Perceptions, conservation orientations, and socio-geographical determinants of bamboo ecosystem services: evidence from Taiwan

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Although bamboo forests provide critical ecosystem services that support human well-being, public perceptions and conservation orientations regarding these contributions remain underexplored. Existing research has predominantly examined small rural communities in the Global South, limiting insights into how bamboo is valued in other contexts. This study addresses this gap by (1) assessing residents' perceptions of bamboo ecosystem services in a newly industrialized economy (i.e., Taiwan); (2) evaluating their conservation orientations toward different management strategies and willingness to pay; and (3) analyzing how socioeconomic and geographical factors determine these views. We conducted a questionnaire survey with 400 valid respondents, using stratified sampling to capture diverse backgrounds. The data were subsequently analyzed through descriptive statistics, ANOVA, and hierarchical logistic regression. The results indicate that leisure and eco-tourism scored the highest at 4.02 on a 5-point scale, while healthy food and handicrafts were the most recognized benefits of bamboo. These findings reflect respondents' preference for ecosystem services that enhance quality of life. However, although respondents acknowledge the importance of proactive conservation, only 29.3% expressed a willingness to pay, with a modal value of TWD 1,000 per year. Notably, collective-oriented environmental attitudes significantly influence respondents' willingness to pay for bamboo conservation. These results extend the literature by demonstrating how the subjective meanings and values of bamboo ecosystem services shift as economies industrialize. We further derived policy recommendations for adaptive management reflecting residents' non-market valuations of bamboo and emphasizing rapid, visible actions to secure public support. Enhancing financial transparency, linking personal contributions to outcomes, and developing incentive-based payment models are likely to increase willingness to pay.

KEYWORDS

perceived ecosystem service, willingness to pay, bamboo management, newly industrialized economy, policy implications

Highlights

- Bamboo matters to residents of newly industrialized economies not for subsistence, but for comfort.
- Women and individuals with higher education and income show greater concern toward specific ecosystem services.
- Respondents expressed a preference for proactive measures and government-led funding in bamboo conservation management.
- Education and income are key determinants of individuals' willingness to pay to conservation.

1 Introduction

Bamboo is a common grass species belonging to the *Poaceae* family. It is an important part of the ecosystems in low-elevation mountain areas and provides a wide range of ecosystem services (ESs) to local communities. The term ES refers to the benefits people obtain from ecosystems (Millennium Ecosystem Assessment, 2005). These benefits are classified into three categories by CICES V5.2: Provisioning, regulation and maintenance, and cultural services (Haines-Young, 2023). These well-documented functions position bamboo as both an ecological and socio-cultural resource (Li et al., 2025).

Previous research has focused on objective facts such as bamboo's biological contributions (Panthi et al., 2017), economic potential (Zhang et al., 2016), and climate regulating services (Zella, 2024; Dai et al., 2017). Researchers have applied many tools to quantify these ESs, such as the InVEST model (Dai et al., 2017, 2022; Feng et al., 2022; Ma et al., 2022). However, there is relatively little research using social science methods. In fact, studying local residents' perceptions and conservation orientations about bamboo ESs has many obvious advantages. It could strategically enhance public support and engagement (Tian et al., 2020), foster a more collaborative approach to environmental stewardship (Grindsted et al., 2025), and aid in designing more targeted policies that address local priorities (Lee and Ahn, 2023). Therefore, more research should utilize social science methodologies to deeply explore local residents' subjective opinions of bamboo ES.

On the other hand, previous studies have predominantly focused on developing countries since bamboo distribution is highly concentrated in tropical and subtropical regions (Canavan et al., 2017). In particular, study sites are often located in small-scale rural areas, which may be attributed either to the relative ease of accessing representative respondents through key insiders, or to the alignment of such research sites with Western researchers' "rural imaginary" of the Global South. For example, 27% of the respondents were engaged in primary industries, while less than 6% were involved in secondary industries in the study by Baul et al. (2021). Although farmers' awareness of ESs is crucial since they are the direct managers and users of these ecosystems (Xun et al., 2017), we argue that the heavy emphasis on farmers' subjective opinions in previous studies may limit the broader applicability of the findings. Non-rural areas have a larger population, but their subjective opinions of bamboo forests are understudied. Given that the samples have been drawn from small-scale rural areas in developing countries, which differ significantly from high-economic development areas, the findings may not fully capture respondents' viewpoints regarding urbanization and industrialization.

Residents in newly industrialized economies (NIEs) generally no longer rely on bamboo primarily for subsistence, and management approaches must therefore account for its non-market benefits. These economies are characterized by diverse urban–rural settings and complex socioeconomic structures, conditions that fundamentally reshape how ESs are perceived (Lapointe et al., 2019). Such differences carry significant implications for governance: policies formulated on the basis of findings from rural study areas may prove ineffective when applied in high-development contexts (Yang et al., 2019). Examining NIEs thus offers critical insights into how economic development and urbanization transform the perceived value of bamboo ESs, while also providing an empirical foundation for policies that are both socially acceptable and effective in rapidly industrializing societies.

This case study in Taiwan presents an excellent opportunity to address the aforementioned two research gaps. Firstly, bamboo forests are widely distributed across the island, with six major economically important bamboo species, including Moso, Makino, Thorny, Long-branch, Ma, and green bamboo. The area covered by bamboo forests makes up approximately 183,000 hectares (Forestry Bureau, 2020), accounting for 8.3% of the total forested area in the country (Lin et al., 2017). Therefore, the people of Taiwan have ample opportunities to interact with bamboo forests, thus forming a valuable foundation for further obtaining local residents' subjective opinions of this species based on their life experiences. Secondly, in regions where bamboo forests are abundant, such as Taiwan, local researchers are able to avoid many of the challenges commonly encountered in cross-national studies, thereby minimizing the unquantifiable biases often associated with qualitative research. For instance, issues such as cultural differences, language barriers, and a lack of understanding of local sensitivities particularly difficult to manage in fieldwork conducted in developing countries (Bamu et al., 2016). The persistent tendency to conceptualize the Global South through sociocentric and culturally bounded frameworks may further complicate research efforts in these contexts (Apthorpe, 1980). Thirdly, due to the robust transportation and information infrastructure, as well as researchers' familiarity with the country, the geographical scope of the study can be expanded. This allows for a transition from localized rural case studies to comparative analyses across urban, suburban, and township settings, thereby underscoring the innovative potential of this research. Specifically, we aim to understand local residents' perceptions and conservation orientations regarding bamboo ESs and to analyze the roles of socioeconomic and geographical factors in shaping these subjective opinions. Thus, we assess residents' perceptions of bamboo ESs (RQ1: which services are perceived as most important), evaluate their conservation orientations (RQ2: which management preferences and levels of willingness to pay are expressed), and

analyze the influence of socioeconomic, geographical, and attitudinal factors (RQ3: how these factors shape perceptions and orientations).
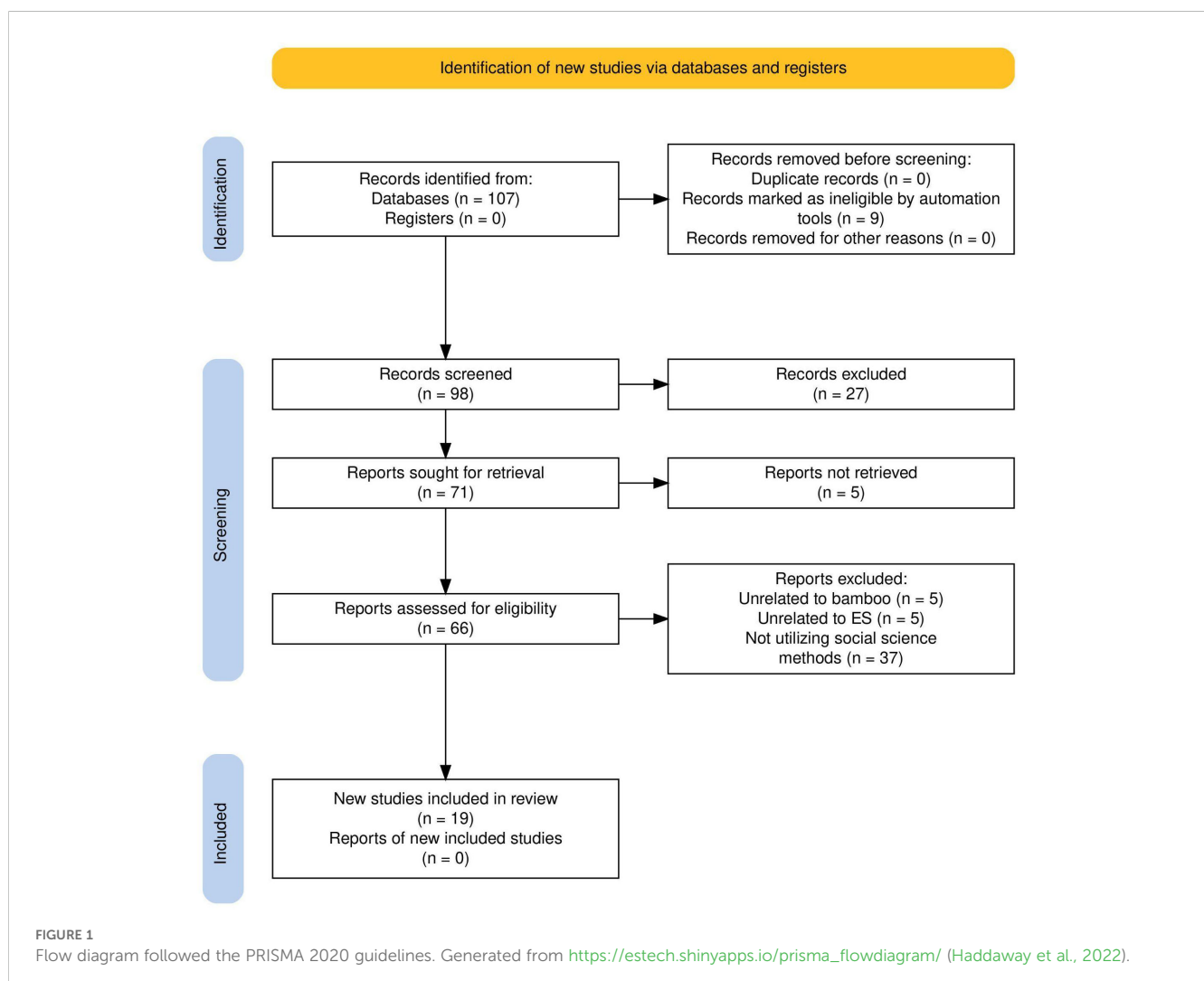
2 Literature review

2.1 Publications about bamboo ES

To address two research gaps identified in the introduction section, we conducted a systematic literature review to support our observations. The review process involved two independent reviewers who initially identified relevant literature, followed by a collaborative screening to determine the exclusion criteria for articles. We used the Scopus database (https://www.scopus.com/) and applied the terms "bamboo" and "ecosystem service" to search titles, abstracts, and keywords. Some relevant studies might not have directly employed the terminology used in our search strategy, but instead employed related expressions (e.g., "perception," "attitudes," "conservation," "willingness to pay"), and thus might have been unintentionally omitted. However, incorporating these

studies would have introduced substantial challenges in terms of research methodology. This complexity necessitated their exclusion from the current review. Furthermore, we excluded gray literature, including unpublished or non-peer-reviewed sources, due to concerns about potential biases and uncertain quality. Our review was also restricted to English, Mandarin, and Japanese publications due to researchers' language limitations.

Initially, we identified 107 results. Nine records were subsequently removed based on their document type and language filters. We then read the abstracts of the remaining 98 studies, and 27 studies were excluded by independent reviewers as they were deemed irrelevant to bamboo ES. Furthermore, five articles were excluded because their full texts were unavailable. Following a review of the full text of the articles, an additional 47 records were excluded for reasons such as being irrelevant to bamboo, irrelevant to ES, or not employing social science methodologies. Ultimately, 19 publications were included for analysis, encompassing all publications up to the cutoff date of May 19, 2023. The process followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension Statement for Scoping Review (PRISMA-ScR; Tricco et al., 2018; Figure 1).

FIGURE 1
Flow diagram followed the PRISMA 2020 guidelines. Generated from https://estech.shinyapps.io/prisma_flowdiagram/ (Haddaway et al., 2022).

Evidence from our publication selection process supports our first observation that social-science approaches are less commonly used in studies of bamboo ES. Thirty-seven studies were excluded for using non-social-science methods, nearly twice the number ultimately included (n = 19), indicating a lower prevalence of social-science approaches in this topic. Next, we categorized the 19 selected studies into two groups to demonstrate the second observation that a certain proportion of research is conducted by Western scientists in developing countries. The first group includes 13 studies conducted in developing countries such as Benin, DR Congo, Bangladesh, India, Nepal, Indonesia, Laos, and Thailand. Within this group, six studies involved collaboration with scholars from developed countries such as Australia, Canada, Sweden, South Korea, and Japan. The remaining seven were authored exclusively by scholars from developing countries. The second group consists of six studies conducted in China and Japan, which (strictly speaking) are not classified as developing countries but have abundant bamboo forest resources. These studies were typically led by scholars from their respective countries (Figure 2). Three common social science research techniques were frequently employed interviews, field observations, and questionnaire surveys. Among the 19 selected studies, these methods were utilized in 14, 7, and 9 publications, respectively, with some articles employing more than one technique. Appendix 1 summarizes nine of 19 selected studies that employed questionnaire survey techniques. All of these have sizes ranging from a single village to multiple villages or small regions, and the respondents were largely engaged in primary industries, with a significant proportion ranging from 27% to 98%. As a result, the heavy focus of prior studies on rural areas in the Global South highlights the need for research in large-scale regions of NIEs, which fills an important comparative gap.

2.2 Publications about perceived ES

Although there is limited literature on perceived bamboo's ES in large-scale study areas, expanding our focus beyond bamboo to other species reveals that many previous studies have explored subjective opinions of ES on a larger geographical scale. Thiemann et al. (2022) explored the perceptions of 3,018 diverse respondents in the Free State of Bavaria, Germany, highlighting that socio-cultural characterization, e.g., gender, education level and hobbies in nature, influences the perceived importance of 21 ESs. Larson et al. (2019) developed a robust method for measuring beliefs about ESs and disservices through a large-scale survey that included 1,400 households from urban, suburban, and fringe areas across various income levels in metropolitan Phoenix, Arizona. Baykalı and Şen (2024) further contributed to clarifying the differing views on forest ESs between urban and rural residents in Kastamonu Province, Türkiye. Similarly, Wu et al. (2022) also identified how socioeconomic and demographic factors affect subjective well-being and perceptions of ESs in Duolun County (3,950 km^2), China. Tian et al. (2020) provided evidence that residents who visited urban green spaces more frequently exhibited a relatively higher willingness to pay.

Taken together, these studies suggest that we should not only examine the influence of socioeconomic variables on perceptions of bamboo ESs, but also account for urban–rural differences. Moreover, the analysis should extend to include attitudes toward environmental engagement. Building on these lessons, our study explicitly incorporates socioeconomic variables and geographical context into the conceptual framework and hypothesis design to examine how they shape perceptions and conservation orientations regarding bamboo ESs.
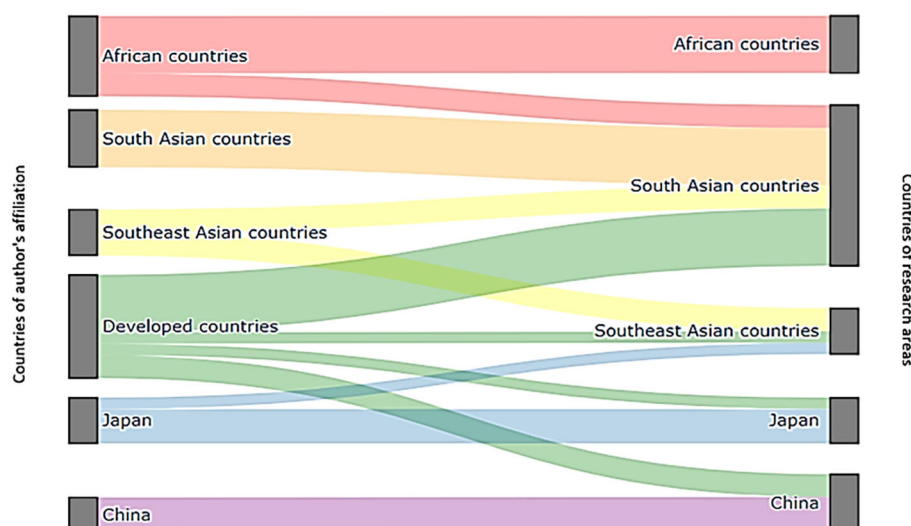

FIGURE 2
Sankey diagram illustrating the connections between countries of authors' affiliation and research areas.

3 Materials and methods

3.1 Study area

The study area is Nantou County (23.9°N, 120.7°E) in inland Taiwan, with an area of 4,106 km² and a population of approximately 450 thousand. This county is mainly composed of mountain ranges that traverse the center of Taiwan Island, and about 95% of the entire territory is hillside (Kuo and He, 2009). The western part is the main distribution area of bamboo forests due to its lower altitude, suitable temperature and rainfall; the eastern part is covered by forests composed of other tree species (Figure 3). The county has a total bamboo forest area of 23,952 hectares, accounting for 10% of the total forest area (Forestry Bureau, 2020). It is a first-level administrative region with some of the richest bamboo forest resources in Taiwan, which makes it representative of the whole of country.

We selected Nantou not only for its bamboo abundance but also for its clearly distinguishable urban, town, and rural settlements. This heterogeneity enables meaningful stratification by residential category and robust comparisons of subjective opinions across settlement types. By contrast, other bamboo-rich regions in Taiwan are located within metropolitan areas, where living environments are relatively homogeneous, which would obscure such differences. Therefore, Nantou offers both ecological relevance and analytical clarity, making it a representative and suitable site for this study.

3.2 Survey methods

We employed a semi-structured questionnaire survey method, incorporating a Likert scale to assess some questions quantitatively. We included options such as "No answer" or "Not sure" for our questions to avoid forcing respondents to choose uncertain answers. The questionnaire is divided into two parts, with the first part aimed at exploring respondents' subjective opinions on bamboo forests, including perceptions and conservation orientations. Regarding perceptions, each common ES is listed in the questionnaire according to the three major categories: provisioning, regulation and maintenance, and cultural (Haines-Young, 2023), allowing respondents to indicate the extent to which bamboo benefits the local area. We further provided an open-ended question to ask respondents to specify any personal benefits they perceive themselves. For conservation orientations, five strategies for managing bamboo forests (monitoring, legal protection, government governance, community development, and industry activities) were identified based on existing literature on bamboo governance (e.g., Utami et al., 2018; Lin et al., 2017; Zhang et al., 2016), and were presented in the questionnaire in order from
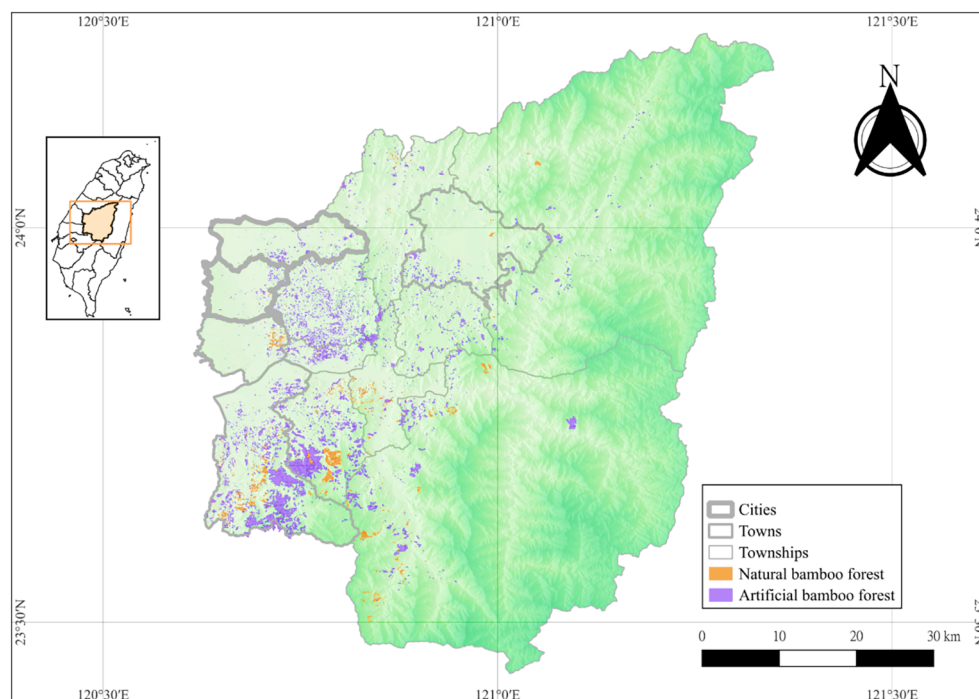

FIGURE 3
Map of the study area.

passive to proactive. Respondents were asked to rate the importance of each strategy. An open-ended question was also provided, inviting respondents to identify which concrete management strategy they consider most effective, as well as to investigate their willingness to pay to implement bamboo management strategies.

The second part of the questionnaire surveyed the socioeconomic and geographical factors of interest in this study, including the gender, age, education, monthly income, residential category (townships, towns, cities), distance from bamboo (near, moderate, far). In addition to the above objective background variables, we also surveyed the respondents' attitudes toward environmental engagement, listing "frequency of connection with nature", "degree of environmental concern", and "support for government protection" in order from individual-centric to collective-centric.

We conducted the questionnaire survey between June 15 and September 23, 2024, with four to five trained interviewers conducting the survey face-to-face rather than by phone or mail to obtain a higher response rate and quality (Lund, 2023). The interviewers were trained in advance on the questionnaire content to ensure consistency in delivery. To minimize bias, they followed a standardized script, avoided leading questions, and were supervised by the research team. Respondents were informed of the study's purpose, assured of anonymity and confidentiality, and told that participation was entirely voluntary. Ethical approval was obtained from the Institutional Review Board for Humanities and Social Science Research at Academia Sinica (approval number: AS-IRB-HS-23049). After deducting the refused or incomplete questionnaires, 400 valid questionnaires were obtained. The study employed a stratified sampling method, dividing respondents into three strata based on their residential categories, from which

samples were randomly drawn in proportion to the total population of each group (Appendix 2).

3.3 Analysis methods

The survey results were analyzed using SPSS software (version 21.0; IBM Corp, Armonk, New York). We conducted descriptive statistics to summarize respondents' perceptions and conservation orientations. Subsequently, we performed five hypothesis tests to provide inferential statistics regarding the relationships between background variables and subjective opinions. We employed t-tests, ANOVA, and Scheffé's *post-hoc* test to examine differences across groups. These methods were applied to examine whether background characteristics suggest statistically significant differences in perceptions and conservation orientations. In addition, we used hierarchical logistic regression to examine the factors associated with willingness to pay. This approach allowed us to sequentially assess the incremental associations of environmental attitudes, geographical factors, and socioeconomic characteristics with willingness to pay. The conceptual framework is illustrated in Figure 4. The large sample size (n = 400) ensures that, by the central limit theorem, the sampling distributions approximate normality, making parametric tests robust to minor deviations. Our stratified sampling design further yielded relatively balanced groups, which mitigates concerns about heterogeneity of variance. We also inspected descriptive statistics and boxplots, and did not observe severe skewness or extreme outliers that would threaten the validity of parametric analyses.

Our hypotheses were based on previous relevant literature. For Hypotheses 1 and 3, the relationship between socioeconomic factors
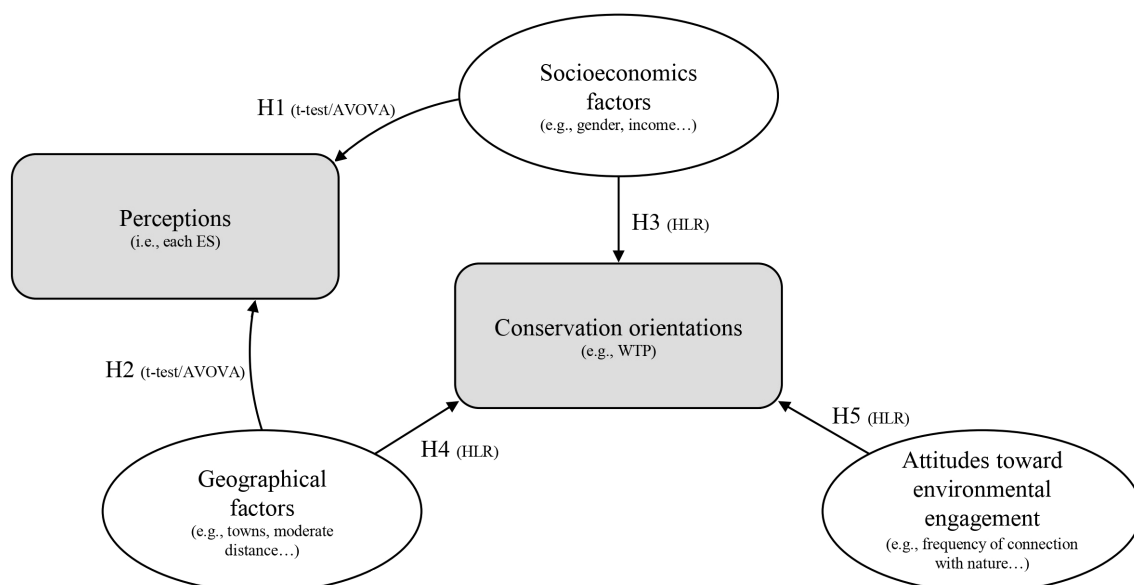

FIGURE 4
Conceptual framework diagram.

and subjective opinions is a topic commonly addressed in the literature. In terms of perceptions, Sales et al. (2024) pointed out that demographic variables such as age, education, location, and occupation linked to environmental perception. Tsvuura et al. (2023) noted that gender and land tenure influenced respondents' perceptions of tree planting. In terms of conservation orientations, previous literature pointed out that gender, education level, age, income, household size, and cultural preferences (Li et al., 2022; Khan et al., 2019; Yu and CMS Collaboration, 2023; An et al., 2024) are related to supporting environmental protection. Therefore, we hypothesize that gender, age, education, and monthly income are associated with significant differences in the perception of individual ESs (H1) and in respondents' willingness to pay for implementing bamboo management strategies (H3).

For Hypothesis 2 and 4, several studies have shown the association between geographical factors and subjective opinions. Fagerholm et al. (2019) found that perceptions of ES are linked to people's accessibility to a landscape. An et al. (2024) further indicated that different geographical locations could lead to variations in respondents' willingness to pay. Similarly, Khan et al. (2019) confirmed that residents living closer to ecosystems are more willing to pay for their improvement. Given these findings, we hypothesize that residential category and distance from bamboo are associated with significant differences in the perception of individual ESs (H2), and that they influence respondents' willingness to pay for implementing bamboo management strategies (H4).

Finally, some studies indicate that attitudes toward environmental participation may also be related to respondents' conservation orientations. For example, Li and Ando (2023) suggested that people who had experience in nature or outdoor activities as children usually pay more attention to environmental protection and have a higher willingness to pay. Ye et al. (2022) noted that environmental protection participation behavior directly affects subsequent participation willingness. Faccioli et al. (2020) explored the influence of general environmental attitudes and place identity perceptions on willingness to pay. Therefore, we hypothesize that the frequency of connection with nature, the degree of environmental concern, and the level of support for government protection are associated with significant differences in respondents' willingness to pay for implementing bamboo management strategies (H5).

4 Results

Before proceeding with data analysis, a reliability test was conducted to assess the internal consistency of the self-compiled questionnaire. A higher Cronbach's α value indicates stronger consistency among the items within the instrument. An α value greater than 0.7 or 0.8 is commonly considered optimal (Cheung et al., 2024). The reliability test results showed that the Cronbach's α values for each set of items exceeded 0.7, indicating satisfactory internal consistency for each construct. Furthermore, the overall Cronbach's α value exceeded 0.8, reflecting good reliability across

the scale, and confirming its appropriateness for subsequent statistical analysis.
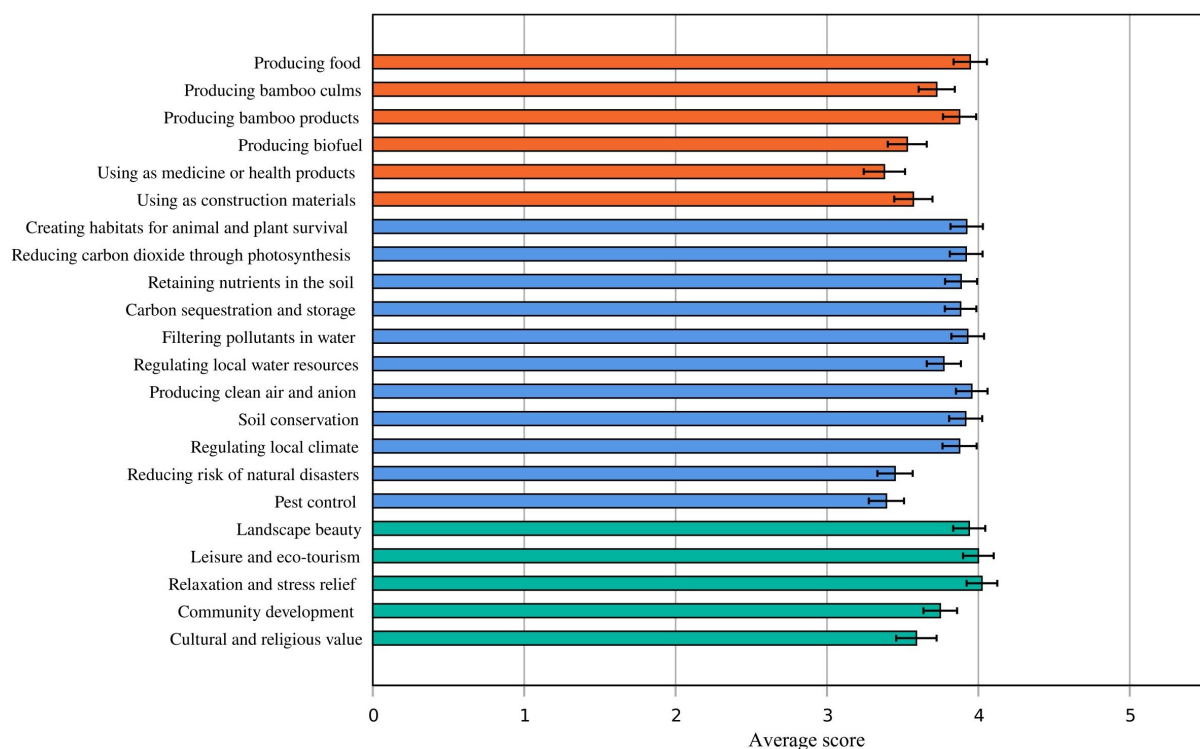
4.1 Perceptions

Respondents rated each ES on a five-point Likert scale, with an average score of 3.77, falling between moderate and important. The survey results indicate the generally positive perceptions of bamboo's benefits to the local area. Although only "leisure and eco-tourism" (score = 4.02) exceeded the threshold of four to be categorized as an outstanding benefit, all ESs received scored above three, indicating broad recognition of bamboo's value. This positive evaluation was consistent across categories, including provisioning, regulation and maintenance, and cultural services (Figure 5). In terms of personal benefits, respondents most frequently mentioned healthy food (16.30%), handicrafts (14.15%), and landscape beauty (6.76%; Figure 6) in the open-ended question. This implies that as the living standards of residents in the study area improve, their utilization of the ecosystem has evolved towards a higher quality of life.

Next, we conducted hypothesis testing and *post-hoc* analysis using t-tests, ANOVA, and Scheffe's test. The test results of H1 and H2 indicated that women significantly believe that bamboo can provide greater contributions or benefits in landscape beauty, leisure and eco-tourism, and community development. Those with higher education levels significantly believe that bamboo can provide greater contributions or benefits in producing food, bamboo culms, bamboo products, and creating habitats for animal and plant survival, pest control, relaxation and stress relief, and cultural and religious value. Those with higher income significantly believe that bamboo can provide greater contributions or benefits in producing food and bamboo culms, use as medicine or health products, and relaxation and stress relief. As for the geographical factor, it presents a special pattern. Respondents living in towns and those within a moderate distance from bamboo forests generally believe that bamboo forests can provide fewer contributions or benefits (Appendix 3).
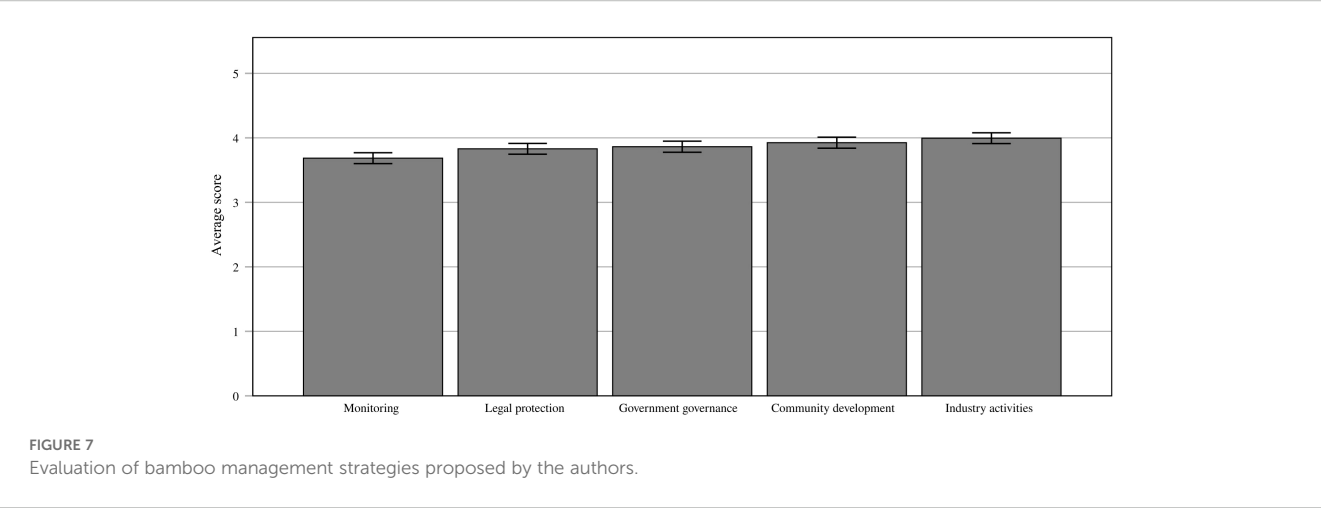
4.2 Conservation orientations

The respondents rated the five strategies for managing bamboo forests on a scale from 1 to 5, resulting in an average score of 3.86. Our findings indicate that residents assign greater importance to a strategy when it is more proactive (Figure 7). Furthermore, the effective management strategies that respondents proposed in response to the open-ended questions included reducing deforestation (17.36%), increasing planting (14.93%), advocacy (12.50%), and environmental education (8.33%), as shown in Figure 8. Regarding the willingness to pay for conservation efforts, the ratio of those willing to pay to those unwilling to pay was 3:7 (Figure 9A). Among those willing to pay, the amounts were primarily concentrated at TWD 1,000 (about USD 33) per year, followed by TWD 500 and TWD 300 per year. Only few

FIGURE 5
Perceived benefits of ESs to the local area by all respondents. Orange bars refer to provisioning services, blue to regulation and maintenance services, and green to cultural services.

respondents were willing to pay more than one thousand dollars (Figure 9B). Most respondents preferred donations (55.6%) as the method of payment, followed by usage fees (23.1%), with only 21.3% supporting taxation to raise funds (Figure 9C). The main reason cited for those unwilling to pay was that they believed the funding should come from the government (51.7%). Other reasons included the belief that payment applies only to tourists and residents (22.2%), and insufficient income to cover payments (21.9%). Only a small percentage of respondents indicated an unwillingness to pay for any environmental issues (2.8%) or stated that protecting the bamboo forest ecosystem was not a priority for them (1.4%; Figure 9D).

FIGURE 6
Respondents' perceptions of the personal benefits of ES.

FIGURE 7
Evaluation of bamboo management strategies proposed by the authors.
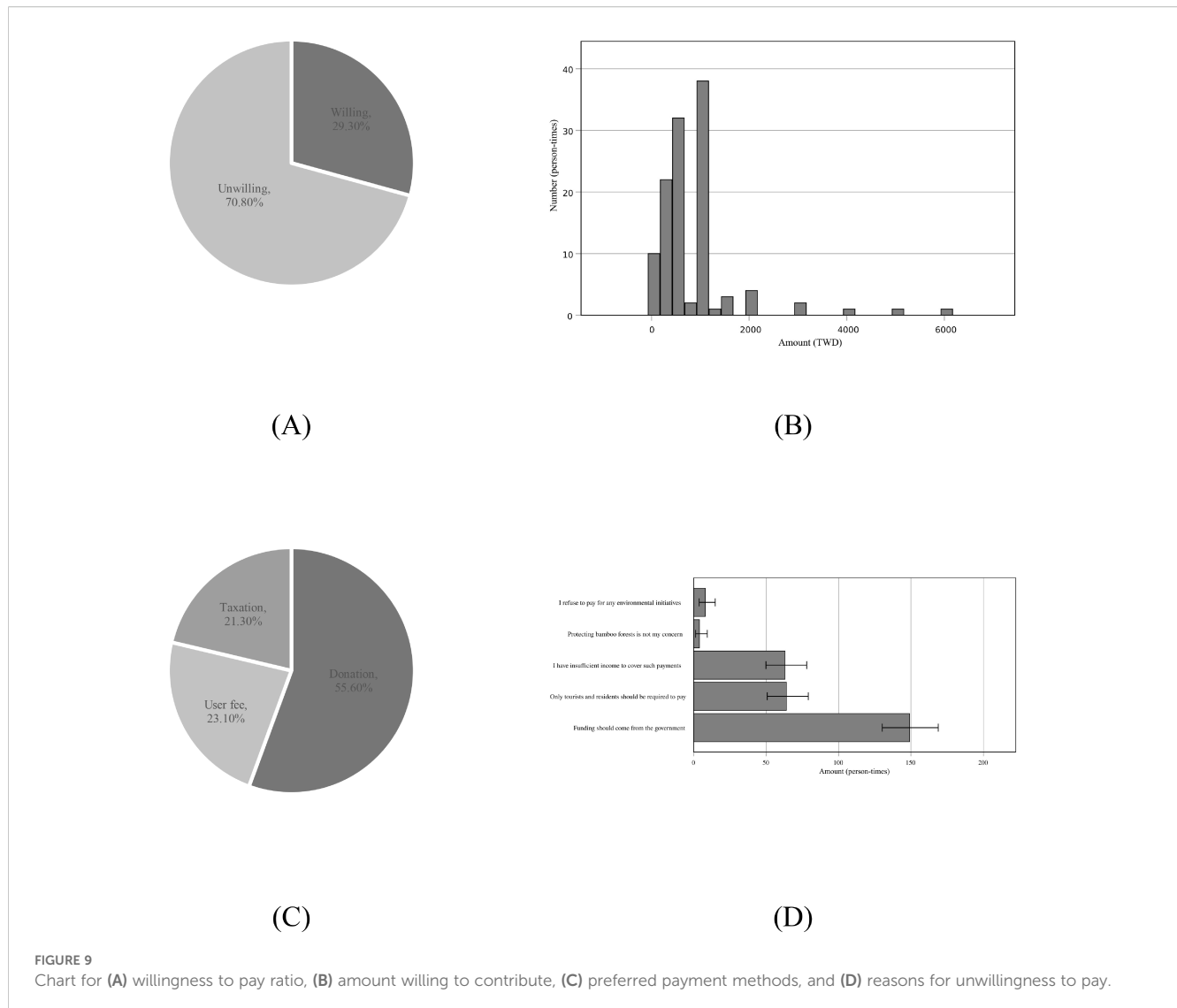
Next, we tested hypotheses 3, 4, and 5 using hierarchical logistic regression analysis (Appendix 4). The results of Model 1 indicate that having collective-centric attitudes toward environmental engagement, that is, "support for government protection," is significantly associated with a higher likelihood of willingness to pay. After incorporating geographical factors, Model 2 reveals that city residents are significantly more likely to exhibit willingness to pay than those in township. Residents living far and moderate distance from bamboo forests are significantly less likely to show willingness to pay compared to those living near bamboo forests. Upon further inclusion of socioeconomic factors, Model 3 demonstrates that, except for residents far away from bamboo who remain significant, other geographical factors become insignificant. On the contrary, respondents with higher monthly income and education levels show significantly higher willingness to pay. The socioeconomic and geographical factors do not affect the relationship between collective-centric attitudes of environmental engagement and willingness to pay.

5 Discussion

5.1 Distinctive perceptions of bamboo's value and policy implications

Our respondents' exhibit relatively balanced or less sensitive perceptions regarding the contributions or benefits of bamboo ESs to the local area, indicating it is challenging to make them realize bamboo's value from this aspect. In contrast, respondents more frequently recognized those ESs that contributed to the comfort of their lifestyle, suggesting that emphasizing the value of these services may be a more effective approach to fostering resonance and recognition of bamboo ESs in our study area. This pattern of consistently high perceptions across most ESs is similar to findings from other developed countries (Thiemann et al., 2022). The current evidence is insufficient to determine the underlying causes of this phenomenon. However, Grum and Bončina (2024) pointed out that individuals' perceptions of forest ESs are strongly

FIGURE 8
Frequency of bamboo management strategies proposed by respondents.

FIGURE 9
Chart for **(A)** willingness to pay ratio, **(B)** amount willing to contribute, **(C)** preferred payment methods, and **(D)** reasons for unwillingness to pay.

influenced by basic human values. Therefore, education systems and institutionalized environmental governance may have fostered shared cognitive and moral frameworks, thereby reducing divergences in how people perceive and evaluate ESs. On the other hand, urbanization may also have limited respondents' direct interaction with the land, making them less sensitive to the tangible benefits of natural resources. Further empirical research is needed to clarify how these structural drivers shape people's perceptions of ESs.

This may represent one of the key differences between the responses from developed and developing countries, as previous studies from developing countries have reported much greater variation in the perception of bamboo ESs (Yeasmin et al., 2021; Gao et al., 2013). The meta-analysis in Appendix 5 showed that our respondents provided assessments with the lowest standard deviation. In other words, the market value of bamboo does not emerge as a prominent issue for local residents. Such perceptions differ from the results of Ahammad et al. (2019), which found that a certain proportion of respondents in Bangladesh (a developing

countries) directly utilize the provisioning services of forests for subsistence. Therefore, they perceive the water purification service as the most important indirect benefit of forests to secure their livelihoods. These findings indicate a shift in the role of bamboo for residents in NIEs, being valued "not for subsistence, but for comfort." This transition can be understood through the lens of post-materialist value theory. Inglehart (1990) argues that as societies attain greater economic stability, people tend to shift their priorities away from material survival concerns toward quality-of-life and environmental values. Such a theoretical perspective is consistent with our evidence that ES valuation in NIE contexts increasingly highlights non-material and non-use values rather than provisioning services.

Moreover, women and individuals with higher education levels and income demonstrated stronger sensitivities to specific ESs, offering valuable insights for developing targeted, stratified policies. For example, distributing bamboo seedlings to female residents might motivate them to cultivate bamboo for landscape enhancement. Developing high-value health products could appeal to high-

income groups who recognize bamboo's unique contributions in this area, thereby increasing bamboo products' economic potential.

5.2 Preferences for proactive management and policy implications

Our results also indicated that passive management strategies, such as monitoring and legal protection, were accorded relatively lower recognition by respondents, who tended to assign greater importance to proactive strategies for bamboo forest conservation. Based on the strategies proposed by the respondents, they prefer direct actions such as reducing deforestation and increasing bamboo planting, which are perceived as more effective than indirect measures like education level and advocacy. This preference indicates that respondents generally expect rapid and visible actions when addressing issues of bamboo's ES. In today's rapidly changing society, such outcomes are more likely to gain public support, especially when environmental problems are perceived as urgent. However, this also implies a skepticism toward strategies that focus on long-term behavioral changes, such as education and advocacy (Powdthavee, 2021), due to their delayed impact and challenges in measuring effectiveness. Therefore, policy design should balance visible actions with long-term strategies to change public attitudes, ensuring that short-term solutions are complemented by lasting shifts in environmental awareness. For example, local authorities can redesign pedestrian routes in parks or community greenways to pass through bamboo groves rather than alongside concrete paths, allowing residents to experience the microclimatic and aesthetic benefits of bamboo directly. Such landscape-based interventions can function as environmental nudges (Grilli and Curtis, 2021) that subtly cultivate appreciation for bamboo's ecological value.

5.3 Willingness to pay for conservation and policy implications

Regarding financial support, the survey results indicate that approximately seventy percent of respondents were unwilling to pay any fees. Even among those willing to pay, the contribution amounts were relatively low, with less support for involuntary tax-based funding models for bamboo conservation. Interestingly, this does not reflect indifference toward environmental issues; rather, respondents generally acknowledge the importance of environmental concerns but believe that the government should take primary financial responsibility for environmental protection. This tendency can be interpreted through the lens of the free-rider (Magistro et al., 2024). Environmental conservation represents a public good characterized by non-excludability and non-rivalry. Individuals thus have an incentive to rely on collective actors, such as the government, to bear the costs while still enjoying the shared benefits. Such free-rider behavior is well documented in environmental economics and helps explain the low willingness to pay observed in this study. Respondents affirm that bamboo forests should be protected but

prefer that a trustworthy and capable collective (i.e., the government) lead and bear the majority of the financial burden. This preference, combined with a potential lack of confidence in the tangible impact of individual contributions, likely explains their reluctance to contribute personally. To this end, the statistical results reveal a significant correlation between support for government protection and willingness to pay, may offer a potential solution. This insight indicates that collective-oriented environmental attitudes strongly shape financial contributions. Future policy design could strengthen individual willingness to pay by increasing financial transparency, demonstrating clear links between personal contributions and environmental outcomes, and developing incentivized donation or user-fee models. For example, integrating community-based funding schemes, such as neighborhood conservation funds or participatory budgeting, may foster a sense of shared responsibility and mitigate free-rider tendencies by linking contribution with local identity and accountability (Brooks et al., 2013).

In addition, monthly income and education significantly influence willingness to pay, whereas geographical factors lose significance once these are considered. From a policy perspective, these findings suggest that policies solely based on geographical location may be insufficient to promote voluntary financial support for bamboo conservation effectively. Instead, greater emphasis should be placed on socioeconomic factors, particularly on improving participation rates among low-education and low-income groups. Although geographical factors appear to lose significance, this does not imply that their influence is absent. In many cases, geographical disparities may indirectly affect willingness to pay through differences in education level and income. For instance, residents in remote areas may have lower financial capacity and environmental education, which hinder their willingness to participate. Therefore, policies targeting these regions should prioritize foundational investments to establish a stronger basis for long-term environmental conservation efforts.

5.4 Limitations and future research

Several limitations should be acknowledged. First, although the sample was stratified by residential category to enhance representativeness, it may still not fully capture the diversity of the entire population of Nantou County or other regions of Taiwan. In particular, the number of elderly respondents in our sample was relatively small (see 50, Appendix 2), which may have constrained the generalizability of age-related findings. Second, as the survey was conducted face-to-face, respondents might have provided socially desirable answers, potentially overstating their environmental concern or willingness to pay. Third, the WTP estimates were based on self-reported intentions rather than actual payment behavior, and should therefore be interpreted as indicative rather than conclusive. Future studies could address these issues by adopting randomized or longitudinal designs, increasing representation across age groups, comparing different survey modes (e.g., online or anonymous questionnaires), and incorporating behavioral or experimental approaches to validate stated preferences.

6 Conclusion

This study provides an empirical contribution to understanding residents' perceptions and conservation orientations toward bamboo ESs in an NIE, using Nantou County, Taiwan, as a case study. It extends the research scope beyond the small-scale rural contexts in developing countries that dominate existing studies and reveals how socioeconomic factors, geographical conditions, and environmental attitudes jointly shape residents' subjective opinions. The findings reflect an ongoing transformation in the human–ecosystem relationship as societies move from resource-dependent to service-oriented economies, where bamboo is increasingly appreciated for its environmental and cultural benefits rather than its material utility.

Theoretically, these results highlight those perceptions of ESs evolve alongside socioeconomic development. As economic structures and lifestyles change, so too do the values people assign to nature and the ways they participate in its conservation. From a policy perspective, the findings underscore the need for governance models that combine government leadership with mechanisms enhancing public trust and participation. Embedding these social dynamics into future ES research could clarify how urbanization and industrialization jointly reshape conservation values across different economic settings.

This study holds broader implications in the context of rapid global development. As more countries transition into NIE status, their residents' perceptions and conservation orientations are likely to align more closely with those observed in Nantou County. Future research should extend this comparative perspective across other NIEs and explore longitudinal changes in environmental perception as societies advance economically.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

Author contributions

C-EL: Writing – original draft, Data curation, Methodology, Software, Validation. C-MH: Data curation, Methodology, Software, Writing – original draft. M-HY: Writing – review & editing, Conceptualization, Data curation, Funding acquisition, Investigation, Project administration, Resources, Supervision.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that Generative AI was used in the creation of this manuscript. Generative AI was used for language editing and polishing of the manuscript. The authors verified the accuracy of all content and take full responsibility for the final version of the text.

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The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2025.1705430/full#supplementary-material

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