

Environmental psychology offers a valuable framework for elucidating the variations in conservation-related responses and behaviors among visitors. The value-belief-norm theory (VBN) and the theory of planned behavior (TPB) indicate that pro-environmental behavior is influenced by the interplay of cognitive, attitudinal, and normative elements, encompassing awareness, beliefs, intentions, and perceived control [21–23]. From this viewpoint, awareness of ecosystem services (ES) is a significant cognitive aspect, as it influences how humans perceive ecological advantages and assess the repercussions of environmental deterioration [24–26]. Recent studies increasingly demonstrate that awareness of ES can foster pro-environmental attitudes and enhance support for conservation, especially in ecologically sensitive tourism environments [26–31]. In reality, visitor management has frequently prioritized visitor numbers, motivations, or happiness over ecosystem-service knowledge as a foundation for comprehending conservation-relevant visitor profiles [21–25].

Current research indicates that visitors do not constitute a homogeneous group. The significance of ecological services from the forest ecosystem may fluctuate among individuals, and psychological segmentation might identify distinct visitor groups with varying values, attitudes, and actions [32,33]. Nonetheless, direct data connecting visitors' understanding of ecological services to specific behavioral segments is scarce, especially in tropical national parks [32,33]. This disparity is significant as several areas of forest-based ecosystem services (FbES), i.e., provisioning, regulating, supporting, and cultural services, may not uniformly influence conservation-related attitudes and behaviors. Determining if these knowledge domains align with distinct visitor profiles would enhance the foundation for more focused conservation communication and visitor management.

Addressing these gaps, this study investigates whether differences in visitors' knowledge of FbES is associated with distinct profiles of conservation-related attitudes and self-reported environmental behavior in Gunung Ciremai National Park (GCNP), West Java, Indonesia. Utilizing the knowledge-attitude-behavior (KAB) framework, the study assesses whether awareness of provisioning, regulating, supporting, and cultural services distinguishes significant visitor segments. Ultimately, the current study enhances studies on visitor behavior in NPs by framing FbES knowledge as a pertinent cognitive dimension for segmentation rather than viewing environmental knowledge as a monolithic construct. Likewise, it offers empirical evidence from a tropical NPs setting, where such connections are scarce in the literature. By identifying distinct visitor segments, the findings are expected to inform more targeted communication, environmental education, and visitor management strategies that better reconcile visitor experiences with conservation goals while improving outcomes in the GCNP.

Materials and Methods

Conceptual Framework

This study employs the KAB conceptual framework to examine how visitors perceive and respond to FbES in a protected area setting. The KAB framework posits that an individual's comprehension of environmental conditions serves as the starting point of a more extensive psychological and behavioral process [34–36]. In this context, knowledge denotes an understanding of ecological roles and the activities of ecosystem services, encompassing their significance in climate regulation, biodiversity preservation, and the enhancement of human well-being. This awareness establishes the cognitive foundation for the formation of attitudes.

Upon establishing their knowledge, individuals commence the formation of attitudes that embody their beliefs, emotional affiliations, and personal apprehensions concerning the surroundings [35]. These attitudes are considered a crucial determinant influencing behavioral intentions, including the propensity to support conservation efforts, the preparedness to adopt sustainable behaviors, or compliance to environmental regulations [24,37]. Consequently, these intentions influence concrete actions, indicating that elevated

awareness correlates with more robust environmental attitudes and consistent behavioral outcomes. The KAB model convincingly argues that fostering awareness is the fundamental prerequisite for promoting both individual and group pro-environmental behavior [24,35,37]. Therefore, this framework reflects a widely accepted psychological pathway for understanding conservation-oriented behavior, particularly in ecologically sensitive settings such as national parks.

Questionnaire Design

The questionnaire has been developed to assess visitors' knowledge, attitudes, behaviors, and sociodemographic characteristics in alignment with the study's objectives and the KAB framework. Following Hayuningsih [38], the instrument used a structured two-section format, and the observed variables were derived from prior investigations [39,40]. The three fundamental constructs were established operationally to enhance conceptual clarity. In this study, knowledge denotes visitors' perceived comprehension of FbES in GCNP, attitude signifies their evaluative disposition towards conservation-related behaviors in the GCNP, and behavior pertains to their self-reported environmental actions during the visit. These operational definitions were employed to provide coherence across the conceptual framework, the questionnaire design, and the interpretation of the results.

The knowledge items were derived from Zhang et al. [39] and utilized to evaluate visitors' comprehension of the primary categories of FbES linked to GCNP. In accordance with the millennium ecosystem assessment typology, these elements were categorized into three domains, which were provisioning, regulating and supporting, and cultural services. This assessment was relevant to the current study as it facilitated the exploration of variation across distinct FbES categories instead of considering environmental knowledge as a singular, homogeneous construct. This enabled the analysis of knowledge as a possible foundation for distinguishing unique visitor profiles.

The attitude and behavior metrics were modified from Wang et al. [40] to evaluate visitors' conservation-related assessments and documented actions inside the park environment. This study assessed the attitude items on the perception of conservation-related activity as prudent, pleasurable, advantageous, and fulfilling. The behavioral items documented self-reported actions pertinent to visitor management in protected areas, including adherence to park regulations, proper waste disposal, minimizing disturbance to wildlife, preventing damage to flora and natural features, and reporting observed environmental damage. These measures were incorporated as they represent actual manifestations of conservation-related behavior during a GCNP visit, thereby closely aligning with the management priorities of GCNP.

All items were evaluated and contextually modified to align with the GCNP environment and the FbES emphasis of this research. The language was enhanced to help improve conceptual clarity and contextual appropriateness while ensuring compatibility with the original constructs. All items were evaluated using a five-point Likert scale, with 1 representing 'strongly disagree' and 5 representing 'strongly agree'.

Research Site

This research was done at three prominent ecotourism sites inside the utilization zone of GCNP, all located in Cisantana Village, Kuningan Regency, West Java, Indonesia as shown in Figure 1. GCNP is the highest stratovolcano in West Java, reaching an elevation of 3,078 meters above sea level and encompassing about 15,000 hectares of tropical montane forest. The park, designated as a protected area under IUCN Category II, combines ecological conservation with nature-based recreational activities [29,41]. It functions as an essential sanctuary for biodiversity and forest-based ecosystem services in West Java. Visitor sites are located within forests that are predominantly preserved and biologically viable [29,42–48]. This integrity allows visitors to experience an extensive range of forest-based ecosystem services, such as cool, clean air, scenic forest views, fresh water from natural springs, and a sense of protection associated with the reduction of landslides and floods. The forest offers substantial regulating services, including erosion management, temperature moderation, and carbon sequestration, while also protecting catchments that deliver clean water to downstream people [42]. These advantages are frequently recognized implicitly and can affect conservation-related attitudes and actions, even in the absence of official environmental education. The park exhibits significant biological diversity, encompassing over 800 plant species, including *Rafflesia patma*, *Schima wallichii*, and indigenous orchids. It also sustains fauna such as the Javan leopard (*Panthera pardus melas*), Javan surili (*Presbytis comata*), and the globally threatened Javan hawk eagle (*Nisaetus bartelsi*) [46–48]. This richness enhances the park's function as a conservation area and a venue for experiential education.

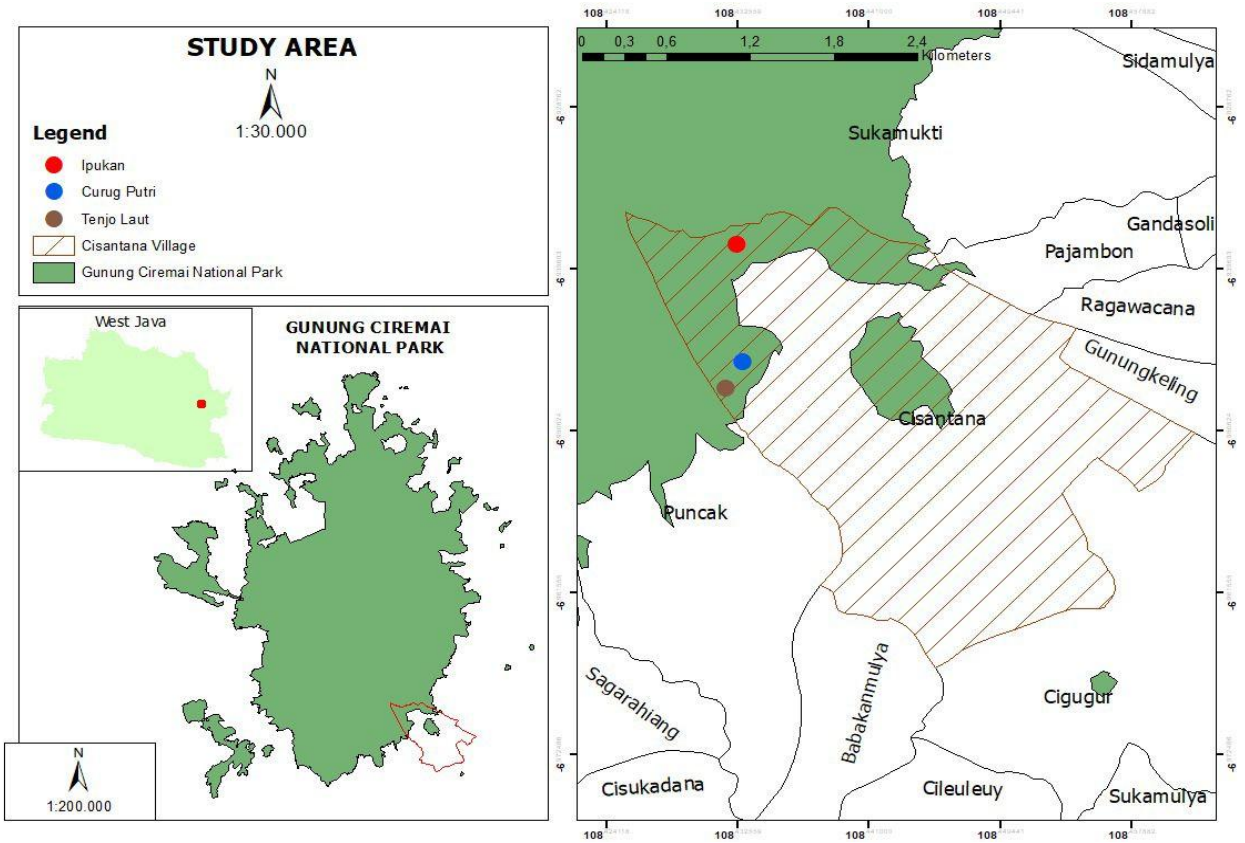

Figure 1. Map of the study area in Gunung Ciremai National Park, West Java, Indonesia. The figure identifies the location of GCNP in West Java and the three selected research sites, Ipukan, Curug Putri, and Tenjo Laut. The inset and enlarged maps show the sites in relation to surrounding settlements and the park boundary, providing spatial context for visitor-based data collection. The figure highlights that the study was undertaken at accessible tourism destinations located near the park's inhabited fringe.

Cisantana Village was chosen for its designation as the most visited buffer community among the 50 villages surrounding GCNP. The village has emerged as a regional leader of community-based ecotourism, providing access to three of the park's most renowned natural attractions which are Ipukan, Tenjo Laut, and Curug Putri. Ipukan is a forest-based camping and scenic area at the foot of Mount Ciremai, known for its cool mountain atmosphere, green landscape, and sunrise-sunset views. Tenjo Laut is a highland nature-tourism site within the broader TNGC tourism area that offers panoramic views of Kuningan Regency from around 1,300 meters above sea level and supports outdoor recreation such as sightseeing and camping. Curug Putri is a waterfall-based attraction in the Palutungan tourism area; in Indonesian, the term 'curug' means waterfall. These locations provide a variety of ecotourism activities, including forest trekking, immersion in pine forests, visits to waterfalls, stunning views, outdoor camping, and cultural engagement with local crafts and foods. Community engagement in tourism is prominently evident [29,41], with local inhabitants acting as guides, interpreters, sellers, and coordinators of traditional performances. Research demonstrates that immersive, place-based tourism in forest environments can enhance awareness of ecosystem services and promote pro-environmental behavior [49–52]. A combination of aesthetic, cultural, and ecological attributes of Ipukan, Tenjo Laut, and Curug Putri provides a robust framework for analyzing how nature-based tourism stimulates psychological processes including appreciation, emotional attachment, and stewardship. Thus, Cisantana Village serves as a suitable setting to examine the impact of exposure to nature-based touris in forested areas of national park on environmental knowledge, attitudes, and self-reported environmental behavior.

Data Collection

Questionnaires were conducted on-site through face-to-face interviews in June and July 2022. This method enabled the researchers to identify eligible visitors, articulate the study effectively, respond to inquiries in real time, and extend invitations to participate courteously. This direct interaction fosters relationships,

diminishes item misinterpretation, and enhances cooperation [53,54]. Data were gathered on-site via face-to-face interviews throughout June and July 2022. This methodology allowed the research team to directly identify eligible participants, indicate the study in real time, address inquiries, and document replies simultaneously throughout the visit. The field team comprised five trained undergraduate forestry students who received instruction in respondent recruitment, unbiased questioning, ethical communication, and precise data recording. Participation was restricted to individuals aged 17 and older. Data collection was conducted on various days and at varied times, including morning, afternoon, and early evening, to account for variations in visitor attendance and site utilization during the research months. This schedule aimed to encompass a wider array of visitor demographics and visitation contexts, acknowledging that visitor traffic at nature-based tourism locations may fluctuate over weekdays, weekends, and daily activity intervals. Interviewers adhered to a consistent administration protocol to minimize variability in recruitment and inquiry.

Participants were chosen using convenience sampling, determined by accessibility, location availability, and desire to engage. The sample should not be regarded as statistically representative of the entire tourist population to GCNP. The findings aim to represent patterns identified among surveyed visitors during the field period. This method may be susceptible to self-selection bias, since participants who were more available or willing to engage may differ from those who declined or were not solicited. Moreover, since all variables were assessed via self-report during a singular field encounter, the findings should be construed as the reported reactions of visitors within the context of the study.

Data Analysis

Initially, we evaluated the dataset for completeness, reasonable ranges, and the impact of outliers, subsequently standardizing inputs as necessary. The reliability of multi-item constructs was evaluated using Cronbach's alpha to confirm internal consistency; coefficients of 0.60 or above were considered appropriate for exploratory research [55]. Composite scores were derived by calculating the means of items for each latent construct. These composites, systematically categorized under the Knowledge–Attitude–Behavior (K–A–B) framework, functioned as the attributes for clustering, guaranteeing that segment creation aligns with theoretically substantiated characteristics of visitor knowledge, evaluative perspective, and self-reported behavior. Cluster extraction using non-hierarchical k-means with several random initializations to mitigate the possibility of local minima and utilized a standard convergence criterion based on within-cluster sum of squares. The most optimal number of clusters (k) was identified using the silhouette approach, which involved picking the solution that maximized the average silhouette width, hence minimizing within-cluster dissimilarity in relation to the nearest surrounding clusters. Upon fixing k, we re-evaluated the k-means solution and characterized clusters based on their K–A–B centroids. Differences between clusters on the composite variables were further analyzed using independent-samples t-tests conducted pairwise, with a conservative adjustment for multiple comparisons to mitigate Type I error. Ultimately, we employed descriptive statistics and cross-tabulations to encapsulate respondent sociodemographics inside each cluster and to provide interpretable segment labels based on the K–A–B framework. All analyses were performed in RStudio utilizing basic functions and additional packages, including psych (v2.4.6.24) for scale diagnostics and ggplot2 (v3.5.1) for visualization.

Results and Discussion

Results

Table 1 shows that all latent constructs achieved acceptable internal consistency (cronbach's alpha > 0.60), supporting their use in the segmentation analysis. For each construct, the table reports cronbach's alpha, mean score, and standard deviation to summarize internal consistency and respondents' overall responses. The results show that all constructs achieved acceptable to high reliability and that respondents generally reported moderate to high levels of ecosystem service knowledge, positive attitudes, and pro-environmental behavior. Our result shows that all latent constructs achieved acceptable internal consistency (cronbach's alpha > 0.60), supporting their use in the segmentation analysis [55]. On this basis, the clustering procedure identified two distinct visitor segments: conservation advocates (CA) and conservation supporters (CS). These clusters signify two fundamentally distinct visitor profiles regarding the comprehension of FbES and the correlation of this understanding with conservation attitudes and self-reported environmental behaviors in GCNP.

Table 1. Latent constructs, observed items, reliability coefficients, means, and standard deviations of the study variables. The table presents the measurement constructs and observed items used to assess visitors' knowledge of provisioning, regulating and supporting, and cultural ecosystem services, as well as their attitudes toward and environmental behavior in GCNP.

No	Latent and observed variables	α	mean	SD
	Knowledge of provisioning services	0.80	3.8	0.64
1	GCNP provides clean water			
2	GCNP supplies food resources for surrounding communities			
3	GCNP provides firewood for surrounding communities			
4	GCNP provides livestock fodder for surrounding communities			
5	GCNP supplies raw materials for traditional medicine			
	Knowledge of regulating & supporting services	0.85	3.9	0.56
6	GCNP serves as a habitat for diverse flora and fauna			
7	GCNP plays a significant role in maintaining clean and fresh air quality			
8	GCNP contributes to climate regulation at both local and regional scales			
9	GCNP supports the management of soil erosion risks			
10	GCNP aids in the prevention of pest and disease outbreaks in agricultural areas			
11	GCNP ensures the preservation and enhancement of water quality			
12	GCNP plays a role in mitigating the risks associated with natural disasters			
13	GCNP contributes to the maintenance of soil fertility			
14	GCNP provides and preserves habitats for various species of flora and faun			
	Knowledge of cultural services	0.82	4	0.54
15	GCNP supports the preservation of cultural practices and traditions within local communities			
16	GCNP protects valuable cultural heritage that holds significant importance and requires conservation			
17	GCNP upholds cultural values that contribute to the spiritual enrichment of communities			
18	GCNP provides scenic natural landscapes that serve as cultural and recreational tourism destinations.			
19	GCNP offers well-maintained recreational spaces that promote community well-being.			
20	GCNP showcases unique landscape aesthetics that provide cultural and aesthetic value.			
21	GCNP serves as an educational platform that supports environmental learning and promotes ecological awareness			
	Attitude toward behavior	0.86	4.2	0.62
22	I perceive protecting the environment in GCNP as a wise action.			
23	I consider protecting the environment in GCNP to be an enjoyable behavior.			
24	I view protecting the environment in GCNP as a beneficial and meaningful action.			
25	I feel satisfied with my efforts to protect the environment in GCNP			
	Environmental behavior	0.86	4	0.51
26	I consistently comply with tourist regulations to protect the scenic attractions in GCNP.			
27	I make conscious efforts to prevent damage to the facilities in GCNP.			
28	During my visits to GCNP, I ensure proper waste disposal as a responsible action.			
29	I actively contribute to maintaining the environmental quality of GCNP.			
30	I follow regulations by refraining from entering restricted or protected areas in GCNP.			
31	I avoid littering and ensure waste is disposed of in designated areas.			
32	I act responsibly by not disturbing wildlife during my visits to GCNP.			
33	I take care not to damage plants or natural features in GCNP.			
34	I respect designated areas by refraining from stepping on grass or damaging vegetation.			
35	I support environmental conservation efforts by making financial contributions to the management of GCNP.			
36	I engage in volunteer activities to contribute to environmental protection in GCNP.			
37	I take the initiative to discourage other tourists from engaging in environmentally harmful behavior in GCNP.			
38	If I notice any environmental damage in GCNP, I promptly report it to the relevant management authorities.			

Table 2 demonstrates that the CA cluster consistently surpassed the CS cluster in all assessed characteristics. This trend was noted in the understanding of provisioning services (4.17 and 3.34, respectively), regulating and supporting services (4.22 and 3.50, respectively), and cultural services (4.31 and 3.67, respectively), in addition to attitudes toward conservation-related behaviors (4.47 and 3.89, respectively) and self-reported environmental behaviors (4.21 and 3.66, respectively). The disparities were statistically significant across all primary dimensions ($p < 0.001$), signifying that the two clusters are not merely descriptively distinct but also

empirically well differed. This pattern indicates that CA visitors possess a more robust and comprehensive conservation orientation, wherein an enhanced acknowledgment of ecosystem-service benefits correlates with more favorable assessments of conservation-related behaviors and heightened reported participation in environmentally responsible actions. In comparison, the CS cluster exhibits a very mild, yet nonetheless affirmative, profile, indicating that conservation support among visitors occurs on a continuum rather than as a mere binary classification.

Table 2. Characteristics of clusters. It demonstrates that the two clusters exhibited consistent differences across all assessed categories, including knowledge of provisioning services, knowledge of regulating and supporting services, knowledge of cultural services, conservation-related attitudes, and self-reported environmental behavior. In every instance, visitors in the CA cluster exhibited higher mean scores than those in the CS cluster, signifying a more robust conservation-oriented profile.

Latent variables	Cluster centers Conservation advocates (n=243)	Conservation supporters (n=209)	t_{value}	p_{value}	Effect size (Cohen's d)
Knowledge of provisioning services	4.17	3.34	17.927	< 0.001	1.69
Knowledge of regualating & supporting services	4.22	3.50	17.663	< 0.001	1.67
Knowledge of cultural services	4.31	3.67	15.413	< 0.001	1.45
Attitude toward behavior	4.47	3.89	11.171	< 0.001	1.05
Environmental behavior	4.21	3.66	13.397	< 0.001	1.26

The differences across clusters were statistically significant across all constructs ($p < 0.001$), confirming that the discovered segments are empirically distinctive rather than reflecting only minor variation within a relatively homogeneous visitor population. More importantly, the incorporation of effect-size estimations enhances the understanding of these results. The Cohen's d values varied from 1.05 to 1.69, signifying consistently substantial disparities between the two clusters. This indicates that the distinction between CA and CS is both statistically significant and substantively meaningful. The separation between the two visitor segments is further illustrated in Figure 2.

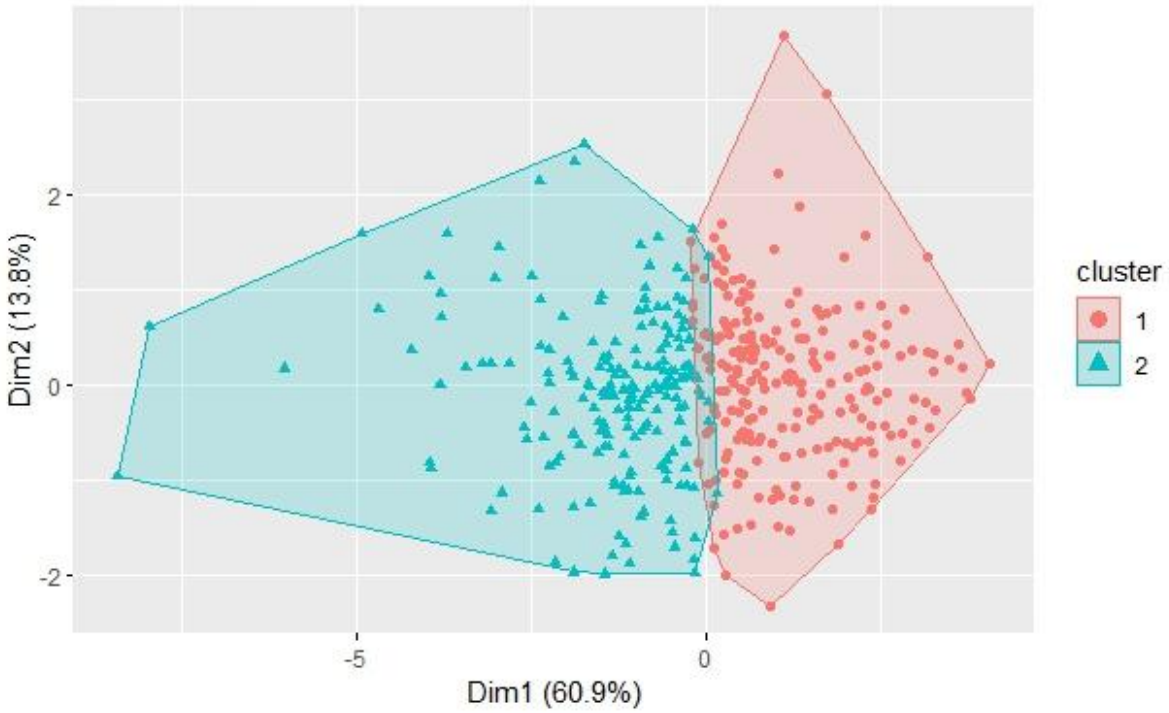

Figure 2. Cluster plot of visitors in GCNP. The plot shows two distinct visitor groups: Cluster 1, labelled as CA, and Cluster 2, labelled as CS. Dim1 explains 60.9% of the variation and clearly separates the two clusters, while Dim2 explains 13.8% and reflects additional within-cluster variation. The separation indicates that CA tend to show stronger and more consistent conservation-related profiles, whereas CS represent visitors with generally positive but comparatively more moderate conservation orientations.

An in-depth analysis of the disparity pattern reveals that the most significant effects were noted for knowledge of provisioning services (d = 1.69) and knowledge of regulating and supporting services (d = 1.67), succeeded by knowledge of cultural services (d = 1.45). The results demonstrate that the most significant differential between the two visitor segments resides in their cognitive acknowledgment of FbES. In contrast, the disparities in attitude (d = 1.05) and self-reported environmental behavior (d = 1.26), while still substantial, were somewhat less pronounced. This trend indicates that differences in ecosystem-service knowledge may be particularly significant in distinguishing visitor profiles, whereas attitudinal and behavioral variations seem to be related but slightly less evident factors.

Substantively, the CA cluster reflects visitors with a robust and cohesive conservation orientation, characterized by an enhanced acknowledgment of FbES, more positive assessments of conservation-related actions, and heightened participation in environmentally responsible behaviors. Conversely, the CS cluster exhibits a very modest, albeit predominantly favorable, character. This suggests that the support for conservation among GCNP tourists should be perceived as a spectrum of intensity rather than a mere binary classification of supportive and non-supportive visitors.

In addition to the between-cluster comparison, correlation analysis was performed to investigate the relationships across knowledge areas, attitudes, and self-reported environmental behavior in the aggregated sample and within each visitor segment. Figure 3 illustrates that all aggregated correlations among the primary constructs were positive and statistically significant. The figure illustrates the bivariate distributions and correlation patterns among the five latent variables used in this study, together with their distribution across the two visitor clusters in GCNP. By showing both within-variable distributions and between-variable associations, the figure provides a visual summary of how ecosystem service knowledge, attitudes, and environmental behavior are interconnected. The most significant correlations were seen among the three FbES knowledge domains: between providing and regulating-supporting knowledge ($r = 0.642$, $p < 0.001$), provisioning and cultural knowledge ($r = 0.555$, $p < 0.001$), and regulating-supporting and cultural knowledge ($r = 0.639$, $p < 0.001$). This pattern indicates that visitors who acknowledged a specific type of ecosystem-service benefit also tended to acknowledge others, suggesting that FbES knowledge constitutes a shared cognitive foundation rather than a collection of discrete perceptions.

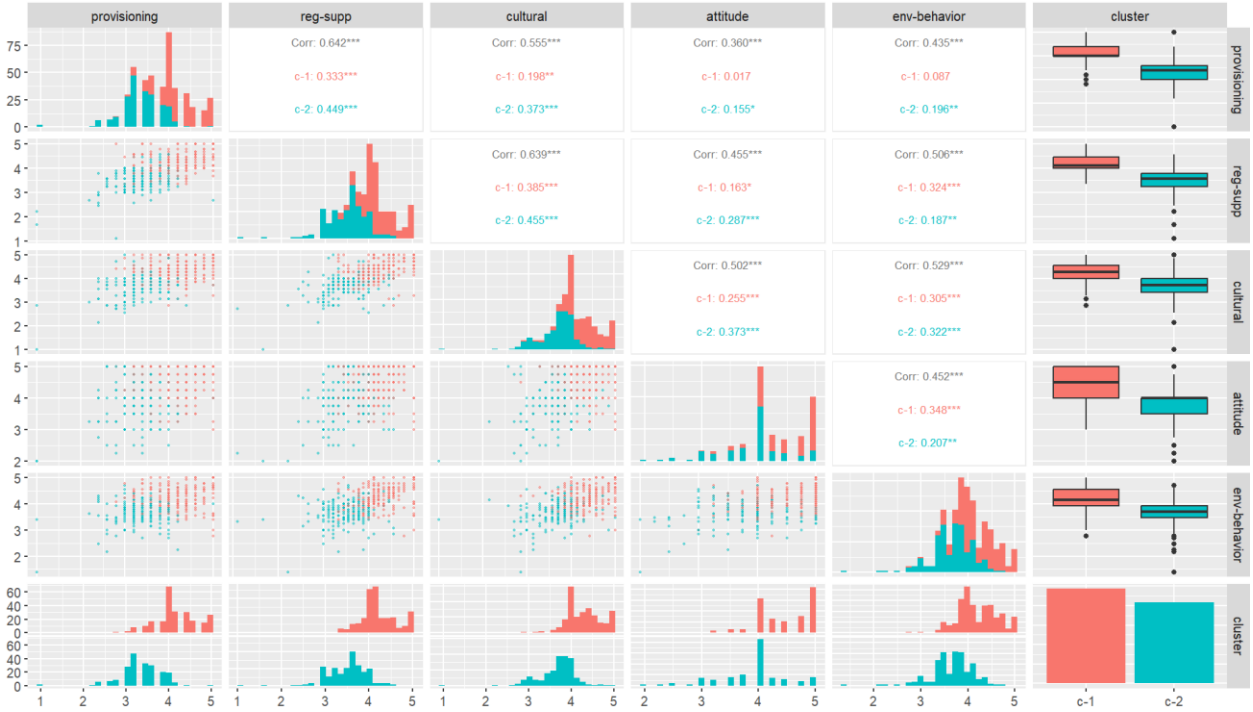

Figure 3. The pairwise correlation matrix among latent variables. The matrix presents the relationships among knowledge of provisioning services, knowledge of regulating-supporting services, knowledge of cultural services, conservation attitude, and self-reported environmental behavior for Cluster 1 and Cluster 2. The figure shows that the two clusters differ not only in variable scores, but also in their internal correlation patterns, with Cluster 2 generally showing stronger interrelationships among ecosystem-service knowledge domains and more evident links between knowledge, attitudes, and behavior.

The aggregated correlations indicate that all three knowledge domains exhibited a positive association with both attitude and self-reported environmental behavior. The acquisition of provisioning knowledge shown a positive correlation with attitude ($r = 0.360$, $p < 0.001$) and behavior ($r = 0.435$, $p < 0.001$). More robust correlations were identified between regulating-supporting information and attitude ($r = 0.455$, $p < 0.001$) and behavior ($r = 0.506$, $p < 0.001$), in addition to cultural knowledge with attitude ($r = 0.502$, $p < 0.001$) and behavior ($r = 0.529$, $p < 0.001$). The attitude had a favorable correlation with self-reported conduct ($r = 0.452$, $p < 0.001$). Collectively, these findings align with the anticipated KAB framework, however they should be seen as associations rather than causal relationships.

Significantly, the segment-specific correlation patterns reveal that the two visitor clusters varied not only in score levels but also in the internal structure of their conservation-related reactions. Within CS, the three knowledge domains exhibited a greater interrelation compared to CA, as evidenced by stronger correlations between provisioning and regulating-supporting knowledge ($r = 0.449$ vs 0.333), provisioning and cultural knowledge ($r = 0.373$ vs 0.198), and regulating-supporting and cultural knowledge ($r = 0.455$ vs 0.385). This indicates that CS visitors possess a more cohesive and less differentiated comprehension of ecosystem-service advantages, while CA visitors seem to more distinctly differentiate among various FbES domains.

The correlation among knowledge, attitudes, and self-reported behavior also differed between sectors. In the context of CS, provisioning knowledge exhibited a substantial correlation with both attitude ($r = 0.155$, $p < 0.05$) and self-reported conduct ($r = 0.196$, $p < 0.01$); however, these correlations were not significant in CA ($r = 0.017$ and $r = 0.087$, respectively). In contrast, within CA, regulating-supporting knowledge exhibited a more robust correlation with self-reported behavior than within CS ($r = 0.324$, $p < 0.001$ vs $r = 0.187$, $p < 0.01$), indicating that less apparent yet ecologically vital ecosystem functions may be more closely associated with reported actions among visitors possessing a heightened conservation orientation. Cultural knowledge exhibited a positive correlation with both attitude and behavior across both clusters; however, the correlation with attitude was more pronounced in CS ($r = 0.373$, $p < 0.001$) compared to CA ($r = 0.255$, $p < 0.001$), while the correlation with behavior was comparable in strength ($r = 0.322$, $p < 0.001$ versus $r = 0.305$, $p < 0.001$). The association between attitude and self-reported conduct was more pronounced among CA ($r = 0.348$, $p < 0.001$) compared to CS ($r = 0.207$, $p < 0.01$), suggesting that positive conservation assessments were more reliably manifested in reported behavior within the CA group.

Collectively, these data indicate that the two visitor groups differ not merely in their average levels of knowledge, attitude, and action, but also in the internal connections among these dimensions. For conservation advocates, more concrete and directly perceived advantages, particularly supplying services, seem to serve as a pragmatic gateway for conservation-related initiatives. For conservation advocates, self-reported environmental behavior is more closely associated with knowledge of regulatory-supporting services and conservation-related views. This reinforces the analytical assertion that visitor segmentation in GCNP is significant both descriptively and structurally, as the connections between ecosystem-service knowledge and conservation-related reactions differ among visitor profiles.

Discussion

The present study investigated whether variations in visitors' understanding of FbES in GCNP are associated with specific profiles of conservation-related attitudes and behaviors within the KAB framework. The findings reveal that visitors to GCNP are not a homogeneous group of individuals but could be categorized into two conservation-related segments: CA and CS. The distinction between these portions extends beyond mere score levels. It illustrates the differences in visitors' recognition of FbES, their assessment of conservation-related behaviors, and their self-reported environmental actions during the visit. This pattern presumably arises because awareness of ecosystem services serves as a cognitive framework through which visitors assess the park's value and the significance of conservation measures [21,23,24,31,34,37].

A significant finding is that the most distinct differentiation between the two segments is in the three knowledge domains: provisioning, regulating-supporting, and cultural services. This indicates that awareness of ecosystem services is not simply a descriptive characteristic, but a significant foundation for differentiating visitor profiles in GCNP. The findings are generally aligned with prior research indicating that environmental knowledge and comprehension of ecosystem services positively correlate with pro-environmental attitudes and behaviors in tourism and protected area contexts [24,31,35,36]. Nonetheless, the current findings enhance the existing research by demonstrating that various categories of ecosystem-service knowledge do not correlate uniformly with conservation-related responses.

The segment-specific patterns clarify the reasons for the disparities between the two groups. Among CS, the three knowledge domains exhibited a closer interconnection, indicating a more cohesive although less distinct awareness framework. An acceptable conclusion is that these tourists continue to view forest advantages in a somewhat aggregated manner, failing to distinctly differentiate between direct uses, ecological functions, and cultural values. In contrast, among CA, the knowledge structure is more nuanced, and self-reported behavior is more closely associated with regulatory-supporting knowledge and conservation-related attitudes. This indicates that visitors possessing a heightened conservation orientation may more effectively associate less apparent biological services, such as habitat support, hydrological regulation, and erosion control, with suitable conduct in the park. These trends ought to be regarded as associations rather than established causal pathways, according to the cross-sectional and self-reported characteristics of the data.

The role involving multiple FbES domains offers additional understanding. Among CS, knowledge of providing was substantially correlated with both attitude and self-reported conduct. This may happen because more concrete and directly experienced advantages offer a more accessible entrance point for people with a moderate conservation inclination. In contrast, among CA, knowledge that supports regulation shown a larger correlation with self-reported behavior, indicating that visitors with a greater conservation focus may be more attuned to biologically significant although less apparent ecosystem functions. Cultural knowledge had a positive correlation with both attitude and conduct across both segments, aligning with research that underscores the influence of recreational, aesthetic, and educational experiences on environmental behavior in tourism contexts [24,31,35,36,40].

The study's originality is attributed to three aspects. Initially, it indicates that FbES awareness must not be regarded as a monolithic construct, as providing, regulating-supporting, and cultural services fulfill distinct functions concerning attitude and self-reported behavior. Secondly, it demonstrates that visitor segments vary not just in their scores on knowledge, attitude, and conduct, but also in the internal structure of these relationships. Third, it offers empirical evidence from a tropical national park setting, where direct correlations between domain-specific ecosystem-service awareness and conservation-relevant visitor characteristics are scarce [32,33].

These findings have immediate implications for visitor education initiatives and behavioral interventions in conservation areas. For visitors that fit the CS characteristics, instructional communication may be more impactful when it commences with tangible and immediately experienced ecological advantages, such as cool air, pure water, aesthetic value, and pleasurable recreational environments. At GCNP, this might be executed via concise interpretive panels, trailhead signage, campsite information boards, and guiding narratives that link those advantages to quotidian responsible conduct. For visitors aligned with the CA profile, educational initiatives can prioritize ecological interdependence, biodiversity enhancement, watershed preservation, and stewardship accountability. In this instance, ranger interpretation, guided excursions, and more substantive ecological narratives may be particularly appropriate [35,36,40].

The identical reasoning pertains to behavioral interventions. For conservation advocates, the robust correlation between attitude and conduct indicates that interventions should emphasize the reinforcement of stewardship identity and commitment. For conservation advocates, treatments ought to diminish the disparity between favorable assessment and action by rendering anticipated behaviors more tangible, discernible, and straightforward to implement. Concrete examples encompass explicit directives for waste disposal, adherence to trail regulations, avoidance of wildlife disturbance, and respect for restricted areas at significant visitor locations. Consequently, the conclusion is not merely that GCNP should "raise awareness," but that it must synchronize the content of messages and the design of interventions with the prevailing knowledge framework of each segment [35,36,40].

The findings indicate that visitor management in GCNP would be enhanced by a segment-sensitive strategy instead of a uniform model. The results are required to be interpreted cautiously. Due to the utilization of convenience sample, self-reported metrics, and a cross-sectional methodology, the identified links should be interpreted as context-dependent associations rather than causal or universally applicable conclusions. Nonetheless, the uniformity of segment disparities and the coherence of segment-specific correlation patterns suggest that the found profiles are significantly important and practically beneficial for protected-area management.

Conclusions

This study demonstrates that visitors to GCNP could be effectively categorized into two categories by integrating multidimensional knowledge of forest-based ecosystem services with conservation-related attitudes and self-reported environmental behaviors. Two distinct parts emerged: CS, characterized by a modest understanding closely associated with concrete ecological benefits, and CA, distinguished by a more extensive knowledge base and heightened pro-environmental attitudes and behaviors. The primary contribution of the study is to demonstrate that ecosystem-service knowledge is domain-specific and pertinent to visitor management. Provisioning knowledge serves as a valuable entrance point for less-engaged visitors, while regulating-supporting and cultural knowledge gain prominence among the stewardship-oriented sector. For GCNP, these findings endorse a viable strategy of segment-based interpretation, focused visitor communication, conspicuous low-effort conservation hints, and enhanced involvement options for highly engaged visitors. The evidence, derived from self-reported, cross-sectional data collected via convenience-intercept sampling, necessitates that the results be regarded as exploratory yet pragmatically beneficial for visitor management in tropical protected areas.

Author Contributions

PN: Conceptualization, Methodology, Software, Validation, Formal Analysis, Resources, Data Curation, Writing – Review and Editing, Supervision, Funding Acquisition; and **CWH:** Conceptualization, Methodology, Investigation, Data Curation, Writing – Original Draft Preparation.

AI Writing Statement

During the preparation of this work, the author(s) used ChatGPT (OpenAI) in order to improve the readability and language quality of the manuscript. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the publication.

Conflicts of interest

There are no conflicts to declare.

Acknowledgments

We gratefully acknowledge funding from Universitas Gadjah Mada through the “Rekognisi Tugas Akhir” research grant (Contract No. 3550/UN1.P.III/Dit-Lit/PT.01.05/2022). We thank the management of Gunung Ciremai National Park and the nature-based tourism managers of Ipukan, Curug Putri, and Tenjo Laut for their cooperation and support. We also appreciate the students of the Forestry Study Program at Kuningan University for their dedicated work during data collection. Finally, we thank the reviewers for their constructive comments and suggestions, which strengthened the rigor and overall quality of this manuscript.

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