

**Five Essays on Valuing Non-market Ecosystem Services of
Natural Resources: Insights from Environmental Attitude,
Perceptions, and Choice Behaviours**

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LIST of ABBREVIATIONS

Abbreviations	Full names
AIC	Akaike Information Criterion
ANOVA	Analysis of variance
ASC	Alternative Specific constant
BIC	Bayesian information criterion
CE	Choice experiment
CL	Conditional logit
CV	Contingent valuation
SBCV	Single bounded contingent valuation
DBCV	Double bounded contingent valuation
DCE	Discrete choice experiment
FES or ES	Forest ecosystem services ecosystem services
HCM	Hybrid choice modelling
HPM	Hedonic price method
I.I.D (i.i.d)	Independent and identically distributed
KFS	Korea Forest Service
KRW	Korea won (Korea monetary unit)
LCA	Latent class analysis
LCM	Latent class models (or latent class choice modelling)
LL	Log-likelihood
MNL	Multinomial logit
MU	Marginal utility
MLE	Maximum likelihood estimator
NIFoS	National Institute of Forest Science
OLS	Ordinary least square
POLS	Pooled ordinary least square
PCA	Principal component analysis
PWD	Pine wilt disease
PWN	Pinewood nematode
RME	Robust mixed effect
RP	Revealed preference
SEM	Structural equation model
RUM	Random utility model (or maximization)
SFM	Sustainable forest management
SQ	Status Quo
SP	Stated preference
TCM	Travel cost method
WOLS	Weighted ordinary least square
WTA	Willingness to accept
WTP	Willingness to pay

Five Essays on Valuing Non-market Ecosystem Services of Natural Resources: Insights from Environmental Attitude, Perceptions, and Choice Behaviours

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Abstract

This dissertation, *Five Essays on Valuing Non-market Ecosystem Services of Natural Resources: Insights from Environmental Attitude, Perceptions, and Choice Behaviors*, investigates how behavioral drivers and contextual factors shape the valuation of forest ecosystem services. By combining meta-analysis, contingent valuation, discrete choice experiments, and hybrid choice models, it offers both methodological innovations and policy-relevant insights into the economics of conservation and restoration.

The first essay tests the hypothesis that ignoring seasonal variation biases economic valuation of ecosystem services. Using a meta-dataset of 476 Korean observations, robust mixed-effects models reveal that willingness to pay (WTP) rises by 67% in autumn but falls by 18% and 65% in summer and winter, respectively. The results confirm that temporal heterogeneity systematically distorts annualized values if seasonality is omitted. Economically, this underscores the need for dynamic valuation models that align with the cyclical supply of ecosystem services.

The second essay examines whether the design of payment vehicles systematically alters conservation values. In the case of the Gotjawal forests of Jeju, contingent valuation surveys with 1,100 residents reveal that entrance fees elicit the highest WTP and policy acceptance, while tax-based mechanisms face strong resistance. This supports the hypothesis that valuation outcomes are not neutral to institutional design, highlighting the economic principle that the incidence and framing of payments critically shape demand for public goods.

The third essay explores the hypothesis that public preferences for restoration are heterogeneous and segmented. A discrete choice experiment with 1,021 citizens, analyzed through principal component analysis and latent class choice modeling, identifies five preference segments with divergent WTP patterns. Acceptance declines steeply at higher costs, validating theoretical expectations of downward-sloping demand for public environmental goods. The findings highlight that efficient and feasible restoration policy requires aligning marginal benefits with socially acceptable cost thresholds.

The fourth essay advances the hypothesis that latent environmental attitudes exert significant and systematic influence on restoration choices. Using a hybrid choice modeling framework that integrates mixed logit with latent class analysis, the study finds that environmental attitudes explain substantial variation in WTP and improve model fitness. This confirms the economic significance of incorporating

unobserved behavioral drivers into preference models, bridging revealed and latent components of choice and extending the frontier of stated preference methods.

The fifth essay investigates whether respondents' choice behavior exhibits systematic deviations from fully rational attendance. Advanced econometric analysis uncovers selective attribute non-attendance and heterogeneous decision types, from deterministic to probabilistic choosers. These results challenge the assumption of fully compensatory preferences, providing empirical evidence that bounded-rationality and cognitive heuristics shape environmental decision-making. From an economic perspective, this stresses the importance of behavioral realism in welfare measurement and policy appraisal.

Taken together, these essays demonstrate that the economic valuation of non-market ecosystem services is deeply conditioned by seasonality, payment design, attitudinal heterogeneity, and behavioral processes. The dissertation strengthens the methodological foundation of environmental economics by refining stated preference approaches and integrating hybrid choice models. At the same time, it delivers actionable insights for conservation finance: that socially legitimate and economically efficient policies must reflect behavioral drivers and contextual realities rather than abstract market analogies.

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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Chulhyun Jeon
December 2024

To my family

Introduction

CHULHYUN JEON

December 2024

Introduction

Sukhdev et al. (2010) – *“Biodiversity in all its dimensions – the quality, quantity and diversity of ecosystems, species and genes – needs to be preserved not only for societal, ethical or religious reasons but also for the economic benefits it provides to present and future generations. We should aim to become a society that recognizes, measures, manages and economically rewards responsible stewardship of its natural capital.”*

Natural ecosystems generate a wide spectrum of services—provisioning, regulating, cultural, and supporting—that are indispensable to human well-being (MEA, 2005). On “spaceship Earth” (Boulding, 1966), sustaining these services for present and future generations requires the maintenance of healthy ecosystems. Boulding urged a rethinking of the relationship between humans and nature in economics, emphasizing ecological limits. Yet, the planet’s finite resources are increasingly threatened by anthropogenic pressures such as climate change, deforestation, forest degradation, wildfires, ocean dumping, and landfill expansion (Halkos et al., 2018; Daily, 1997; MEA, 2005). These forces undermine resilience and sustainability, with adverse feedback on human health and welfare, risking a vicious cycle between ecological decline and social vulnerability (Brundtland, 1987). At the extreme, humanity approaches ecological tipping points. Against this background, this dissertation re-examines environmental valuation through the lens of choice behavior and attitudes, advocating more active forest management and stronger policy responses.

The field of environmental and resource economics has significantly advanced public awareness of the importance of ecosystem services through the development of non-market valuation methods (Haab et al., 2003; Dasgupta, 2021; Whitehead et al., 2011; Johnston et al., 2017; Carson, 2012; Champ et al., 2017; Bateman et al., 2002; Mariel et al., 2021). Landmark contributions include Costanza et al. (1997), who estimated the global annual value of ecosystem services at approximately US\$33 trillion, and more recent evidence from the World Economic Forum (2020), which highlighted that nature underpins US\$44 trillion in economic value—more than half of global GDP. Complementary to these studies, international valuation databases such as TEEB¹, ESVD², EVRI³, ENVALUE⁴, EVIS⁵, BeTa⁶,

¹ The Economics of Ecosystem and Biodiversity (TEEB, website <https://teebweb.org/>) is a global initiative to help achieve ?? through a structured valuation help decision makers. TEEB is a global initiative focused on making nature's values visible. The platform provides guidance and reports on the economic valuation of biodiversity and ecosystem services.

² Ecosystem Services Valuation Database (ESVD) provide 15 terrestrial and marine biomes, 1,300 studies with 9,400 value estimates in monetary units over 140 countries (Brander et al. 2024) (<https://www.esvd.net/>). In Netherlands, the ESVD currently contains 10,874 value records from over 1,100 studies distributed across all biomes, ecosystem services and geographic regions. Our repository of valuation studies contains over 2000 studies and the number is growing continuously so the number of value records in the ESVD will increase over time.

³ EVRI club (Canada, USA, UK, and France) and EVRI by Environment Canada; The Environmental Valuation Reference Inventory is a searchable storehouse of empirical studies on the economic value of environmental assets and human health effects (<https://evri.ca/en>). The EVRI database now contains over 5,000 summaries of valuation studies and information from new studies is being added on an ongoing basis.

⁴ Australia ENVALUE NSW government (<https://apps.environment.nsw.gov.au/envalueapp/default.asp>).

⁵ In Korea, EVIS contains 571 research and 2,802 estimates since 2009 (environmental valuation information system; evis.kei.re.kr).

⁶ The Benefits Table (BeTa) database was created for European Commission DG Environment by Netcen (part of AEA Technology in the UK), to provide a simple ready tool for estimation of the external costs of air pollution. BeTa presents average default values for marginal external costs for different air pollutants in different geographical areas based on the damage function approach tool developed with the ExternE project series (i.e. the Impact pathway approach and the Ecosense software). Value transfer in BeTa is based on unit value transfer.

ValueBase^{SWE7} and NZ NMVD⁸ provide systematic repositories, while institutions such as the World Bank⁹, IUCN¹⁰, and initiatives like The Natural Capital Coalition¹¹ and The Nature Conservancy's NatureVest^{12, 13, 14} promote applied policy use. These resources underscore that ecosystem services have become embedded in economics and policy. Yet the task ahead is to move beyond awareness and ensure that valuation outcomes influence decision-making at societal, policy, and household levels.

At this juncture, the challenge is not only to quantify the magnitude of ecosystem service values but also to understand how such values are perceived, internalized, and acted upon by individuals and stakeholder groups. Since environmental issues are inherently collective, it is necessary to investigate latent environmental attitudes and behaviours, and to analyze how heterogeneity across groups affects willingness to pay (WTP). A strategic policy approach must therefore recognize how attitudes and perceptions condition preferences, and how valuation can be designed to promote legitimacy and action. In summary, while non-market valuation is essential to demonstrate the importance of ecosystem services, it is limited in its ability to generate behavioural change unless accompanied by insights into environmental attitudes, perceptions, and choice processes. This dissertation addresses these issues by designing stated-preference studies—including choice experiments and contingent valuation—that explicitly link valuation to behavioural drivers.

Figure 1 synthesizes key discourses in the ecosystem services literature: the relationship between ecosystems and human-centred utility (or well-being); intergenerational equity (Matson et al., 2016); the integration of economic and ecological perspectives (Costanza, 1991; Grafton et al., 2005); and debates over anthropocentric and biocentric values (Farley, 2012; Pearce, 1993; Turner et al., 1997). Although this dissertation does not fully resolve these broad philosophical debates, it acknowledges their importance for environmental economics and situates its own contributions within this conceptual landscape. Specifically, the research aligns with calls for a paradigm shift from unsustainable, short-term exploitation toward practices that respect ecological thresholds and future generations.

⁷ The Valuation Study Database for Environmental Change in Sweden (ValueBaseSWE) was developed by Sundberg and Söderquist (2004) within a project funded by Naturvårdsverket. The database is the result of a survey of empirical economic valuation studies on environmental change in Sweden. ValueBaseSWE is a Microsoft Excel workbook with two spreadsheets. The first sheet contains data, and the second sheet contains a list of abbreviations used in the database (www.beijer.kva.se/valuebase.htm).

⁸ Non-Market Valuation Database (NZ NMVD) is developed and managed by Lincoln University in Christchurch, NZ. It is an easily searchable database of all valuation studies and value transfers undertaken in New Zealand only. The information about each study is, however, more limited than for e.g. EVRI and ENVALUE. NZ NMVD reports only year of study, type of object, a more detailed description of valued item, method, and mean value estimate (but contains a useful list of authors/valuation practitioners). Thus, it lacks information critical for benefit transfer, and it is e.g. not possible to evaluate the quality of the study by the information provided (<http://learn.lincoln.ac.nz/markval>).

⁹ WAVES (The World Bank's Wealth Accounting and the Valuation of Ecosystem Services) is a global partnership that promotes sustainable development by integrating natural capital in development planning and economic decision-making (Website: WAVES).

¹⁰ Biodiversity Economics IUCN-The World Conservation Union and WWF (<http://www.biodiversityeconomics.org/>).

¹¹ The Natural Capital Coalition offers a framework (Natural Capital Protocol) for organizations to identify, measure, and value their impacts and dependencies on natural capital.

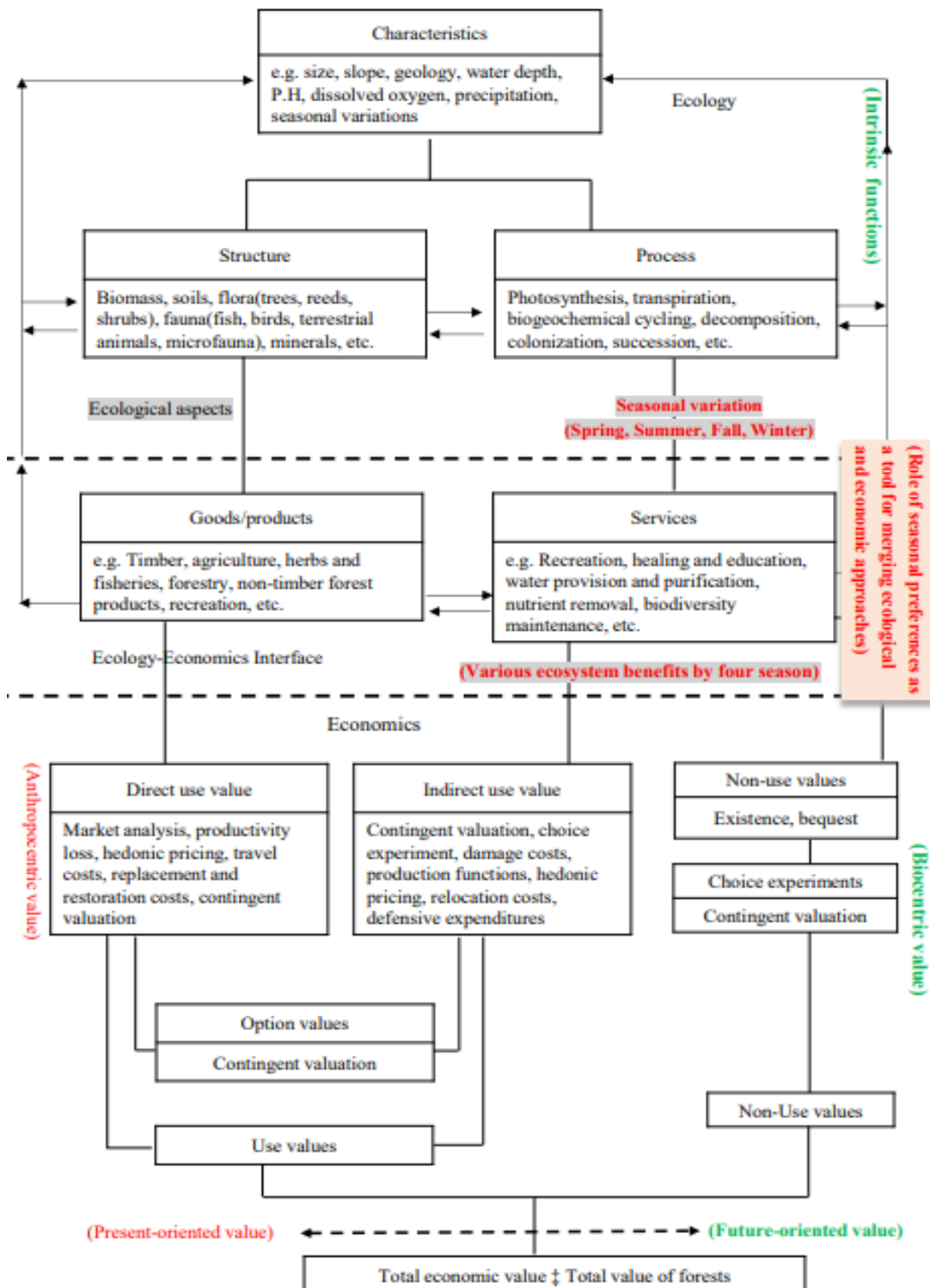
¹² NatureVest works on innovative financing for environmental conservation, including the economic valuation of environmental projects and natural capital (Website: NatureVest).

¹³ This site provides easy-to-understand methods for assigning economic values to ecosystems and the services they provide. It's widely used for environmental assessments and policy-making. This website describes how economics value the beneficial ways that ecosystems affect people (<https://www.ecosystemvaluation.org/>).

¹⁴ Ecosystem Services Database: Gund Institute for Ecological Economics (University of Vermont <http://esd.uvm.edu>); Beneficial Use Values database Department of Agricultural and Resource Economics, University of California (Davis <http://buvd.ucdavis.edu>).

Environmental economists and policy-makers bear responsibility for advancing this shift by integrating rigorous valuation with behavioural insights ¹⁵.

Figure 1. Exploring the topology of healthy ecosystem services and economic valuation



Source: Edited by the author (Turner et al. 1997)

¹⁵ For more information on these topics, see Dasgupta (2021).

Within this broader framework, the dissertation addresses four thematic areas. First, it explores seasonality in ecosystem service valuation, emphasizing that ignoring temporal variation risks biased estimates. Meta-analysis provides an efficient solution to this problem by pooling estimates across studies (Hoffmann, 2020; Nelson et al., 2009), enabling more robust inference despite the time and cost constraints of repeated seasonal surveys. Second, the research investigates the conservation value of Jeju's Gotjawal forests—a rare volcanic ecosystem that is ecologically and culturally significant yet under pressure from rapid development. Using contingent valuation, it estimates WTP across different payment vehicles (taxes, entrance fees, donations) and environmental attitudes, thus addressing a central question in non-market valuation regarding institutional design and public acceptance. Third, it examines forest restoration under threats from wildfires, pests, and diseases, using large-scale choice experiments to uncover preference heterogeneity and cost thresholds for policy acceptance. Finally, it advances a behavioral economics perspective, integrating latent attitudes, attribute non-attendance, and choice heuristics into valuation models to capture the behavioural realism of environmental decision-making.

Although grounded in Korean case studies, these analyses have broader implications for forest management and ecosystem conservation globally. The research highlights the complexity of linking environmental policies, ecosystem processes, and human welfare, underscoring the necessity of interdisciplinary integration between economics, ecology, and policy science. Above all, it emphasizes the deep interconnectedness between humans and ecosystems, recognizing that valuation is not simply about estimating the “total” value of ecosystems but about understanding the changes in service flows relevant to human welfare. While acknowledging intrinsic (biocentric) values beyond human use, the dissertation adopts an anthropocentric framework as most relevant for policy, while also recognizing that expressed preferences may include altruistic or stewardship motives toward nature.

In sum, this dissertation contributes to non-market valuation by addressing underexplored dimensions—seasonality, cultural heritage, restoration preferences, and behavioural heterogeneity—while situating them within broader discourses on sustainability, intergenerational equity, and human–nature relations. Figure 1 provides the conceptual topology guiding this approach, illustrating how healthy ecosystems underpin welfare and how valuation can serve as a bridge between ecological realities and policy decision-making.

The overview of the thesis is provided in the next section.

Overview of the Thesis

This dissertation comprises five essays that collectively develop a behavioral–economic framework for valuing non-market ecosystem services of forests and natural resources. The overarching objective is to provide policy-makers and stakeholders with evidence-based insights for designing more efficient

and socially legitimate environmental policies, while also advancing academic literature on environmental and resource economics.

The thesis is grounded in the economic theory of consumer choice, specifically the random utility framework (Thurstone, 1927; McFadden, 1974). This framework enables the application of probabilistic econometric models to human decision-making in environmental contexts, where preferences for non-market goods are inferred from stated or revealed choices. In line with the established valuation literature (Bateman et al., 2001; Freeman III et al., 2014; Louviere et al., 2000; Train, 2009; Hensher et al., 2005), the dissertation employs multiple methodologies—including contingent valuation (single- and double-bounded formats), discrete choice experiments, hybrid choice models, and meta-analysis—to capture preference heterogeneity and behavioral complexity. Each method is applied strategically to align with the specific research question, thereby maximizing both empirical rigor and policy relevance.

The first essay tests the hypothesis that excluding seasonality introduces systematic bias in valuing forest ecosystem services. Using a meta-dataset of 476 Korean observations, and applying pooled ordinary least squares (POLS), weighted ordinary least squares (WOLS), robust mixed-effects (RME), and weighted robust mixed-effects (WRME) models, the study uncovers significant seasonal heterogeneity: willingness to pay (WTP) rises in autumn but declines markedly in summer and winter. These findings demonstrate that temporal variation reflects both ecological rhythms and behavioral responses, highlighting the risks of static annual valuation models and the necessity of temporally sensitive benefit transfer practices.

The second essay evaluates how payment vehicles condition the conservation value of cultural–historical resources in Jeju’s Gotjawal forests, a globally significant volcanic ecosystem. Based on in-person contingent valuation surveys with 1,100 residents, the results show that entrance fees elicit the highest WTP and enjoy greater public acceptance, whereas tax-based instruments face strong opposition. The analysis confirms that valuation outcomes are institutionally contingent, reinforcing the economic principle that the incidence and framing of payments strongly shape demand for public environmental goods (Tietenberg et al., 2018; Freeman III et al., 2014).

The third, fourth, and fifth essays address the economics of forest restoration under threats such as wildfires, pests, and diseases, using a large-scale discrete choice experiment with 1,021 respondents and 10,210 choice observations.

- The third essay applies latent class choice modeling (LCM) in combination with principal component analysis (PCA) to identify five distinct preference segments. Results reveal sharp declines in acceptance at higher cost levels, confirming theoretical expectations of downward-sloping demand for environmental public goods and underscoring the importance of setting financially realistic thresholds in restoration policy.
- The fourth essay develops a hybrid choice modeling (HCM) framework, integrating mixed logit and latent class models with environmental attitudes as latent variables. Findings show that

attitudes exert a significant and systematic influence on WTP, improving model fit and explanatory power. This provides methodological evidence that incorporating unobserved attitudinal constructs enhances the behavioral realism of stated preference models (Louviere et al., 2000; Train, 2009).

- The fifth essay investigates the roles of latent attitudes, attribute non-attendance, and heterogeneous choice strategies in restoration decision-making. Advanced econometric models, including the independent availability logit and latent class analysis, indicate that respondents do not ignore attributes entirely but instead practice selective non-attendance at the attribute-detail level. Behavioral classes range from deterministic to probabilistic choosers, illustrating bounded rationality and cognitive heuristics. These results challenge the assumption of fully compensatory preferences and provide empirical support for integrating behavioral realism into welfare estimation and policy design (Bateman et al., 2001; Freeman III et al., 2014).

Taken together, the five essays demonstrate that the economic valuation of ecosystem services is not merely a technical application of stated preference methods, but a fundamentally behavioral process shaped by attitudes, perceptions, and institutional context. The dissertation contributes to environmental economics by:

1. Advancing methodological practice through hybrid modeling, meta-analytic techniques, and behaviorally integrated approaches.
2. Providing empirical evidence on how seasonality, payment vehicles, and attitudinal heterogeneity influence WTP.
3. Offering practical guidance for conservation finance and restoration management, emphasizing that social legitimacy and acceptance are as critical as economic efficiency.

While the dissertation makes substantial methodological and empirical contributions, certain limitations remain, particularly the reliance on context-specific case studies in Korea and the use of stated preference methods, which may face challenges of external validity. Future research should extend these insights through comparative cross-country analyses, integration with revealed-preference data, and longitudinal designs that capture the dynamics of environmental attitudes and preferences over time. Such efforts would further enhance the robustness, generalizability, and policy relevance of the findings presented here.

Table 1 provides a summary of these results, with further details elaborated in the following chapters.

Table 1. Overview of the five empirical studies

Study	Respondents	Research contents	Method ^a	Model ^b	Number of respondents or observations	Type of ecosystems and natural resources
1	Consumers, Visitors, Citizens	Uncovering Seasonal Heterogeneity in Forest Ecosystem Valuation: Evidence from a Meta-Analysis with Experimental Insights	Meta-analysis	POLS, WOLS, WME, RME	1,270 estimates (1,360 initial estimates)	All types of natural resources
2	Citizens in Jeju	Willingness to Pay for the Conservation of Cultural and historical Resources within the Gotjawal: The Role of Payment Vehicles	SBCV, DBCV	Logit	1,100 respondents	Forest ecosystems and cultural resources
3	General citizens	Exploring Preference Heterogeneity and Acceptability for Forest Restoration Policies: Latent Class Choice Modelling and Principal Component Analysis	DCE, PCA	LCM, MNL	1,021 respondents (10,210 choice responses)	Forest ecosystems
4		A Hybrid Choice Modelling Approach to Valuing Forest Restoration Through Environmental Attitudes: A Korean Case Study	DCE, PCA	HCM		
5		Understanding environmental decision-making in forest restoration: the role of latent attitudes, attribute non-attendance, and choice behaviour	DCE, PCA	IAL, MNL		

^a SBCV= Single bounded contingent valuation; DBCV=Double bounded contingent valuation; DCE= Discrete choice experiment; PCA=Principal component analysis.

^b POLS=Pooled Ordinary Least Square; WOLS=Weighted Ordinary Least Square; WME= Weighted Mixed Effect; RME=Robust Mixed Effect; MNL=Multinomial Logit; LCM=Latent Class Models; HCM=Hybrid choice Model; IAL=Independent availability logit.

Outline of the Thesis

The thesis is organised as follows. The methodology, study design, models, results and conclusions of the five studies are separately outlined in the next five chapters. The final chapter summarises and concludes the thesis with key findings, contributions, policy implications, limitations, and possible future extensions. Full copies of the surveys are provided at the end of the Appendices.

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Chapter 1

(Uncovering seasonal heterogeneity in forest ecosystem valuation: Evidence from a meta-analysis with experimental insights.)

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Price (2007) – “Securing a healthy natural environment for today and the future.”

Uncovering seasonal heterogeneity in forest ecosystem valuation: Evidence from a meta-analysis with experimental insights

Abstract

Seasonal variation not only influences the ecological functioning of forest ecosystems but also alters the benefits people derive from them, ranging from physical to psychological restoration. Ignoring such variation in valuation risks, thereby producing seasonally biased and unreliable estimates, constitutes an issue that previous valuation studies have largely overlooked. This study investigates the extent of seasonal bias in willingness to pay (WTP) for forest ecosystem services using a meta-dataset of 476 observations from Korea. Applying pooled, weighted, and robust mixed-effects models, we uncovered substantial seasonal heterogeneity through our analysis: WTP increases by 67% in autumn but declines by 18% and 65% in the summer and winter, respectively. The robust mixed-effects model provided the best empirical fit, highlighting the methodological value of explicitly modeling temporal effects in meta-regression. These results reflect seasonally differentiated engagement with forests and suggest that individuals implicitly recognize the temporal value of ecosystem services. Nevertheless, limitations remain, particularly the heterogeneity of research designs, survey methods, and elicitation formats, which may introduce variability and potential bias. Therefore, while seasonal differences are statistically significant, the results should be interpreted with caution. Extrapolating annual values from single-season data risks systematic distortion, especially when stated preference methods are used. Beyond methodological implications, the findings also underscore a broader point: seasonal rhythms shape not only ecosystem dynamics but also human well-being. Accurately valuing these shifting benefits is essential for making credible economic assessments and sustaining long-term reciprocity between people and nature.

Keywords: Seasonal preferences, forest ecosystem services, meta-analysis, willingness to pay, robust mixed-effects models

1. Introduction

Healthy forest ecosystems deliver a vast array of direct and indirect benefits to human societies. Representing over 60% of the Earth's total biomass and storing more than half of global carbon stocks, forests provide crucial provisioning, regulatory, cultural, and support services [1–6]. However, the value and perception of these ecosystem services are not static—they are deeply influenced by seasonal dynamics. Seasonal variation—driven by the Earth's axial tilt and orbital rotation—is a fundamental ecological force that shapes both the supply and of ecosystem services and humans' experiences relating to them [7,8]. Across the spring, summer, autumn, and winter, ecosystems exhibit cyclical changes in biophysical characteristics such as vegetation cover, biodiversity, and resource availability. These natural cycles, in turn, affect human engagement with forests, influencing outdoor recreational use, cultural activities, mental well-being, and responses to environmental externalities [9–12]. Recognizing

and incorporating these seasonal patterns are essential for capturing the true economic and experiential value of forest ecosystem services. A failure to account for seasonality may result in undervaluation or misrepresentation, ultimately weakening the foundation for equitable, time-sensitive, and sustainable forest management strategies [13,14].

Forest ecosystems in Korea, a country in the Northern Hemisphere, provide seasonally dependent public services and functions, covering more than 64% of the country's land area [15,16]. The sustained delivery of these services is critical to public well-being [17,18]. According to the National Institute of Forest Science and the Korea Forest Service (2023) [15], Korean forests contribute to 12 major ecosystem functions—including carbon sequestration, recreation, and landscape aesthetics—generating an estimated annual value of approximately KRW 259 trillion (or, as of 2020, approximately USD 224 billion) [15,19]. Despite these substantial benefits, the valuation of forest ecosystem services in Korea exhibits significant seasonal variation [19]. Korea's distinct four-season climate—characterized by hot, humid summers (June–August) and cold, dry winters (November–February)—results in marked differences in recreational use and tourism demand [20,21]. During the summer, vacationers flock to coastal and forested regions to escape the heat, while vibrant autumn foliage attracts large numbers of visitors to mountainous areas [22,23]. In the winter, recreational preferences shift toward snow-based activities, particularly in ski resorts. These seasonal patterns influence not only outdoor recreation behaviour but also the perceived aesthetic and cultural value of forest landscapes [9,10].

Previous research on forest ecosystem benefits primarily examined recreational values, public goods, biodiversity conservation, and the valuation of protected areas [22]. This research focuses on Korea's high engagement in mountain-related activities, with an estimated 23 million annual visits for hiking, camping, healing, and outdoor pursuits [15]. The 2023 National Travel Survey (allowing multiple responses) found that the most common travel activities in Korea included nature and landscape appreciation (78.3%), rest and relaxation (60.8%), food tourism (60.2%), visiting family and friends (13.7%), and historical-site exploration (7.7%) [20]. These results highlight a strong national preference for nature-based recreation. Analysis of domestic travel experience rates (2019–2023, excluding 2020–2021 because of COVID-19 disruptions) reveals further seasonal trends. The highest travel experience rates were recorded in the fall (53.7%), followed by the summer (51.8%), winter (51.0%), and spring (50.2%). The lowest travel participation occurred in colder months such as March 2022 (41.9%), February 2023 (46.6%), and January 2019 (48.1%), while peak travel was observed in September 2022 (54.3%), September 2023 (56.5%), and February 2019 (62.8%). These trends demonstrate strong seasonal variations in recreational demand, with the highest activity in the fall and the lowest in early spring and winter [21].

Given these seasonal fluctuations, there is potential for seasonal bias in willingness-to-pay (WTP) estimates for forest ecosystem benefits. If seasonal variations in recreation patterns, tourism behavior, and landscape valuation are not properly accounted for, WTP estimates may be distorted, leading to the over- or underestimation of ecosystem benefits [9,14,23]. Due to time and cost constraints, many

environmental valuation studies extrapolate annual benefit estimates from surveys conducted in a single season or a limited timeframe [24,25]. This approach can introduce measurement errors, reducing the accuracy of cost–benefit analyses for forest policies and increasing the risk of market and policy failures [26,27].

To address this issue, we compiled a meta-dataset of 476 WTP observations from 90 Korean valuation studies and applied robust mixed-effects meta-regression to statistically verify seasonal heterogeneity in preferences. To the best of our knowledge, this is the first meta-analysis that systematically quantifies seasonal variation in WTP for forest ecosystem services in Korea. Whereas previous meta-analyses have synthesized valuation studies under the assumption of temporally static preferences [22,28,29], this study uniquely incorporates the seasonal dimension, revealing how the autumn, summer, and winter yield markedly different WTP outcomes. This explicit treatment of seasonality not only strengthens methodological rigor but also provides novel insights into how temporal dynamics shape valuation outcomes and forest-related behaviours.

While stated preference methods dominate the dataset (368 estimates: 296 contingent valuation and 72 choice experiments), a smaller number of revealed preference estimates were also included, primarily based on the travel cost method and hedonic pricing. However, because the number of revealed preference studies is relatively limited, our main statistical analysis relies on the stated preference, with revealed preference results reported descriptively for context. This distinction ensures clarity while acknowledging the complementary value of both approaches.

The originality of this study lies in three aspects. First, it empirically demonstrates that ignoring seasonality can introduce systematic bias into benefit transfer and cost–benefit analysis, a point rarely addressed in previous meta-analyses [29,30]. Second, it introduces a conceptual framework linking ecological seasonality, human behaviour, and economic valuation, thereby bridging ecological and behavioural economics perspectives [30,31]. Third, it provides policy-relevant recommendations on how forest management, pricing, and marketing strategies can be designed in a season-sensitive manner [32]. In doing so, this study extends the broader literature that underscores the economic and organizational significance of environmental values [31,32] while remaining grounded in the core tradition of WTP-based environmental valuation. By integrating these contributions, this paper advances both methodological innovation and policy discourse on ecosystem service valuation.

Against this backdrop, this study addresses the following research questions:

- To what extent does willingness to pay (WTP) for forest ecosystem services vary across different seasons (spring, summer, autumn, and winter)?
- How robust are these seasonal differences in WTP once socioeconomic, methodological, and regional moderators are controlled for in a meta-regression framework?
- What are the implications of seasonal heterogeneity in WTP for policy design, benefit transfer, and sustainable forest management strategies?

By answering these questions, this paper makes three contributions: (i) it provides empirical evidence that overlooking seasonality can bias benefit transfer and policy evaluation, (ii) it provides a robust modelling framework for capturing temporal heterogeneity, and (iii) it offers policy-relevant insights into season-sensitive forest management. We further applied diagnostic tests to validate the choice of model and propose methodological improvements for benefit transfer. The remainder of this paper is structured as follows: Section 2 reviews the theoretical background and prior research; Sections 3 and 4 present the empirical analysis; and Section 5 provides our conclusions along with policy implications.

2. Literature Review on Seasonal Preferences and the Application of Mixed-Effects Models

2.1. Seasonal Preferences

Despite the growing interest in environmental valuation, little attention has been paid to seasonal preferences. This section first reviews the previous literature on seasonal preferences and then expands the discussion to meta-analyses of environmental services and benefits, given the importance of seasonality in natural recreation demand—a key research topic in environmental economics and tourism. Although seasonality plays a crucial role in environmental valuation and consumer behaviour in forest-related activities, studies explicitly addressing seasonal variations remain scarce [33,34]. For example, Bartczak et al. (2012) [33] developed a single-site travel cost model for urban forests in Poland to estimate seasonal recreation demand based on travel frequency data. Using a Poisson count data model, they estimated consumer surplus per trip as follows: EUR 2.43 in the summer, EUR 3.68 in the fall, EUR 2.85 in the winter, and EUR 2.60 in the spring. Their findings indicate that fall was the most preferred season, followed by winter, spring, and finally summer. While the average consumer surplus was EUR 2.89, seasonal variations ranged from -15.9% to $+27.3\%$, suggesting that tourists' satisfaction levels fluctuate significantly across seasons.

Similarly, a contingent valuation study on Haeundae Beach in Busan, Korea, found a 20% difference in WTP between peak and off-peak seasons. Specifically, the WTP for preserving the beach's scenic beauty was KRW 16,917 (USD 14.63) per person per visit during peak season and KRW 14,099 (USD 12.19) during off-peak season [35]. This discrepancy underscores the impact of seasonal variation on WTP estimates, potentially leading to differences in valuation outcomes.

Since the 1990s, meta-analysis has been playing an increasingly important role in environmental research [36]. For environmental policymakers and natural resource managers managing non-market resources—such as forests, rivers, wetlands, and other natural assets—conducting original empirical valuations can be both time-consuming and costly [37,38]. As these non-market goods and services are non-excludable and non-rivalrous, researchers often rely on benefit transfer, involving the application of empirical estimates from previous studies to new contexts [39]. For instance, Grammatikopoulou et al. (2021) [40] conducted a meta-analysis on forest ecosystem services using a dataset of 30 studies (71 observations) primarily from Europe. They applied benefit transfer techniques to the Czech Republic,

demonstrating forest ecosystem services' substantial economic contribution to the national GDP. Newbold and Johnston (2020) [41] estimated the value of information using meta-analysis for water quality improvement, while Roldan et al. (2021) [42] examined WTP differences for drinking water quality between developed and developing countries, highlighting the influence of income levels on valuation outcomes.

Additionally, Filho et al. (2021) [43] used the Environmental Service Valuation Database (ESVD) to estimate local environmental services across 12 biomes, comparing the performance of meta-analytic transfer versus simple value transfer. In Korea, Kim et al. (2018) [28] conducted a meta-analysis of 51 studies (131 observations) to estimate the marginal WTP and economic benefits of drinking-water-quality improvements. Giergiczny et al. (2014) [44] conducted a meta-analysis of 53 studies (253 estimates) that applied the contingent valuation method (CVM) and travel cost method (TCM) to estimate the recreational value of forests in Europe, including Austria, Germany, Ireland, Italy, Northern Ireland, Poland, and Spain. Their findings indicated that protected areas significantly enhance forest recreational value, emphasizing the ecological and economic importance of conservation efforts.

Although both stated preference and revealed preference methods are increasingly employed in economic valuation research [45], relatively few studies have comprehensively examined the influence of seasonal variations on environmental service valuation. Given the potential for seasonal biases in WTP estimates, addressing these variations is critical for improving the accuracy of benefit assessments. Similar approaches to valuing ecosystem services have been applied in several meta-analyses (Table 1). As shown in Table 1, we identified the key studies that have contributed to this body of research, providing the study author(s), publication year, type of ecosystem services, research areas, and the valuation methodology used, allowing for a clearer understanding of the various approaches and contexts under which seasonal variations in WTP have been analysed.

Table 1. Summary of major meta-analyses in the ecosystem service valuation literature

Authors	Ecosystem Services	Scale (Country, Area)	Value Type	Survey Method (Valuation Methods)	Observations (No. of Estimates)
Kim et al. (2018) [28]	Water quality (mainly rivers)	Korea	Indirect use	CVM CE	51 studies, 139 observations
Grammatikopoulou et al. (2021) [40]	Forest ecosystem services	Europe	Indirect use	Stated preference	30 studies, 71 observations
Newbold and Johnston (2020) [41] ^b	Water quality improvement	US	Total (use + non-use)	Stated preference	51 studies, 140 observations
Roldan et al. (2021) [42]	Drinking water quality	30 countries	Indirect use	Face-to-face survey	30 studies, 30 observations
Filho et al. (2021) [43]	Ecosystem services ^a	Global scale	Total (use + non-use)	General valuation method	636 observations (ESVD)
Giergiczny et al. (2014) [44]	Forest recreation	Europe	Direct use	CVM TCM	53 studies, 253 observations

^a Ecosystem services: provisioning, regulation and maintenance, and cultural services. Biomes: coastal systems, coastal wetlands, coral reefs, cultivated areas, desert, freshwater, grasslands, inland wetlands, marine, temperate or boreal forests, tropical forests, and woodland. ^b Year estimated or published.

Through statistical tests and modelling, this study makes three key contributions to advancing the meta-analysis approach and understanding the significance of seasonal effects, preferences, and WTP variations across the four seasons: (1) it highlights the necessity of incorporating seasonal effects in valuing environmental services, an aspect that has been largely overlooked in previous research; (2) it provides a newly developed robust mixed-effects model to address heterogeneity and heteroskedasticity in meta-regression; and (3) it quantifies WTP variations in percentage terms for each season, providing conclusive justification for coefficient adjustments when using partial datasets across different times of the year.

Beyond these empirical examples, the existing literature remains largely descriptive and fragmented, offering limited integration of ecological, behavioural, and economic perspectives. To provide a more cohesive theoretical foundation, in this study, we propose a conceptual framework that links seasonal dynamics to human behaviour and, ultimately, WTP outcomes (Figure 1). Specifically, seasonal variation in ecological conditions—such as vegetation cycles, climatic factors, and landscape aesthetics—influences human interactions with forests, including in terms of recreational demand, cultural attachment, and psychological restoration. These behavioural responses then shape stated and/or revealed preferences, as reflected in WTP estimates. This framework highlights why ignoring seasonal dynamics can bias valuation results and underscores the need for meta-analyses that explicitly incorporate temporal variation [12,20,23,33]. By situating seasonality at the intersection of ecology, behaviour, and economics, this framework provides a guiding model for the subsequent empirical analysis.

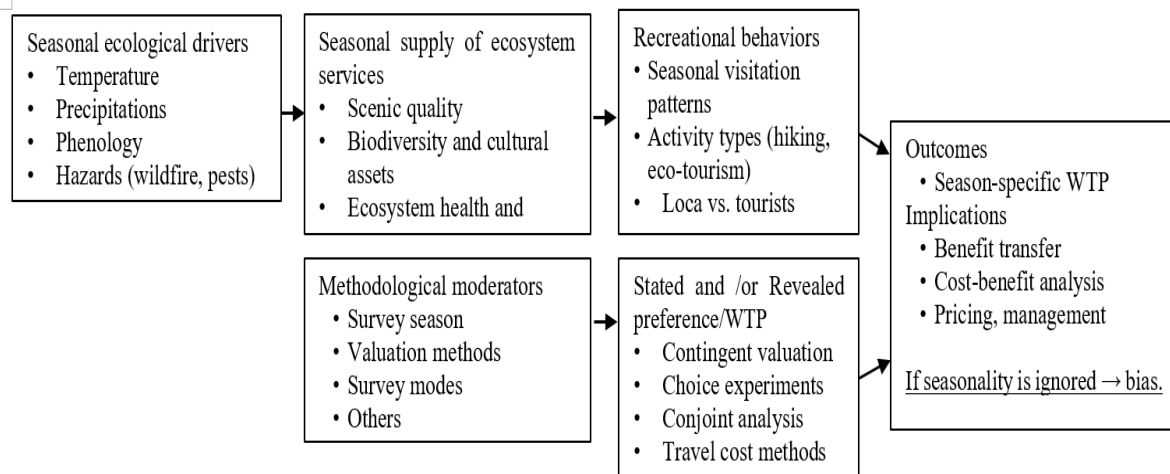


Figure 1. Conceptual framework linking seasonal dynamics, behavior, and valuation for forest ecosystem services.

2.2. Meta-Analysis Framework and the Role of Mixed-Effects Modelling

Meta-analysis is widely used in environmental economics to synthesize WTP estimates for ecosystem services across multiple primary studies [25,29,31,38–40]. Unlike conventional cross-sectional data, meta-analytic datasets typically have an unbalanced panel structure, where multiple value estimates are

extracted from the same studies using different methods or sample designs, and the basic framework for the panel structure consists of a regression model [46]. This hierarchical data structure requires more flexible modelling approaches that account for both within- and between-study variation [39]. Nelson et al. (2009) [47] summarized a few key points as part of a meta-analysis: sample selection criteria, basic data summary, primary data heterogeneity, heteroskedasticity, and non-independence of multiple observations from primary studies. They also suggested a set of best-practice guidelines for other areas of economics and indicated that with some solutions, sample heterogeneity can be explained by the binary dummy and random effect. Second, the heteroskedasticity of effect-size variance should be a high priority in collecting primary data on variance and sample sizes. Finally, the non-independence of primary estimates can be addressed using panel data methods and other econometric methods for managing correlated data.

Mixed-effects models are increasingly applied in meta-analyses to address these complexities. These models incorporate both fixed effects (explaining overall trends) and random effects (capturing unobserved heterogeneity across studies). This structure allows for the inclusion of clustered data, missing values, and unbalanced designs while also improving model robustness and predictive performance. Robust mixed-effects models can handle study-specific deviation and reduce residual variance through random slopes and intercepts [48–51].

In this study, random intercepts were specified for both study year and region. The temporal random effect captures unobserved heterogeneity across time, such as macroeconomic shifts or evolving methodological standards, while the regional random effect accounts for contextual differences in forest ecosystems, cultural preferences, and policy environments that may systematically influence WTP estimates. Compared to fixed-effects or single-level specifications, this structure provides greater flexibility in partitioning variance and improves the generalizability of results across different spatiotemporal contexts [44,52]. To ensure the reliability of this specification, model diagnostics were conducted. In addition, sensitivity analyses with alternative specifications (e.g., random intercepts for either time or region only) produced consistent seasonal patterns, though with slightly different effect magnitudes, supporting the robustness of the chosen specification [53].

Given the nested nature of the meta-dataset—476 value estimates from 90 studies—this study specifies the following linear mixed-effects regression model (1), which is well suited for continuous outcomes such as the natural logarithm of WTP [48,49,53]. A linear specification is appropriate because the dependent variable is continuous and log-transformed, allowing effect sizes to be interpreted in relative percentage terms. The mixed-effects framework is further justified by the hierarchical structure of the data: multiple observations are clustered within individual studies, inducing within-study correlation that cannot be captured by simple linear regression. By combining fixed effects (to estimate average moderator impacts) with random effects (to capture study-level heterogeneity), the model reduces residual correlation and improves the generalizability of the results for benefit transfer applications.

$$y_{in} = \alpha + \sum_{k=1}^K \beta_k x_{k,in} + \varepsilon_i + \mu_n \quad (1)$$

where y_{in} represents the n^{th} WTP estimate from study i ; β^k denotes fixed-effect coefficients for explanatory variables $x_{k,in}$; ε_i denotes the study-level random effect; and μ_n is the estimate-level residual. This structure enables us to account for both study-specific clustering and observation-level noise, thereby improving the reliability of the valuation estimates [53].

3. Empirical Analysis

3.1. Systematic Review

We first applied a systematic review to identify empirical research estimating willingness to pay (WTP) for forest resources and ecosystem services. The review was conducted following a stepwise approach consisting of three stages: (1) identifying and screening relevant studies, (2) compiling a structured meta-database of WTP estimates and explanatory variables, and (3) applying regression models to account for heterogeneity across studies [25,54,55].

To ensure comprehensiveness, we searched multiple databases and academic sources, including RISS, DBpia, the Korea Environment Institute's EVIS system, major university library sites, and key journal publisher websites, for reports published between 1999 and 2022. The search involved the use of predefined keywords related to forest ecosystems (e.g., forest, mountain, and parks), non-market valuation methods (e.g., WTP, contingent valuation, and choice experiment), and environmental valuation themes (e.g., recreation, biodiversity, and preservation) [54,56–58]. A summary of the databases, keywords, and scope is presented in Table 2.

Table 2. Overview of systematic review procedure and metadata coverage

	Content
Main databases	EVIS (http://riss.or.kr/index.do), major academic sites (riss.or.kr; DBpia), relevant journal websites, major university library sites, National assembly libraries, and relevant research institute reports
Main relevant keywords	Main natural resources: forests, mountains, wetlands, parks (national, provincial, local, etc.), and forest-dependent animals Non-market valuation: willingness to pay, willingness to accept, stated preference, revealed preference, contingent valuation, choice experiment/modelling, travel cost, hedonic price, and conjoint analysis Meta-topics: environment, economic value, non-market values, use value, non-use value, preservation value, environmental services, recreation, tours, visits, satisfaction, healing, education, and biodiversity
Types of prominent journals and research institutes	Environmental economics, agricultural economics, economics, tourism and applied fields, marine economics, forest economics, forest management, and relevant natural science and public organizations
Number of studies	93 (initial) → 90 (after screening)
Number of estimates	485 (initial) → 476 (after screening)
Timespan	1999~2022

We compiled a meta-dataset from 90 studies on forest ecosystem services in Korea. Table 2 presents a summary of the data sources, selection criteria, and meta-data coverage. The table includes information on the number of studies, the research fields covered, the methodologies used, and the temporal and seasonal characteristics of the data. These elements were crucial for ensuring the comparability and robustness of the meta-analysis.

Each study had to report at least one WTP estimate for forest ecosystem services, obtained through stated or revealed preference methods. Abstracts were initially screened to exclude irrelevant studies, such as those not focused on forest resources, those lacking valuation estimates, or those based solely on value transfer methods. We searched the gray literature to find as many estimates as possible and test the influence of the gray reports; however, this research was excluded from the final model. Full texts were then reviewed to confirm eligibility. The inclusion criteria were defined in accordance with the MAER-Net guidelines [24,25] to ensure the validity and replicability of the meta-analysis, as emphasized in [47,59–61].

Out of the 93 studies initially identified, 90 were retained after screening, yielding 476 usable WTP estimates. Studies were excluded if they reported negative or inconsistent values (e.g., one negative WTP, six transfer-based values, and two statistical outliers). Such values are typically considered implausible in economic valuation or reflect methodological inconsistencies that compromise comparability across studies. However, we acknowledge that excluding negative or highly inconsistent estimates may introduce upward bias by underrepresenting protest responses or zero-WTP segments, thereby limiting full generalizability of the findings. To address this concern, we conducted sensitivity checks including these excluded studies, and the overall seasonal patterns of WTP were found to remain robust, though the absolute mean levels were slightly lower. This result suggests that the exclusion improved internal consistency and comparability across studies while only marginally affecting external validity. Each estimate was subsequently coded with relevant moderator variables, including resource type, valuation method, publication characteristics, and survey timing. Seasonal variables—derived from reported survey months—were also coded to capture seasonal preference effects. Socioeconomic variables were incorporated to enrich the dataset and reduce bias inherent in meta-level data [48,62].

The final dataset averages 5.2 estimates per study and includes a mix of published articles, gray literature, and reports. All moderator variables were coded systematically, primarily as dummy variables (0, 1), to facilitate empirical analysis. Table 2 summarizes the data sources, selection criteria, and meta-data coverage.

3.2. Database Compilation

Table A1 summarizes the structure of the meta-database used in this study along with the variables, including data sources, coding schemes, valuation methods, seasonal classifications, and regional distributions. This structured dataset was compiled following the screening of 90 primary studies and includes 476 WTP estimates covering forest ecosystem services in Korea from 1999 to 2022. The dataset integrates various sources—including peer-reviewed articles, government reports, and academic theses—and emphasizes seasonal variation as a key moderator variable. In addition to standard meta-regression variables, socioeconomic attributes and valuation design factors were systematically coded to capture heterogeneity in WTP estimates. The database includes peer-reviewed journal articles (405), reports and working papers (52), and dissertations (17), with a focus on forest ecosystem services in Korea. The full structure and coding framework of the meta-database—including all dependent and independent variables—are presented in Appendix A, Table A1.

A major challenge in constructing meta-datasets is the heterogeneity of reporting formats across primary studies [52,57]. To address this, we applied standardized coding procedures based on the guidelines reported by Havranek et al. (2020) and MAER-Net [24,25]. The dependent variable is the natural logarithm of the WTP value, standardized across studies. The independent variables include study-level and observation-level characteristics, with particular attention to seasonal and socioeconomic attributes.

In the Korean case studies included in our analysis, environmental services were monetarily valued through respondents' stated willingness to pay, expressed in Korean Won (KRW). Payment vehicles varied across studies, including entrance fees pertaining to forest sites, annual household taxes, earmarked donations, and restoration funds. The parameters commonly valued included biodiversity conservation, forest restoration cost, landscape aesthetics, carbon sequestration, recreational access, and protection against forest disasters such as pests or fire. To enhance comparability across sources, all reported WTP values were adjusted to a common base year (2020) using the Korean Consumer Price Index (CPI), depending on the reporting format of the primary study. Where necessary, lump-sum or monthly contributions were annualized, along with monetary values. This harmonization ensured that variations in WTP reflect genuine preference heterogeneity rather than inconsistencies in valuation metrics or scaling procedures.

Seasonal variation is central to this study: In the spring, plants sprout, leaves unfurl, and flowers bloom, creating landscapes dominated by light green. Summer brings the most daylight and warmth, promoting rapid plant growth and deep-green vegetation. In autumn, falling temperatures lead to color changes in leaves—yellow, orange, and deep red—before they fall. Winter is marked by cold weather, limited daylight, and minimal plant activity. Each observation is categorized by the month in which the original survey was conducted, mapped onto the four-season classification of the Northern Hemisphere. The seasonal distribution of the estimates was as follows: spring (151), summer (201), fall (212), and winter (62). These seasonal classifications allow us to assess their statistical significance in shaping WTP estimates, beyond the effect of other study characteristics.

To enhance the robustness of the analysis, we incorporated socioeconomic variables not often included in prior meta-analyses. These include average income (coded into seven intervals), education level (broken into four categories), age (grouped by decade), and gender ratio. Missing data were replaced with population-level averages where appropriate. We also coded valuation method types: stated preference methods dominate (368 estimates), with contingent valuation (296) and choice experiments (72) being the most common. In addition to these methods, the authors of some studies also employed conjoint analysis and best-worst scaling to elicit preferences, though these methods were less frequently used than contingent valuation and choice experiments. The inclusion of these additional methods contributes to the diversity of the valuation approaches and further enriches the findings of this meta-analysis [53].

The independent variables are grouped into 13 categories: resource type, economic value type, valuation approach, elicitation format, payment vehicle, scope of nature, sample size, study year, publication year, survey method, seasonal classification, socioeconomic profile, and study quality. These moderator variables allow us to account for systematic differences in WTP estimates.

The dataset has an unbalanced panel structure. To account for hierarchical data and within-group correlation, we applied a mixed-effects modeling approach. Fixed effects capture average trends across observations, while random effects adjust for grouped structures such as study year and geographic region. These group-level variables—modeled as random effects—reflect unobserved heterogeneity and improve the estimation of fixed coefficients. Random effects were applied to regional groupings, classified as Gyungang (113 estimates), Jeonra (73), Chungcheong (52), Gangwon (49), Seoul (39), Gyeonggi (30), Jeju (17), and nationwide studies (103). By accounting for region-level variation and survey timing, we reduced residual error and enhanced the generalizability of the results for benefit transfer applications.

4. Meta-Analysis Specification and Estimation Results

4.1. Empirical Specification

One of the key advantages of meta-analysis is its ability to mitigate researcher subjectivity by providing a systematic and statistical framework for synthesizing existing evidence [24,62]. While meta-analysis is widely applied across fields such as business, macroeconomics, and agricultural economics—particularly in studies on seasonal price fluctuations—its application in environmental valuation, especially concerning seasonal preferences, remains limited.

Most non-market valuation studies derive WTP estimates from surveys conducted during a single season, often ignoring the potential influence of seasonal variation [63]. As a result, these estimates may reflect only a partial snapshot rather than the comprehensive annual value of ecosystem services. This issue is particularly problematic in forest valuation, where public preferences and perceived benefits can vary markedly across seasons because of visual, experiential, and ecological differences.

To address this issue, we explicitly incorporated seasonal variation into the meta-regression model. Seasonal distinctions—such as spring freshness, summer greenery, autumn foliage, and winter snow cover—can shape individual perceptions and thus influence WTP. The timing of survey administration relative to these seasonal characteristics can result in systematic differences in valuation outcomes, underscoring the need to control for seasonality in environmental valuation.

In the log-linear meta-regression model, dummy variables were used to capture qualitative characteristics, including seasonal effects. These binary variables assume a value of 1 if a condition is met (e.g., surveys conducted in the autumn) and 0 otherwise. In a log-linear context, the percentage change in the dependent variable associated with the presence of a dummy variable is calculated as $\text{percentage change} = 100\% \times (e^{\beta} - 1)$. While theoretical expectations regarding the direction of each variable's effect on WTP can guide model interpretation, these relationships may vary depending on context. Thus, coefficients may be positive, negative, or neutral [64].

To maintain sample size and avoid listwise deletion, missing values in socioeconomic variables (e.g., income and age) were imputed using variable means. This approach ensures there is a more completed and balanced dataset for statistical estimation. A comprehensive summary of the explanatory variables—including descriptive statistics, value ranges, and expected coefficient signs—is provided in Appendix A, Tables A1 and A2. To enhance the readability of the main text and avoid overloading the model description segment with technical detail, Appendix A, Table A2, is presented separately at the end of the manuscript. This placement allows readers to refer to the complete summary of descriptive statistics and expected signs of explanatory variables as needed.

4.2. Econometric Specification for Testing Seasonal Preferences and Their Effects

The structure of the data in the meta-analysis is inherently complex, as the selected WTP values are derived from different studies conducted at various times, at different geographical locations, and using diverse valuation formats. Controlling for heterogeneity and heteroscedasticity is crucial for ensuring validity, reliability, and credibility in benefit transfer [65,66]. To account for these variations, geographical location and time variables were incorporated as random effects in the mixed-effects model.

This empirical meta-regression model has a semi-log functional form, as specified in Equation (2), where the dependent variable (y_{it}) represents WTP values in Korean Won (KRW) for the estimated year. The semi-log functional form is widely used because it helps normalize the variation in WTP, which is presented on vastly different scales across primary studies. In the semi-log component, the coefficient measures the proportional change in the dependent variable, while in the log-log component, the coefficient of socioeconomic variables corresponds to elasticities, indicating the proportional change in the dependent variable in response to a proportional change in an explanatory variable [65,66].

This approach is frequently adopted in environmental economics and ecosystem services valuation studies because of its ability to address heteroscedasticity and the large-scale variations inherent in WTP

estimates. The log transformation stabilizes the variance of the dependent variable and reduces the influence of extreme values (outliers), thereby enhancing the robustness of the results. Furthermore, this functional form allows for a more intuitive interpretation of the coefficients as percentage changes, facilitating a clearer understanding of the impact of different predictors on WTP [67,68].

The authors of several studies have utilized similar approaches to deal with WTP heterogeneity and distributional issues. For instance, Brander et al. (2024) [1] employed a semi-log model to standardize WTP estimates across diverse ecosystem services and regions. Groot et al. (2020) [2] applied the semi-log approach in valuing forest ecosystem services across multiple studies, while Newbold and Johnston (2020) [27] used the log-transformation to analyse WTP for water quality improvement. Additionally, Filho et al. (2021) adopted a semi-log model in their meta-analysis of ecosystem service valuations, demonstrating its effectiveness in managing heterogeneity and skewed data distributions [43].

The explanatory variables used in the model are categorized into four groups, as detailed in Appendix A, Table A1: (1) types of natural resources, (2) methodological characteristics of the studies, (3) seasonal variables, and (4) socioeconomic characteristics.

In the mixed-effects model, two R-squared measures were calculated, namely, marginal R-squared and conditional R-squared, both of which provide valuable insights into model fit. Marginal R-squared reflects the proportion of variance explained by the fixed effects alone. This value suggests that the fixed factors modelled in this study (such as seasonality, payment vehicle, and WTP methods) only explain the variance in WTP. They often exhibit significant unobserved variability due to factors like study design, regional differences, and other unmeasured factors. Conditional R-squared, on the other hand, includes both the fixed and random effects (study- and region-specific variability) and accounts for the total variance in WTP.

This higher value indicates that when unobserved heterogeneity is considered, the model provides a much stronger fit, highlighting the importance of incorporating both observed and unobserved factors in modelling WTP estimates. This difference in R-squared values underscores the need to consider both fixed and random effects in meta-regressions. While marginal R-squared captures the explanatory power of the model's systematic components, conditional R-squared provides a more comprehensive understanding by accounting for study-specific and regional variations that significantly contribute to the variability in WTP estimates.

The estimated model is specified as follows:

$$y_{it} = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \dots + \delta_1 \text{Season1} + \delta_2 \text{Season2} + \delta_3 \text{Season3} + \delta_4 \text{Season4} + \varepsilon_{it} \quad (2)$$

where

- α is the constant term;
- β represents the vector of coefficients for the continuous or categorical explanatory variables;
- δ_1 through δ_4 are coefficients for the seasonal dummy variables, capturing the seasonal heterogeneity in WTP estimates;
- ε_{it} is the error term, assumed to be independently and identically distributed;
- i denotes the study identified, and t refers to the time dimension (if applicable).

To analyse the data, we employed a robust mixed-effects model, which integrates both fixed and random effects to accommodate unbalanced panel data. This approach is advantageous because it eliminates the complex decision-making process associated with choosing between purely fixed-effects and random-effects models. Given that there are multiple observations for certain studies in the dataset, a panel data structure is well suited for estimation. The mixed-effects analysis was conducted using R software (R-4.5.1), specifically using the *lme4* and *robustlmm* packages [59,60]. Additionally, pooled ordinary least squares (POLS) and weighted least squares (WLS) models were included to ensure robustness. To test the validity of the hypotheses, we estimated the model and conducted an F-test on the seasonal dummy variables using unrestricted and restricted models. In particular, to avoid multicollinearity caused by the dummy variable trap, one of the four seasonal dummies was omitted from the estimation model. The null hypothesis was formulated as follows:

$$H_0: dum1 = 0, dum2 = 0, dum3 = 0, dum4 = 0 \quad (3)$$

This implies that all four seasons have the same WTP and that seasonal preferences do not significantly influence WTP values. The alternative hypothesis is

$$H_1: dum1 \neq 0, dum2 \neq 0, dum3 \neq 0, dum4 \neq 0$$

If the seasonal dummy variables are statistically significant, the null hypothesis is rejected, indicating that WTP varies across seasons. The null hypothesis is rejected when the F-statistic exceeds the critical value of the F-distribution at a predetermined significance level (e.g., 0.05 or 0.01). Since the F-statistic is a monotonic function of the likelihood ratio statistic, the F-test serves as a likelihood ratio test.

Given the well-established nature of the F-statistic and the log-transformation, these specific formulae are not presented here in order to avoid redundancy. Instead, this research focuses on the interpretation of the results in the context of the data. The key takeaway from the F-test is that the inclusion of seasonal variables significantly improved the model's fit, supporting the hypothesis that WTP varies across seasons.

5. Results

5.1. Descriptive Results

The metadata for this study spans the period from 1999 to 2022. In terms of geographic distribution, the dataset includes 113 cases (23.7%) from Gyeongsang-do, 102 cases (21.4%) from Seoul, 74 cases (15.5%) from Jeonra Province, 52 cases (10.9%) from Gyeonggi Province, 49 cases (10.3%) from Jeju Province, 30 cases (6.3%) from Gangwon Province, 17 cases (3.6%) from Chungcheong Province, and 39 cases (8.2%) from other regions. The average reported income is approximately KRW 3.3 million, while the average education level falls between high school and college. The mean age of the respondents is in the early 40s, with men and women averaging 50.69 and 49.7 years of age, respectively.

In terms of seasonal distribution, the dataset includes 151 cases (24.1%) from spring, 201 cases (32.1%) from summer, 212 cases (33.9%) from autumn, and 62 cases (9.9%) from winter.

5.2. Meta-Regression Estimation and Results

Table 3 presents the estimation results across different model specifications. The first column reports the results from the POLS model and the WLS estimates, and the next column (ME) provides results from the robust mixed-effects model and weighted robust mixed-effects model. All the specifications include the same moderators. The parameter estimates in the panel measure the average WTP (in KRW) for each observation. The coefficients of the moderators (independent variables) capture the variations in WTP, and the study characteristics illustrate how WTP estimates change depending on methodological approaches and sample characteristics. To address the key concerns raised by Nelson et al. (2009) [47] regarding meta-analysis, our model accounts for (1) sample heterogeneity through the use of binary dummy variables and random effects, (2) heteroskedasticity by prioritizing the collection of primary data on variance and sample sizes, and (3) the non-independence of primary estimates by employing panel data methods and other econometric techniques to handle correlated data [69]. This research incorporates these considerations to enhance the robustness of the analysis.

Table 3. Estimation results from pooled and weighted OLS and mixed-effects and weighted mixed-effects models (unrestricted)

	Ordinary Least Squares (OLS)				Mixed Effects (MEs)			
	Pooled OLS (POLS)		Weighted OLS (WOLS)		Robust MEs (RMEs)		Weighted RMEs (WRMEs)	
Coefficients	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
Intercept	5.90	15.20 ***	5.87	15.55 ***	6.44	15.86 ***	6.63	15.25 ***
A. Types of items								
River	0.37	0.16	0.53	0.21	-0.53	-0.32	-0.11	-0.07
Sea	-0.17	-0.39	0.01	0.02	-0.68	-2.05 *	-0.67	-2.16 *
Animals	-0.26	-0.17	-0.43	-0.25	1.35	1.27	1.05	0.93
National Parks	0.28	1.44	0.28	1.31	-0.33	-1.33	-0.41	-1.68
Provincial Parks	1.22	3.24 **	1.23	2.88 **	0.79	2.56 *	1.01	3.01 **
B. Instruments								
Use and Non-Use Value	2.96	1.87 *	3.45	2.53 *	1.81	1.47	2.58	2.41 *
Unit: per Person	2.13	4.63 ***	1.46	2.93 **	2.13	6.02 ***	1.59	4.17 ***
Unit: per Household	2.66	5.50 ***	2.42	4.63 ***	2.71	7.09 ***	2.44	5.95 ***
CVM	-0.70	-2.82 **	-0.59	-2.11 *	-0.88	-4.33 ***	-0.85	-3.90 ***
CE	-0.60	-2.00 *	-0.66	-2.03 *	-0.94	-3.65 ***	-0.95	-3.63 ***
Single-Bounded	0.55	2.17 *	0.30	1.14	0.44	2.23 *	0.36	1.82 *
Double-Bounded	0.28	1.06	0.19	0.76	0.49	2.30 *	0.68	3.39 **
National vs. Local	2.62	9.54 ***	2.66	9.82 ***	1.51	4.43 ***	1.21	2.77 **
Number of Samples	0.00	-1.29	-0.00	-2.05 *	-0.00	-0.95	-0.00	-0.20
Payment of Tax	-0.56	-2.67 **	-0.76	-3.56 ***	-0.66	-4.11 ***	-0.85	-5.24 ***
Face to Face	0.92	2.57 *	1.45	4.08 ***	0.94	2.99 **	1.00	3.23 **
Academic Journals	0.07	0.32	0.42	1.85 *	0.06	0.34	0.15	0.87
C. Seasons								
Summer	0.00	0.02	-0.24	-1.33	-0.18	-1.16	-0.10	-0.65
Fall	0.46	2.81 **	0.35	2.05 *	0.67	5.17 ***	0.71	5.38 ***
Winter	-1.44	-5.66 ***	-1.66	-6.26 ***	-0.65	-2.69 *	-0.64	-2.60 *

Model Fit Criteria	Multiple R ² : 0.34 Adjusted R ² : 0.31	Multiple R ² : 0.43 Adjusted R ² : 0.39	Conditional R ² : 0.59 Marginal R ² : 0.29	Conditional R ² : 0.08 Marginal R ² : 0.03
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Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively. Marginal R² (R²m): the proportion of variance explained only by the fixed effects in the model. Conditional R² (R²c): the proportion of variance explained by both the fixed and random effects in the model.

Among the four models in Table 3, the robust mixed-effects specification offers the best overall fit. Using Nakagawa & Schielzeth's framework, its conditional R² is 0.59, exceeding the OLS (R² = 0.34) and WLS (R² = 0.43) benchmarks. These results indicate that the robust mixed-effects model explains a larger share of variance in WTP than conventional meta-analytic specifications [39]. Consistent with model diagnostics, the residual plots show no systematic patterns, and the VIFs indicate no critical multicollinearity among moderators.

Focusing on the robust mixed-effects specifications, Table 3 reports the results for the unrestricted model exploring seasonal preferences. The adjusted model explains approximately 29% (R²m) to 59% (R²c) of the variation in WTP estimates, serving as an indicator of model goodness of fit. Here, R²m concerns the explanation of just fixed effects, while R²c is the full model. In this case, the R squared values are similar between models, and, most importantly, R²c is only slightly different from R²m, indicating that including random effects does not improve accuracy. Thus, the estimated models account for a substantial proportion of the observed variability in mean WTP values. It is essential to interpret the signs of the estimated coefficients, as these indicate positive or negative relationships between explanatory variables and WTP. Variables were retained in the model based on their expected direction, regardless of their statistical significance at the 0.05 or 0.1 level.

The fixed-effects component of the model captures the mean effects of each variable, like a standard regression framework, while the random-effects component models heteroskedasticity. The variance and standard deviation estimate of the random intercepts provide insights into the extent to which WTP varies across years and geographic locations. For instance, the standard deviation of the year-specific random intercept suggests that WTP for forest resources fluctuates around the mean intercept of 6.42% WTP by approximately 0.73% WTP (random effects: time (Intercept) 0.55 (variance), 0.73 (Std. Dev.); id (Intercept) 0.06 (variance), 0.99 (Std. Dev.); Residual 0.98 (variance), 0.99 (Std. Dev.) [45].

Based on the meta-data compiled for forest ecosystem services [70] and the robust mixed-effects model applied, seasonal preferences significantly influence WTP. Specifically, WTP is negative in the summer and winter but positive in the autumn, indicating a clear preference for autumn among Koreans [71]. This finding aligns with observed patterns of more forest and mountain visits during the autumn. Additionally, natural resources such as rivers and oceans exhibit a negative association with WTP for forests, suggesting a substitution effect, particularly during summer vacations when individuals choose between visiting mountains, rivers, or coastal areas. Provincial parks emerge as a statistically significant variable with a positive WTP, indicating their distinct appeal and value to consumers. This finding

underscores the importance of location-specific and seasonal considerations in environmental valuation [72].

Regarding the unit of payment in non-market valuation methodologies [73], the results indicate positive WTP when the unit of payment is per person or household, while negative WTP can be observed when using stated preference methods such as CV and CE. Additionally, WTP is negatively associated with tax-based payment instruments [74,75], whereas it is positively associated with payment instruments linked to national resources rather than local forest resources. Moreover, face-to-face survey methodologies yield a positive WTP, suggesting their effectiveness in eliciting higher valuation responses.

Although they were found to be statistically insignificant, several other patterns emerged: WTP is positive when both use and non-use value are considered simultaneously as well as when a single- and double-bounded format is used. Conversely, WTP decreases with larger sample sizes, potentially indicating that larger samples reduce bias and provide more precise WTP estimates reflecting broader population attitudes. Additionally, studies published in academic journals using non-market valuation approaches report higher WTP values [24].

The constant term in the model is positive and statistically significant at the 1% level, reinforcing the conclusion that the respondents were generally willing to pay for forest resources. Regarding sample size adjustments to account for heterogeneity and heteroscedasticity [42,47,63], we adopted an alternative weighting method, using sample sizes instead of inverse variances owing to the limited primary study information. The practical implication of this approach is that larger sample sizes tend to yield lower WTP estimates, reflecting more precise valuations that mitigate bias.

More specifically, the estimated coefficient for the dummy variable ‘payment vehicle’ in the model in Table 3 indicates that WTP is, on average, 66% lower relative to other payment methods when income tax is used as the payment vehicle. Furthermore, WTP is approximately 88–94% (*ceteris paribus*) lower, relative to other revealed-preference approaches, when using contingent valuation and choice experiment methods. This finding aligns with prior research indicating that dichotomous choice formats yield significantly lower WTP estimates than other elicitation techniques, such as iterative bidding procedures. Survey methodology also plays a crucial role in determining WTP. Face-to-face survey methods significantly increase WTP estimates, likely because of their ability to enhance respondent reliability and improve response rates [56,73].

In addition to these methodological factors, the robust mixed-effects model reveals significant seasonal variations in WTP. The seasonal dummy coefficients are statistically significant at the 0.01 and 0.05 levels. Specifically, the coefficients for summer (−0.18), fall (0.67), and winter (−0.65) suggest that WTP is 18% and 65% lower in the summer and winter, respectively, and 67% higher in the fall. These findings indicate that autumn is the most preferred season for forest-related activities, followed by summer and winter, for which there were significantly lower WTP estimates. To ensure these results were robust, we attempted to incorporate socioeconomic variables (e.g., income, education, and age)

and methodological controls into our models, isolating the effects of seasonality from other potential confounders. Nevertheless, the estimated effects of those variables were statistically insignificant across model specifications.

5.3. Testing Seasonal Variation Using the F-Test

As illustrated in Table 3 and Table A3, the above observations allowed us to conduct an F-test to assess the significance and influence of seasonal variation with respect to the regression, independently of other variables. An F-test is a statistical test in which the test statistic follows an F-distribution under the null hypothesis [64]. Based on the RME in Table 3, the F-value was calculated as follows:

$$F = \frac{(Restricted\ part)}{(Unrestricted\ part)} = \frac{(811.16 - 776.32)/3}{(776.32/476 - 23 - 1)} = 6.76 \quad (4)$$

where SSR_r is 811.16 (please see Appendix A, Table A3); SSR_{ur} is 776.32; q is 3; n is 476; and k is 23. The resulting F-statistic follows an $F_{3,476}$ distribution. The restricted (SSR_r) values are provided in Appendix A, Table A3.

Based on the F-distribution table, the critical value for $F_{3,476}$ at the 5% significance level is 2.60. Since the computed F-statistic (6.76) exceeds this critical value, the null hypothesis (H_0) can be rejected. This indicates that at least one of the seasonal dummy variables differs from zero and that the alternative hypothesis (H_1) is jointly statistically significant at the 5% level. These findings confirm that seasonal variables are critically important factors in ecosystem service valuation. Ignoring seasonal variations in WTP could lead to biased estimates, potentially overestimating or underestimating the true WTP. Therefore, WTP estimates must be adjusted to account for seasonal variation.

5.4. Seasonal WTP Distributions

To illustrate the distribution of WTP across seasons, coefficients and standard errors from the previous model in Table 3 were used to simulate approximately 1,000,000 draws. Figure A1 presents the resulting distributions, with WTP expressed as percentage changes relative to the spring (baseline). Autumn shows the highest WTP (+67%), while the values for summer (−18%) and winter (−65%) are negative. Autumn also exhibits the least variability, whereas winter displays the greatest, indicating more diverse preferences. The seasonal WTP distributions indicate that autumn has the highest WTP (0.67), followed by summer (−0.18) and winter (−0.65), which show negative WTP, reflecting a preference for autumn and a lower WTP for summer and winter. Autumn also has the most consistent preferences (that is, the least variability), while winter shows the greatest variability, indicating diverse opinions. These findings suggest that forest policies and pricing strategies should emphasize attributes aligned with autumn preferences, while improvements or incentives may be needed to enhance the appeal of summer and winter [74].

According to the result of the simulation shown in Figure A1, the seasonal pattern is consistent between the RME and WLS models across specifications: WTP is highest in autumn and lowest in the

winter, with summer not differing significantly from spring in this regard. The robust mixed-effects model implies a larger autumn premium (+83.7%, 95% confidence interval: +42.9% to +136.1%) and a moderate winter discount (−51.8%, 95% confidence interval: −69.8% to −23.2%), whereas the WLS model suggests a smaller autumn premium (+49.2%, 95% confidence interval: +6.3% to +109.4%) but a much stronger winter discount (−80.7%, 95% confidence interval: −88.5% to −67.6%). Summer effects are statistically indistinguishable from zero in both models.

5.5. Results of Experimental Estimation Using Robust Mixed-Effects Model

We applied the RME results in Table 3 to three experimental questions relevant to non-market valuation. The first hypothesis examines how the stated preference method affects WTP compared to other methodologies. The second hypothesis introduces an interaction effect assumption by incorporating season with the stated preference framework. The third hypothesis focuses on the use of taxes as a payment instrument within the stated preference method. The results, presented in Table 4, are as follows: In experimental test 1, the estimation results for the CVCE variable, analysed using both the choice experiment and contingent valuation methodologies, show a statistically significant negative WTP. This finding suggests that these methodologies result in lower WTP values compared to alternative approaches. In experimental test 2, the analysis of interaction effects on seasonal dummies showed that the impact of key explanatory variables on WTP varied significantly by season, emphasizing the moderating role of seasonal context in stated preference responses. In experimental test 3, which examined the use of taxes as a payment instrument within the stated preference method (CVCETAX), the results are statistically significantly lower WTP values. Overall, these three experiments provide valuable insights.

Table 4. Experimental model estimates testing stated preference and interaction effects.

Experimental Test 1			Experimental Test 2			Experimental Test 3		
Variables	Estimate	t-value	Variables	Estimate	t-value	Variables	Estimate	t-value
Intercept	6.45	16.15 ***	Intercept	6.44	15.86 ***	Intercept	6.55	15.20 ***
River	−0.57	−0.35	River	−0.53	−0.32	River	−0.55	−0.34
Sea	−0.67	−2.05 **	Sea	−0.68	−2.05 **	Sea	−0.68	−2.08 **
Animals	1.36	1.28	Animal	1.35	1.27	Animals	1.37	1.29
Provincial Parks	0.80	2.61 ***	Provincial Parks	0.79	2.56 **	Provincial Parks	0.79	2.56 ***
Use and Non-Use Value	1.83	1.49	Use and Non-Use Value	1.81	1.47	Use and Non-Use Value	1.80	1.46
Unit: per Household	2.72	7.13 ***	Unit: per Household	2.71	7.09 ***	Unit: per Household	2.66	6.93 ***
Unit: per Person	2.15	6.08 ***	Unit: per Person	2.13	6.02 ***	Unit: per Person	2.08	5.82 ***
Single-Bounded	0.46	2.36 **	CE	−0.94	−3.65 ***	CE	−0.98	−3.66 ***

Double-Bounded	0.50	2.42 **	CVM	−0.88	−4.33 ***	CVM	−0.93	−4.22 ***
Payment of Tax	−0.65	−4.08 ***	Single bound	0.29	1.56 **	Single-Bounded	0.45	2.24 **
National vs. Local	1.51	4.48 ***	Double bound	0.37	1.80 *	Double-Bounded	0.48	2.29 **
Number of Samples	−0.00	−1.12	Payment of Tax	−0.66	−4.11 ***	Payment of Tax	−1.00	−2.04 **
Academic Journals	0.05	0.32	National vs. Local	1.51	4.43 ***	National vs. Local	1.51	4.36 ***
Face to Face	0.92	2.96 **	Number of Samples	−0.00	−0.95	Number of Samples	−0.00	−0.99
Summer	−0.18	−1.17	Academic Journals	0.06	0.34	Academic Journals	0.07	0.43
Fall	0.67	5.18 ***	Face to Face	0.94	2.99 ***	Face to Face	0.92	2.92 ***
Winter	−0.67	−2.92 ***	Summer	−0.18	−1.16	Summer	−0.20	−1.28
National Parks	−0.32	−1.31	Fall	0.67	5.17 ***	Fall	0.65	4.69 ***
-	-	-	Winter	−0.65	−2.69 ***	Winter	−0.66	−2.73 ***
			National Parks	−0.33	−1.33	National Parks	−0.31	−1.26
Experimental and interaction variables								
CVCE	−0.89	−4.52 ***	Summer: Use Value	−0.96	−4.84 ***	CVCETAX	−0.76	4.89 ***
			Face to Face: Fall	4.05	8.29 ***			
			Unit for People: Summer	1.15	4.36 ***			
			Face to Face: Summer	1.77	2.12 **			
			National vs. Local: Fall	1.36	3.31 ***			
Model Fit Criteria	Conditional R ² : 0.59 Marginal R ² : 0.29		Conditional R ² : 0.65 Marginal R ² : 0.53		Conditional R ² : 0.59 Marginal R ² : 0.28			

Notes: *, **, and *** denote significance at 10%, 5%, and 1%, respectively.

6. Conclusions and Discussion

Despite the growing body of research on ecosystem service valuation, seasonal preference remains one of the most overlooked dimensions in non-market valuation studies. Most existing studies rely on data collected during a single season—typically spring or summer—thereby omitting the full temporal spectrum of benefits that forest ecosystems provide. This oversight results in biased estimates that either over- or undervalue environmental resources, depending on when and how the data are collected [27,29,39,55].

This study addresses this critical gap by statistically validating the influence of seasonal variation on WTP for forest ecosystem services. Using a meta-dataset of 476 estimates from 90 studies in Korea and applying pooled, weighted, and robust mixed-effects (RME) models, we found consistent evidence of significant seasonal fluctuations. The RME specification, which better accounts for study-level heterogeneity, confirmed that autumn generates the highest WTP premiums, whereas winter is associated with sharp reductions. These results underscore the importance of modelling temporal dynamics when synthesizing non-market values [25,45,61].

However, it is important to recognize the heterogeneity inherent in the studies included in the meta-analysis. Different research designs, survey methods, sample sizes, and regional contexts introduce variability in WTP estimates [36,37,47,49]. For example, variations in payment vehicles, elicitation formats, and survey timing can lead to discrepancies between studies. While we accounted for some of this variation using random effects, the fact that such differences may affect the comparability of the results remains a limitation [24,25]. Consequently, this finding should be interpreted with caution. The seasonal effects observed here represent general trends rather than precise, universally applicable values. Socioeconomic factors, though determined not significant herein, could be explored in the future.

In this analysis, winter showed the most significant decrease in WTP (65% reduction), which seems to suggest that people appreciate forests less in the winter because of the colder weather and limitations regarding outdoor activities [10,32,55]. However, upon further consideration, it becomes clear that this decrease in WTP is likely influenced by more complex factors. In many regions, winter is characterized by lower visibility of forests' aesthetic value, as leafless trees and sparse vegetation can make forests appear less appealing. Additionally, people may have different recreational preferences during the winter, such as engaging in snow-related activities (e.g., skiing and snowboarding) instead of typical forest-based recreation. Furthermore, in the winter, the emotional and psychological benefits provided by forests may be less emphasized owing to seasonal affective disorders or the general tendency for people to focus on indoor activities during colder months [11,12]. Therefore, the seasonal variation in WTP is likely due to multiple interacting factors, such as perceived aesthetic value, recreational availability [23,29], and psychological experiences related to the season, not simply a reduction in attention to forests [22,23,55].

The findings reveal that seasonal variation is not a marginal factor but a core determinant of preference heterogeneity, with WTP increasing by up to 67% in the autumn and decreasing by 65% in the winter. Autumn emerged as the most preferred season, confirming that people assign distinct value to seasonal experiences. These results not only align with but also extend those of prior studies [29,32] by offering empirical evidence, obtained using advanced statistical tools, across a broader national dataset. Furthermore, this experimental analysis underscores a persistent issue in stated preference methods: the tendency to generate lower WTP estimates relative to other approaches [3,74,75]. By integrating both seasonal variation and methodological testing, this study provides a more realistic and behaviourally grounded framework for environmental valuation [3,61].

This research challenges the prevailing assumptions in non-market valuation, where temporally static models dominate despite the dynamic nature of both ecosystems and human preferences. We propose that failing to account for seasonal dynamics contributes to the systematic mispricing of environmental assets, ultimately distorting policy priorities and resource allocation [57,65,66,69]. Recognizing the intrinsic temporal variability of ecosystem services is not only a methodological refinement but also a necessity for designing equitable, accurate, and sustainable forest management

policies. Integrating seasonal variation into valuation practices can lead to more precise benefit estimations, better-informed policy design, and greater societal welfare [20,21,26,58,76,77,78].

From a practical perspective, the findings provide several directions for policymakers [79,80,81]. First, season-sensitive pricing strategies could be introduced, such as differentiated entrance fees across peak and off-peak seasons, to stabilize revenues and manage visitor flow more efficiently [13,55]. Second, restoration and conservation campaigns may be strategically timed to coincide with seasons during which public willingness to pay is higher (e.g., autumn), thereby maximizing funding potential, while winter campaigns may require stronger awareness-building measures. Third, marketing and communication strategies should emphasize the distinct seasonal benefits of forests—for instance, cooling and shade in the summer and aesthetic landscapes in the autumn—to strengthen public engagement [9,10,13]. Finally, incorporating seasonal adjustment factors into cost–benefit analyses and benefit transfer practices can reduce systematic bias and support more equitable and sustainable forest policy decisions [36,38,69].

Methodologically, this study reinforces the value of robust mixed-effects and meta-regression frameworks for synthesizing heterogeneous datasets [45,49,61]. Researchers should continue to refine meta-analytic approaches by integrating geospatial validity [14], testing for publication bias [47], and adopting Bayesian hierarchical models [50,51]. Beyond national contexts, comparative meta-analyses across climatic zones would illuminate how seasonal valuation patterns differ globally, thus providing a foundation for international forest governance and climate adaptation strategies [7,26,40].

In conclusion, recognizing the intrinsic temporal variability of ecosystem services is not merely a methodological refinement but a fundamental requirement for designing accurate, equitable, and sustainable forest management policies. Integrating seasonality into valuation practice will improve benefit estimation, guide cost–benefit analysis and ultimately enhance societal welfare. Looking ahead, in future research, we intend to expand this research through international collaboration to analyse seasonal consumption patterns in diverse climatic and cultural contexts, aiming to build a globally relevant valuation framework that captures the full spectrum of ecosystem service benefits across time and space.

Appendix A

Table A1. Structure and coding framework of the meta-database (1999–2022).

Category		Value	Descriptions
WTP	WTP Estimated	KRW	WTP Estimated (KRW (Korean Won))
Type of natural resource	Mountain (forests)	0, 1	1 if mountain and 0 otherwise
	Sea	0, 1	1 if sea and 0 otherwise
	River (freshwater wetland)	0, 1	1 if river/freshwater wetland and 0 otherwise
	Stream	0, 1	1 if stream and 0 otherwise
	National Park	0, 1	1 if national park and 0 otherwise
	Provincial Park	0, 1	1 if provincial park and 0 otherwise
	Local facilities	0, 1	1 if local level and 0 otherwise
	Others (local park)	0, 1	1 if others and 0 otherwise
	Tidal flat	0, 1	1 if tidal flat and 0 otherwise
	Animal	0, 1	1 if animal and 0 otherwise
Type of economic value (value type)	Other ^a	0, 1	1 if other and 0 otherwise
	Use value	0, 1	1 if the use value is included and 0 otherwise
	Non-use value	0, 1	1 if non-use value is included and 0 otherwise
	Use and non-use value	0, 1	1 if both use and non-use value are included and 0 otherwise
Payment unit of WTP	Unit on people	0, 1	1 if payment unit is per person and 0 otherwise
	Unit on household	0, 1	1 if payment unit is per household and 0 otherwise
	Others	0, 1	1 if payment unit is ‘other’ and 0 otherwise
Stated or Revealed preference	Stated preference ^b	0, 1	1 if SP and 0 otherwise (RP)
	Contingent valuation	0, 1	1 if contingent valuation and 0 otherwise
	Choice experiment	0, 1	1 if choice experiment and 0 otherwise
	Others	0, 1	1 if other methods were applied and 0 otherwise
Elicitation formats	Single-bounded	0, 1	1 if single-bounded and 0 otherwise
	Double-bounded	0, 1	1 if double-bounded and 0 otherwise
	Others	0, 1	1 if other formats were applied and 0 otherwise
Scope of nature	National vs. local	0, 1	1 if national and 0 otherwise
Research site location	Seoul	0, 1	1 if the site is Seoul and 0 otherwise
	Gyeonggi	0, 1	1 if the site is Gyeonggi and 0 otherwise
	Gangwon	0, 1	1 if the site is Gangwon and 0 otherwise
	Chungcheong	0, 1	1 if the site is Chungcheong and 0 otherwise
	Jeonra	0, 1	1 if the site is Jeonra and 0 otherwise
	Kyungsang	0, 1	1 if the site is Kyungsang and 0 otherwise
	JeJu	0, 1	1 if the site is JeJu and 0 otherwise
Total sample	Number of samples	Number	The sample size
Year	Year estimated	Number	The year in which the survey was conducted
	Year published	Number	The year in which the paper was published
Quality of articles (studies) and data characteristics	Ph.D. thesis report	0, 1	1 if WTP is from a Ph.D. thesis and 0 otherwise
	Natural science journal	0, 1	1 if WTP is from a natural science journal and 0 otherwise
	Economic journal	0, 1	1 if WTP is from an economic journal and 0 otherwise
	Academic paper	0, 1	1 if WTP is from an academic paper and 0 otherwise
	Number of authors	0, 1	1 if the author is in the paper is one and 0 otherwise
	Replications	0, 1	1 if WTP is replicated and 0 otherwise
Payment vehicle	Tax	0, 1	1 if tax is applied and 0 otherwise
Survey methods	Face to face	0, 1	1 if face-to-face is applied and 0 otherwise
Four seasons	Spring	0, 1	1 if survey was conducted in spring and 0 otherwise
	Summer	0, 1	1 if survey was conducted in summer and 0 otherwise
	Fall	0, 1	1 if survey was conducted in fall and 0 otherwise
	Winter	0, 1	1 if survey was conducted in winter and 0 otherwise

Socioeconomic	Household monthly income	Number	(a) under KRW 1 million; (b) more than KRW 1 million~less than KRW 2 million; (c) more than KRW 2 million~less than KRW 3 million; (d) more than KRW 3 million~less than KRW 4 million; (e) more than KRW 4 million~less than KRW 5 million; (f) more than KRW 5 million~less than KRW 6 million; (g) more than KRW 7 million
	Education	Number	(a) under middle school; (b) high-school level; (c) undergraduate level; (d) postgraduate level
	Age	Number	(a) under 20; (b) 30s; (c) 40s; (d) 50s; (e) 60s; (f) over 70
	Gender	Male	Number
		Female	Number
			Percentage of male respondents
			Percentage of female respondents

Notes: This table outlines the variable names, value coding, and brief descriptions of the 476 WTP estimates included in the meta-analysis, categorized by natural resource type, valuation method, socioeconomic attributes, seasonal classification, and study characteristics. ^a Hereafter, the data included in ‘other’ for each category are those that are not included in the significant items for each category. These ‘other’ data were not included in the final model, but an estimate was obtained. ^b Here, the dummy variables are separated to distinguish between the stated and revealed preference methods, and only one of the two variables was used in the final model. Because stated preference involves contingent valuation and choice experiments, the use of both variables in the same model raises a multicollinearity problem. The results presented in the table are based on stated preference studies (contingent valuation and choice experiments), which constitute the majority of the dataset.

Table A2. Summary statistics and expected signs of explanatory variables.

Variables		Mean	Std. Dev.	Min.	Max.	Expected Sign	
Willingness to pay	WTP (KRW Korean Won)	26,951.9	48,679.5	0.1	316,248.0		
Region	Id	4.34	2.380	1	8	N	
Year	Time	2006.71	5.743	1991	2020	+ or N	
Type of natural resources	River	0.00	0.046	0	1	+	
	Sea	0.03	0.169	0	1	+	
	Stream	0.00	0.046	0	1	+	
	Park	0.38	0.486	0	1	+	
	National park	0.42	0.495	0	1	+ or N	
	Provincial park	0.04	0.206	0	1	+ or N	
	Local park	0.25	0.435	0	1	+ or N	
	Local facilities	0.03	0.175	0	1	+	
	Tidal flats	0.00	0.046	0	1	+	
	Animals	0.00	0.065	0	1	+	
	Other	0.01	0.120	0	1	+	
Type of values	Use value	0.49	0.500	0	1	+	
	Non-use value	0.51	0.500	0	1	+	
	Use and non-use value	0.00	0.046	0	1	+	
Payment unit of WTP	Unit: per person	0.61	0.489	0	1	–	
	Unit: per household	0.33	0.471	0	1	+	
	Unit: other	0.06	0.239	0	1	+	
Methodology	Stated preference	0.77	0.419	0	1	–	
Stated preference or revealed preference	Contingent valuation	0.62	0.485	0	1	–	
	Choice experiment	0.15	0.359	0	1	–	
	Other methods	0.23	0.419	0	1	+	
Elicitation formats	Closed	0.47	0.500	0	1	–	
	Single-bounded	0.18	0.364	0.0	1.0	+	
	Double-bounded	0.12	0.302	0.0	1.0	–	
	Others	0.20	0.386	0.0	1.0	–	
Scope of nature	National vs. local	0.22	0.412	0	1	+	
Total sample	Number of samples	749.13	999.266	26	8457	–	
Years	Year published	2008.43	5.728	1999	2022	– or N	
Quality of articles	Ph.D. thesis report	0.04	0.186	0	1	–	
	Natural science journal	0.27	0.443	0	1	+	
	Economics journal	0.22	0.416	0	1	–	
	Academic journal	0.85	0.357	0	1	–	
	Number of authors	0.31	0.462	0	1	N	
	Replications	0.59	0.493	0	1	– or N	
Payment vehicle	Tax	0.42	0.4829	0.0	1.0	–	
Survey method	Face to face	0.91	0.284	0	1	–	
Four seasons	Spring	0.32	0.466	0	1	N	
	Summer	0.42	0.494	0	1	N	
	Autumn	0.45	0.498	0	1	N	
	Winter	0.13	0.337	0	1	N	
Socioeconomic variables	Income	3.33	2.006	1.00	23.00	+ or N	
	Education	2.78	0.200	2.00	4.00	+ or N	
	Age	3.07	0.477	1.00	5.00	N	
	Gender	Male	50.69	5.734	28.00	88.10	N
		Female	49.71	5.775	11.90	72.00	– or N

Notes: KRW 1291.95 is equal to USD 1 (2022) [80]. The positive (+) sign shows the same direction between dependent and independent variables; negative (–) is the opposite; N = neutral.

Table A3. Estimation results from the restricted robust mixed-effects model.

Random Effects	Groups	Name	Variance	Std. Dev.	
	Time	Intercept	1.00	1.00	
	Id	Intercept	0.15	0.38	
	Residual	1.7077	1.31		
Number of observations	476	Groups:	Time (28)	id	8
Fixed effects					
	Estimate	Std. error	df	t-value	Pr(> t)
Intercept	6.18 ***	0.50	127.80	12.40	0.00
River	−1.24	2.07	450.40	−0.60	0.55
Sea	−0.71.	0.42	445.00	−1.71	0.09
Animals	1.77	1.35	432.10	1.32	0.19
Provincial parks	0.95 *	0.38	428.60	2.48	0.01
Use and non-use value	1.11	1.53	421.90	0.72	0.47
Unit: per household	3.15 ***	0.47	451.40	6.72	0.00
Unit: per person	2.68 ***	0.44	456.30	6.08	0.00
CVM	−0.99 ***	0.26	449.70	−3.89	0.00
CE	−1.43 ***	0.32	450.60	−4.45	0.00
Single-bounded	0.50 *	0.25	455.60	1.97	0.05
Double-bounded	0.20	0.26	453.00	0.77	0.44
Nation vs. local	1.35 *	0.48	5.18	2.82	0.04
Number of samples	0.00	0.00	438.20	0.96	0.34
Academic journals	0.14	0.20	438.70	0.69	0.49
Payment of tax	−0.55 **	0.20	456.80	−2.74	0.01
Face to face	0.63	0.38	433.90	1.66	0.10
National parks	−0.25	0.30	451.50	−0.84	0.40

Notes: *, **, and *** denote significance at the 10%, 5%, and 1% levels, respectively.

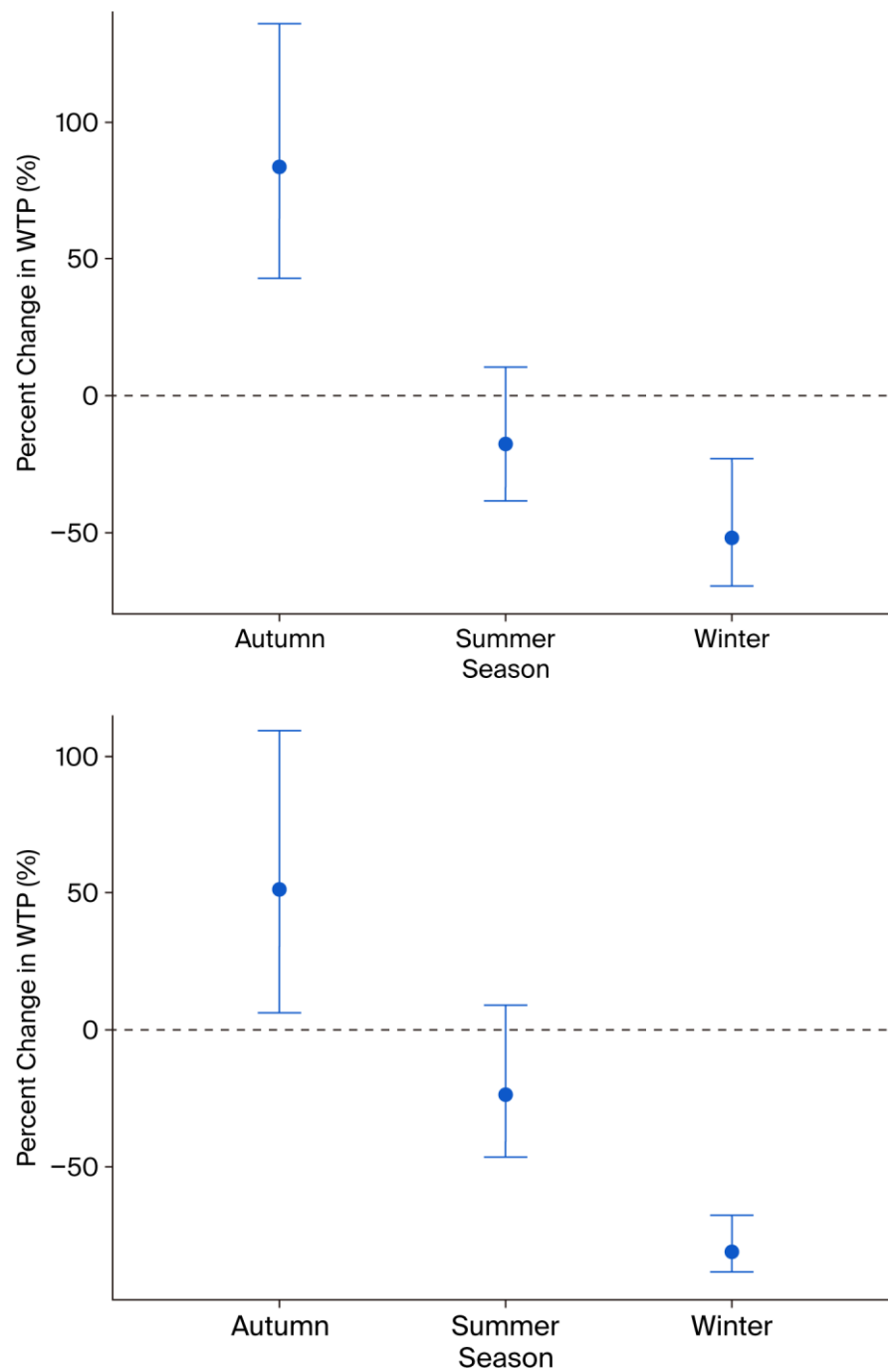


Figure A1. Simulated seasonal WTP distribution based on the RME (first) and WLS (second) models. Note: Points show percent change in WTP relative to spring; error bars denote 95% critical intervals. Other moderators are held constantly. The distributions of the pooled OLS and weighted OLS models are similar.

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Chapter 2

*(Willingness to Pay for the Conservation of Cultural and historical Resources
within the Gotjawal: The Role of Payment Vehicles)*

MEA (2005) – “Ecosystems can collapse abruptly, without much prior warning.”

Willingness to Pay for the Conservation of Cultural and historical Resources within the Gotjawal: The Role of Payment Vehicles

Abstract

This study estimates the willingness to pay (WTP) for conserving the cultural–historical resources of the Gotjawal forests in Jeju, Korea—an internationally renowned tourism destination and UNESCO “Triple Crown” site. Using contingent valuation (single- and double-bounded formats), in-person interviews with 1,100 residents revealed three main findings. First, the double-bounded approach consistently produced lower WTP than the single-bounded format, underscoring methodological sensitivity in valuation. Second, payment vehicles significantly shaped outcomes: entrance fees elicited the highest WTP and were the most acceptable mechanism, while tax-based payments faced strong resistance. Third, perceived importance strongly influenced WTP, with respondents who valued the resources highly willing to pay nearly twice as much as those with neutral perceptions. Together, these results demonstrate that both valuation format and payment design matter, and that conservation policies are more viable when they align with user-based financing and enhanced cultural awareness. By situating the analysis within Jeju’s globally significant forest heritage, this research provides novel insights into how socio-cultural context shapes policy acceptability and sustainable financing of conservation.

Keywords: payment vehicles; cultural–historical resources; Gotjawal forests; contingent valuation; Jeju

1. Introduction

The conservation of unique cultural and historical resources embedded within rare volcanic forests requires careful recognition of their non-use values, which are not captured by market data yet play a critical role in policy decision-making. The Gotjawal forests in Jeju¹⁶, South Korea (hereafter Jeju), represent one of the world’s rare volcanic open green spaces and serve as ecologically, historically, and culturally significant resources for ecotourism. Jeju is also globally distinguished as the only location to hold the “UNESCO Triple Crown” in the natural sciences: designated a Biosphere Reserve in 2002, inscribed as a World Natural Heritage site in 2007, and certified as a Global Geopark in 2010. Despite this international recognition, these forests face increasing threats from tourism-driven development, including resorts, housing, and golf facilities (Kim, 2014; Jeju Province, 2018, 2021). To ensure the sustainable preservation of historical and cultural relics within these sites, it is essential to identify and quantify their non-use values using contingent valuation methods (CVM).

Contingent valuation (CVM) has been widely applied to assess the benefits of environmental

¹⁶ Jeju island is a volcanic and the largest island off the southern coast of the Korean Peninsula with Halla Mountain and contains the UNESCO Natural World Heritage Site. In addition, it won the Global Geopark certificate and has been selected as the New 7 Wonders of Nature. The coastline is 253 km long and has a total area 1,825 km², which is 1.8% of the total land area in the Republic of Korea. Total population is approximately 679,016 people and its density are 363.16/km². The annual average temperature is approximately 15.5°C and precipitation 1,653 mm with increase in precipitation and temperature.

conservation, yet the choice of payment vehicle remains a critical design issue (Faccioli et al., 2022; Champ et al., 2017; Ivehammar, 2009). In Jeju—a leading global tourism destination where forests such as the Gotjawal are deeply tied to the tourism economy—payment mechanisms (donation, entrance fee, tax) not only shape financial feasibility (Reynisdottir et al., 2008) but also determine public acceptance of conservation policies. Understanding how awareness of historical–cultural significance interacts with payment design is therefore essential for developing sustainable and socially legitimate policy instruments (Kotchen et al., 2000; Liu et al., 2020; Halkos et al., 2017).

Against this background, the present study investigates the effect of payment vehicles on residents' willingness to pay (WTP) for conserving threatened historical and cultural resources in the Gotjawal forests. Employing both single-bounded (SB) and double-bounded (DB) contingent valuation techniques, we conducted face-to-face surveys with 1,100 Jeju households, administered by a professional local research firm. Unlike many previous studies focusing on tourists, our analysis emphasizes the preferences of local residents and integrates the non-use values of historical and cultural resources with issues of policy acceptability across different payment mechanisms (donation, entrance fee, and local tax) (Vilela et al., 2022; Varela et al., 2020; Meyerhoff & Liebe, 2021; Wang et al., 2022; Sun & Xu, 2023).

This study contributes to the literature in three ways. First, it applies a comparative CVM approach (SB vs. DB) to demonstrate methodological differences in WTP estimation. Second, it explicitly examines the role of payment vehicle design in shaping WTP and policy acceptability. Third, it highlights the unique case of Jeju's Gotjawal forests—globally renowned yet locally contested spaces—thereby extending the limited body of research on the valuation of forest-based cultural heritage. The remainder of this paper is structured as follows: Section 2 reviews the relevant literature on payment vehicles and the theoretical background. Section 3 details the survey design, data collection, and empirical methods. Section 4 presents the results of the CV analysis. Section 5 concludes with policy implications and recommendations for the conservation of cultural–historical forest resources.

2. Theoretical backgrounds

2.1. Evidence of the effect of payment vehicles

A growing body of literature has examined the role of payment vehicles in contingent valuation (CV) studies of natural resource management, including cultural and historical heritage sites (Aldrich et al., 2007; Noonan, 2003; Giudice et al., 2016). While CV is widely used to estimate willingness to pay (WTP) for nonmarket goods, its validity can be affected by potential biases such as hypothetical bias, strategic responses, and the choice of payment vehicle (Johnston et al., 2017; Carson, 2012; Alberini et al., 2006). To mitigate these issues, careful questionnaire design incorporating realistic payment instruments is essential.

Recent studies highlight the evolving role of payment methods. Beyond traditional vehicles such as

voluntary donations, entrance fees, and taxes, researchers have explored how actual modes of payment—cash, credit card, and mobile systems—affect stated preferences. For example, Isaque et al. (2021) reported that WTP for reforestation in Brazil was 35% higher when paid by credit card and 30% higher when paid by mobile systems compared to cash. Similarly, Vilela et al. (2022) found that Chilean households expressed higher WTP through donations than through tariffs, with tariff-based WTP being 23–36% lower. These findings suggest that the design of the payment vehicle can substantially influence valuation outcomes and policy acceptability (Hassan et al., 2018; Zhang et al., 2022).

Building on these insights, this study applies single-bounded (SB) and double-bounded (DB) CV methods to estimate WTP for conserving historical and cultural resources in Jeju’s Gotjawal forests using different payment vehicles. To ensure validity and reliability, the survey followed best-practice guidelines (Johnston et al., 2017; Carson, 2012; Whitehead et al., 2011), including expert interviews, a pre-test, and provision of detailed information (e.g., photographs of cultural relics and endangered plant species). These steps minimize bias and enhance the robustness of the valuation results.

2.2. WTP estimation procedure

Research on non-use values that explicitly incorporates payment vehicles has largely relied on single-bounded (SBDC) and double-bounded (DBDC) contingent valuation approaches. Considering payment vehicles such as income taxes, entrance fees, and donations can enhance environmental policy design and promote broader public participation (Kanninen, 2006; Kim et al., 2014; Snowball, 2012). A typical CV question describes a stylized market to elicit respondents’ maximum WTP for nonmarket goods when no market data are available (Champ et al., 2017). However, potential biases remain, including hypothetical, strategic, and information effects (Bateman et al., 2002; Tietenberg et al., 2018). To address these concerns, Johnston et al. (2017) recommend best practices in survey design, such as clear valuation scenarios, pre-testing, and the inclusion of visual aids.

In this study, both SBDC and DBDC formats are employed, though particular emphasis is placed on the DBDC approach, which offers greater statistical efficiency and more precise estimation than the SBDC format (Hanemann et al., 1991; Carson & Hanemann, 2005). The SBDC format asks respondents a single yes/no question (e.g., “If the proposed change cost ₩A, would you be willing to pay this amount?”), while the DBDC format follows up with a higher or lower bid depending on the initial response, thereby narrowing the range of plausible WTP values (Hanemann, 1985).

Formally, the indirect utility function is specified as $V = V(D, Y, S)$, where D denotes the payment vehicle, Y income, and S a set of socioeconomic variables (Johansson et al., 2004; Mariel, 2021). The unobserved component of utility is treated as a random error term assumed to follow an i.i.d. distribution (Train, 2009; Greene, 2012). The probability of a “yes” response to a bid amount d is given by

$$P(\text{yes} | d) = Pr(\Delta V + \varepsilon \geq 0) = F(\Delta V),$$

where $F(\cdot)$ is the cumulative distribution function of the error term. Mean WTP is derived from the survival function $S(d)$, while alternative measures such as median, adjusted mean, and truncated mean

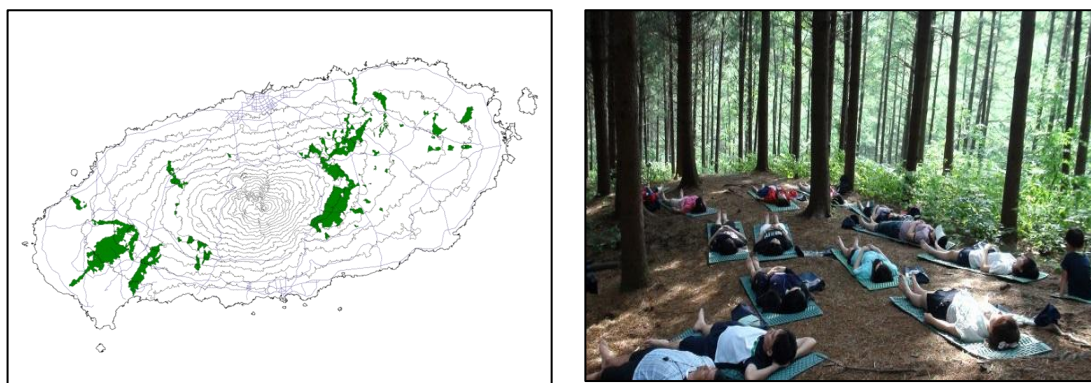
WTP can also be estimated (Hanemann, 1984, 1989; Haab et al., 2003; Aizaki et al., 2015).

For the present study, we adopt the mean and median as the preferred measure of central tendency, consistent with prior recommendations (Wackerly et al., 2008; Watanabe et al., 2009). The DBDC format is estimated via maximum likelihood, with the log-likelihood function constructed from the joint probabilities of first- and second-stage responses (Bateman et al., 2002; Train, 2009). In addition to examining the influence of different payment vehicles (donation, entrance fee, and local tax), the study also estimates WTP by levels of perceived importance of historical and cultural resources in the Gotjawal forests. This allows us to capture how stronger recognition of cultural–historical significance corresponds to higher WTP, thereby providing robust evidence for designing effective and socially acceptable conservation policies.

3. Case study

3.1. Study site and resources in Gotjawal forests

The Gotjawal forests of Jeju Island, South Korea, are unique volcanic ecosystems of exceptional cultural, historical, and ecological importance. Covering approximately 110 km² (about 6% of Jeju) at elevations below 600 m, they are distributed across the island’s eastern and western regions. Their distinctive geological and climatic conditions allow tropical and temperate plants to coexist, supporting 614 plant taxa across 129 families, 376 genera, 554 species, and 56 subspecies, thereby sustaining rich biodiversity and forest genetic resources (Choi et al., 2014) (Figure 1).

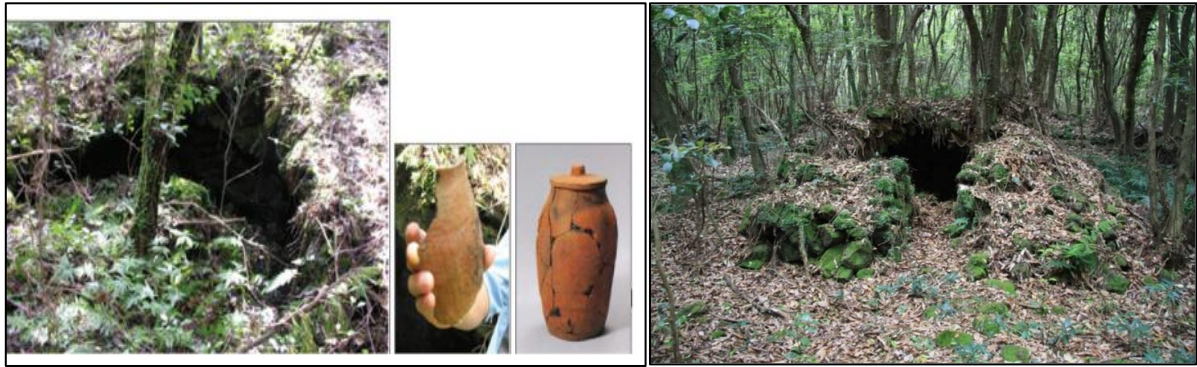


Source: Choi et al. 2014

Figure 1. Distribution of Gotjawal forests in JeJu and residents’ activities in Gotjawal forests

The cultural and historical significance of the Gotjawal forests is equally profound. As local oral traditions and historical texts suggest, the term Gotjawal is rooted in the local dialect and often associated with the idea of “lungs” or a provider of clean air (Sum-gol). Archaeological evidence confirms their continuous use from the Bronze Age through the mid-20th century, including remains of cave dwellings, agricultural traces, and ritual sites. Excavations in areas such as Joji Gotjawal and Sunheul Gotjawal have uncovered numerous relics, underscoring the forests’ role as living repositories

of Jeju's cultural and spiritual heritage (Choi et al., 2014) (Figure 2).



Source: Choi et al. 2014.

Figure 2. Cave dwelling sites, relics, and sites excavated in Joji Gotjawal and Sunheul Gotjawal forests

Despite their outstanding ecological and cultural values, Gotjawal forests face severe development pressures, particularly from tourism-driven projects such as resorts, housing, and golf courses. These tensions highlight the urgent need for conservation policies that balance development with the preservation of irreplaceable cultural and historical resources. Importantly, safeguarding the Gotjawal forests requires not only ecological protection but also recognition of their spiritual traditions, cultural assets, and agricultural heritage (Choi et al., 2014).

This study therefore emphasizes that preserving the Gotjawal forests is not simply a matter of environmental management but also of protecting Jeju's cultural identity and historical legacy. To ensure that policy decisions reflect the full range of benefits—including ecological services, cultural values, and recreational opportunities—nonmarket valuation approaches are essential (Choi et al., 2014). By estimating residents' willingness to pay for the conservation of historical and cultural resources in Gotjawal, this research provides critical evidence for sustainable policy design and long-term ecosystem stewardship.

3.2 Designing the questionnaire and scenario

Following the recommendations of Carson (2012) and Alberini et al. (2006), the contingent valuation (CV) scenario was designed to be realistic, simple, and concise. To ensure clarity, visual aids such as photos and maps of the Gotjawal forests were included. The survey scenario described the preservation of cultural and historical resources under a hypothetical policy, and respondents were asked to state their willingness to pay (WTP) for such conservation efforts. The questionnaire design was refined through expert advisory meetings, a focus group, and a pretest.

Data were collected via personal interviews administered by the Mirae Research Institute, a professional survey agency with over 20 years of experience in Jeju. A total of 1,100 valid responses were obtained from residents who had experience visiting the Gotjawal forests. Although personal

interviews are resource-intensive, they allow for better control over data quality and respondent understanding.

Table 1. The main contents of the survey and questionnaire

	Contents
Survey method	Face to face
Population	Residents in Jeju province
Period and number of samples	November 24th ~ October 1st, 2016, and 1,100
Resources and services being valued	Historical and cultural resources within Gotjawal forests in Jeju
Payment mechanisms	Single-bounded and Double-bounded CV for preserving cultural and historical resources within Gotjawal forests
Payment vehicle	Choosing one of three options: voluntary donation, entrance fee, and local tax
Commodity effects	Preservation of historical and cultural resources Provision of recreational activities, forest experience and education
Main survey questions	Experienced behaviours in Gotjawal: frequency, time of staying, transportation means, types of companions, types of forest activities Environmental awareness and perception of public common resources Asking WTP value for historical and cultural resources in Gotjawal forests, payment vehicles, reason for WTP resistance; General questions regarding gender, residence area, education, income, age, occupation, and place of birth.

The questionnaire consisted of two main parts. The first addressed respondents' behaviour and perceptions, including visit frequency, forest functions, and attitudes toward public services. The second included the CV questions in a double-bounded dichotomous choice format regarding the preservation of historical and cultural resources. In addition, the survey incorporated questions on payment vehicles (voluntary donation, entrance fee, and local tax), reasons for WTP refusal, and socioeconomic characteristics. To minimize bias and improve respondent comprehension, detailed information and photographs of cultural relics, rare and endangered species, and typical forest activities were provided. The payment scenario specified an annual contribution, with bid levels ranging from ₩1,000 (US\$0.83) to ₩10,000 (US\$8.30).

The main survey instrument was finalized based on pretest feedback and literature review. Random sampling ensured that respondents had prior knowledge or experience of the Gotjawal forests. Basic descriptive analyses were conducted using SPSS 24.0, while WTP estimates (mean, median, and truncated mean) were modelled in R (<https://cran.r-project.org/>). Invalid or incomplete responses were re-verified by follow-up phone calls, ensuring reliability of the dataset. The resulting data provide robust insights into residents' preferences and the potential economic benefits of preserving the cultural and historical resources of the Gotjawal forests, thereby offering empirical support for conservation-oriented policy design (Hanemann, 1984; Bateman et al., 2001; Dutta et al., 2007).

4. Results and discussion

4.1 Descriptive results

A total of 1,100 valid responses were collected from Jeju residents (Table 2). The sample comprised 41.3% males and 58.7% females, with most respondents in their 40s and 50s. Education levels were relatively high, with 59.1% holding a university degree. The average monthly household income was ₩3.0 million (approximately US\$2,500), and 44.3% of households fell within this bracket. In terms of occupation, company employees (24.3%), housewives (19.6%), and the self-employed (17.4%) represented the largest groups. Overall, the sample can be considered broadly representative of the Jeju population in terms of demographic structure.

Table 2. Socioeconomic characteristic information of the respondents

		Frequency	Percent			Frequency	Percent
Gender	Male	454	41.3	Employment	Self-business	191	17.4
	Female	646	58.7		Professional	113	10.3
Age	Under 20	8	0.7		Primary industry	76	6.9
	20~29	62	5.6		Civil servant	74	6.7
	30~39	206	18.7		Student	35	3.2
	40~49	341	31.0		Housewife	216	19.6
	50~59	306	27.8		Company staff	267	24.3
	Over 60	177	16.1		others	128	11.6
Education	Undermiddle school	67	6.1	Monthly household income*	Under ₩2 M.	339	30.8
	High school	311	28.3		₩2 M. ~ ₩4 M.	487	44.3
	Undergraduate	650	59.1		₩4 M. ~ ₩6 M.	201	18.3
	Postgraduate	72	6.5		Over ₩6 M.	73	6.6

* ₩2 million Korean won is equivalently equal to US \$1,657 (US \$1 vs. ₩1,207 Korea won in 2016).

Table 3 summarizes visitation behaviour and awareness of the Gotjawal forests. Approximately 78% of respondents reported visiting more than twice within the past five years, with half visiting one to two times annually and about one-quarter visiting monthly. The average visit duration was between one and two hours, and most respondents travelled by private car (86.6%). Visits were typically group-based (average group size: 5.4 persons), most often with family members or relatives (47.5%).

Table 3. Gotjawal visits and behaviour results

Main question results					
Frequency of visits over 5 years (1)	First time	22.0%	Number of accompany	Male (average)	2.4 people
	More than 2 times	78.0%		Female (average)	3.0 people
	1~2 times per month	24.8%		1 hour	11.7%
Details about visit frequency (2)	1~2 times per year	50.6%	Time spent in the forests	1~2 hours	49.2%
	3~4 times per year	16.2%		2~3 hours	18.5%
	Other	8.4%		4 hours above	10.6%

Environmental awareness	Importance of history and cultural resources	4.43(0.71)	Purposes of visit to Gotjawal **	Historical and cultural space	395 (35.9%)
	Importance of various trees and plants	4.40(0.72)		Collecting general materials	21 (1.9%)
	Beautiful scenery and healing space	4.54(0.64)		Education of natural area	71 (6.5%)
	Opportunity for ecological education	4.57(0.66)		Exercise and walking	540 (49.1%)
	Contribution of regional development	4.06(0.94)		Living space	46 (4.2%)
	Knowing status of Gotjawal resources	4.31(0.82)		Agriculture, others	27 (2.5%)

* We use a 5-point Likert scale (1. Never important, 2. Not important, 3. Neither, 4. Important, 5. Very important) and standard errors are in parentheses. ** Frequency analysis and percent distribution.

With respect to motivations, the most frequently cited activities were recreation and walking (49.1%), followed by historical and cultural purposes (35.9%) and educational activities (6.5%). On a 5-point Likert scale, respondents rated “opportunities for forest and ecological education” (mean = 4.57) and “beautiful scenery and healing space” (mean = 4.54) as the most important attributes, followed by “importance of historical and cultural resources” (4.43), “importance of diverse trees and plants” (4.40), and “status of Gotjawal preservation” (4.31). By contrast, “contribution to regional economic development” received a relatively lower importance score (4.06).

These results highlight that Jeju residents place stronger value on the ecological, cultural, and educational roles of the Gotjawal forests than on their economic functions. This finding underlines the significance of incorporating cultural and historical resource values into conservation policy and provides a foundation for the subsequent WTP analysis.

4.2. WTP estimation results

4.2.1. Bid responses and modelling WTP estimation

The mean and/ or median WTP were estimated using data from 1,100 valid questionnaires, following the contingent valuation framework of Hanemann (1989). This approach provides multiple measures of WTP—mean, median, and truncated mean—allowing decision-makers to select the most appropriate indicator depending on policy objectives. In line with Hanemann (1989), the median WTP is often considered more robust, as it accounts for skewness in the distribution of responses and provides a conservative estimate. Summary statistics of the double-bounded CVM responses are presented in Table 4, which reports the starting bids, sample sizes, response distributions, and WTP patterns across bounds (Alberini, 1995; Hanemann, 1984).

In this study, limited dependent variable models were employed to estimate WTP for the preservation of cultural and historical resources in the Gotjawal forests. Both logit and probit models were initially considered (Greene, 2012). While the probit model assumes a normal distribution, the logit model allows for heavier tails and is often more suitable for behavioural data. Consistent with

prior studies (Hill et al., 2011), the logit model was selected due to its better fit, intuitive coefficient signs, statistical significance, and ease of interpretation. The binary logit estimates the log-odds ratio of “yes” versus “no” responses, and WTP values were subsequently derived from the estimated coefficients.

Table 4 illustrates the frequency distribution of responses across the six bid levels (₩1,000–₩10,000). The results show the expected downward-sloping demand curve: in the single-bounded (SB) format, acceptance was very high at the lowest bid ($\approx 86\%$ at ₩1,000) but dropped sharply to only 9% at ₩10,000. This indicates strong price sensitivity among respondents. By contrast, the double-bounded (DB) responses consistently yielded higher acceptance rates, particularly at higher bids. Even at ₩10,000, about 40% of respondents accepted the bid in the DB format, reflecting the impact of follow-up questioning in capturing more moderate WTP values. Taken together, these results confirm the internal validity of the CV design and the tendency of SB formats to produce more conservative estimates compared to DB. From a policy perspective, the steep decline in SB acceptance at higher bids suggests that excessively high entrance fees or levies could face local resistance, whereas moderate levels may remain acceptable.

Table 4. Statistical characteristics of bid value

Starting value (KRW)	Sample distribution	SB		DB			
		yes	no	yes-yes	yes-no	no-yes	no-no
1,000	183	157	26	86	71	7	19
3,000	183	92	91	8	84	56	35
5,000	183	63	120	10	53	67	53
7,000	183	38	145	7	31	73	72
9,000	182	23	159	4	19	63	96
10,000	186	17	169	4	13	71	98
Total	1,100	390	710	119	271	337	373

* US \$1 is about ₩1,207 Korean won in 2016.

Figure 3. Acceptance rate by bid levels using SB and DB

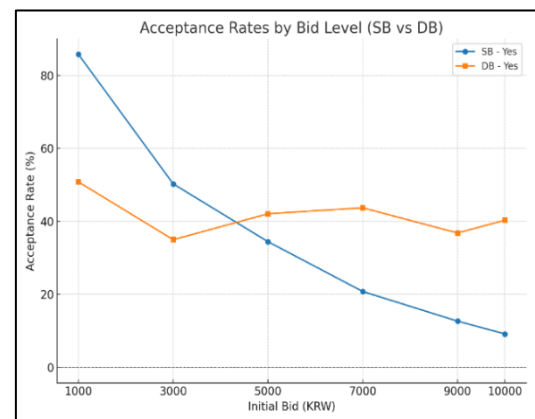


Figure 3 illustrates the acceptance rates across bid levels under both SB and DB formats. From a methodological perspective of contingent valuation, the estimated mean ($\approx$ median) willingness to pay (WTP) using the single-bounded (SB) approach is KRW 3,870, with a 95% confidence interval (CI) ranging from KRW 3,500 to KRW 4,239. In contrast, the double-bounded (DB) approach yields a mean ($\approx$ median) WTP of KRW 3,163, with a 95% CI of KRW 2,580 to KRW 3,746, representing a reduction of approximately 18%. These results suggest that while the DB format generally improves statistical efficiency, it may also lead to downwardly adjusted WTP estimates compared to the SB format. This finding highlights the importance of carefully considering survey design when applying contingent valuation methods, as the choice of elicitation format can substantially influence the magnitude of the

estimated values.

Table 5 reports the estimated coefficients of the WTP models across different payment vehicles using both SBCV and DBCV formats. For each case, two specifications were tested: a simple model including only the bid variable, and an extended model incorporating additional covariates (e.g., time spent in the forest, visit frequency, number of companions, age, birthplace, and income). Across all specifications, the bid coefficient is consistently negative and highly significant ($p < 0.01$), confirming that higher contribution levels significantly reduce the likelihood of acceptance. This result is robust across both simple and extended models as well as across SBCV and DBCV formats. Notably, the DBCV models show larger absolute bid coefficients and improved goodness-of-fit indices (lower AIC/BIC values), suggesting that the double-bounded format provides more efficient and stable WTP estimates. Comparing the simple vs. covariate-augmented models, several patterns emerge.

In the extended models, behavioural variables such as the number of companions and visit frequency often carry positive signs, indicating that more frequent and social users of the Gotjawal forests are more willing to contribute. Similarly, income is positively associated with WTP in some DBCV specifications, though statistical significance varies. By contrast, birthplace tends to have a negative sign, implying that residents born in Jeju show slightly lower WTP than in-migrant residents, though the effect is generally not significant. Importantly, the perception variable (Impo7, reflecting the perceived importance of cultural and historical resources) is negative and significant in the entrance fee and tax models, suggesting that lower perceived importance reduces WTP under these payment schemes.

From a policy perspective, these results indicate that payment vehicle choice matters: entrance fees consistently yield higher and more significant WTP than donations or local taxes, and the effect remains robust when covariates are introduced. The difference between simple and extended models also underscores the importance of including socio-behavioural variables, which not only improve model fit but also provide richer insights into the determinants of residents' willingness to contribute.

Table 5. Estimated coefficients for the WTP model by payment vehicles using SBCV and DBCV

CV formats (Payment vehicles) Models	SBCV						DBCV					
	Donations		Entrance fee		Local taxes		Donations		Entrance fee		Local taxes	
	Simple model	Model with covariates	Simple model	Model with covariates	Simple model	Model with covariates	Simple model	Model with covariates	Simple model	Model with covariates	Simple model	Model with covariates
Intercepts	13.89 (4.33)***	14.69 (4.14)***	13.41 (10.31)***	13.45 (9.2)***	13.06 (8.48)***	14.20 (8.27)***	21.30 (6.32)***	23.99 (5.79)***	24.40 (11.58)***	25.70 (10.24)***	25.10 (9.43)***	24.73 (8.73)***
Time spending within forests	-	0.01 (1.24)	-	0.01 (3.38)***	-	0.01 (0.61)	-	0.17 (0.39)	-	0.01 (2.71)**	-	-
Visit frequency	-	0.15 (0.22)	-	-	-	0.01 (0.70)	-	0.01 (1.14)	-	-	-	0.37 (0.82)
Number of companions	-	-0.02 (-0.71)	-	0.04 (2.88)**	-	0.03 (1.91)*	-	-0.01 (-0.12)	-	0.05 (1.98)*	-	0.03 (0.93)
Age	-	0.01 (0.30)	-	-	-	-	-	-	-	0.21 (1.34)	-	-
Birthplace	-	-1.05 (-1.18)	-	-	-	-	-	-	-	-0.73 (-1.02)	-	0.91 (1.26)
Income	-	-0.00 (-0.03)	-	0.14 (1.12)	-	0.24 (1.71)*	-	0.14 (0.45)	-	0.19 (1.00)	-	0.09 (0.37)
Impo7	-	-	-	-0.59 (-2.43)**	-	-1.04 (-3.45)***	-	-0.78 (-1.54)*	-	-0.14 (-0.40)	-	-
Bid	-1.71 (-4.47)***	-1.83 (-4.43)***	-1.67 (-10.72)***	-1.77 (-10.70)***	-1.63 (-8.91)***	-1.72 (-8.87)***	-2.53 (-6.28)***	-2.82 (-6.17)***	-2.91 (-11.47)***	-3.18 (-11.32)***	-3.02 (-9.34)***	-3.11 (-9.27)
Model fitness (log-likelihood, AIC, BIC)	-53.2, 110.4, 115.6	-51.7, 119.4, 140.2	-258.5, 521.1, 529.5	-241.4, 496.9, 526.5	-198.6, 401.3, 409.3	-186.8, 387.6, 415.4	-48.9, 101.8, 107.0	-45.2, 104.5, 122.8	-156.8, 317.7, 326.2	-147.0, 310.0, 343.8	-99.2, 202.5, 210.4	-97.5, 206.9, 230.8

Notes: *, **, and *** represent coefficient significance at the 10%, 5%, and 1% level, respectively.

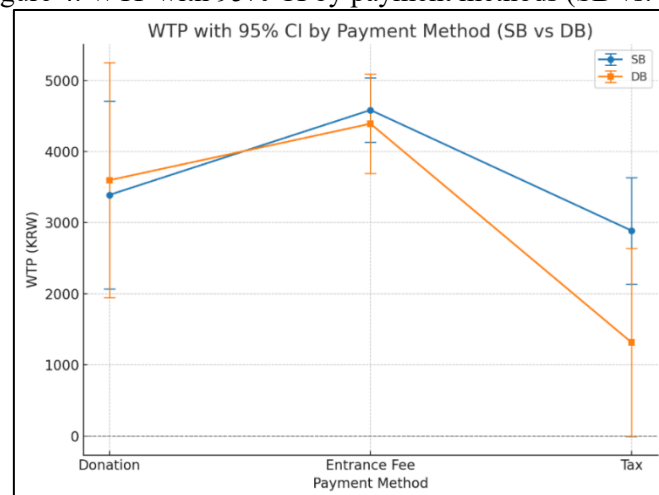
4.2.2. WTP estimation results by different payment vehicles

The second set of analyses considers differences in payment vehicles, which reflect the varying degree of enforcement associated with payment compliance (Table 6). Respondents who selected the entrance fee option ($n = 111$) exhibited the highest willingness to pay (WTP), with SB estimates of approximately KRW 4,586 and DB estimates of approximately KRW 4,393. This suggests that the entrance fee mechanism may represent the most politically and socially acceptable payment vehicle. For the donation option ($n = 542$), the estimated WTP was KRW 3,392 (SB) and KRW 3,599 (DB), indicating a relatively consistent level across the two elicitation formats. Although donations received generally positive responses, the wider confidence intervals imply greater uncertainty in these estimates. By contrast, the tax option ($n = 447$) yielded the lowest WTP values, with the DB estimate falling to KRW 1,316 and including a negative lower bound in its confidence interval. This pattern suggests that compulsory forms of payment are less acceptable to respondents and that resistance to taxation is reflected in the valuation outcomes. Figure 4 further illustrates these differences, offering a clearer picture of respondents' preferences across payment vehicles. Taken together, the evidence from Table 6 and Figure 4 indicates that the entrance fee is the most suitable instrument for implementing policies aimed at conserving the historical and cultural forest resources within the Gotjawal. This outcome underscores the principle that those who directly use and benefit from the area should bear the costs associated with its management and protection.

Table 6. WTP variations by payment vehicles using SB and DB CV with simple models

Payment vehicles Format	Entrance fee		Donation		Tax	
	WTP	95% CI	WTP	95% CI	WTP	95% CI
SB(KRW)	4,586	4,132 ~ 5,040	3,392	2,071 ~ 4,713	2,889	2,140 ~ 3,638
DB(KRW)	4,393	3,697 ~ 5,089	3,599	1,947 ~ 5,251	1,316	-6 ~ 2,637

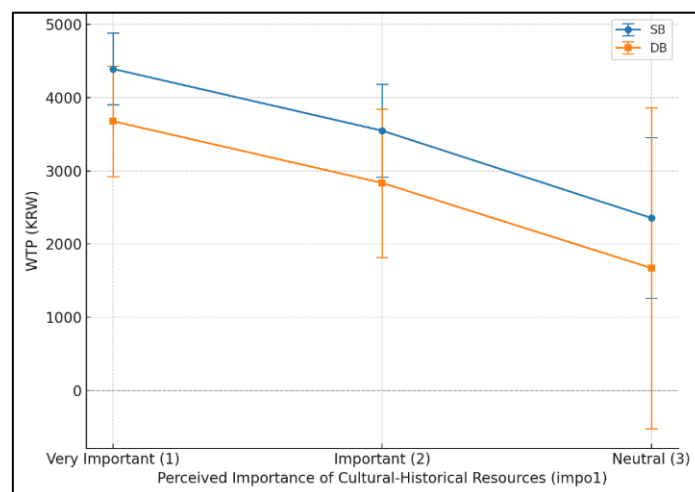
Figure 4. WTP with 95% CI by payment methods (SB vs. DB)



4.2.3. WTP estimates by the perceived importance of historical and cultural resources in the Gotjawal

Table A1 in the appendix presents the WTP estimates differentiated by respondents' perceived importance of the Gotjawal's historical and cultural resources. Among the respondents, 612 rated the resources as "very important," 354 as "important," and 127 as "moderately important (or neutral)." Under the single-bounded (SB) format, the estimated WTP values were KRW 4,391 for the "very important" group, KRW 3,547 for the "important" group, and KRW 2,356 for the "moderately important" group. In comparison, the double-bounded (DB) format yielded lower estimates, with KRW 3,676, KRW 2,834, and KRW 1,672 for the respective groups. As illustrated in Figure 5, WTP values increase consistently with the level of perceived importance, confirming a clear positive association between resource importance and willingness to pay. Moreover, across all levels of importance, SB estimates tended to be higher than DB estimates, reinforcing the general pattern observed in earlier analyses.

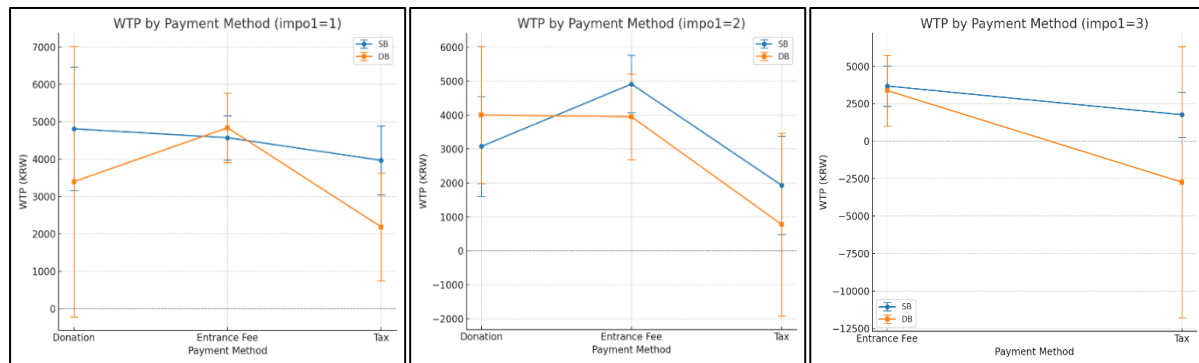
Figure 5. WTP with 95% credential interval by importance levels



According to Table A2 in the appendix and Figure 6, the second set of analyses considers both the perceived importance of the Gotjawal's cultural–historical resources and the choice of payment vehicle. For respondents who regarded these resources as very important, the entrance fee mechanism consistently generated the highest willingness to pay (WTP), with both SB and DB estimates exceeding KRW 4,500. This indicates strong public acceptance of usage-based payment schemes among highly motivated individuals. By contrast, tax-based payments yielded substantially lower WTP, particularly under the DB model ($\approx$ KRW 2,200), reflecting respondents' resistance to compulsory financing mechanisms. Donations produced moderate WTP levels, but with wide confidence intervals, suggesting heterogeneity in preferences for voluntary contributions. Overall, these results imply that when conservation is perceived as highly important, entrance fees represent the most effective and socially acceptable policy instrument. Among respondents who considered the resources important but not at

the highest level, the overall pattern remained similar. Entrance fees again yielded the highest WTP (SB≈KRW 4,900; DB≈KRW 3,950), while donations showed moderate values but with higher uncertainty, likely due to smaller sample sizes. Willingness to contribute through taxes was weak or absent, echoing the resistance observed in the highly motivated group. These findings confirm that entrance fees are consistently the preferred mechanism, although the magnitude of WTP decreases as the perceived importance declines.

Figure 6. WTP with 95% CI by importance levels with payment vehicles



Finally, for respondents with a neutral perception of cultural–historical importance, WTP levels declined markedly across all payment vehicles. Both SB and DB estimates were substantially lower than those of the other groups, and the confidence intervals were wide, with DB estimates in some cases approaching zero. This pattern highlights not only reduced financial support but also significant uncertainty in valuation. The neutral group is therefore less reliable as a funding base, suggesting that targeted awareness-raising initiatives are needed to enhance their recognition of the conservation value before expecting meaningful financial contributions.

The comparison of payment vehicles across different levels of perceived importance (impo1) reveals a consistent and systematic pattern. Respondents who regarded cultural–historical resources as very important exhibited the highest willingness to pay (WTP), particularly through entrance fees, which emerged as the most preferred and socially acceptable mechanism. Those who considered the resources merely important displayed a similar ordering of preferences, albeit with somewhat lower WTP levels, again highlighting entrance fees as the most viable option. In contrast, respondents with a neutral perception expressed substantially lower and more uncertain WTP values across all payment vehicles, with some double-bounded (DB) estimates approaching zero. Across all groups, tax-based schemes consistently produced the weakest support, reflecting resistance to compulsory payment instruments, while donation-based mechanisms showed moderate WTP with considerable heterogeneity. These results underscore the dual importance of both perceived cultural–historical significance and the design of payment vehicles in shaping financial contributions to conservation. Policies that emphasize transparent, usage-based financing (e.g., entrance fees) are likely to achieve the greatest public acceptance, particularly among those who already recognize the importance of Gotjawal’s cultural–

historical resources, while awareness-raising initiatives will be necessary to mobilize support from less engaged groups.

Table 7 presents the reasons why some respondents chose not to pay for the conservation of historical and cultural resources in the Gotjawal. Among non-payers, the majority (60.1%) stated that they were “satisfied with the current condition of the forests and resources.” A sizable minority (23.3%) indicated that “the government should provide financial support for conservation,” while 9.4% expressed “concerns about the reliability of fund management.” In addition, 5.4% cited “economic unaffordability” as their reason for non-payment, with a few other minor opinions also recorded. Notably, responses related to satisfaction with current conditions or limited affordability are not considered protest responses, whereas those referring to project validity, governmental responsibility, or the reliability of fund expenditure may be classified as protest responses.

Table 7. Reasons why a subset of people would not pay

Reason	Percent (frequency)
I cannot afford to pay at this time	5.4 (20)
I am content with the present status of Gotjawal forest and its resources	60.1 (224)
There is no difference between land forests and Gotjawal forests	0.5 (2)
It is the responsibility of the government	23.3 (87)
Lack of reliability of fund expenditures	9.4 (35)
I do not like the payment methods	0.3 (1)
It is unfair to expect improvement in forest services	1.1 (4)
Total	100.0 (373)

5. Conclusions and implications

Jeju in Korea is widely recognized as a premier international tourism destination, attracting millions of visitors annually, and is one of the few natural heritage regions worldwide to achieve the “triple crown” designation—UNESCO World Natural Heritage, Global Geopark, and Biosphere Reserve (JeJu Province, 2018; 2021). Within this global context, the Gotjawal forest not only provides critical ecological and recreational services but also holds profound cultural and historical significance (Choi et al., 2014; Gang et al., 2014). Preserving such resources is therefore of heightened importance, both for sustaining Jeju’s status as a world-class natural tourism hub and for safeguarding its unique heritage for future generations. Against this backdrop, the present study applied contingent valuation (CV) methods (Bateman et al., 2002; Alberini & Kahn, 2006; Champ et al., 2017) to estimate the willingness to pay (WTP) for conserving the cultural–historical forest resources of the Gotjawal. By employing both single-bounded (SB) and double-bounded (DB) formats (Hanemann, 1984; Torres-Ortega & Riera, 2022), the study compared methodological differences while examining how payment vehicles and perceived importance shape conservation values.

The results revealed several key findings. First, SB estimates of WTP were consistently higher than

those from the DB format, with the difference amounting to approximately 18% at the aggregate level. This suggests that while the DB approach may improve statistical efficiency, it tends to yield more conservative value estimates (Watanabe & Asano, 2009), which has implications for policy design and benefit–cost analyses.

Second, the choice of payment vehicle substantially influenced WTP. Entrance fees generated the highest values, followed by donations, while tax-based payments yielded the lowest. These findings are consistent with prior research highlighting the influence of payment vehicles on stated preferences (Ivehammar, 2009; Hassan et al., 2018; Varela et al., 2020; Zhang et al., 2022). Importantly, the entrance fee option appears to align with the principle that beneficiaries of the resource should bear the costs of its management, making it the most viable policy instrument for conserving the Gotjawal (Reynisdottir et al., 2008; Vilela et al., 2022).

Third, perceived importance of cultural–historical resources was strongly associated with higher WTP. Respondents who regarded these resources as “very important” exhibited significantly greater WTP than those who considered them less important or neutral. This pattern was consistent across payment vehicles, underscoring the role of cultural value recognition in motivating financial contributions (Dutta et al., 2007; Faccioli et al., 2022; Kwame et al., 2022; Wang et al., 2022; Sun & Xu, 2023). However, respondents with neutral perceptions displayed both low and highly uncertain WTP levels, suggesting that awareness-raising initiatives are necessary before expecting meaningful participation from this group.

Finally, the analysis of protest responses provides additional insights. While some respondents expressed genuine satisfaction with the current state of the forests or cited economic constraints—responses that are not classified as protest (Akcura, 2015)—others questioned the validity of the project, emphasized governmental responsibility, or doubted the reliability of fund management. These protest responses highlight the importance of institutional trust and governance in shaping public support for conservation financing (Meyerhoff & Liebe, 2021; Dupont & McEvoy, 2021).

The findings carry several policy implications. Entrance fees are likely to be the most socially acceptable and politically feasible financing mechanism, particularly among respondents who place high importance on conservation. However, reliance on voluntary donations may yield unstable revenue, and tax-based instruments are likely to encounter strong resistance unless coupled with efforts to increase transparency and trust (Carneiro & Carvalho, 2014; Li et al., 2021). Moreover, enhancing public awareness of the cultural and historical significance of the Gotjawal is crucial to broadening the support base, especially among less motivated groups (Powdthavee, 2021; Lades et al., 2021).

From an academic perspective, this study confirms that WTP estimates are sensitive not only to methodological design (SB vs. DB) but also to contextual factors such as payment vehicle and cultural importance. The results contribute to the literature on non-market valuation by demonstrating how socio-cultural perceptions interact with elicitation format and payment mechanisms to shape conservation values (Noonan, 2003; Johnston et al., 2017). Future research may build on these findings

by exploring hybrid choice models (Train, 2009; Mariel et al., 2021) or integrating psychometric measures of attitudes and trust (Aldrich et al., 2007; Halkos & Massiori, 2017) to better capture the drivers of heterogeneity in WTP.

This study is not without limitations. First, as with all contingent valuation applications, the results may be subject to hypothetical bias and framing effects, despite the use of both SB and DB formats (Carson, 2012; Johnston et al., 2017). Second, because the survey focused solely on Jeju residents, the generalizability of the findings to other regions is limited; comparative studies across different cultural and institutional contexts would be valuable (Wang et al., 2022; Sun & Xu, 2023). Third, while protest responses were distinguished, deeper insights into the roles of trust, governance, and attitudes could be gained by integrating psychometric measures or hybrid choice models (Aldrich et al., 2007; Faccioli et al., 2022; Mariel et al., 2021). Finally, future work could test alternative or combined payment mechanisms—such as differentiated entrance fees or earmarked local taxes—using discrete choice experiments to evaluate equity, efficiency, and acceptability (Bateman et al., 2002; Train, 2009).

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Appendix

Table A1. WTP estimates under single-bounded and double-bounded formats by the perceived importance of historical and cultural resources in the Gotjawal

Importance levels	Single bounded CV results				Double bounded CV results			
	WTP	CI_low	CI_high	Frequency	WTP	CI_low	CI_high	n
Very important	4391.0	3902.7	4879.4	612	3676.4	2919.4	4433.5	1224
Important	3547.9	2916.1	4179.7	354	2834.3	1821.8	3846.8	708
Neutral	2356.8	1262.2	3451.4	127	1672.7	-517.8	3863.4	254

Table A2. WTP estimates by importance and payment methods

Importance levels	Payment methods	Single bounded CV results				Double bounded CV results			
		WTP	CI_low	CI_high	n	WTP	CI_low	CI_high	n
Very important	Donations	4808.2	3155.8	6460.6	59	3395.0	-222.4	7012.5	118
	Entrance fees	4570.5	3974.1	5166.9	309	4836.3	3905.2	5767.4	618
	Local taxes	3965.7	3042.9	4888.5	244	2182.4	742.5	3622.3	488
Important	Donations	3077.3	1611.4	4543.1	35	4006.3	1986.2	6026.3	70
	Entrance fees	4915.2	4066.4	5764.0	171	3951.1	2686.2	5216.1	342
	Local taxes	1933.3	485.7	3380.8	148	778.4	-1920.2	3477.1	296
Neutral	Entrance fees	3685.3	2331.5	5039.1	59	3383.7	1027.3	5740.1	118
	Local taxes	1768.2	268.8	3267.5	51	-2729.8	-11775.3	6315.6	102

Chapter 3

(Exploring Preference Heterogeneity and Acceptability for Forest Restoration Policies: Latent Class Choice Modeling and Principal Component Analysis.)

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Daily et al. (1995) – “Human society would cease to exist in the absence of ecosystem services.”

Exploring Preference Heterogeneity and Acceptability for Forest Restoration Policies: Latent Class Choice Modelling and Principal Component Analysis

Abstract

The restoration of forest ecosystems damaged by wildfires and pest outbreaks has become increasingly urgent. However, the public-good nature of forests, the involvement of diverse stakeholders, and the spatial variability of degradation present significant challenges to effective policy design. In particular, previous studies have largely examined these threats in isolation, and few have provided integrated economic analyses of their combined impacts. This gap underscores the need to better understand heterogeneous public preferences and their implications for restoration policy. To address this, we conducted a discrete choice experiment (DCE) with 1,021 Korean citizens and applied a two-stage analytical framework combining principal component analysis (PCA) and latent class choice modeling (LCM). Five distinct preference segments were identified, each exhibiting substantial variation in willingness to pay (WTP) for restoration attributes. Policy simulations further revealed that public acceptance declines sharply at higher cost levels, highlighting the importance of setting realistic financial thresholds for broad support. While visual materials, consequentiality checks, and cheap talk scripts were employed to mitigate hypothetical bias, the limitations of external validity and potential sampling biases should be acknowledged. Our findings provide empirical evidence for tailoring restoration policies to different stakeholder groups, while also stressing the financial and institutional constraints of implementation. In particular, the results suggest that cost thresholds, citizen engagement, and awareness-raising strategies must be carefully balanced to ensure both effectiveness and public acceptance. Taken together, these insights contribute to evidence-based forest policymaking that is both economically efficient and socially acceptable, while recognizing the context-specific limitations of the Korean case and the need for comparative studies across countries.

Keywords: forest restoration; policy acceptance; choice experiments; latent class choice modeling; preference heterogeneity

1. Introduction

Since the Korean War, South Korea (hereafter Korea) has been globally recognized as a leading nation in forest restoration [1,2]. However, the quality of its forest ecosystems has deteriorated significantly in recent years due to large-scale forest fires, landslides, and the spread of invasive species [3–6]. These ecological disturbances are expected to intensify further with climate change [7,8,9]. According to the FAO (2020), forests continue to face alarming rates of degradation and deforestation due to anthropogenic pressures—such as fires, invasive species, and logging—that undermine their health, vitality, and ability to provide essential ecosystem services [10,11]. Without active restoration, achieving sustainable forest management (SFM) and meeting the Sustainable Development Goals (SDGs) will become increasingly difficult, while the public benefits provided by forests will likely

diminish [12]. Although Korea urgently needs to restore deforested and degraded forests, such efforts require substantial financial resources and long-term commitment in alignment with the United Nations' Decade on Ecosystem Restoration (2021–2030).

A key challenge in designing and implementing effective restoration policies lies in the considerable heterogeneity of public preferences, values, and attitudes, and while previous research has examined wildfires in terms of prevention, suppression, and restoration costs [13–15] (as well as pest outbreaks in relation to timber losses, control expenditures, and forest health impacts [16–18]), very few studies have jointly analyzed these two critical drivers of ecosystem degradation in an economic context [19–21]. Despite its importance, the segmentation of environmental behavior has been relatively underexplored in forest-related research compared to other sectors like health or transportation [22–24]. By explicitly addressing this gap, the present study contributes to the literature by jointly analyzing preferences for restoration under wildfire and pest scenarios, thereby providing a more comprehensive understanding of how the public values ecosystem recovery when facing multiple, interacting threats.

To reduce the uncertainty of forest restoration policy, therefore, the discrete choice experiment (DCE) provides valuable tools to uncover this heterogeneity and to design and implement forest restoration policies effectively. It is essential to account for the latent environmental preferences of citizens and various stakeholders [19,20]. If environmental preferences are treated as uniform, it can lead to policy failures and public resistance, yet overly fine segmentation can also be inefficient. Grouping stakeholders based on latent attitudes and behaviors offers a practical balance in helping to design targeted and acceptable forest restoration strategies [20,21]. Moreover, as economic valuation studies focusing on forest fires, pests, and ecological risks are still rare, estimating willingness to pay (WTP) is critical for evaluating the feasibility and efficiency of such policies [15,20,23,24].

The purpose of our study is to identify heterogeneous preferences, estimate WTP, and assess acceptability for forest restoration policies using a two-stage modeling framework combining latent class choice modeling (LCM) and principal component analysis (PCA) [25]. First, we estimated latent classes through LCM; then, PCA was applied to further explore group-level environmental behaviors and WTP patterns. This combined approach enabled a deeper understanding of how citizens' and stakeholders' preferences influence support for forest restoration. Furthermore, we used each of the estimated LCM and PCA classes simultaneously to cross-check the distribution of WTP by groups and attributes in indicating their environmental preferences. The remainder of our study is structured as follows. The next section sets the stage with a review of econometric model specification and literature. Section 3 presents our empirical study, while the estimation results are discussed in Section 4. This paper then concludes with a summary in Section 5. Additionally, the appendix is at the back of this paper.

2. Discrete Choice Framework and Model Specification

2.1. Evidence on Preference Heterogeneity and Environmental Risks

To explore heterogeneity in environmental preferences, this study employed both principal component analysis (PCA) and latent class choice modeling (LCM). PCA is a straightforward statistical technique that reduces dimensionality while preserving the maximum possible variation in the dataset [25,26], and it has been widely applied to uncover latent attitudinal structures across fields such as environment, health, and transportation [15,27–39]. For example, Rhead et al. (2018) used PCA to classify environmental concerns into four ecological groups [32], while Chen et al. (2019) identified three distinct preference classes for urban river restoration using LCM [14,33]. Other applications have compared different econometric models—such as LCM, mixed logit, and random parameter logit—in analyzing heterogeneous preferences for recreation or environmental management [15,34]. These studies consistently demonstrate that unobserved heterogeneity in environmental preferences can be meaningfully captured through latent class segmentation, providing important insights for policy design [31–38].

2.2. Choice Experiment and Model Specification

The DCE we applied is based on Lancaster’s theory of consumers [39], which holds that consumer utility is based on the characteristics of a good rather than on the product or service itself. It is a theory of the consumer based on the economic rationality of utility maximization advocated by McFadden’s random utility theory [40], which assumes that randomly selected individual consumers are economically rational and utility-maximizing decision makers concerning the given alternatives. Under this random utility theory, the utility derived from a choice decision in choice modeling is composed of an observable part, such as the choice attributes that reflect the respondents’ preferences in the presented choice set and an unobservable component (the stochastic error component). The underlying utility function applied in our study follows the assumptions of the basic model of choice modeling. The DCE is a very efficient methodology for capturing a wide range of latent preferences, which consist of a variety of attributes and levels that can define environmental goods or environmental services (although modeling a wide range of social preferences, in general, poses practical difficulties).

In a fresh approach to explore these latent environmental preferences, we used a combined LCM approach in a stepwise fashion [41–43], linking the latent class model classification of PCA with the LCM approach. In general, multinomial logit models assume that all respondents have the same preference parameters, but in practice, each respondent’s preference parameters might be different. To overcome this limitation, we applied the combined LCM model, which assumes a discrete distribution of preference coefficients, where the choice behavior of individuals is based on observable attributes and latent heterogeneity due to variation in attribute factors that are theoretically unobserved by the researcher [15]. The advantage of an LCM is that it does not require any special assumptions about the shape of the parameter distributions for individual consumers. Instead, individuals are essentially partitioned into finite identifiable classes, and the partitioning/grouping process is stochastic based on the selected environmental attributes and levels. Environmental preferences are assumed to be

heterogeneous across classes and homogeneous within classes. The remaining advantage is that the heterogeneity of environmental preferences can be inferred, and the identifiers that characterize the environmental characteristics of the group can be uniformly identified in the model framework. As a result, we demonstrated that the heterogeneity of environmental preferences in specific DCE environmental data can be better described by the LCM model. We experimentally analyzed the distribution of latent environmental preferences and WTP by considering those grouped by the PCA in addition to the procedures applied in many of these studies [25]. These flexible advantages make latent class models more popular in various fields of consumer theory, market analysis, and environment [44]. Given this situation, we used two statistical methodologies in our study: LCM and PCA. In this section, we mainly describe the theoretical background of LCM. To understand these latent and complicated attributes behind the numbers and choices in our DCE data, this LCM, which is a type of latent class model that uses a probabilistic class allocation model, consists of two sub-models as the first part of a class-specific choice model and the last part of a class membership model [15,45]. The former part assigns the probability of choosing each alternative [46], and the latter contains the likelihood of an individual n belonging to a certain class, given that individual n belongs to a certain class q [47-50]. In general, the class membership model is defined as logit, where the utility of an individual n belonging to class q can be expressed as Equations (4) and (5) [51].

The class-specific choice model specified with the MNL model returns the probability that individual n chooses a specific alternative i on choice task t , given that respondents belong to a certain class q . To begin, the utility of individual n derives from choosing an alternative i choosing task t , given that respondents belong to the class q , and it is formulated as Equation (1):

$$U_{nit|q} = V_{nit|q} + \varepsilon_{nit} = ASC_i + \beta_q X_{nit} + \varepsilon_{nit}, \quad (1)$$

where $V_{nit|q}$ is the observed part of the utility; ε_{nit} is an independent and normally distributed Extreme Type I error term over individuals, alternatives, and classes; X_{nit} is the vector of observed attributes of alternative i and normally includes an alternative-specific constant (ASC) that captures the systematic utility of omitted variables [54]; and β_q is the vector of unknown parameters that need to be estimated. Therefore, the probability associated with an individual n 's chosen alternative i is conditioned on class q as follows:

$$P(y_{nit}|X_{nit}, \beta_q) = \frac{e^{V_{nit|q}}}{\sum_{j=1}^J e^{V_{njt|q}}}. \quad (2)$$

The probability of the sequence of T_n choices made by an individual n , denoted by y_n , is the product of the probability associated with each chosen alternative in their sequence:

$$P(y_n|X_n, \beta_q) = \prod_{t=1}^T (p(y_{nit}|x_{nit}, \beta_q)). \quad (3)$$

The probability that individual n belongs to class q given their characteristics is represented by the following logit formula:

$$P(q) = \frac{e^{(\alpha_q)}}{\sum_{q=1}^Q e^{(\alpha_q)}}, \quad (4)$$

where $\alpha_1 = 0$ for identification reasons.

Therefore, the overall choice probability, which is weighted across all classes by the class membership probability $P(q)$, of observing y_n is formulated as Equation (5):

$$P(y_n | X_n, \beta, Q) = \sum_{q=1}^Q P(q) P(y_n | X_n, \beta_q) = \sum_{q=1}^Q \frac{e^{(\alpha_q)}}{\sum_{q=1}^Q e^{(\alpha_q)}} \prod_{t=1}^T (p(y_{nit} | X_{nit}, \beta_q)). \quad (5)$$

Finally, the overall log-likelihood of all individuals N for our LCM is as follows:

$$\ln L = \sum_{n=1}^N \ln P(y_n | X_n, \beta, Q). \quad (6)$$

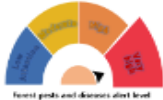
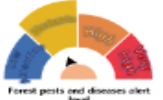
We employed this LCM formulation throughout our study. Our results provide a better model fit, with stronger explanatory power than the single model, and they capture more realistic environmental choice behaviors by incorporating environmental attitudes and behaviors. This may explain why our more complex model yields both higher and lower WTP estimates.

3. Empirical Study

3.1. Attributes, Experimental Design, and Scenario

The research questionnaire was divided into three sections. The first section employed a five-point Likert scale to measure the environmental attitudes, choices, and behaviors of the public [55], as well as to elicit their hidden specific environmental attitudes and final latent consequences because such factors are becoming increasingly important to address ecological problems in research [32]. Second, respondents read our specific environmental scenario, and descriptions of the attributes and levels were shown as an example of a choice experiment. Respondents were asked to complete a series of ten choice tasks depicting the current forest status (SQ) and two preferred forest management policies (alternative1 and alternative2) that would restore the degraded and deforested forests from the damage incurred by the two environmental threats of forest pests and diseases and forest fires. After selecting the preferred choice sets, respondents answered follow-up questions, such as identifying protesters, two types of consequentiality [56], prioritizing attributes, awareness of environmental threats to ecosystem services, and socioeconomic questions. The attributes and levels used in the choice experiment are outlined in Table 1. Visual images were applied to present each attribute level to improve our questionnaire comprehension, and a cheap talk question was added to prevent respondents from overestimating their WTP [81] and to remind them of the level of their disposable income before selecting the main choice tasks [23,57].

Table 1. The attributes and levels of a sustainable forest management scenario.

Attributes	Level1	Level2	Level3	Level4
	Extreme (Red)*	High level (orange)	Moderate level (Yellow)	Low level (Blue)
Forest fires	 (Very high, 85↑)	 (High, 66~85)	 (Moderate, 51~65)	 (Low, 51↓)
Forest pests and diseases	 Forest pests and diseases alert level	 Forest pests and diseases alert level	 Forest pests and diseases alert level	 Forest pests and diseases alert level
Restriction on forest-related outdoor activities	No restriction *  (zero)	Slightly restriction  (0~1 million)	Moderately restriction  (1~2 million)	Strong restriction  (2~5 million)
Biodiversity loss (Number of pine trees damaged)	Very large losses *  (-300~400k trees)	Large loss  (-200~300k trees)	Moderate loss  (-100~200k trees)	Slightly loss  (0~100k trees)
Forest recreation fund	Low * ₩0~₩10,000 won	Slightly increase ₩10,100~₩25,000 won	Moderately increase ₩25,100~₩35,000 won	Substantially increase ₩35,100~₩50,000 won

Note: * It represents the status quo (SQ) reference; adapted from Jeon (2025), *Frontiers in Behavioral Economics*, 4, 1596416. <https://doi.org/10.3389/frbhe.2025.1596416>, CC BY 4.0. ↑: More than 85

Our questionnaire and hypothetical scenario were carefully designed to capture the specific conditions of Korean forests, with a particular emphasis placed on environmental threats to ecosystem services and sustainable forest management (SFM) [58,81]. In discrete choice experiment (DCE) studies, the definition of attributes and levels plays a central role in shaping the experimental design. Thus, it is crucial to align the selected attributes with both theoretical considerations and practical assumptions about forest policy. An excessive number of attributes or levels can confuse respondents and may reduce the statistical efficiency of the design [23]. To address this, we considered current forest policies, fire occurrence patterns, and pest and disease control systems, and we also adjusted the attributes and levels to reflect biodiversity loss and the impacts of outdoor recreational activities. The cost attribute for forest restoration was specified across a range of payment intervals appropriate for the respondent population [59]. The following section provides details of the policy scenario developed for this study, including the final attributes and levels, the expert consultation process, the pilot survey, and the overall questionnaire design.

Considering the situation above, we selected five major attributes through a relevant literature review [59] and from expert advice from the National Institute of Forest Science (NIFoS) in Korea. To begin with, we examined a ‘forest fire’ threat that has the most significant negative impacts on ecosystem services, both at national and global levels, and we then selected the direct and critical attributes arising from them as attributes and variables. Forest fire risk is a growing factor that is simultaneously and continuously connected with successful growing stumpage stock. The damaged area and costs in forestry are becoming larger, even though the frequency of forest fires varies slightly from year to year [60,61]. For instance, the area affected by fire was 24,797 ha in 2022, but it was 2920 ha in 2020; hence, it has been steadily increasing over the years. The frequency and damage of forest fires are rapidly increasing and the Statistical Yearbook of the KFS (2021) reveals that the main causes of them include the following: ‘carelessness of visitors’ at 38.1%, ‘weed burning’ at 6.3%, ‘trash burning’ at 7.7%, ‘cigarette littering’ at 9.7%, ‘visitors to ancestral graves’ at 4.6%, ‘children’s carelessness’ at 0.9%, and at ‘building fire’ 5.7% of the recent forest fire incidents. Meanwhile, 26.9% of incidents are attributed to other minor causes [17]. Following the statistical yearbook of the KFS (Law No. 19115), the scheme of the KFS provides a four-level forest fire alert system [0 (lower risks) →100 (higher risk)] in accordance with the data analysis results of the NIFoS forest fire forecasting system (forestfire.nifos.go.kr): ‘blue level’ (under 50), ‘yellow level’ (51~65), ‘orange level’ (66~85), and ‘red level’ (higher than 86).

Secondly, regarding ‘forest pests and diseases’, a case of pine wilt diseases (PWDs) were unintentionally introduced from Japan and recognized as a global threat to the forestry sector, and they are also viewed as a major threat to healthy ecosystems in forests and to the provision of ecosystem services [7]. More than 12 million pine trees infected with PWDs have been urgently removed throughout all nations with a huge cost to prevent and control the spread of PWDs with bestial injection vaccination since 1988, and outbreaks of forest pest damage are about 35 million hectares of forests

annually over the globe [9]. To combat these threats, the KFS has already implemented ‘the forest disease and pest outbreak index and alert system’ with four levels: ‘interest’ (blue, lower than 50), ‘caution’ (yellow, 51~65), ‘serious’ (orange, 66~85), and ‘very serious’ (red, higher than 86). These levels were established from the results of periodic surveillance and were based on the scale of occurrence, the speed of spread, and the degree of damage in accordance with Article No. 4 of the Forest Pest Control Regulation.

The third attribute was ‘restrictions on forest-related outdoor activities (or forest access restrictions)’ to control and manage these two risky factors, but forest outdoor activities are one of the favored ecosystem services in Korea [3,35]. An average of 15 million tourists has visited annually for camping, hiking, healing, and education in forests [3]. As previously discussed, the majority of forest fires in Korea are caused by human activity, so we set up a scenario in which restricting outdoor activities related to forests would reduce the risk. Specifically, the assumption for the restriction attribute was that there are currently no restrictions; hence, the potential for forest fires and pests and diseases to spread is currently at high risk. Therefore, the direction of forest management policies in our research scenario was set to restrict these two environmental risks. Regarding the key information, there are more than 170 recreational sites within national, public, and private forests across the country, and the number of visitors has continuously increased from 4 million in the 2000s to more than 15 million in the 2020s, which is about 15 million tourists that visit the facilities on average.

Our DCE design put these attributes onto four levels: zero restriction (no restriction), 1~1 million people restriction, 1~2 million people restriction, and 2~5 million people restriction. The fourth attribute was ‘biodiversity loss’ in forests, which includes the number of pine trees infected by PWDs as an impact directly related to and caused by the above two risk factors, where the causal pathogen is the pine wood nematode (PWN), *Bursaphelenchus xylophilus* [7]. In Korea, pine trees are one of the main trees infected by *Bursaphelenchus xylophilus*, which is a PWD transmitted by vector pine sawyer beetles in the genus *Monochamus*. It has also been supposed that once they are infected by PWDs, all pine trees must be chopped down or the suspected pine trees by infection are removed all together (<https://www.apsnet.org> (accessed on August 15, 2023)). Furthermore, pine trees hold a special place in Korean history as an evergreen tree with a long lifespan, and they are the most favorite trees with an iconic importance and a long historical background. It is also an economically important natural resource as timber worldwide. Based on the KFS statistics of PWD damage, the possible levels of pine trees damaged by two risky attributes are distributed across four levels: 0~100,000 trees, 100,000~200,000 trees, 200,000~300,000 trees, and 300,000~400,000 trees.

The last monetary attribute, ‘forest restoration cost’, which charts the cost to restore deforested and degraded forests, can also be called a forest restoration fund. This fund is a tax instrument for a one-time payoff of one year per household because forest management and restoration in Korea is mainly funded by the government’s budget. To be specific, it is classified into 11 categories, including KRW

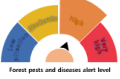
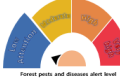
0~KRW 50,000 KRW (USD 38.29) by the unit of KRW 5000 KRW (USD 3.8). For reference, a citizen per year paid about KRW 6700 (USD 5.13) in taxes for the forest sector (KFS) in 2020.

To set our realistic forest restoration policy scenario to reflect the reality of Korea's forests by including the situation thus far, we firstly set it such that the forest ecosystem is constantly threatened by forest fires and pests and diseases. Consequently, pine tree populations have been increasingly damaged, and both tourists and forest users have been adversely affected. To address this, the scenario assumes a restoration of the degraded forests. Table 1 summarizes the attributes and levels included in the questionnaire, each illustrated with visual materials. Respondents were presented with ten choice tasks, each containing three alternatives (two policy options and the status quo), as shown in the second section of the survey. After completing each choice set, participants answered follow-up questions. To ensure clarity and realism, the survey design emphasized tangible and relatable choice settings. Accordingly, graphics and pictorial representations were employed to convey alternatives more effectively than words or numbers alone.

While the use of visual images, cheap talk scripts, and realistic policy attributes enhances the comprehensibility and plausibility of the survey design, it is important to acknowledge the potential limitations of external validity. As with most stated preference methods, our hypothetical choice setting may not fully replicate actual decision-making behavior in real-world forest policy contexts. Respondents could be subject to hypothetical bias—overstating their willingness to pay in a survey setting compared to actual financial commitments—or social desirability bias, whereby answers reflect socially approved attitudes rather than true preferences. These limitations cannot be entirely eliminated; however, several measures were adopted to mitigate them. First, we incorporated visual representations of attribute levels and scenarios to increase realism and cognitive engagement. Second, a cheap talk script was provided to remind respondents of their budget constraints and the importance of realistic responses [62]. Third, we employed follow-up questions on consequentiality and protest responses to detect potential bias and to interpret responses with caution. Taken together, these approaches strengthen the validity of the results, but the findings should still be interpreted with awareness of the limitations inherent in hypothetical choice experiments.

For the design of the experimental choice set for our research, we used an efficient design method to design a total of 200 choice sets and iterated them through the design process to ensure that each attribute was as evenly distributed as possible, and the D-error of our design was 0.101, the A-error was 0.192, and the S-error was 9.67 [63]. In the DCE survey, we asked our respondents to choose between two improved alternatives (Alternatives A and B) and the current situation of the degraded forest (which stated zero-additional cost for no increase in restoration funding). Finally, 10 choice sets from among them were randomly assigned to each respondent (see Table 2).

Table 2. An example of a choice set

Alternatives Attributes and levels	Improved situation		Current situation
	Alternative 1	Alternative 2	Alternative 3 (status quo)
Forest fires	 (Blue)	 (Orange)	 (Red)
Forest pest and diseases	 (Orange)	 (Blue)	 (Red)
Restriction on forest-related outdoor activities	 (3~5million restriction)	 (Under 1million restriction)	 (No restriction)
Biodiversity loss (No. of pine trees infected)	 (-100k~200k pine trees loss)	 (-200k~300k pine trees loss)	 (-300k~400k pine trees loss)
Forest restoration costs	 (₩10,000won)	 (₩25,000won)	0 ₩ Zero won

Note: See Figure A1 (Ethics approval of the questionnaire survey).

3.2. Results

3.2.1. The Sample Demographics of the Respondents

A stratified random sampling strategy was employed to ensure that the survey reflected the demographic structure of Korean adults being aged 20 years and above. Fieldwork was carried out nationwide from August to September 2023 through face-to-face interviews conducted by a professional survey company (ST Innovation). Sampling quotas were applied across all major administrative regions to secure balanced representation in terms of gender, age, and income. The survey was administered using tablets, allowing for real-time data entry and quality control during the discrete choice experiment, which assessed public preferences for forest restoration under threats to ecosystem services and sustainable forest management (SFM). Table A1 summarizes the demographic characteristics of the 1021 participants, which yielded 10,210 valid choice responses. In total, 1021 individuals participated, producing 10,210 valid observations. Among them, 569 (55.7%) were female, while 621 (60.8%) were between the ages of 30 and 49. More than 70% of respondents held at least a bachelor's degree, and approximately 60% were employed full time. Around 40% reported monthly household incomes above USD 3001. Although residents from metropolitan regions were slightly overrepresented, responses were obtained from all areas: Seoul (33.8%), Incheon/Gyeonggi (28.4%), Busan/Ulsan/Gyeongnam (13.7%), Daegu/Gyeongbuk (9.8%), Chungcheong (5.6%), Jeolla (5.0%), Gangwon (2.9%), and Jeju (0.8%).

3.2.2. Results from the PCA-Based Classification of Latent Environmental Attitudes and Behaviors

Following the IBM guidelines for PCA clustering, the results were interpreted to classify groups of environmental attitudes. Accurately identifying public attitudes and behaviors is essential for evaluating

the acceptability of forest restoration policies given the close connection between environmental issues and the general population. To capture these attitudes among Korean citizens, 20 items were selected from Milfont et al. (2010) [55], and these were measured on a five-point Likert scale ranging from “strongly disagree” to “strongly agree” (see Appendix B, Table A4). This section examines the reliability, validity, and model fit of the data, and it also further analyzes how the derived latent variables and classes influenced WTP for sustainable forest management policies through PCA and latent class choice modeling.

As an initial step, PCA was conducted on the responses to the environmental attitude and behavior items using IBM SPSS Statistics 28 (licensed) [52]. Prior to extracting factors, internal consistency and reliability were assessed. Cronbach’s alpha for the 20 items was 0.83, exceeding the commonly accepted threshold of 0.70. Sampling adequacy was confirmed by a Kaiser–Meyer–Olkin (KMO) value of 0.86, while Bartlett’s test of sphericity yielded a Chi-Square statistic of approximately 6251.30 ($df = 190$, $p < 0.001$). These results demonstrate that the dataset is well suited for PCA. Overall, the test statistics indicate that the structural model of environmental attitudes and behaviors provides a robust framework to explain both support for SFM and the actual WTP for forest ecosystem services [81].

According to Appendix A, Table A2, the problem seemed amenable to a five-factor solution as the 58% of variance explained decreased sharply in the five components; in addition, there was less than 1 eigenvalues and the factor loadings appeared in the columns for Factors 1~5. To summarize the main responses in Table 3, the respondents (Component 1, 14.7%) tended to prioritize their convenience and economic pursuit even though they were aware of the environment and the importance of nature (called this the human self-benefit-centred group). On the other hand, for the respondents who the contribution of ecosystem services to stress relief, well-being, and happiness in nature (Component 2) was considered very important we categorized them as the environmental activity preferred group (13.5%). Third, the respondents of Component 3 recognized that the planet Earth and natural ecosystems are at risk were called the ecosystem sensitivity awareness group (20.2%). Fourthly, respondents of Component 4 showed that natural problems can be solved and mitigated by scientific and technological innovation and were named the active environmental protection group (27.5%). The items regarding saving electricity and controlling heating temperatures were also understood as another component (Component 5), and these items also reflected positive attitudes towards sustainable forest management (called the passive environmental protection group (24.1%)) [21,65].

Table 3. The results of the environmental class ratio when subjected to PCA.

	Component 1	Component 2	Component 3	Component 4	Component 5
Question items	A3_6, A3_4, A2_2, A2_1, A3_5, A3_3	A1_3, A1_2, A1_4, A1_1	A2_4, A2_3, A2_5, A1_5	A1_7, A3_7, A1_8, A1_6	A3_1, A3_2
Ratio (N = 1021)	150 (14.7%)	138 (13.5%)	206 (20.2%)	281 (27.5%)	246 (24.1%)
Group characteristics	Human self-benefit -centered group	Environmental activity preferred group	Ecosystem sensitivity awareness group	Active environmental protection group	Passive environmental protection group

Note: The full list of 20 question items is provided in Appendix Table A4 and A6 (coding Q1–Q20 corresponds to the questionnaire items used in the PCA analysis); adapted from Jeon (2025), *Frontiers in Behavioral Economics*, 4, 1596416. <https://doi.org/10.3389/fbhe.2025.1596416>, CC BY 4.0.

Appendix B, Table A6 presents the background characteristics of the respondents in the five latent classes, and it also summarizes the mean and standard deviation values of the socioeconomic variables, environmental attitudes and behaviors, and the follow-up questions for each of the five classes.

3.2.3. Results of Classifying Latent Environmental Groups Using LCM Based on Environmental Attitudes and Behaviors

By applying the LCMs, we aimed to address the limitation in logit models, which typically rely on a strong IID (independent and identically distributed) assumption. This assumption constrains the ability to adequately explain variations in preferences. If only this basic model is applied to environmental issues where various stakeholders are involved, the results and models lead to inaccurate inferences and environmental policies. It is, therefore, essential to analyze their diverse environmental preferences in greater detail and to develop and implement policies that align with their latent preferences using LCMs.

In this study, the probabilistic latent class model was applied to identify the five latent classes of the groups (log-likelihood $-10,877.06$)(AIC 21,766.13) at Class I model $\rightarrow -9580.23$ (AIC 19,186.46) at Class II model $\rightarrow -9412.63$ (AIC 18,865.28) at Class III model $\rightarrow -9173.36$ (AIC 18,400.74) at Class IV model $\rightarrow -9079.56$ (AIC 18,277.13) at Class V model, as shown in Table 4. Additionally, the results show that, although there was some overlap in the environmental behavior among the groups, there was a strong tendency for the groups to have different environmental attitudes and preference heterogeneities. This was only possible to establish through the analysis of these LCMs [30,47,66]. In addition, the statistically significant variables in the table were different for each class and attribute and were important factors that distinguished the characteristics of the groups. This is consistent with the results of the previous analysis of environmental attitudes when subjected to PCA. Therefore, it is necessary to establish forest restoration policies that reflect environmental preferences as accurately as possible in terms of degraded forest restoration policies, forest recreation use patterns, forest biodiversity, and environmental threats.

The results of our estimated LCM models were as follows. In addition to estimating the best fit for the LCMs for our discrete choice data based on the information criteria loglikelihood values, we also found that the best goodness-of-fit measures of the model estimation were obtained when there were five types of LCMs (Table 4). This is relatively consistent with the results of the previous analysis of environmental attitude data when using PCA, as discussed in Section 3.2.2. We based our findings on the five LCMs, focusing primarily on the statistically significant attributes in each model. Before presenting the results, it is important to highlight that the class membership coefficients for the five latent environmental classes (constant.class2~class5) were all highly statistically significant. This indicates that the latent characteristics of the five groups were clearly present among our researches

Table 4. The result of the attribute estimates by latent class when considering heterogeneity in environmental preference using LCM.

		Model I		Model II		Model III		Model IV		Model V	
	Attribute	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value	Estimate	t-value
Latent class1	Forest fire.class1	0.231	2.065**	1.756	4.887***	1.838	6.180***	0.681	3.145***	0.049	0.245
	Forest pests and diseases.class1	0.159	1.318	0.579	1.583	0.598	1.696*	0.414	1.618	-0.131	-0.584
	Forest access restrictions.class1	-0.001	-0.100	0.032	0.986	0.046	1.356	0.008	0.327	-0.013	-0.640
	Forest Biodiversity Loss.class1	0.001	0.106	0.002	0.038	0.010	0.265	0.023	0.787	0.023	0.871
	Cost (forest restoration fund).class1	-0.017	-16.371***	-0.028	-8.859***	-0.021	-8.809***	-0.012	-6.347***	0.002	0.855
	SQ_asc.class1	-0.978	-18.888***	0.337	2.288**	0.569	4.785***	-0.356	-3.485***	-3.323	-14.693***
Latent class2	Forest fire.class2	-	-	-0.083	-0.636	-0.054	-0.370	-0.060	-0.374	-1.106	-3.008***
	Forest pest and diseases.class2	-	-	0.059	0.414	-0.017	-0.109	-0.087	-0.500	0.143	0.243
	Forest access restrictions.class2	-	-	-0.012	-0.934	-0.007	-0.450	-0.012	-0.714	-0.030	-0.606
	Forest Biodiversity Loss.class2	-	-	-0.004	-0.226	0.021	1.112	0.006	0.271	-0.180	-2.650***
	Cost (forest restoration fund).class2	-	-	-0.017	-13.291***	0.000	0.185	-0.003	-1.623	-0.097	-14.813***
	SQ_asc.class2	-	-	-2.195	-25.873***	-1.854	-24.012***	-3.294	-19.979***	-4.859	-17.722***
Latent class3	Forest fire.class3	-	-	-	-	-0.466	-1.203	4.284	4.685***	0.203	0.179
	Forest pests and diseases.class3	-	-	-	-	0.478	1.010	-0.617	-0.663	0.935	1.111
	Forest access restrictions.class3	-	-	-	-	-0.064	-1.652*	0.098	1.040	-0.153	-1.808*
	Forest Biodiversity Loss.class3	-	-	-	-	-0.082	-1.554	0.037	0.334	-0.118	-1.315
	Cost (forest restoration fund).class3	-	-	-	-	-0.101	-16.722***	-0.047	-5.525***	-0.176	-7.831***
	SQ_asc.class3	-	-	-	-	-4.014	-18.200***	1.465	4.805***	-3.822	-7.772***
Latent class4	Forest fire.class4	-	-	-	-	-	-	-0.949	-1.949*	0.573	2.301**
	Forest pests and diseases.class4	-	-	-	-	-	-	0.418	0.726	0.325	1.289
	Forest access restrictions.class4	-	-	-	-	-	-	-0.055	-1.193	0.010	0.398
	Forest Biodiversity Loss.class4	-	-	-	-	-	-	-0.106	-1.572	0.034	1.108
	Cost (forest restoration fund).class4	-	-	-	-	-	-	-0.120	-13.881***	-0.004	-1.612
	SQ_asc.class4	-	-	-	-	-	-	-4.729	-15.728***	-0.246	-1.956*
Latent class5	Forest fire.class5	-	-	-	-	-	-	-	-	4.381	4.325***
	Forest pests and diseases.class5	-	-	-	-	-	-	-	-	-0.832	-0.955
	Forest access restrictions.class5	-	-	-	-	-	-	-	-	0.060	0.658
	Forest Biodiversity Loss.class5	-	-	-	-	-	-	-	-	0.030	0.262
	Cost (forest restoration fund).class5	-	-	-	-	-	-	-	-	-0.037	-3.780***
	SQ_asc.class5	-	-	-	-	-	-	-	-	1.688	4.466***
Class membership probability	Constant.class2	-	-	0.975	11.071***	0.745	8.809***	0.351	3.936***	-0.865	-6.101***
	Constant.class3	-	-	-	-	-0.290	-2.305**	-0.978	-8.034***	-1.782	-9.643***
	Constant.class4	-	-	-	-	-	-	-0.729	-5.025***	-0.278	-2.697***
	Constant.class5	-	-	-	-	-	-	-	-	-1.194	-10.069***
Model fit criteria (Log-Likelihood, AIC)		-10,877.06 21,766.13		-9,580.23 19,186.46		-9,412.63 18,865.28		-9,173.36 18,400.74		-9,079.56 18,227.13	

***: $p < 0.001$, **: $p < 0.05$, and *: $p < 0.1$.

subjects, aligning with the previous PCA findings and strongly supporting the existence of heterogeneous environmental preferences.

First, from an estimated consequence of LCMs (the first latent class in Class I), all attributes showed appropriate signs, as was expected in our research hypothesis. Since the first SQ_asc in Class I was negative as the coefficient of the status quo, it represented a situation where the degraded and deforested forests stayed as such, which is a scenario that is negative for our utility. On the other hand, this also addresses the fact that the restoration of degraded forests seems to positively affect the utility. Regarding the results of the remaining main attribute variables, the cost attribute forest restoration fund was negative and was very statistically significant at the 99% level, which means that, as the cost values increased, the probability decreased. Next, the attribute coefficient of forest fires showed a positive sign, which means the respondents had a WTP to lower the fire levels from the red level (status quo) to the blue safe level. The coefficient of the forest pest and disease attribute was also represented as positive but statistically insignificant, which means that it represented a positive WTP to release environmental threat. Even if it was statistically insignificant, the coefficient of forest outdoor-related restriction was negative, which means that the effect of our visitors' restrictions in forests was negative on our utility. Lastly, a positive WTP for reducing forest biodiversity loss was estimated. The Class V model, with a log-likelihood value of $-9,079.56$, outperformed expectations; thus, we selected the Class V model to explain the latent environmental preferences, to analyse behaviour patterns, and to estimate the final WTP.

In this V model, the respondent results for Latent Class 1 showed a very interesting feature: only the ASC coefficient, which indicates the current degradation of the forest, was statistically significant, while the other main attribute variables were statistically insignificant. This can be interpreted as the respondents in this group saying, 'I dislike the current degraded forest, and I don't care about the other important attributes'. Hence, this group was characterized as being cost-insensitive (an insignificant positive coefficient for the cost attribute) [14] and not caring about other attributes; thus, they were labeled 'disengaged'. In the next class, Latent Class 2, the coefficient of both forest fire and biodiversity loss attributes was paradoxically estimated with the opposite sign to that expected and statistically significant at 5% and 10%. This means that we needed to explain the tendency to disfavor improvement of the degraded forests in environmental threats. This can be summarized as a group that tends to be resistant or opposed to paying forest restoration funds as a tax instrument. According to the follow-up questions, 24% of the respondents chose the SQ alternative, which was due to WTP resistance (with the main reasons being resistance to the creation of a forest restoration fund, the burden of paying taxes, and government accountability for environmental problems). Therefore, this class was labeled a paradoxical group with cost sensitivity. In the third latent group, Latent Class 3, only the restriction on outdoor-related activities attribute (restrn.class3) had a statistically significant and negative value. This means that the restriction of the activities by forest management policy had a negative impact on our utility. This result suggests that they are a group that is relatively sensitive to and enjoy being in the forests. Therefore, this class was categorized as the forest recreational active group. In Latent Class 4, this group considered only the coefficient of the forest fire attribute, which was statistically significant at 5%, while the coefficient of cost was insensitive, with the

appropriate expected sign shown. This group was named the forest policy passive group because they did not exhibit any distinct group characteristics. The last latent class, Latent Class 5, was aware that the attribute variable (SQ_ASC.class 5) was positive, which means that the currently degraded forest condition was preferred. Given the sign and magnitude of these coefficients in Group 5, this suggests that they were sensitive to the cost of forest disasters and showed WTP enough to mitigate for forest fire risks, but the choice of the status quo reflected a strong resistance to paying a forest restoration fund tax instrument. Therefore, this was a potential group where forest restoration costs and forest fire shocks had a large impact on our utility but also reflected resistance to paying taxes and to government environmental policies. This group was called the cost-sensitive resistor group.

Appendix A, Table A3 shows the details regarding marginal WTP from LCM, and we established five types of LCMs (model I~V) to analyze the economic value of the environmental attributes. We used LCM because we wanted to estimate the economic value of each attribute in our dataset using the best-fit models. In general, if all respondents had the same environmental behaviors, then the coefficients of an attribute tended to be the same WTP in each class and matched the expected sign of the researcher. However, environmental preference and behaviors are separated by each class, so when these environmental behaviors were divided into different groups, the sign of each attribute coefficient was characterized by a different sign. In other words, the sign of the attribute and the magnitude of the coefficient were logically explained and inferred according to the characteristics, environmental attitudes, and environmental preferences of the group. Looking at the WTP magnitudes of the statistically significant coefficients in each latent class, first, the coefficient of forest fire attribute was statistically significant across the board, with magnitudes estimated to range from KRW 13,431.31 (USD 10.29)~KRW 135,919 (USD 104.09). On the other hand, the negative values of the forest fire attribute were distributed from KRW -7,933.60 (USD -6.08) (fourth latent class in the Class IV model) to KRW -11,412.56 (USD 8.74) (second latent class in Class V model). For the forest pests and disease attribute, it was estimated to be KRW 27,981.1 (USD 21.43) (fifth latent class of the Class I model). Next, the forest outdoor activity restriction attribute was only significant in the third latent class of the Class III model, with an estimated value of KRW -632.18 (USD -0.48). Finally, for the economic WTP of the forest biodiversity attribute, no class or latent class showed a statistically significant value. From these results, we can interpret and use the coefficient values that were prominent in each class of models to infer the characteristics of the latent class group.

In this section, we synthesize the results of applying LCM and PCA to our experimental choice data to obtain common probability from each PCA and Model V, from which we can estimate the WTP for the main attributes, as shown in Appendix A, Table A3. The results of estimating the WTP by the attributes using the results in Table 5 and the marginal WTP in Appendix A, Table A3 that is, the WTP for each attribute was estimated using a latent class model (the class-specific WTP values are also presented in Table 6). The average WTP for each attribute was calculated by taking the weighted average of the WTP values from each class based on the class probabilities (as shown in Table 5). The average WTP for each attribute was calculated using the following procedure. First, the class-specific WTP values were multiplied by the probability of belonging to each class, and then these

values were summed. For example, the average WTP for the forest fire attribute was calculated as follows: $Average\ WTP = \sum_{i=1}^n (WTP_i * P_i)$, where WTP_i represents the WTP value for class i and P_i is the probability of being in class i . For example, the average WTP for the forest fire attribute was calculated as follows: average WTP fire = [KRW -23,576.5 * 0.0% + (KRW -11,412.6 * 1.0%) + KRW 1154.6 * 41.7% + KRW 135,919 * 53.2% + KRW 119,550.9 * 4.1%]. This resulted in an average WTP of KRW 77,529.22. This version maintains a formal tone and provides a clear explanation of the process, making it more appropriate for inclusion in a research paper. The WTP for the forest fire risk attribute was KRW 77,529.2 (USD 59.37), for the forest pests and diseases it was KRW 31,165.1 (USD 23.87), for the forest access restriction attribute it was KRW 1905.7 (USD 1.46), and for the forest biodiversity loss attribute it was KRW -1414.5 (USD -1.08). Considering the magnitude of WTP, it can be concluded that the public considers the forest fire and forest pest attributes to be important in restoring degraded forests and for providing sustainable forest ecosystem services. On the other hand, the remaining two attributes forest access restriction and forest biodiversity loss seem to have less economic significance.

Table 5. Probability results of the PCA and LCM classes.

Classification	Latent Classes				
	LCM 1	LCM 2	LCM 3	LCM 4	LCM 5
PCA1	0.0	1.0	41.7	53.2	4.1
PCA2	16.6	43.4	13.9	25.4	0.6
PCA3	19.9	0.1	37.4	42.7	0.0
PCA4	0.0	94.0	0.0	4.0	2.1
PCA5	0.0	45.4	33.4	0.4	20.8
Average	7.3	36.8	25.3	25.1	5.5

Table 6. WTP estimation results by class.

Attributes	Class 1	Class 2	Class 3	Class 4	Class 5	WTP
Forest fire	KRW -23,576	KRW -11,412	KRW	KRW	KRW	KRW
	.5	.6	1154.6	135,919.4	119,550.9	77,529.2
	(USD -18.06)	(USD -8.74)	(USD 0.88)	(USD 104.09)	(USD 91.55)	(USD 59.37)
Forest pests and diseases	KRW	KRW 1479.5	KRW	KRW	KRW	KRW
	62,244.2	(USD 1.13)	5318.5	77,053.9	-22,697.5	31,165.0
	(USD 47.67)		(USD 4.07)	(USD 59.01)	(USD -17.38)	(USD 23.87)
Forest access restrictions	KRW	KRW	KRW	KRW	KRW	KRW
	6272.6	-311.1	-871.4	2311.7	1625.5	1905.7
	(USD 4.80)	(USD -0.24)	(USD -0.67)	(USD 1.77)	(USD 1.24)	(USD 1.46)
Forest biodiversity loss	KRW	KRW	KRW	KRW	KRW	KRW
	-10,773.7	-1859.1	-670.4	7976.6	809.0	-1414.5
	(USD -8.25)	(USD -1.42)	(USD -0.51)	(USD 6.11)	(USD 0.62)	(USD -1.08)

WTP	KRW 34,166.6 (USD 26.17)	KRW −12,103.2 (USD −9.27)	KRW 4931.3 (USD 3.78)	KRW 223,261.5 (USD 170.98)	KRW 99,288.0 (USD 76.04)	KRW 109,185.5 (USD 83.62)
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Note: we calculated the confidence interval at 95% of the WTP and gained almost the same value at two decimal places.

3.2.4. Simulation Results for Forest Restoration Policy Acceptance Using LCM

To evaluate the implications of the estimated LCM, we simulated the overall acceptability of forest restoration policies under a realistic scenario. The estimated utility coefficients for the five latent classes—each with six choice parameters—and four class membership constants were applied. In this simulation, the policy alternative was defined as a forest restoration program with the most ecologically favorable attributes allowed under real-world constraints. Specifically, the scenario assumed the lowest fire risk (Level 4), the lowest pest and disease risk (Level 4), the minimal biodiversity loss (0), and the minimal but necessary access restriction (KRW 1 million). The restoration cost attribute was set at KRW 20,000, reflecting a reasonable financial burden for respondents. The alternative-specific constant (ASC) was set to 1 to represent the policy alternative, while the status quo was assigned $ASC = 0$ with the worst environmental conditions and zero cost (Table 7).

To calculate the overall acceptability of this scenario, we applied a weighted probability aggregation method using the class membership shares and the class-specific choice probabilities. The formula is expressed as follows:

$$P_{total} = \sum_{c=1}^5 \pi_c \cdot P_c,$$

where

P_{total} is the total policy acceptance rate across the population;

π_c is the probability of belonging to Latent Class C;

P_c is the multinomial logit-based choice probability for the policy in Class C.

Each P_c is a conditional probability within its respective class; therefore, the sum $\sum P_c$ can exceed 1. The actual overall acceptance must be computed as a weighted average using the posterior class membership probabilities π_c , ensuring that the final total acceptance rate remains between 0 and 1.

Table 7. Class-specific policy acceptance under the realistic scenario.

Classes	Class Probability (π_c)	Policy Choice Probability (P_c)	Weighted Probability ($\pi_c \times P_c$)
Class 1	37.74%	3.48%	1.31%
Class 2	15.89%	0.06%	0.01%
Class 3	6.35%	0.01%	≈0.00%
Class 4	28.58%	40.12%	11.47%
Class 5	11.44%	66.66%	7.62%

Notes: All other attributes were fixed to represent an environmentally optimal scenario with minimum required access restriction. And Table 7 presents the results obtained from the author's own simulation experiment.

These results show that the total weighted and predicted policy acceptance rate under the given scenario was approximately 20.4%. Most of the support stemmed from Class 4 and Class 5, who exhibited higher sensitivity

to positive ecological outcomes and were relatively tolerant to moderate restoration costs. In contrast, Classes 2 and 3, which show strong cost aversion, contributed minimally to the overall acceptance. These findings suggest that balancing ecological restoration benefits with moderate financial and behavioral burdens is key to maximizing public support for forest restoration policies.

In addition, to evaluate the policy implications of the estimated LCM, we conducted a simulation of the overall policy acceptance rate under various forest restoration cost scenarios. In this exercise, we applied the estimated coefficients for the five latent classes (each with six utility parameters and four class membership constants) obtained from our LCM. The goal was to identify a realistic policy alternative that maximizes social acceptance while maintaining necessary constraints for implementation. We fixed certain attributes to represent an ideal forest restoration program under real-world constraints. Specifically, the fire risk level was set at the safest level (Level 4: Blue), pest and disease impacts were minimized (Level 4), forest access restriction was fixed at the lowest feasible level (KRW 1 million, representing minimal but necessary restrictions), and biodiversity loss was assumed to be negligible. The alternative-specific constant (ASC) was set to 1 to indicate the active policy alternative, while the status quo alternative was represented with the worst-case environmental conditions and zero cost. The cost attribute varied systematically from KRW 10,000 to KRW 50,000 in increments of KRW 5,000. For each cost level, we computed the utility for the policy and status quo alternatives for each latent class, calculated the class-specific choice probabilities using the multinomial logit formula, and then aggregated these using the class membership probabilities. This provided the expected overall policy acceptance rate for each cost level.

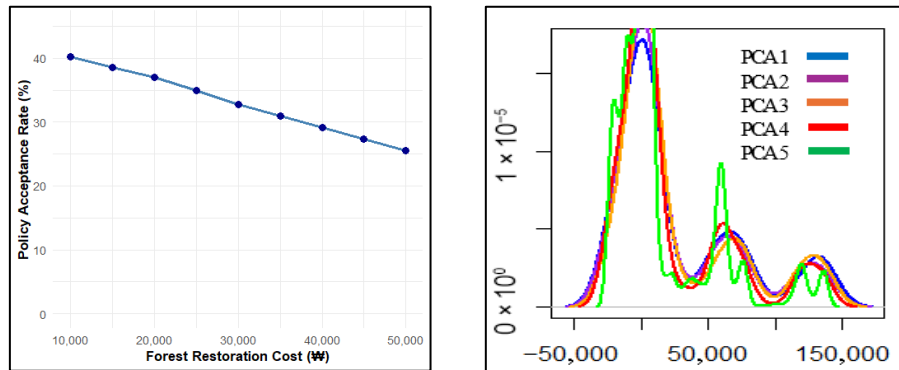


Figure 1. Simulation results of the policy acceptance rate on forest restoration cost using latent class modeling (Left) and a probability density function of individual WTP using PCA (Right).

The simulation results, as shown in Figure 1 (Left), reveal that the policy acceptance rate decreased monotonically with increasing costs. At KRW 10,000, the acceptance rate was approximately 40%, while at KRW 50,000, it dropped to below 30%. This highlighted the sensitivity of the population—particularly cost-averse latent classes—to even modest increases in forest restoration fund contributions. The optimal policy design under realistic constraints, therefore, lies in the cost range of KRW 10,000 to KRW 20,000, where

acceptance is maximized without compromising ecological feasibility. And the results in Figure 1 (right) present the density of the individual WTP, indicating that WTP declines as the payment amount increases, regardless of class membership.

4. Discussion

This study investigated the heterogeneity in public preferences [27,69–71] and the acceptability of forest restoration policies in Korea, aiming to support the efficient design and implementation of strategies for restoring degraded forests and ecosystems. A choice experiment survey was conducted with 1021 Korean citizens aged 20 and older, yielding 10,210 individual choice observations. Based on this dataset, five distinct latent classes were identified using latent class modeling (LCM) and principal component analysis (PCA) through such a segmentation approach (latent environmental classes): an acceptance group of environmental policies, a support group for environmental policy, a resistance group to environmental policy, an indifferent group to environmental policies, and a group for seeking environmental technological solutions to environmental problems.

As summarized in Table 1, the attributes included restoration cost, biodiversity loss, restrictions on forest access, forest fires, and pest outbreaks. The LCM results enabled estimation of marginal willingness to pay (WTP) for each class and showed that, even for identical attributes, preference directions and WTP values differed substantially across classes. For instance, some groups displayed strong sensitivity to restoration cost, while others prioritized biodiversity loss or access restrictions. This pattern highlights substantial variation in the environmental values and attitudes among the public, and it is consistent with broader evidence from environmental choice experiments in Europe and North America [20,72,73]. Rather than generalizing such results, they are better understood as suggestive trends that may highlight directions of potential interest for future research, but they also lack sufficient robustness for direct policy application [74].

To address this heterogeneity, restoration strategies should reflect the environmental preferences of different segments of the population. For instance, highly engaged citizens could be mobilized through participatory programs, such as tree planting and environmental campaigns, while less engaged groups may benefit more from awareness-raising efforts and targeted education. These approaches align with previous studies showing that tailoring engagement strategies to audience characteristics can increase the effectiveness of forest conservation programs [75,76]. Given that wildfires and pest outbreaks are often linked to human behavior, preventive education and proactive communication are essential, particularly during high-risk periods.

Our findings provide a richer explanation for degraded forest restoration management than the general assumption of homogeneous environmental preferences. The empirical application of an integrated latent choice model in the management of forest restoration after degradation due to environmental threats greatly contributes to our understanding of restoration choice behavior. This approach is consistent with studies advocating for hybrid or integrated models to capture complex behavioral drivers in environmental valuation [15,77]. Such a

model would also be useful to apply to other complex environmental issues involving multiple stakeholders across diverse contexts.

Simulations of policy acceptance under varying cost levels, directly linked to the restoration cost attribute in Table 1 and the experimental structure illustrated in Table 2, revealed that acceptance exceeded 40% for policies costing less than KRW 10,000, which dropped to approximately 30% for costs between KRW 10,000 and KRW 35,000 and fell again to around 25% for costs of KRW 50,000. These findings mirror patterns in other stated preference studies, where public acceptance of environmental levies declines steeply beyond low-to-moderate payment levels [78]. This underscores the importance of setting realistic cost thresholds to ensure broad public support.

Finally, given that most wildfires in Korea are caused by human negligence, forest fire prevention strategies may benefit from the integration of behavioral economics approaches. Methods such as nudging, social norm messaging, emotional framing, and default settings could help influence public behavior and promote responsible forest use. This suggestion aligns with recent experimental studies demonstrating the effectiveness of behavioral interventions in encouraging pro-environmental behaviors [79,80]. Incorporating these insights may offer an innovative and effective direction for both wildfire prevention and broader forest policy development in Korea.

Our policy recommendations thus suggest tailoring restoration strategies to the different preference segments identified in this study and the attributes, as summarized in Table 1, ranging from participatory programs for highly engaged citizens to awareness-raising campaigns for less engaged groups. However, the feasibility of these strategies is contingent upon financial and institutional constraints. For example, local governments may face budgetary limitations in allocating resources for restoration and education programs, while the Korea Forest Service may encounter jurisdictional or administrative barriers in expanding policy implementation. Moreover, successful enforcement of restoration measures requires the cooperation of local residents, whose support cannot be assumed without appropriate incentives or trust-building mechanisms. Therefore, while our recommendations offer differentiated strategies, their implementation should be carefully evaluated within the broader financial and institutional context to ensure both effectiveness and cost-efficiency.

5. Conclusions

This study, which considered the involvement of diverse stakeholders and the localized and variable nature of forest disasters, demonstrates the importance of accounting for latent environmental preferences and policy acceptance when designing forest restoration policies. By identifying distinct preference groups and their willingness to pay, the findings offer valuable insights for tailoring policies to improve acceptance and effectiveness. There is considerable preference heterogeneity with a group of latent stakeholders assigning relatively higher importance to the factors they perceive. This heterogeneity underlines the need to measure a wide range of outcome dimensions when evaluating forest restoration policy, including latent environmental

classes. We conclude that multidimensional measures have further informed our understanding of environmental risks and ecosystem services.

While this study provides useful policy implications, it also has several limitations. First, multicollinearity among attributes may influence the estimation results, and future studies should consider strategies to address this issue. Second, increasing the sample size would enhance the robustness of simulations and enable more detailed subgroup analysis. Differences in the preferences between urban and rural residents or between those with and without experience of forest-related disasters warrant further investigation. We will analyze how the attribute coefficients change and how the overall explanatory power of the model can be improved by simultaneously adding environmental attitudes and socioeconomic variables in a future paper using the hybrid choice model [67]. In addition, considering forest fire and pests and disease attributes, the impact on the utility may be similar, in which case we want to test which of the two attributes respondents are more responsive to, or vice versa (attribute of non-attendance) [68].

In addition, the findings are context-specific and reflect the Korean case, which limits the generalizability of the results to other cultural and institutional settings. The sample also slightly overrepresents respondents from metropolitan areas, which may bias estimates of preference heterogeneity by under- or over-emphasizing certain regional attitudes. These limitations highlight the need for caution when extrapolating our results and suggest directions for future research. In particular, cross-country comparative studies and more balanced sampling strategies will be important to validate and extend the findings.

Overall, our results suggest that differentiated strategies are needed to align restoration costs with public acceptance levels and to design engagement programs that reflect heterogeneous environmental preferences. These policy implications complement the limitations noted above and point toward practical avenues for more effective forest governance.

Appendix A

Appendix A.1

Table A1. Demographic characteristics of the respondents (N=1,021).

Variables	Description of Variables	Frequencies (ratio)	Mean	Standard Deviation
Gender	1. Male	452 (44.3%)	1.56	0.49
	2. Female	569 (55.7%)		
Age	1. 20 ~ 29	178 (17.4%)	2.6	1.16
	2. 30 ~ 39	352 (34.5%)		
	3. 40 ~ 49	269 (26.3%)		
	4. 50 ~ 59	140 (13.7%)		
	5. Older than 60	82 (8.0%)		
Education	1. Primary school or below	3 (0.3%)	3.96	0.57
	2. Secondary school	7 (0.7%)		
	3. High school	146 (14.3%)		
	4. University	732 (71.7%)		
	5. Postgraduate or above	133 (13.0%)		
Employment status	1. Students	43 (4.2%)	2.13	1.59
	2. Employed full time	613 (60.0%)		
	3. Housekeeper	173 (16.9%)		
	4. Public officer	67 (6.6%)		
	5. Unemployment	64 (6.3%)		
	6. Others	61 (6.0%)		
Monthly income level (in USD)	1. Below KRW 2,000,000 (USD 1538)	112 (11.0%)	3.23	1.34
	2. KRW 2,000,000~KRW 2,900,000 (USD 1538~USD 2231)	225 (22.0%)		
	3. KRW 3,000,000~KRW 3,900,000 (USD 2308~USD 3000)	265 (26.0%)		
	4. KRW 4,000,000~KRW 4,900,000 (USD 3077~USD 3769)	155 (15.2%)		
	5. More than KRW 5,000,000 (USD 3846)	264 (25.9%)		

Table A2. The total variance of environmental attitudes and behaviors.

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	Percent of Variance	Cumulative Percent	Total	Percent of Variance	Cumulative Percent	Total	Percent of Variance	Cumulative Percent
1	5.13	25.66	25.66	5.13	25.66	25.66	2.75	13.75	13.75
2	2.83	14.17	39.84	2.83	14.17	39.84	2.69	13.47	27.23
3	1.40	7.03	46.87	1.40	7.03	46.87	2.32	11.61	38.84
4	1.24	6.21	53.09	1.24	6.21	53.09	2.20	11.01	49.86
5	1.03	5.16	58.26	1.03	5.16	58.25	1.67	8.39	58.25

Table A3. Marginal WTP estimation result by each type of class model (I~V) using LCMs.

Attribute		Model I	Model II	Model III	Model IV	Model V
Latent Class 1	Forest fire.class1	KRW 13,431.31 ** (USD 10.3)	KRW 61,933.74 *** (USD 47.4)	KRW 86,045.00 *** (USD 65.9)	KRW 54,939.13 *** (USD 42.1)	KRW -23,576.50 (USD -18.1)
	Forest pests and diseases.class1	KRW 9204.96 (USD 7.0)	KRW 20,441.79 (USD 15.7)	KRW 27,981.10 * (USD 21.4)	KRW 33,365.09 (USD 25.6)	KRW 62,244.18 (USD 47.7)
	Forest access restrictions.class1	KRW -66.86 (USD -0.1)	KRW 1126.24 (USD 0.9)	KRW 2144.13 (USD 1.6)	KRW 668.24 (USD 0.5)	KRW 6272.59 (USD 4.8)
	Forest Biodiversity loss.class1	KRW 86.52 (USD 0.1)	KRW 53.87 (USD 0.0)	KRW 487.49 (USD 0.4)	KRW 1855.59 (USD 1.4)	KRW -10,773.68 (USD -8.3)
Latent Class 2	Forest fire.class2	-	KRW -4790.48 (USD -3.7)	KRW 171,195.40 (USD 131.1)	KRW -21,250.62 (USD -16.3)	KRW -11,412.56 *** (USD -8.7)
	Forest pest and disease.class2	-	KRW 3403.32 (USD 2.6)	KRW 55,180.60 (USD 42.3)	KRW -30,880.53 (USD -23.6)	KRW 1479.51 (USD 1.1)
	Forest access restrictions.class2	-	KRW -723.44 (USD -0.6)	KRW 22,304.35 (USD 17.1)	KRW -4322.33 (USD -3.3)	KRW -311.10 (USD -0.2)
	Forest Biodiversity loss.class2	-	KRW -215.01 (USD -0.2)	KRW -65,910.20 (USD -50.5)	KRW 1956.75 (USD 1.5)	KRW -1859.05 (USD -1.4)
Latent Class 3	Forest fire.class3	-	-	KRW -4621.50 (USD -3.5)	KRW 90,643.93 *** (USD 69.4)	KRW 1154.55 (USD 0.9)
	Forest pests and diseases.class3	-	-	KRW 4740.00 (USD 3.6)	KRW -13,063.63 (USD -10.0)	KRW 5318.51 (USD 4.1)
	Forest access restrictions.class3	-	-	KRW -632.18* (USD -0.5)	KRW 2066.44 (USD 1.6)	KRW -871.41 * (USD -0.7)
	Forest Biodiversity loss.class3	-	-	KRW -816.95 (USD -0.6)	KRW 785.07 (USD 0.6)	KRW -670.35 (USD 0.5)
Latent Class 4	Forest fire.class4	-	-	-	KRW -7933.60 * (USD -6.1)	KRW 135,919.37 ** (USD 104.1)
	Forest pests and diseases.class4	-	-	-	KRW 3497.82 (USD 2.7)	KRW 77,053.85 (USD 59.0)
	Forest access restrictions.class4	-	-	-	KRW -458.98 (USD -0.4)	KRW 2311.65 (USD 1.8)
	Forest Biodiversity loss.class4	-	-	-	KRW -888.75 (USD -0.7)	KRW 7976.62 (USD 6.1)
Latent Class 5	Forest fire.class5	-	-	-	-	KRW 119,550.87 *** (USD 91.6)
	Forest pests and diseases.class5	-	-	-	-	KRW -22,697.46 (USD -17.4)
	Forest access restrictions.class5	-	-	-	-	KRW 1625.52 (USD 1.2)
	Forest Biodiversity loss.class5	-	-	-	-	KRW 809.03 (USD 0.6)

***: $p < 0.001$, **: $p < 0.05$, and *: $p < 0.1$.

Appendix B

Table A4. The respondents' environmental attitude and behavior results.

1. To what extent do you personally agree with the following statements?			
Items	Mean	Mode	Standard deviation
1. I am the kind of person who loves spending time in wild, untamed wilderness areas.	3.55	4	0.96
2. Being out in nature is a great stress reducer for me.	3.95	4	0.79
3. I have a sense of well-being in the silence of nature.	3.99	4	0.78
4. I find it more interesting in the forest looking at trees and birds than in a shopping mall.	3.64	4	0.96
5. Nature is important because of what it can contribute to the pleasure and welfare of humans.	4.15	4	0.81
6. What concerns me most about deforestation is that there will not be enough lumber for future generations.	3.72	4	1.00
7. We should protect the environment for the well-being of plants and animals rather than for the welfare of humans.	3.56	4	1.01

8. Conservation is important even if it lowers peoples' standard of living.	3.71	4	0.92
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2. To what extent do you personally agree with the following statements?			
Items	Mean	Mode	Standard deviation
1. Most environmental problems can be solved by applying more and better technology.	3.53	4	0.91
2. Science and technology will eventually solve our problems with pollution, overpopulation, and diminishing resources.	3.54	4	0.95
3. If things continue their present course, we will soon experience a major ecological catastrophe.	4.08	4	0.82
4. The Earth is like a spaceship with very limited room and resources.	4.03	4	0.82
5. The balance of nature is very delicate and easily upset.	3.84	4	0.89

3. To what extent do you personally agree with the following statements?			
Items	Mean	Mode	Standard deviation
1. I make sure that during the winter the heating system in my room is not switched on too high.	3.98	4	0.77
2. In my daily life I try to find ways to conserve water or power.	3.95	4	0.81
3. Even if public transportation was more efficient than it is, I would prefer to drive my car.	2.94	2	1.24
4. It is all right for humans to use nature as a resource for economic purposes.	3.08	3	1.03
5. The question of the environment is secondary to economic growth.	3.57	4	1.07
6. The benefits of modern consumer products are more important than the pollution that results from their production and use.	2.97	2	1.13
7. I would like to join and actively participate in an environmentalist group.	3.20	3	1.02

Table A5. The PCA results with IBM SPSS 24 (28.0.1.1).

Variables	Components				
	1	2	3	4	5
A3_6	0.782	−0.018	−0.108	0.189	−0.148
A3_4	0.752	0.021	−0.155	0.095	−0.096
A2_2	0.656	0.130	0.017	−0.074	0.457
A2_1	0.610	0.109	0.084	−0.047	0.492
A3_5	0.593	0.033	0.259	0.022	0.026
A3_3	0.545	0.085	−0.195	0.360	−0.203
A1_3	0.025	0.758	0.296	0.078	0.064
A1_2	0.052	0.756	0.199	0.202	0.143
A1_4	0.087	0.727	0.033	0.188	0.004
A1_1	0.096	0.689	0.051	0.238	0.102
A2_4	−0.061	0.159	0.806	0.087	0.094
A2_3	−0.073	0.188	0.724	0.167	0.143
A2_5	0.078	0.104	0.655	0.273	0.079
A1_5	−0.089	0.461	0.462	−0.073	0.230
A1_7	0.098	0.164	0.168	0.725	0.090
A3_7	0.213	0.123	0.050	0.704	0.102
A1_8	−0.081	0.344	0.183	0.624	0.195
A1_6	0.092	0.170	0.330	0.485	0.113
A3_1	−0.090	0.096	0.187	0.148	0.698
A3_2	−0.017	0.158	0.140	0.315	0.689

Notes: Extraction method—principal component analysis; rotation method—varimax with Kaiser normalization, where rotation converged in six iterations.

Table A6. Class-specific respondent characteristics.

	Class 1 (n = 150)		Class 2 (n = 138)		Class 3 (n = 206)		Class 4 (n = 281)		Class 5 (n = 246)	
	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation
Socioeconomic background										
Gender	1.52	0.50	1.51	0.50	1.46	0.49	1.58	0.49	1.67	0.47
Age	37.63	8.77	41.49	12.45	36.75	11.07	42.26	12.26	42.69	11.31
Income	3.11	1.20	3.03	1.33	3.33	1.36	3.30	1.34	3.26	1.38
Education	3.95	0.41	3.75	0.62	3.99	0.56	4.01	0.58	4.02	0.58
Environmental attitudes and behaviors										
A1 1	4.26	0.54	3.12	0.70	2.85	1.16	3.58	0.67	2.39	1.73
A1 2	4.68	0.49	3.21	0.61	3.48	0.96	3.90	0.33	3.91	0.90
A1 3	4.56	0.52	3.27	0.66	3.58	0.97	3.97	0.45	4.37	0.58
A1 4	4.36	0.67	3.17	0.70	3.05	1.17	3.65	0.65	4.40	0.58
A1 5	4.47	0.60	3.40	0.63	3.90	1.06	4.05	0.51	3.96	0.89
A1 6	4.47	0.57	3.22	0.62	3.08	1.18	3.74	0.73	4.71	0.50
A1 7	4.49	0.55	3.03	0.71	2.97	1.16	3.63	0.76	4.04	1.04
A1 8	4.50	0.51	3.07	0.65	3.00	1.10	3.72	0.58	3.72	0.98
A2 1	4.23	0.69	3.29	0.55	3.36	1.01	3.55	0.72	4.16	0.70
A2 2	4.37	0.83	3.31	0.60	3.45	1.03	3.52	0.71	3.35	1.07
A2 3	4.46	0.68	3.30	0.60	3.74	1.04	4.00	0.53	3.28	1.07
A2 4	4.38	0.65	3.28	0.59	3.68	1.06	3.93	0.48	4.68	0.46
A2 5	4.50	0.57	3.19	0.57	3.34	1.05	3.82	0.53	4.62	0.54
A3 1	4.35	0.53	3.46	0.56	3.64	1.00	3.95	0.48	4.25	0.88
A3 2	4.58	0.55	3.49	0.60	3.48	1.00	3.89	0.47	4.37	0.73
A3 3	4.44	0.78	3.22	0.68	2.74	1.25	2.89	1.00	4.28	0.75
A3 4	4.11	0.98	3.18	0.56	3.19	0.95	3.18	0.79	2.11	1.08
A3 5	4.43	0.57	3.36	0.55	3.59	1.01	3.50	0.87	2.18	0.81
A3 6	4.36	0.71	3.21	0.54	3.04	1.09	2.98	0.88	3.24	1.44
A3 7	4.13	1.16	2.86	0.71	2.54	1.07	3.31	0.69	1.91	0.79
Follow-up questions: WTP resistance, attribute ranking, consequentiality, questionnaire relevant questions, others										
D1 1	3.48	1.23	3.40	0.73	3.21	1.09	3.36	0.77	3.25	0.88
D1 2	3.65	1.14	3.40	0.55	3.49	0.85	3.46	0.65	3.17	1.04
D1 3	3.13	1.35	2.97	0.72	2.87	1.03	2.69	0.88	3.59	0.70
D1 4	3.13	1.33	3.04	0.66	2.67	1.12	2.63	0.92	2.39	0.91
D1 5	3.23	1.26	3.03	0.74	3.18	1.05	2.91	0.89	2.22	0.98
D1 6	3.31	1.34	3.20	0.68	3.10	1.12	2.93	0.84	2.54	0.99
D1 7	3.50	1.17	3.40	0.73	3.54	0.99	3.43	0.84	2.74	1.08
D1 8	3.50	1.21	3.34	0.69	3.43	0.96	3.22	0.81	3.33	1.07
D1 9	2.79	1.44	2.93	0.66	2.73	1.10	2.43	0.86	3.03	1.05
D2 1	2.00	1.16	1.70	1.13	2.05	1.29	1.91	1.36	1.78	0.70
D2 2	2.65	1.19	2.75	1.13	2.54	1.22	2.68	1.13	1.98	1.38
D2 3	2.91	1.28	3.08	1.13	2.88	1.16	3.03	1.20	2.64	1.15
D2 4	3.44	1.19	3.30	1.20	3.30	1.19	3.30	1.13	2.91	1.21
D2 5	4.00	1.34	4.17	1.21	4.23	1.14	4.09	1.25	3.29	1.14
D3 1	4.11	0.68	3.18	0.65	3.04	1.00	3.48	0.66	4.18	1.15
D3 2	4.19	0.72	3.10	0.62	3.08	0.99	3.36	0.73	3.35	0.89
D4 1	4.16	0.68	3.28	0.63	3.47	0.94	3.52	0.60	3.34	0.93
D4 2	4.25	0.77	3.34	0.64	3.52	0.79	3.56	0.62	3.71	0.73
D4 3	4.24	0.77	3.30	0.63	3.42	0.86	3.63	0.65	3.79	0.69
D4 4	4.04	0.86	3.26	0.68	3.33	0.98	3.34	0.75	3.88	0.78
D4 5	4.28	0.72	3.34	0.58	3.33	0.93	3.52	0.63	3.40	0.98

15/06/2023

Dear Chulhyun

Ethics Application Form : A choice experiment study between ecosystem services and forest risks for sustainable forest management 14107

Thank you for your submission of the above ethics application.

The ethical approaches of this project have been approved and you can now proceed with your project.

Please note that should any of your proposal change, a further amendment submission will be necessary.

If you have any further queries, please do not hesitate to contact the Panel by email to ethics@stir.ac.uk

Yours sincerely,

General University Ethics Panel

Figure A1. Ethics approval of the questionnaire survey.

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Chapter 4

*(A Hybrid Choice Modelling Approach to Valuing Forest Restoration Through
Environmental Attitudes: A Korean Case Study)*

Goodall (2009) – “Each one of us matters, has a role to play, and makes a difference. Each choice we make as consumers, as citizens of our countries, and as inhabitants of our planet, reflects the state of our attitudes and awareness. If enough people are aware, care deeply, and act positively, change can happen.”

A Hybrid Choice Modelling Approach to Valuing Forest Restoration Through Environmental Attitudes: A Korean Case Study

Abstract

Forest ecosystems are increasingly degraded by natural disasters and human intervention, creating an urgent need for restoration. To secure the financial resources necessary for these efforts, it is essential to understand how citizens' environmental attitudes influence their willingness to pay (WTP) and shape their preferences for restoration policies. This study applies data from a discrete choice experiment on forest restoration in Korea, employing a hybrid choice modelling framework that integrates a mixed logit model with latent class analysis. Environmental attitudes were incorporated as latent variables, enabling the estimation of the heterogeneous WTP across restoration attributes and the identification of distinct attitudinal segments. The combined modelling approach revealed significant preference heterogeneity, with clear differences in the WTP across attributes and attitudinal classes. Environmental attitudes were found to exert a statistically significant and substantial effect on the WTP, while the hybrid choice framework allowed for the inclusion of unobserved behavioural factors, improving the explanatory power of the model. The estimated WTP values provide critical economic justification for urgent forest restoration initiatives. Moreover, the identification of two distinct attitudinal segments offers valuable guidance for developing behaviourally targeted and more effective forest restoration policies that align with public preferences.

Keywords: forest restoration; hybrid choice model; environmental attitudes; forest fires; willingness to pay

1. Introduction

Ecosystem disturbances by forest disasters and human action are increasingly undermining the provision of sustainable ecosystem services such as recreation activities, water quality improvement, and carbon sequestration [1,2]. Addressing these challenges requires substantial budgets for restoring and managing deforested and degraded forests. However, stakeholders such as citizens and environmental NGOs exhibit diverse and heterogeneous preferences for environmental issues, reflecting varied perceptions of the benefits and costs of ecosystem services. Psychological factors such as attitudes, values, and perceptions significantly influence environmental decision-making [3] beyond traditional socioeconomic determinants. This study aims to reflect attitudinal decision-making measures by incorporating psychological dimensions, particularly environmental attitudes and behaviours, alongside established economic theories (Mariel et al., 2024) [4]. By integrating these latent environmental attitudes, our model offers an understandable framework for explaining willingness to pay (WTP) for various environmental behaviours.

Forests worldwide face significant pressures from deforestation and forest degradation, driven by anthropogenic factors such as forest fires [57], invasive species [5], forest conversion, and illegal logging [6,53]. These disturbances threaten forest health and vitality, reducing their ability to deliver goods and ecosystem services. In Korea, forest fires and outbreaks of pests and diseases have intensified over the past two decades (KFS, 2023) [7,67]. Globally, wildfires cause an estimated USD 50 billion in annual damages and released

approximately 6,450 megatons of CO₂ in 2021 [57]. Damages due to invasive species have exceeded USD 1.288 trillion over the past 50 years, with costs projected to rise [58]. To address these environmental challenges, a proactive approach to sustainable forest management is essential. Understanding the underlying causes of these threats—particularly through research into stakeholders’ latent environmental preferences and choice behaviours—is crucial for developing effective management strategies. When designing policy-relevant discrete choice experiments (DCEs) that accurately reflect respondents’ decision-making processes, it is essential to incorporate cognitive elements that influence their choices [8,9].

Hybrid choice models (HCMs), including latent-class HCMs and mixed logit models (MXLs), offer more flexibility in integrating attitudes and latent behaviours into decision-making frameworks, which otherwise assume homogeneous preferences across individuals. While MXLs capture unobserved heterogeneity through random parameters, HCMs complement these models by capturing underlying psychological constructs, allowing for a more comprehensive understanding of choice behaviour [10–12]. Combined and mixed-modelling approaches are more suitable than traditional economic behaviour models in addressing the complexity of environmental challenges, because a comprehensive understanding of citizens’ environmental decision-making is also crucial. This study, therefore, applies latent class hybrid choice experiments, extending conventional choice experiments to better reflect the intricacies of environmental decision-making. We further demonstrate that this modelling approach must vary depending on the data structure of indicators or alternative choices (choice sets). Indicators or alternatives may be continuous, ordered, or ordinal (or cardinal), with studies by Maya et al. (2024) [59] and Kim et al. (2014) [10] addressing continuous latent variables, and other studies utilising ordered data [13,14,60]. Our study, using these ordered data structures, aims to estimate latent behaviours through two indicators representing latent environmental attitudes, relying on different theoretical frameworks than the continuous data structure. This approach is achievable only through the HCM framework. Additionally, principal component analysis (PCA) is applied to the 20 items to categorise respondents by latently distinct environmental attitudes, and these results are integrated into the hybrid model, producing insightful findings, with additional insights drawn from mixed logit models.

The contribution of this study is its application of a latent-class HCM to forest management policy, including essential forestry attributes such as forest fire risk, forest pests, and disease risk attributes, making this the first discrete choice modelling study to simultaneously address these environmental risks [15,16]. Integrating latent environmental behaviours and attitudes into the model contributes meaningfully to forestry research [17,62], and these findings can ultimately improve the effectiveness of forest restoration policies. The purpose of this study is to examine the influence of environmental attitudes and to estimate the WTP to support a shift toward behaviour-based design in sustainable restoration policies for forest management. The structure of this paper is as follows: Section 2 outlines the econometric methods and the relevant literature; Section 3 presents the case study; Section 4 discusses the estimation results; and Section 5 concludes with a summary of our findings.

2. Theoretical Background

Environmental concerns, which reflect our latent attitudes toward the environment and anticipated behaviours, represent a complex construct that encompasses a wide variety of environmental preferences. Mediated by knowledge and institutional factors, environmentalism influences the immediate costs perceived by individuals, while also capturing the interactions between environmental attitudes and behaviours. Given the latent nature of these environmental issues, HCMs provide an effective framework for their analysis [18]. Econometrically, the environmental latent variable model comprises two main components: structural equations that relate latent variables to observed exogenous variables and measurement equations that link these latent constructs to survey-based indicators. Because latent variables are not directly observed, they are inferred from individuals' responses to attitudinal and behavioural questions. Depending on the response format, these indicators may be ordered (as in our data), binary, categorical, or continuous. Notably, the standard random utility model used in discrete choice analysis also embodies latent structures. The utility associated with each alternative—although unobservable—is inferred from revealed or stated choices, which function as indirect indicators of the decision-making process.

The issue of threatened forests and sustainable ecosystem services such as recreation activities and water contamination in Korea provides a compelling context for applying the DCE and HCM. Forest management policies in Korea are increasingly challenged by external threats such as forest fires, pests, and diseases, all of which compromise the ecological integrity of forest systems and the services they deliver. Forest restoration involves complex trade-offs among ecological, economic, and social objectives, and stakeholder preferences are often diverse and fragmented. In this context, the utility derived from forest policy alternatives—both in terms of direct and indirect benefits—can be better understood by evaluating multiple relevant attributes. A key contribution of this study lies in the integration of psychological variables, including latent attitudes and behaviours. While previous models have primarily focused on economic and socioeconomic determinants, our approach addresses this gap by incorporating attitudinal dimensions, enabling the segmentation of heterogeneous preferences.

2.1. Latent Class Hybrid Choice Modelling

The theoretical assumptions of environmental behaviour and the foundational concepts underpinning the HCM were introduced above. In this subsection, we provide a detailed description of the HCM used to estimate these assumptions, focusing on the integrated choice latent variable model and the inclusion of flexible disturbances [19–21]. The integrated choice latent variable framework offers a more nuanced representation of the economic choice process by incorporating unobserved psychometric attitude variables as latent variables in the environmental choice model [54,55,63]. These environmental attitude variables reflect the importance that individuals place on different attributes of alternatives. They are linked to individual heterogeneity, such as variations in environmental preferences, which, in turn, reflect personal tastes, needs, and environmental values. These factors evolve and are influenced by experience, as well as by external variables such as the

socioeconomic characteristics of the decision-maker [20]. Ben-Akiva et al. (2002) [9] comprehensively explained the theoretical foundations, advantages, procedures, and challenges associated with HCM. Furthermore, Vij and Walker [22] extended the application of the integrated choice latent variable model by incorporating latent structural variables, such as attitudes, norms, cognitive perceptions, and beliefs, into an environmental recycling choice model.

The methodology for our HCM application is grounded in choice modelling [23,24] and based on the random utility model. Our approach aims to provide more realistic and comprehensive explanations and outcomes by incorporating heterogeneous environmental attitudes and behaviours—factors often overlooked in previous economic decision-making models. The first theoretical component of our study is DCM, a highly flexible statistical methodology with diverse applications across various fields, including health [13], transportation mode selection [18,22,25,63], environmental economics [14,17,26], and agricultural economics [27,28]. Specifically, there is a lack of research applying latent-class HCM in environmental economics [3,11,21,54], making this approach rare in our field. The second theoretical component is the economic theory of random utility maximization (RUM) proposed by McFadden (1974) [29] and Luce (1958) [30].

Given this gap in the literature, we apply statistical methodologies, latent-class choice modelling and PCA. This section focuses on the theoretical background of HCM. To better understand the latent and complex attributes behind the choices in our DCE data, we use HCM, a type of latent-class model that employs a probabilistic class allocation model. HCM consists of two sub-models: the first part is the class-specific choice model, which assigns the probability of choosing each alternative, and the second part is the class membership model, which estimates the likelihood of an individual belonging to a particular class [31,61,65,66].

In a latent-class model, the class-specific choice model specified with the multinomial logit model returns the probability that individual n chooses a specific alternative i on choice task t , given that respondents belong to a certain class q . In our empirical analysis, we adopt a linear-in-parameters specification, and the utility of individual n is derived from choosing an alternative i in choosing task t , given that respondents belong to the class q . This is formulated in Equation (1):

$$U_{nit|q} = V_{nit|q} + \varepsilon_{nit|q} = ASC_i + \beta'_q x_{nit} + \varepsilon_{nit|q}, \quad (7)$$

where U_{int} represents the overall utility, $V_{nit|q}$ is the observed part of the conditional indirect utility for individual n choosing alternative i in the choice situation t (alt1, alt2, alt3) conditioned on class q , and $\varepsilon_{nit|q}$ refers to an independently and identically distributed extreme type-I error term over individuals, alternatives, and classes. x_{nit} is the vector of the observed attributes of alternative i . It normally includes an alternative specific constant (ASC) which captures the systematic utility of omitted variables [64]. β'_q is the vector of unknown parameters that need to be estimated, and x_{nit} denotes the explanatory variables, consisting of key attributes and levels related to alternative i . For the theoretical background on choice probability, see the work of Train (2009) [68] and Mariel et al. (2021) [23]. To estimate the marginal WTP, we usually divide the coefficient of the nonmonetary attributes by the negative of the coefficient of the cost attributes, calculated

separately for each latent class. This implicit price is useful for demonstrating the trade-offs between attributes. Comparing the implicit prices reflected by respondents' environmental preferences for attribute and level combination choices helps us to understand the relative importance and the relative economic values respondents place on each attribute [32,66].

The probability associated with individual n 's chosen alternative i , conditioned on class q , is formulated as follows:

$$P(y_{nit} | x_{nit}, \beta) = \frac{e^{V_{nit}|q}}{\sum_{j=1}^J e^{V_{njt}|q}}. \quad (8)$$

The probability of the sequence of T_n choices made by individual n —denoted by the y_n conditional—being in class q is the product of the probability associated with each chosen alternative in their sequence:

$$P(y_n | x_n, \beta_q) = \prod_{t=1}^T P(y_{nit} | x_{nit}, \beta). \quad (9)$$

The probability that individual n belongs to class q , given their characteristics, is represented by $P(q_n)$. Therefore, the overall choice probability for respondent n , which is weighted across all classes by the class membership probability $P(q_n)$ of observing y_n , is formulated as Equation (4):

$$P(y_n | x_n, \beta, Q) = \sum_{q=1}^Q P(q_n) P(y_n | x_n, \beta_q). \quad (10)$$

We employ this LCM formulation throughout our study. Our results can provide a better model fit, showing better explanatory power. The complexity of our model, considering environmental attitudes and behaviours through a variety of indicators, enables it to explain more reasonable environmental choice behaviour. To account for the effect of latent variables such as environmental attitudes and behaviours, using latent HCM, the model incorporates structural equations for the utility and latent (indicators) variables and a measurement equation (choice model). In this model, it can be assumed that the responses to the attitudinal questions are mapped to a latent variable included directly in the class membership expression. Latent constructs are based on attitudinal (environmental) indicators, often employing Likert scales that can be modelled through measurement equations. In our case, we potentially consider two latent variables: one representing anthropocentric views and another with pro-environmental views. In both cases, the latent variable, LV_{nm} , is given by the following structural equation:

$$LV_{nm} = \eta_n \quad (11)$$

where η_n is a deviate from an independent standard normal distribution, representing the value of the m^{th} latent variable for respondent n . Note that a measurement equation can be described by more than one latent variable. In this work, we assume that each latent variable is described by a single latent variable and that each latent variable explains only a single indicator (in addition to entering the choice probabilities; hence, the m indexing, in our case, covers both the latent variable and the indicator). Responses to our behaviour questions are given on a 5-point Likert scale. Since the response is given on an ordered scale, we need to use an ordered model for the measurement equation [56,66], as explained below. Let I_{nm} be the m^{th} measurement variable for respondent n , which is assumed as a function of the latent variable LV_{nm} and a random component v_n , as in the following:

$$I_{n_m} = \xi_m' LV_{n_m} + v_{n_m}, \quad (12)$$

where ξ_m is a vector of parameters measuring the association between respondent n 's response to the m^{th} indicator and latent variable LV_{n_m} , and v_{n_m} is a random disturbance term. Given the presence of the error term, I_{n_m} is unobserved. However, what is observed are responses $i_1, i_2, \dots, i_5$, indicated by individuals on a 5-point Likert scale. It is assumed that $i_1 < i_2 < \dots < i_5$, and

$$i = \begin{cases} i_1 & \text{if } -\infty < I_{n_m} \leq \tau_{m_1} \\ i_2 & \text{if } \tau_{m_1} < I_{n_m} \leq \tau_{m_2} \\ i_3 & \text{if } \tau_{m_2} < I_{n_m} < \tau_{m_3} \\ i_4 & \text{if } \tau_{m_3} < I_{n_m} < \tau_{m_4} \\ i_5 & \text{if } \tau_{m_4} < I_{n_m} < +\infty \end{cases} \quad (13)$$

where $\tau_{m_1}, \tau_{m_2}, \tau_{m_3}$, and τ_{m_4} are threshold parameters to be estimated through an ordered probability model (Strazzera et al. 2022; Campbell and Sandorf, 2020) [14,33].

The probability of observing the specific answer, i , in the m th Likert scale is expressed as follows:

$$P(z_{n_m} = i | \xi_m, LV_{n_m}, \tau) = F(I_{n_m} \leq \tau_{m_i}) - F(I_{n_m} \leq \tau_{m_{i-1}}), \quad (14)$$

where F is the distribution function (logistic). Then, the probability of observing the respondent n 's response to the m^{th} attitudinal item is expressed as follows:

$$P(z_{n_m} | \xi_m, LV_{n_m}, \tau_m) = \prod_{i=1}^5 P(z_{n_m} = i | \xi_m, LV_{n_m}, \tau)^{z_{n_m}^i}, \quad (15)$$

where $z_{n_m}^i$ is an indicator equal to one if respondent n selected the i^{th} item on the m^{th} attitudinal question. The probability associated with the sequence of the M attitudinal questions can thus be represented by Equation (10):

$$P(z_n | \xi, LV_n, \tau) = \prod_{m=1}^M P(z_{n_m} | \xi_m, LV_{n_m}, \tau_m). \quad (16)$$

In addition to influencing responses to the indicators, the latent variables also appear in the choice probabilities. In this case, it is assumed that they affect the class membership; therefore, they are introduced in the class membership equation, $P(q_n)$. Specifically, $P(q_n)$ is expressed as follows:

$$P(q_n) = \frac{e^{(c_q + \sum_{m=1}^M \delta_{q_m}' LV_{n_m})}}{\sum_{q=1}^Q e^{(c_q + \sum_{m=1}^M \delta_{q_m}' LV_{n_m})}}. \quad (17)$$

Therefore, an HCM consists of three model components: the structural equation model, the measurement equations, and the choice model. The joint log-likelihood (LL) of such a model is expressed as follows:

$$LL = \sum_{n=1}^N \ln \int_{-\infty}^{\infty} P(y_n | x_n, \beta, Q, c, \delta) P(z_n | \xi, LV_{n_m}, \tau) dLV_1 dLV_2, \quad (18)$$

where the choice probability now includes c and δ . Since the expression in Equation (12) does not have a closed form, it is necessary to approximate the log-likelihood (LL) via simulation. The empirical application of the latent HCM and PCA in our case study is detailed in the subsequent sections.

2.2. Selection of Attitudinal Indicators

To select the latent environmental attitudes and behaviours among Korean citizens to apply to the HCM, in Section 2.1, among the 20 items selected from Milfont et al. (2010) [34], rated on a 5-point Likert scale (1 =

strongly disagree; 5 = strongly agree), our immediate focus is on identifying how many distinct environmental attitudes will emerge from the analysis. Indicators will be grouped into attitude and behaviour factors. As survey questions with similar conceptual characteristics are clustered together, not all indicators will necessarily be retained. From these clusters, we selected those that best represent each construct using PCA. These items are listed in Table A2. The selected indicators were then incorporated into HCM [10,14,25,35]. For example, respondents rated their agreement with statements measuring the latent variable “attitude toward the environment.” PCA was conducted using IBM SPSS Statistics version 28 and R software (4.4.2). The model specification was guided by evidence from the psychological literature, which distinguishes attitudes and behaviours as separate constructs both generally [36,37] and in the context of environmental behaviour [38].

3. Case Study

Considering the theoretical considerations of the HCM discussed above, Korea presents a relevant case for applying DCEs. Korea’s forest sector is recognized globally as a success story in forest rehabilitation, following extensive deforestation and degradation during the Korean War era [39]. Since the 1970s, forest ecosystems in Korea have stabilized, and growing timber stocks have steadily increased from 13 m³ to 170 m³ in 2023. This recovery has spurred a rise in citizens’ forest visitation, particularly to natural recreational forests, driven by increasing national income and growing public interest in enhancing the quality of life through nature-based recreation activities. However, despite these achievements, Korean forests face significant threats to ecosystem services. For example, large-scale forest fires, exacerbated by climate change, and the ongoing impact of forest pests and diseases, such as the invasive pine wilt disease (PWD), pose serious risks to the stability of forest ecosystems. These challenges, compounded by climate change, demand urgent attention and provide a compelling context for using DCE to assess forest management policy options and public preferences in mitigating these threats [40].

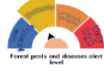
At this stage, Korean forests, which have been disrupted by forest fires, pests, and diseases, face significant threats to the continued provision of various ecosystem services reliant on a healthy forest ecosystem. As a result, there is an urgent need for forest restoration and management policies that integrate the perspectives of diverse stakeholders. These environmental challenges, impacting forests that deliver broad ecosystem services, are inherently multi-faceted, involving not only economic considerations but also social, psychological, and heuristic dimensions. Incorporating these complex aspects—including heterogeneous preferences and a variety of influential factors—into statistical choice models enhances the reliability of the results in representing latent environmental decision-making processes. Our empirical study designs a choice experiment scenario that captures these threats as realistically as possible and applies the HCM to analyse the survey data.

Attributes, Levels, and Scenarios

The choice experiment survey aims to estimate diverse WTP and measure different preference for forest management policies in Korea. Considering the situation, we selected five major attributes based on a relevant

literature review [70] and the advice of experts from the National Institute of Forest Science in Korea. The attributes and levels selected for our survey and forest restoration scenarios are realistic scenarios based on the currently enacted Korean forest fire and forest pest management control system and the ongoing forest restoration policy of the Korean Forest Service to fully reflect the realistic forest situation [69].

Table 1. Attributes and levels of sustainable forest management scenarios.

Attributes \ Levels	Level 1	Level 2	Level 3	Level 4
Forest fire risk	 (Red, 85 ↑) *	 (Orange, 66~85)	 (Yellow, 51~65)	 (Blue, 51 ↓)
Forest pests and disease risk	 (Red) *	 (Orange)	 (Yellow)	 (Blue)
Restriction on forest-related outdoor activities	 (Zero) *	 (0~1 million)	 (~1~2 million)	 (~2~5 million)
Biodiversity loss (pine trees damaged)	 (~300~400 k trees) *	 (~200~300 k trees)	 (~100~200 k trees)	 (0~100 k trees)
Forest recreation fund	KRW 0 *	KRW 1~KRW 25,000 (USD 0~USD 19.14)	KRW 25,100~KRW 35,000 (USD 19.22~USD 26.80)	KRW 35,100~KRW 50,000 (USD 26.88~USD 38.29)

* Represents the status quo condition.

The first attribute in our choice set is forest fires, which are an ongoing and growing threat factor to sustainable forest ecosystem services, with the successfully growing stumpage stock simultaneously fuelling forest fires. The damaged area and costs are becoming larger, even though the number of forest fires varies slightly from year to year. For instance, in 2022, the area affected by the fire was 24,797 ha, but it was 2920 ha in 2020; so, surprisingly, it has been increasing. The frequency and resulting damage of forest fires are rapidly increasing, and their main causes, according to the Statistical Yearbook of the Korea Forest Service (2024) [40], include the carelessness of visitors (38.1%), weed burning (6.3%), trash burning (7.7%), cigarette littering (9.7%), visits to ancestral graves (4.6%), children (0.9%), and building fire (5.7%), while 26.9% were attributed to other causes. (Note that in Korea, there are no statistics on forest fires due to natural phenomena.) Following the Statistical Yearbook of the Korea Forest Service, the scheme of KFS determines four levels of forest fire alert system [0 (lower risks) → 100 (higher risk), namely, blue (under 50), yellow (51~65), orange (66~85), and red (higher than 86), according to the data analysis result of NIFoS's forest fire forecasting system. (The forest fire alert system has increased the level of forest response policy; for more information, please visit the following site: <https://www.forest.go.kr/kfswb/kfs/areaIdx/Index.do?mn=AR04>. accessed on 3 August 2023) In addition,

forest fires are often caused by minor negligence leading to disproportionately large damage. It is important to minimize the damage of forest fires by implementing measures to control them.

The second attribute is forest pests and diseases. Pine wilt diseases (PWDs), introduced from Japan, which are recognized as a global threat to forestry, are a major threat to forest ecosystem health and the provision of ecosystem services. More than 12 million pine trees infected with PWDs have been urgently removed worldwide, which has led to a huge cost of prevention and control via bestial injection vaccination being incurred since 1988 [41–43]. To combat these threats, the forest authority has already implemented “the forest disease and pest outbreak index and alert system,” which has four levels, namely, Interest (blue, lower than 50), Caution (yellow, 51~65), Serious (orange, 66~85), and Very Serious (red, higher than 86). This system is based on the results of the periodic surveillance, accounting for on the scale of occurrence, the speed of the spread, and the degree of damage, according to forest pest control regulation article No. 4 [40].

The third attribute is restrictions on forest-related outdoor activities (or forest access restrictions) to control and manage the above two risks. This is one of the representative ecosystem services in Korea. Human activities are responsible for most forest fires in Korea; so, limiting human activity in a forest can help to limit forest fire threats. The assumption in scenario, however, is that there are currently no restrictions, so the potential for forest fires, pests, and diseases to spread remains high. Therefore, the goal of forest policy is to implement restrictions to reduce these two environmental risks. There are currently more than 170 recreational facilities within national, public, and private forest areas across the country, and the number of visitors has continuously increased from 4 million in the 2000s to more than 15 million in the 2020s; i.e., there are roughly 15 million tourists, on average, visiting the forest facilities. In our scenario, we organize the restriction policies in place into four levels: zero restriction (no restriction); restriction to 1~1 million people, restriction to 1~2 million people; and restriction to 2~5 million people.

The fourth attribute is biodiversity loss in forests, i.e., the number of pine trees infected by PWDs, which has effects directly related to, and caused by, the above risk factors. The causal pathogen is the pine wood nematode (PWN), *Bursaphelenchus xylophilus*. In Korea, pine trees are some of the main trees infected by *Bursaphelenchus xylophilus*, which is transmitted via pine sawyer beetles of the genus *Monochamus*. It is understood that all pine trees suspected or being infected by PWDs must be chopped down (<https://www.apsnet.org>, accessed on 28 August 2023). It is important to note that pine trees, as an evergreen trees with a long lifespan, hold a special place in Korean history, and they are also an economically important natural resource as a timber worldwide. Based on the KFS statistics for PWD damage, the possible numbers of pine trees damaged by PWDs can be distributed into four levels: 0~100 thousand trees; 100~200 thousand trees; 200~300 thousand trees; and 300~400 thousand trees.

The last attribute in our set is the forest restoration fund, which is a tax instrument involving a one-time contribution per year per household, given that forest management and restoration in Korea is mainly funded by the government. To be specific, it is classified into 11 categories, ranging from KRW 0 to ~KRW 50,000 (USD 38.29), according to units of KRW 5000 (USD 3.8) (as of 2023, USD 1 is equal to 1305.8 Korean won (KRW))

(<https://ecos.bok.or.kr/#/SearchStat>) accessed on 28 August 2023). For context, the average citizen paid about KRW 6700 (USD 5.13) in taxes dedicated to the forest sector (KFS) in 2020.

Our experimental designs, covering all attributes and levels, are optimized for a discrete choice model [24]. These attributes and levels are defined according to the literature review, pilot studies, consultations with subject matter experts, and the relevant forest policies that the Korean Forest Services could implement. Following this approach, a total of 200 choice sets were calculated using the following efficient design criteria: the D-error of our design is 0.101; the A-error is 0.192; and the S-error is 9.67. We aim to minimize the variance in the WTP using the priors obtained from a pilot study of 77 respondents (770 choice responses) [24].

For the design of the experimental choice set for our research, we iterated the set through the design process to ensure that each attribute is as evenly distributed as possible. In the DCE survey, we asked respondents to choose between two improved alternatives (alternatives A and B) and the current situation (SQ), which promises zero additional cost for implementing no improvements to forest restoration. Finally, 10 choice sets are randomly assigned to each respondent (see Table A1 for an example of a choice set), which balances the concerns of learning and respondent fatigue [68]. The experimental choice set and scenario applied in this study were designed to be as easy as possible for respondents to understand. The status quo option (alt3) referred to the current situation, and the other two choice set options (alt1 and alt2) referred to forest management policies aimed at improving the situation. The attributes and levels within each choice set were also designed to be easy to understand, incorporating visual aids and easy-to-determine trade-offs between attributes and levels. Moreover, it is made clear that the SQ choice set is a zero-cost option. Table A1 is an example of a choice set for experimental scenarios in which three options are presented to each respondent: two choice sets and a status quo option.

In addition, a pilot study was conducted from 2 to 16 October 2023, using face-to-face surveys with 67 participants (670 choice observations) to test the questionnaire. The survey, administered by a professional firm using tablet devices, included sections on environmental attitudes [34], experimental choice sets, and respondent demographics. The pilot results showed that while some attribute coefficients were statistically significant and aligned with expectations, others were not. Feedback indicated that the questionnaire was clear and visually appealing but slightly lengthy. Based on this, redundant questions were removed, and the scenario section was streamlined, allowing the final survey to be completed within 15–20 min.

4. Results

4.1. Socioeconomic Background

The sampling design employed a stratified random sampling approach to ensure demographic representation of the Korean adult population aged 20 and above. Respondents were recruited from all major administrative regions in Korea, encompassing both metropolitan and rural areas, with quotas applied to achieve balanced distributions across gender, age, and income levels. Although metropolitan areas (e.g., Seoul and Gyeonggi) were slightly over-represented, the sample included a diverse range of socioeconomic groups to reflect national

variation. Data were collected in October 2023 through in-person surveys conducted by a professional survey firm (ST Innovation), using a tablet-assisted questionnaire to enable real-time data entry and quality control. The dataset is derived from a choice experiment in which 1021 individuals (yielding 10,210 discrete choice responses) selected between two policy alternatives: improved forest management options and a status quo scenario representing deforested and degraded forests affected by environmental threats such as forest fires and pest outbreaks.

Table 2 shows the descriptive statistics for the respondents in the questionnaire used in this study, the items were organized as follows: Age data were collected through an open-ended question; gender was categorized as male or female; and education level was classified into five groups—primary school (1), middle school (2), high school (3), university (4), and graduate school (5). Income was measured on a five-point scale. Socio-economic reference data from Korea (KOSIS; kosis.kr) indicate the following: gender ratio—male 49.4%, female 50.6%; average age—44.4 years (20s: 11.4%, 30s: 13.1%, 40s: 15.7%, 50s: 17.1%, 60s and above: 27.3%); education level—53% have attained education beyond high school; and average monthly income—4,390,000 KRW (KOSIS National Statistics Portal). The sample size was sufficient to ensure the statistical value of the main parameters and was larger than most discrete choice experiments in this area. Of the 1021 participants, 569 (55.7%) were female, and 621 (60.8%) were in their 40s. Over 70% of the respondents had a bachelor’s degree, and around 40% of our respondents had a monthly income level of over USD 3001. A survey was collected alongside the choice experiment. In this survey, sociodemographic information on respondents was collected. We also collected the preference data on respondents’ environmental behaviours. These data include environmental attitudes and behaviours and forest management attributes such as forest fires, forest pests and diseases, restriction on forest-related outdoor activities, forest biodiversity loss, and forest restoration costs.

Table 2. Summary of statistics.

Variables	Description	Mean	Standard Deviation	Minimum	Maximum
AGE	Age	40.47	11.64	20	81
GEN	Gender: Female (1); Male (0)	0.56	0.49	0	1
EDU	Level of Education	3.96	0.57	1	5
		(University level)			
		KRW 3,000,000~KRW			
INC	Monthly Income	3,900,000 (USD	1.34	1	5
		2308~USD 3000)			

For this debriefing and follow-up questions, the main items in the second half of the questionnaire included questions referring to the rank of attribute prioritization, policy and WTP payment consequentiality (Welling et al., 2022 [44,72], and the literacy difficulty of the questionnaire. To summarize respondents’ responses to the key questions, a significant proportion of respondents said that “they could not afford it,” were at least somewhat aware of the threats to forest ecosystem services and were somewhat interested in forests. Most important of all, for the main items related to government and forest policy, respondents emphasized the importance of the government’s role and responsibility in countering environmental problems and showed a moderately

favourable response to the tax instrument. Lastly, respondents tended to be positive about the monetary value of forest protection and the difficulty faced in preventing ecosystem service disasters (Table 3).

Table 3. Debriefing and follow-up questions.

	Mean	Standard Deviation
1. I cannot afford to pay.	3.31	0.99
2. I have a better option nearby where I would go to.	3.51	0.80
3. It is not feasible to stop the spread of forest pests and forest fires.	2.76	1.02
4. I do not want to put a monetary value on protecting forests.	2.67	1.07
5. I do not recognize the risks and threats to forest ecosystem services.	2.94	1.03
6. The payment method is inappropriate.	3.01	1.05
7. I pay enough tax already. It is the government's responsibility.	3.43	0.98
8. The benefits I receive are not worth my rate increases.	3.28	0.97
9. I am not interested in forests.	2.45	1.05

Notes: The default scale is 1–5.

4.2. Result of Attitudinal Indicator Selection by Latent Group

To investigate how environmental attitudes and behaviours related to ecosystem services and forest management policy influenced the WTP for forest restoration, this section describes the tests for the reliability, validity, and fit of the model. It also presents the analysis of how the latent variables and classes derived from the PCA and choice modelling affected the actual WTP behaviour. As a first step, we conducted a PCA with IBM SPSS on the responses to the environmental attitude and behaviour questions. However, before performing the PCA with principal axis factor analysis, we first determined the internal consistency and reliability in the data. The Cronbach's alpha coefficient for the 20 indicators shows a good fit of 0.83, exceeding the general criterion (0.7) for reliability. To test sampling adequacy, the Kaiser–Meyer–Olkin (KMO) measure shows a result of 0.86, indicating very appropriate data for PCA. The significance of Bartlett's test of sphericity is 0.00, with 190 degrees of freedom (chi-square = 6251.3), confirming the suitability of the data for PCA. In our data and model, all test statistics exceeded the critical values, indicating that the structural model of environmental attitudes and behaviours is appropriate for explaining the impact of sustainable forest management and actual WTP for forest ecosystem services.

We conducted a principal component analysis (PCA) on 20 attitudinal items related to environmental values and behaviours. This resulted in two components representing distinct environmental orientations: an anthropocentric attitude (Component 1) and an ecocentric attitude (Component 2). The respondents were classified into two latent attitudinal groups based on their scores on these components (see Appendices A.3 and A.4). As summarised in Table 4, Component 1 reflects a utilitarian and self-benefit-centred perspective on nature. Its representative indicator is item A3_6, which asks whether “human consumption benefits outweigh environmental pollution.” Approximately 35% of respondents agreed with this statement. In contrast,

Component 2 captures pro-environmental and emotionally connected views of nature, best represented by item A1_2, where over 76% of respondents agreed that “enjoyment of nature significantly contributes to stress relief.” To improve interpretability, the full decoding list of all 20 attitudinal items—along with their factor loadings and thematic labels—is shown in Table 4. These items help illustrate how the two components reflect distinct cognitive and affective orientations toward the environment (Stern et al., 1999; Dunlap et al., 2000) [45,46]. Of the 20 items, approximately 13 loaded strongly onto Component 2 (ecocentric), while the remainder loaded onto Component 1 (anthropocentric). These two components serve as attitudinal constructs and are incorporated into the HCM as covariates to explain preference heterogeneity.

Table 4. The representative indicators of latent environmental attitudes (PCA).

	Component 1	Component 2
Question items classified	A3_6, A3_4, A2_2, A2_1,	A1_2, A1_3, A1_4, A1_1, A2_4, A2_3,
↓	A3_5, A3_3	A2_5, A1_5, A1_7, A3_7, A1_8, A1_6,
Extraction procedures (Group characteristics)	Anthropocentric attitude	A3_1, A3_2
↓	↓	↓
Final indicators	A3_6	A1_2

Notes: Please refer to Table A2 and A4 for the item numbers of the environmental attitude variables.

Table 4 presents the two key items (A3_6 and A1_2) used as interaction variables within the choice model to test whether attitudinal segmentation improves the model fit and reveals meaningful preference structures (see also Table A3). Table 5 summarises the response distribution for these two indicators, and further detail is provided in Table A5.

Table 5. Response distribution of A3_6 and A1_2 by component.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
A3_6 (Ratios)	86 (8.4%)	319 (31.2%)	251 (24.6%)	269 (26.3%)	96 (9.4%)
A1_2 (Ratios)	4 (0.4%)	45 (4.4%)	191 (18.7%)	541 (53.0%)	240 (23.5%)

4.3. Results of HCM and Mixed Logit Estimation

Table 6 presents the results of two estimated choice models: an HCM estimated using the Apollo package (version 0.2.5) in R (version 4.0.2) (Hess & Palma, 2019) [47] and an MXL model. Among them, the HCM outperformed the others across fit criteria, achieving better explanatory power (pseudo-R² = 0.17), an AIC of 24,250, and the lowest BIC (18,316). The MXL model improved in terms of the log-likelihood and pseudo-R² (0.14) but resulted in a considerably inflated BIC (37,714), likely due to the model complexity and reduced parsimony. These results highlight the strengths of each model: MXL captures unobserved preference heterogeneity, and HCM incorporates both heterogeneity and latent attitudinal constructs. Rather than viewing the models as mutually exclusive, this study adopts a complementary modelling strategy, using each framework to shed light on different dimensions of forest restoration preferences and to enhance the robustness of policy-relevant insights.

Table 6. Results of the latent-class HCM and MXL.

Models Attributes and Variables		HCM					Mixed Logit Model (MXL)			
		Class 1		Class 2			Estimate (mu)	Rob.t.rat	S.D.	Rob.t.rat
		Estimate	Rob.t.rat	Estimate	Rob.t.rat					
Forest fire risk	Fire2	-0.36	-2.82**	0.07	1.31	Forest fire risk	0.28	1.86 *	2.22	8.31 **
	Fire3	-0.33	-2.47**	0.05	0.81					
	Fire4	-0.57	-3.39**	0.02	0.40					
Forest pest and disease risk	Pest2	-0.09	-0.93	-0.01	-0.16	Forest pest and diseases risk	0.24	1.58 *	1.46	4.33 **
	Pest3	-0.12	-1.17	-0.10	-1.73 *					
	Pest4	-0.24	-2.07**	0.00	-0.05					
Forest-related outdoor restriction	Restm2	0.16	1.43	0.12	2.30 **	Forest-related outdoor restriction	-0.01	-0.73	-0.12	-3.17**
	Restm3	0.04	0.32	0.12	2.14 **					
	Restm4	0.24	2.05 **	0.02	0.39					
Biodiversity loss	Biolos2	-0.02	-0.19	0.10	1.86 *	Biodiversity loss	0.00	0.23	0.18	4.73 **
	Biolos3	-0.08	-0.70	0.08	1.38					
	Biolos4	-0.06	-0.49	0.03	0.49					
Forest restoration fund	Cost	-0.26	-5.61 **	-0.16	-7.97**	Forest restoration fund	-0.03	-12.25 **	0.04	17.19**
Alternative specific constant (ASC)	Asc_A	-0.68	-3.08 **	2.13	8.36**	ASC	-2.40	-17.75 **	2.81	21.01 **
	Asc_B	0.18	0.85	2.46	10.73 **					
Class membership	c ₂	1.66	1.64 *	-	-		-	-	-	-
	δ _{2₁} (A3_6)	1.19	1.21	-	-		-	-	-	-
	δ _{2₂} (A1_2)	3.04	1.33	-	-		-	-	-	-
Measurement component of the HCM model							-			
		Estimate	Rob.t.rat. (0)							
Environmental attitude indicators	ξ ₁ (A3_6)	-0.92	-2.51 **	-			-	-	-	-
	τ _{1₁} (A3_6)	-2.71	-9.87**	-			-	-	-	-
	τ _{1₂} (A3_6)	-0.50	-5.33 **	-			-	-	-	-
	τ _{1₃} (A3_6)	0.69	6.57**	-			-	-	-	-
	τ _{1₄} (A3_6)	2.58	9.84**	-			-	-	-	-
	ξ ₂ (A1_2)	0.19	1.58	-			-	-	-	-
	τ _{2₁} (A1_2)	-5.55	-11.08 **	-			-	-	-	-
	τ _{2₂} (A1_2)	-3.00	-20.26 **	-			-	-	-	-
	τ _{2₃} (A1_2)	-1.19	-15.87 **	-			-	-	-	-
	τ _{2₄} (A1_2)	1.19	15.81 **	-			-	-	-	-
Goodness of fit (Log-likelihood, AIC, BIC)		(-9393.14, 24,250.20, 18,316.68)					(-9116.77, 18,257.54, 37,714.77)			

Notes: Each significant code indicates statistical significance at 0.05 “**” and 0.1 “*”. A total of 1000 draws are used to simulate the likelihood (Sobol).

The HCM finally reveals two latent classes that exhibit distinct forest policy orientations. Class 1 is characterized by strong aversion to forest fire risk, pest and disease damage, and restoration costs, as reflected in statistically significant negative coefficients (e.g., Fire2: $t = -2.82$, Fire4: $t = -3.39$, cost: $t = -5.61$). This group likely represents individuals with heightened sensitivity to disaster-related risks and financial burdens, suggesting that forest policy instruments aimed at this segment should focus on risk reduction and cost-efficiency, such as early warning systems, hazard zoning, and publicly funded restoration programmes. In contrast, Class 2 is more oriented toward recreational and ecological values, as shown by positive and statistically significant responses to the reduction in forest access restrictions (Restrn2–3: $t = 2.30$, 2.14) and moderate support for biodiversity protection (Biolos2: $t = 1.86$). This group appears less reactive to immediate

risk but more supportive of long-term ecological well-being and public access to natural spaces. Policies for this class may emphasize participatory restoration initiatives, biodiversity conservation incentives, and forest-based recreational infrastructure. The inclusion of attitudinal variables (A3_6 and A1_2) in the class membership function adds interpretive depth. Individuals who agree with A3_6 are more likely to belong to Class 1, while those who endorse A1_2 tend to fall into Class 2. These findings suggest that forest policy design should incorporate latent environmental values to ensure that interventions align with stakeholder motivations and cognitive frameworks.

The HCM offers the most comprehensive framework for forest restoration policy analysis. It not only quantifies willingness to pay for key attributes but also segments the population based on underlying environmental values. These insights enable policymakers to tailor restoration strategies—e.g., disaster-risk mitigation, access management, biodiversity enhancement—to distinct public segments, thereby increasing both the effectiveness and legitimacy of forest management interventions. In the latent-class HCM estimation, the coefficient of class membership ($\delta_{2_1}(A3_6)$ and $\delta_{2_2}(A1_2)$) is a predictor of which latent class an individual is more likely to belong to base on their characteristics. This helps us to better understand the heterogeneity in choice behaviour through the latent-class model. First, the coefficient of Latent Class 1 is 1.19, and the coefficient of latent class 2 is 3.04, indicating that the higher the value, the higher the probability of belonging to that class. Therefore, it can be concluded that latent class 2 may represent a larger group of respondents, and the higher the value of a particular characteristic (such as environmental concern), the higher the likelihood of belonging to this class.

The coefficient values of $\xi_1(A3_6)$ and $\xi_2(A1_2)$, the environmental attitude indicators selected through PCA, are estimated to be -0.92 and 0.19 , respectively. First, -0.92 (A3_6) means that the zeta value (ξ) is negative, which suggests that people with a strong anthropocentric interest tend to have relatively low environmental attitudes. However, as environmental attitudes increase, the score of the anthropocentric attitude indicator may decrease significantly. The tau (τ) coefficients suggest that those who select 3 or higher on the scale are more likely to demonstrate more human-centred behaviours. Next, the coefficient value of $\xi_2(A1_2)$ is 0.19 , which means that the zeta value (ξ) is positive, indicating that higher environmental attitudes may increase the score of the pro-environmental indicator. This suggests that people with positive environmental attitudes are more likely to give higher scores to pro-environmental attitudes or behaviours. The tau (τ) value shows a positive response for those selecting 4 or above. However, since 0.19 is not a large value in absolute terms, it can be understood that environmental attitudes have a small but positive effect on the eco-indicators, although this increase is relatively weak. The results of the HCM for class 2 of the choice model show that the coefficient is statistically significant for alternatives (A and B), which represent alternatives with restored forests, indicating a preference for improved forest restoration management over degraded forests. The coefficient for the forest restoration fund (cost) also has a statistically significant negative value, indicating that the probability of answering “yes” decreases as the WTP increases. The coefficient for the forest activity

restriction attribute is statistically significant, indicating that respondents are willing to accept forest authorities' measures to restrict forest activities to some extent to reduce forest threats. Additionally, the restoration of forest biodiversity loss is found to have a positive effect on utility improvement.

The MXL accounts for unobserved heterogeneity through random parameters. Importantly, the coefficients for forest fire risk and pest risk are statistically significant ($t = 1.86$ and 1.58 , respectively), reinforcing the idea that these threats are salient drivers of restoration support. Furthermore, the significant standard deviations for fire, pest, and restriction attributes confirm that individuals vary substantially in their sensitivity to environmental risks. This model is valuable for identifying the range of preferences in the population, but without attitudinal segmentation, it cannot reveal the structure of preference heterogeneity.

Table 7 presents the estimated WTP values for forest restoration attributes and levels across two models: the MXL model and the HCM. In the HCM, the estimated coefficients for forest fire risk and forest pest and disease risk attributes are negative. While this might initially suggest a WTP, several important considerations clarify the interpretation of these results. First, the negative sign does not imply that respondents would require compensation to accept a reduction in risk; rather, the risk attributes were dummy-coded categorical variables based on textual levels (e.g., “very severe,” “moderate,” and “safe”). Therefore, the negative coefficients should be interpreted as disutility associated with higher risk levels, indicating that respondents derive higher utility from lower risk. In economic terms, this reflects risk-averse preferences: as risk levels decrease, utility increases. This inverse relationship is analogous to the classical law of demand, where an increase in cost leads to a decrease in utility. Consequently, when calculating WTP, it is appropriate to use the absolute value of the coefficient to reflect the value respondents place on risk reduction.

Similar practices have been observed in international studies—for example, Didendera et al. (2023) [70] presented negative signs for risk attributes but reported WTP values via their absolute magnitude for clarity and interpretive consistency. Second, negative WTP estimates for risk reduction scenarios can also reflect the perceived trade-off between cost and benefit. Specifically, when risk is substantially reduced—such as from “Very Severe” to “Safe”—but the accompanying cost is perceived as disproportionately high, respondents may be reluctant to pay, even if they approve of the improvement. This results in a net negative WTP. From a modelling perspective, the MNL model estimates WTP as a ratio of the attribute coefficient to the cost coefficient. If the utility gain from risk reduction is modest relative to the disutility of cost, this ratio can produce a negative WTP. This reflects the functional limitation of compensatory utility models when the marginal utility of cost dominates the effect. A perceived imbalance between cost and benefit may also contribute: if the respondents feel that the costs associated with risk mitigation exceed the benefits, especially in scenarios involving substantial changes (e.g., from “Very Severe” to “Safe”), then a negative WTP may emerge.

In this study, the risk reduction scenarios were deliberately designed to represent substantial improvements in forest conditions. However, if respondents perceived these improvements as accompanied by unreasonably high financial burdens, their resistance to paying such costs would manifest as negative WTP estimates in the HCM framework. This comparison reveals key differences in how forest risks and benefits are valued across

models and respondent classes. In the MXL model, all WTP values are expressed as population means. The results indicate strong public support for reducing forest fire risk and pest and disease risk, with WTP estimates of KRW 10,287 and KRW 8661 units, respectively, with both being statistically significant. This suggests that these two ecological threats are perceived as high-priority areas for investment. \

In contrast, respondents are not willing to pay significantly for improvements in recreation access or biodiversity conservation in this model, reflecting potentially lower salience or higher variation in preferences for these attributes. The HCM offers more interpretive depth by revealing heterogeneity in WTP across two latent attitudinal classes. Class 1 is characterized by stronger risk aversion and cost sensitivity, showing high and statistically significant WTP for fire risk reduction (e.g., Fire2: KRW 14,129; Fire4: KRW 22,412) and moderate support for mitigating pest and disease risk (e.g., Pest4: KRW 9057). This group is less responsive to biodiversity improvements or recreation enhancements, suggesting a preference for disaster risk mitigation over ecological or leisure values. Class 2 places relatively greater value on non-risk-related forest benefits. A statistically significant WTP is found for relaxing recreational restrictions (Restr2: KRW 7191; Restr3: KRW 7249), and moderate positive values are observed for biodiversity conservation (e.g., Biolos2: KRW 5927). However, the WTP for risk reduction (fire and pest) is generally lower and statistically insignificant, indicating a distinct preference orientation from Class 1.

These findings have direct implications for forest restoration policy. The heterogeneity revealed through the HCM and MXL suggests that a one-size-fits-all restoration strategy may be ineffective. Instead, policy design should be targeted and segmented, focusing disaster mitigation efforts on risk-averse stakeholders (Class 1) and investing in recreation and biodiversity programmes for those with pro-environmental orientations (Class 2). The integration of attitudinal factors into the HCM proves critical in uncovering these preference patterns and strengthening the behavioural foundation for forest restoration initiatives.

Table 7. WTP estimation results (unit: KRW).

Attributes	MXL (Mean)	Levels	HCM			
			Class 1		Class 2	
			Mean	95% CI	Mean	95% CI
Forest fire risk	10,287 * (USD 7.9)	Fire2	-14,129 *	-22,199~-6059	4193	-1631~10,018
		Fire3	-12,867 *	-21,013~-4721	2950	-3431~9331
		Fire4	-22,412 *	-32,425~-12,398	1498	-4760~7757
Forest pests and disease risk	8661 * (USD 6.6)	Pest2	-3562	-10,933~3809	-534	-6471~5402
		Pest3	-4657	-12,881~3566	-6249 *	906~408
		Pest4	-9057 *	-17,802~-311	-295	-7262~6671
Forest-related outdoor restriction	-377 (USD 0.3)	Restr2	6253	-1431~13,938	7191 *	1056~13,325
		Restr3	1459	-6527~9445	7249 *	857~13,642
		Restr4	9264 *	810~17,718	1422	-5081~7927
Forest biodiversity loss	146 (USD 0.1)	Biolos2	-669	-8558~7219	5927 *	-416~12,271
		Biolos3	-3000	-11,076~5075	4855	-1672~11,382
		Biolos4	-2198	-10,571~6174	1829	-4818~8476

Notes: In 2023, USD 1 was equal to KRW 1305.8 (<https://ecos.bok.or.kr/#/SearchStat>) accessed on 3 August 2023; 95% CI: 95% confidence interval; * indicates the value obtained from a statistically significant estimate from Table 6.

Figure 1 illustrates the conditional class membership probabilities for Class 1 in relation to two attitudinal indicators: A3_6 (anthropocentric attitude) and A1_2 (ecocentric attitude). For A3_6, those who disagreed with the anthropocentric statement showed low probabilities of belonging to Class 1 (typically 0.1–0.3), while agreement was associated with slightly higher probabilities (0.3–0.5), though rarely exceeding 0.5. A similar pattern was observed for A1_2, where disagreement corresponded with low probabilities (<0.3), and even among those who agreed or strongly agreed, probabilities remained concentrated between 0.3 and 0.5. These patterns suggest that neither anthropocentric nor ecocentric attitudes strongly predict Class 1 membership. Instead, Class 1 appears to reflect individuals with heightened risk sensitivity and cost aversion, rather than distinct environmental value orientations. While A3_6 and A1_2 offer some explanatory value, they are not definitive predictors of class assignment, highlighting the need to integrate multiple attitudinal and behavioural factors when interpreting latent class structures. To support this interpretation, Table 8 provides descriptive comparisons of attitudinal responses across classes, complementing the conditional membership patterns shown in Figure 1 (detailed results for Class 2 are provided in Appendix B).

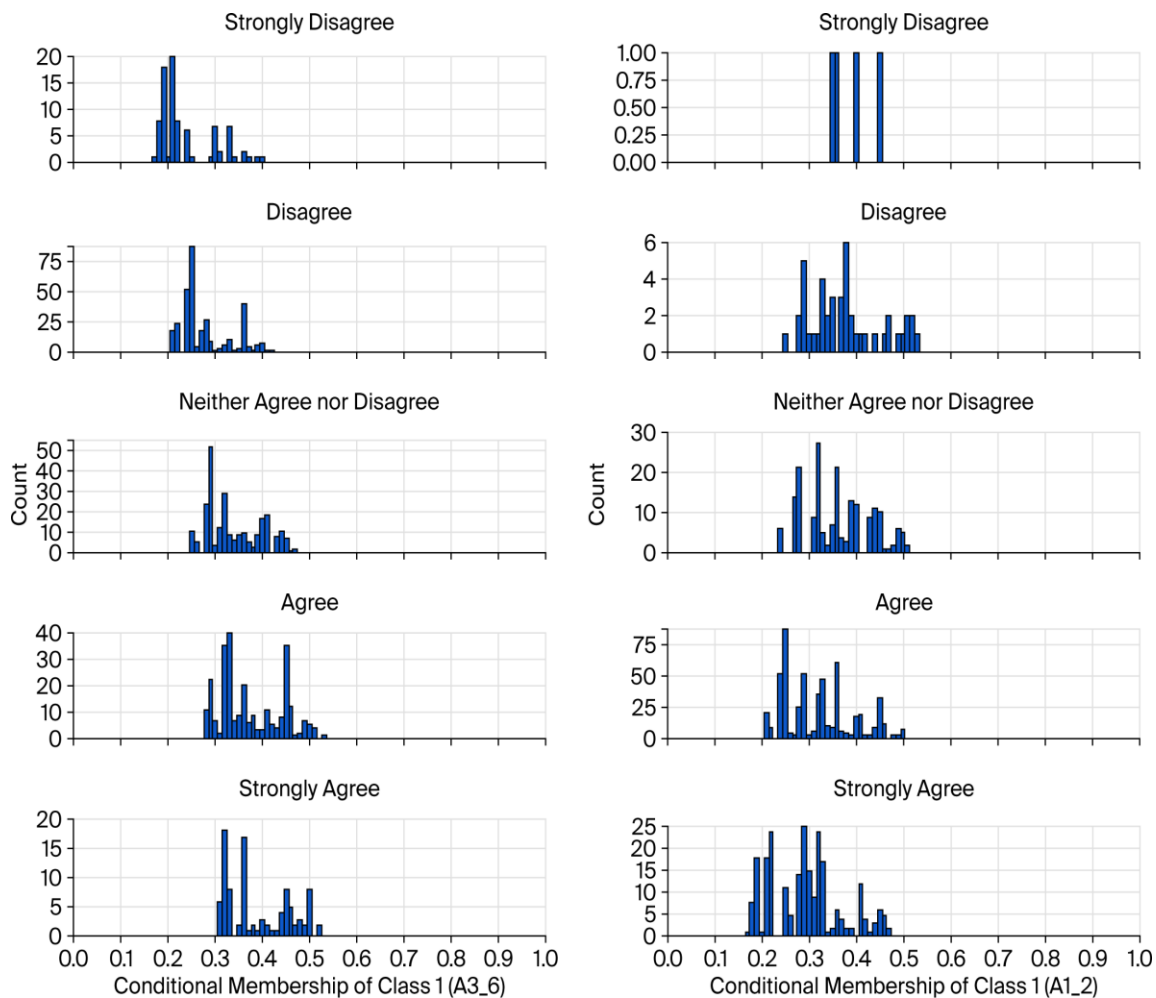


Figure 1. Distribution of conditional class membership to Class 1 for different values of A3_6 and A1_2.

The class differences shown in Table 8 provide a descriptive snapshot of how attitudinal expressions vary across segments. These tables are included to support the exploratory interpretation of class profiles and to complement the conditional membership analysis.

Table 8. Summary of conditional class membership by attitude response on A3_6 and A1_2.

	Mean		Median		Standard Deviation	
	A3_6	A1_2	A3_6	A1_2	A3_6	A1_2
Strongly	0.238	0.388	0.214	0.377	0.058	0.045
Disagree	0.276	0.380	0.247	0.375	0.053	0.076
Neither	0.339	0.361	0.320	0.356	0.058	0.070
Agree	0.373	0.320	0.356	0.323	0.066	0.073
Strongly	0.390	0.294	0.357	0.293	0.067	0.076

Table 9 summarizes the WTP estimates derived from the relationship between forest management policies, restoration attributes, and respondents' environmental attitude responses (A3_6). For the forest fire attribute, WTP is relatively high at the “strongly agree” response level, with the highest WTP being observed at the safest level (Fire 4). In the case of the forest pest and disease attribute, WTP is notably high at the “strongly disagree” response level, peaking at the intermediate level (Pest 3). The forest-related outdoor activity restriction exhibits the highest WTP at the initial level of restriction (Restr2), followed by a declining trend as restrictions intensify. Lastly, the forest biodiversity loss attribute shows the highest WTP at the “strongly disagree” level, with WTP decreasing as responses shift toward the “strongly agree” level.

Table 9. Summary of the WTP by attitude response (A3_6).

		Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Forest fire risk	Fire2	-157.95	-857.31	-2003.01	-2633.02	-2942.86
	Fire3	-806.02	-1409.72	-2398.70	-2942.53	-3209.99
	Fire4	-4177.74	-5090.08	-6584.68	-7406.55	-7810.76
Forest pests and disease risk	Pest2	-1253.04	-1368.51	-1557.68	-1661.71	-1712.87
	Pest3	-5868.26	-5807.06	-5706.81	-5651.68	-5624.56
	Pest4	-2375.15	-2709.39	-3256.93	-3558.03	-3706.11
Forest-related outdoor restriction	Restr2	6965.14	6928.84	6869.36	6836.66	6820.58
	Restr3	5871.86	5650.38	5287.56	5088.04	4989.92
	Restr4	3283.45	3582.50	4072.41	4341.81	4474.30
Forest biodiversity loss	Biolos2	4358.61	4106.49	3693.45	3466.33	3354.63
	Biolos3	2988.18	2688.09	2196.48	1926.15	1793.20
	Biolos4	872.19	718.39	466.44	327.89	259.75

Note: In 2023, USD 1 was equal to KRW 1305.8 (<https://ecos.bok.or.kr/#/SearchStat>) accessed on 3 August 2023.

Table 10 presents the WTP estimates based on the relationship between forest management restoration attributes and respondents' environmental attitude responses (A1_2). For the forest fire attribute, WTP is relatively high at the “strongly disagree” response level, with the highest overall WTP observed at the safest stage (Fire 4). Similarly, the forest pests and disease attribute show elevated WTP at the “strongly disagree” response level, peaking at the intermediate stage. The forest-related outdoor activity restriction attribute

demonstrates the highest WTP at the initial level of constraints imposed by forest policy, followed by a declining trend; however, this relationship is not strongly linked to respondents' attitudes. Finally, the forest biodiversity loss attribute exhibits an overall high WTP at the “strongly agree” response level.

Table 10. Summary of the WTP by attitude response (A1_2).

		Strongly Disagree	Disagree	Neither	Agree	Strongly Agree
Forest fire risk	Fire2	-2908.86	-2750.21	-2406.35	-1663.80	-1189.55
	Fire3	-3180.64	-3043.69	-2746.87	-2105.89	-1696.51
	Fire4	-7766.39	-7559.43	-7110.86	-6142.18	-5523.50
Forest pests and disease risk	Pest2	-1707.25	-1681.06	-1624.28	-1501.68	-1423.37
	Pest3	-5627.54	-5641.42	-5671.51	-5736.49	-5777.99
	Pest4	-3689.85	-3614.03	-3449.70	-3094.82	-2868.17
Forest-related outdoor restriction	Restrn2	6822.34	6830.58	6848.43	6886.97	6911.59
	Restrn3	5000.69	5050.93	5159.82	5394.98	5545.17
	Restrn4	4459.76	4391.92	4244.88	3927.36	3724.57
Forest biodiversity loss	Biolos2	3366.89	3424.08	3548.04	3815.74	3986.71
	Biolos3	1807.79	1875.87	2023.41	2342.03	2545.53
	Biolos4	267.23	302.12	377.74	541.03	645.33

Note: In 2023, USD 1 was equal to KRW 1305.8 (<https://ecos.bok.or.kr/#/SearchStat>) assessed on 3 August 2023.

The application and analysis results presented in Tables 6–10 and Figure 1 contribute to foundation-based research for advancing sustainable forest restoration policies. By identifying heterogeneous environmental preferences and behaviours among citizens, the findings support a shift beyond traditional market-oriented approaches, such as WTP estimation and feasibility assessments, toward designing more behaviourally informed policy strategies.

5. Discussion and Conclusions

Forests are increasingly threatened by environmental and anthropomorphic pressures, jeopardizing the sustainable provision of ecosystem services and necessitating more effective forest management strategies. To address this challenge, this study captures the various spectra of stakeholder responses. Concerning preference heterogeneity, psychological factors, such as environmental attitudes, play a significant role in shaping individual decision-making [20,38,48,49], underscoring the need for integrated models that reflect both the economic and behavioural dimensions of forest policy. This study applies the HCM and MXL models to elicit diverse WTP and to estimate the effect of environmental attitude on preferences for the restoration of deforested and degraded forests [16,10,9,74,50].

According to the HCM results, the identification of two latent classes with distinct preference profiles underscores the need for segmented forest policy strategies that respond to underlying stakeholder motivations. One group—characterized by risk aversion and cost sensitivity—places high value on fire and pest risk reduction, indicating that policies targeting this segment should prioritize practical outcomes such as risk mitigation, public safety, and cost-effectiveness. In contrast, the second group places greater value on biodiversity conservation and recreational access, reflecting a more ecologically motivated orientation. For this

segment, restoration policies should emphasize the intrinsic and experiential benefits of forest ecosystems, including nature appreciation, stress relief, and long-term ecological legacy. Although attitudinal indicators such as A1_2 (ecocentric orientation) and A3_6 (anthropocentric orientation) do not solely determine class membership, they offer meaningful insights into the motivational structure of each segment. This behavioural information supports the development of more targeted communication strategies, i.e., employing risk- and cost-based messaging for the first group and nature-based, value-oriented narratives for the second, thus improving policy alignment and stakeholder engagement [51–53].

The results from the MXL model further confirm the presence of significant preference heterogeneity, especially concerning risk-related attributes. The model reveals statistically significant mean and standard deviation estimates for fire and pest risk reductions, indicating that while the average WTP is moderate, individual-level variation is substantial. This suggests that restoration policies addressing ecological risks will likely elicit mixed responses depending on perceived risk intensity. Additionally, the MXL model finds limited significance for biodiversity and recreational attributes at the population level, suggesting more polarized opinions about non-risk-related benefits. Policymakers should therefore use the MXL-derived distributions to better understand the range of stakeholder responses, identify thresholds for support, and tailor policies that accommodate varying levels of sensitivity and WTP.

The WTP estimates derived from two models reveal consistent and meaningful differences in how stakeholders value forest restoration attributes, offering practical guidance for policy prioritization. Fire and pest risk reduction show consistently significant and positive WTP values across models, particularly in the MXL and Class 1 of the HCM, reinforcing public support for forest disaster prevention as a policy priority. Conversely, WTP for recreational access and biodiversity conservation is notably higher in Class 2 of the HCM, reflecting stronger ecological and experiential values among certain segments. These patterns suggest that effective restoration policy should prioritize risk mitigation to gain widespread support, while integrating biodiversity and recreation enhancements to engage more environmentally motivated stakeholders. Tailoring restoration strategies to reflect these differentiated valuation patterns can improve both effectiveness and public acceptance.

The identification of heterogeneous preferences and the influence of environmental attitudes through discrete choice models enhances the capacity of forest policymakers to design targeted and socially responsive strategies. Aligning restoration efforts with distinct stakeholder segments allows for the optimization of risk communication, resource allocation, and cost-sharing mechanisms.

While this study advances the understanding of environmental preference heterogeneity and the role of attitudes in shaping forest restoration choices, several methodological and empirical limitations should be noted. First, although the HCM improves behavioural realism, attitudinal variables were included only in the class membership component, limiting their influence on direct utility estimation. Second, the use of stated preference data may introduce hypothetical bias, and the cross-sectional country-specific nature of the dataset may constrain generalizability to other contexts. Third, although comparison across the three models revealed consistent patterns for key attributes, variation in the WTP estimates suggests model sensitivity to structural assumptions.

Despite these limitations, this study remains closely aligned with its research aims, namely, (1) to explore the diversity of environmental preferences in forest restoration, (2) to assess how environmental attitudes influence WTP and choice behaviour, and (3) to demonstrate how advanced choice modelling techniques can inform more adaptive and socially responsive forest policy. By addressing these questions, this study contributes to both the methodological advancement and practical application of differentiated, attitude-informed forest restoration strategies capable of addressing the complexity of contemporary environmental governance.

Appendix A

Table A1. An example of a choice set for forest management policy.

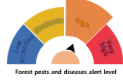
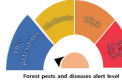
Attributes and Levels	Alternatives	Improved Situation		Current Situation
		Alternative 1	Alternative 2	Alternative 3 (Status Quo)
Forest fire risk		 (Blue)	 (Orange)	 (Red)
Forest pests and disease risk		 (Orange)	 (Blue)	 (Red)
Restriction on forest-related outdoor activities		 (3~5 million restriction)	 (Under 1 million restriction)	 (No restriction)
Biodiversity loss (no. of pine trees damaged)		 (-100 k~200 k pine trees loss)	 (-200 k~300 k pine trees loss)	 (-300 k~400 k pine trees loss)
Forest restoration costs		 (KRW 10,000)	 (KRW 25,000)	KRW Zero

Table A2. Respondents' results for environmental attitude and environmental behaviour (5-point Likert scale: 1. strongly disagree; 2. disagree; 3. neither agree nor disagree; 4. agree; 5. strongly agree).

(A1) To what extent do you personally agree with the following statements?				
Items	Mean	Mode	Standard Deviation	
1. I am the kind of person who loves spending time in wild, untamed wilderness areas.	3.55	4	0.96	
2. Being out in nature is a great stress reducer for me.	3.95	4	0.79	
3. I have a sense of well-being in the silence of nature.	3.99	4	0.78	
4. I find it more interesting to be in the forest looking at trees and birds than in a shopping mall.	3.64	4	0.96	
5. Nature is important because of what it can contribute to the pleasure and welfare of humans.	4.15	4	0.81	
6. What concerns me most about deforestation is that there will not be enough lumber for future generations.	3.72	4	1.00	
7. We should protect the environment for the well-being of plants and animals rather than for the welfare of humans.	3.56	4	1.01	
8. Conservation is important even if it lowers peoples' standard of living.	3.71	4	0.92	
(A2) To what extent do you personally agree with the following statements?				
Items	Mean	Mode	Standard Deviation	
1. Most environmental problems can be solved by applying more and better technology.	3.53	4	0.91	
2. Science and technology will eventually solve our problems with pollution, overpopulation, and diminishing resources.	3.54	4	0.95	
3. If things continue their present course, we will soon experience a major ecological catastrophe.	4.08	4	0.82	
4. The Earth is like a spaceship with very limited room and resources.	4.03	4	0.82	
5. The balance of nature is very delicate and easily upset.	3.84	4	0.89	

(A3) To what extent do you personally agree with the following statements?				
Items	Mean	Mode	Standard Deviation	
1. I make sure that during the winter the heating system in my room is not switched on too high.	3.98	4	0.77	
2. In my daily life, I try to find ways to conserve water or power.	3.95	4	0.81	
3. Even if public transportation was more efficient than it is, I would prefer to drive my car.	2.94	2	1.24	
4. It is alright for humans to use nature as a resource for economic purposes.	3.08	3	1.03	
5. The question of the environment is secondary to economic growth.	3.57	4	1.07	
6. The benefits of modern consumer products are more important than the pollution that results from their production and use.	2.97	2	1.13	
7. I would like to join and actively participate in an environmentalist group.	3.20	3	1.02	

Table A3. Total variance attributed to environmental attitudes and behaviours to extract indicators.

Component	Initial Eigenvalues *			Rotation Sums of Squared Loadings		
	Total	Percent of Variance	Cumulative Percent	Total	Percent of Variance	Cumulative Percent
1	5.13	25.66	25.66	2.75	13.75	13.75
2	2.83	14.17	39.84	2.69	13.47	27.23
3	1.40	7.03	46.87	2.32	11.61	38.84
4	1.24	6.21	53.09	2.20	11.01	49.86
5	1.03	5.16	58.26	1.67	8.39	58.25

* Note: Extraction sums of squared loadings are the same as the initial eigenvalues.

Table A4. Results of component estimation with PCA using IBM SPSS 24 (28.0.1.1).

Environmental Attitude Items *	Component	
	1	2
A1_2	0.710	-0.089
A1_3	0.665	-0.161
A1_8	0.646	-0.108
A1_1	0.611	0.023
A1_7	0.583	0.101
A2_3	0.577	-0.347
A1_4	0.565	0.017
A2_5	0.556	-0.157
A1_6	0.555	-0.002
A3_2	0.549	-0.094
A2_4	0.547	-0.372
A1_5	0.526	-0.330
A3_7	0.520	0.249
A3_1	0.441	-0.195
A3_6	0.153	0.789
A3_4	0.120	0.759
A3_3	0.183	0.624
A2_2	0.358	0.531
A2_1	0.393	0.466
A3_5	0.299	0.438

Notes: * Please refer to Table A2 for the item numbers of the environmental attitude variables. ** Extraction method: principal component analysis; Rotation method: Varimax with Kaiser normalization. Rotation converged in six iterations.

Table A5. Class-specific respondent characteristics.

	Class 1		Class 2	
	Mean	Standard Deviation	Mean	Standard Deviation
Socioeconomic background				
Gender	0.55	0.49	0.57	0.49
Age	40.94	12.34	39.76	10.46
Income	3.24	1.36	3.22	1.30
Education	3.96	0.60	3.97	0.51
Environmental attitude and behaviour indicators				
A1_1	3.21	0.96	4.05	0.72
A1_2	3.65	0.78	4.39	0.58
A1_3	3.71	0.77	4.40	0.60
A1_4	3.34	0.95	4.10	0.77
A1_5	3.94	0.85	4.46	0.61
A1_6	3.33	0.98	4.29	0.73
A1_7	3.13	0.93	4.20	0.74
A1_8	3.36	0.90	4.22	0.67
A2_1	3.23	0.87	3.97	0.77
A2_2	3.24	0.88	4.00	0.86
A2_3	3.85	0.85	4.43	0.64
A2_4	3.82	0.86	4.33	0.65
A2_5	3.56	0.87	4.26	0.74
A3_1	3.81	0.80	4.24	0.64
A3_2	3.67	0.80	4.36	0.62
A3_3	2.60	1.06	3.46	1.30
A3_4	2.88	0.89	3.37	1.14
A3_5	3.28	1.00	4.01	1.01
A3_6	2.69	0.97	3.39	1.22
A3_7	2.80	0.84	3.79	0.98

Appendix B. Conditional Class Membership to Class 2 for Different Values of A3_6 and A1_2

Table A6. Summary of conditional class membership to class 2 by attitude response on A3_6 and A1_2.

	Mean		Median		Standard Deviation		Minimum		Maximum	
	A3_6	A1_2	A3_6	A1_2	A3_6	A1_2	A3_6	A1_2	A3_6	A1_2
Strongly	0.762	0.612	0.786	0.623	0.058	0.045	0.602	0.551	0.602	0.551
Disagree	0.724	0.62	0.753	0.625	0.053	0.076	0.579	0.471	0.579	0.471
Neither	0.661	0.639	0.68	0.644	0.058	0.070	0.526	0.492	0.526	0.492
Agree	0.627	0.68	0.644	0.677	0.066	0.073	0.471	0.497	0.471	0.497
Strongly	0.61	0.706	0.643	0.707	0.067	0.076	0.482	0.527	0.482	0.527

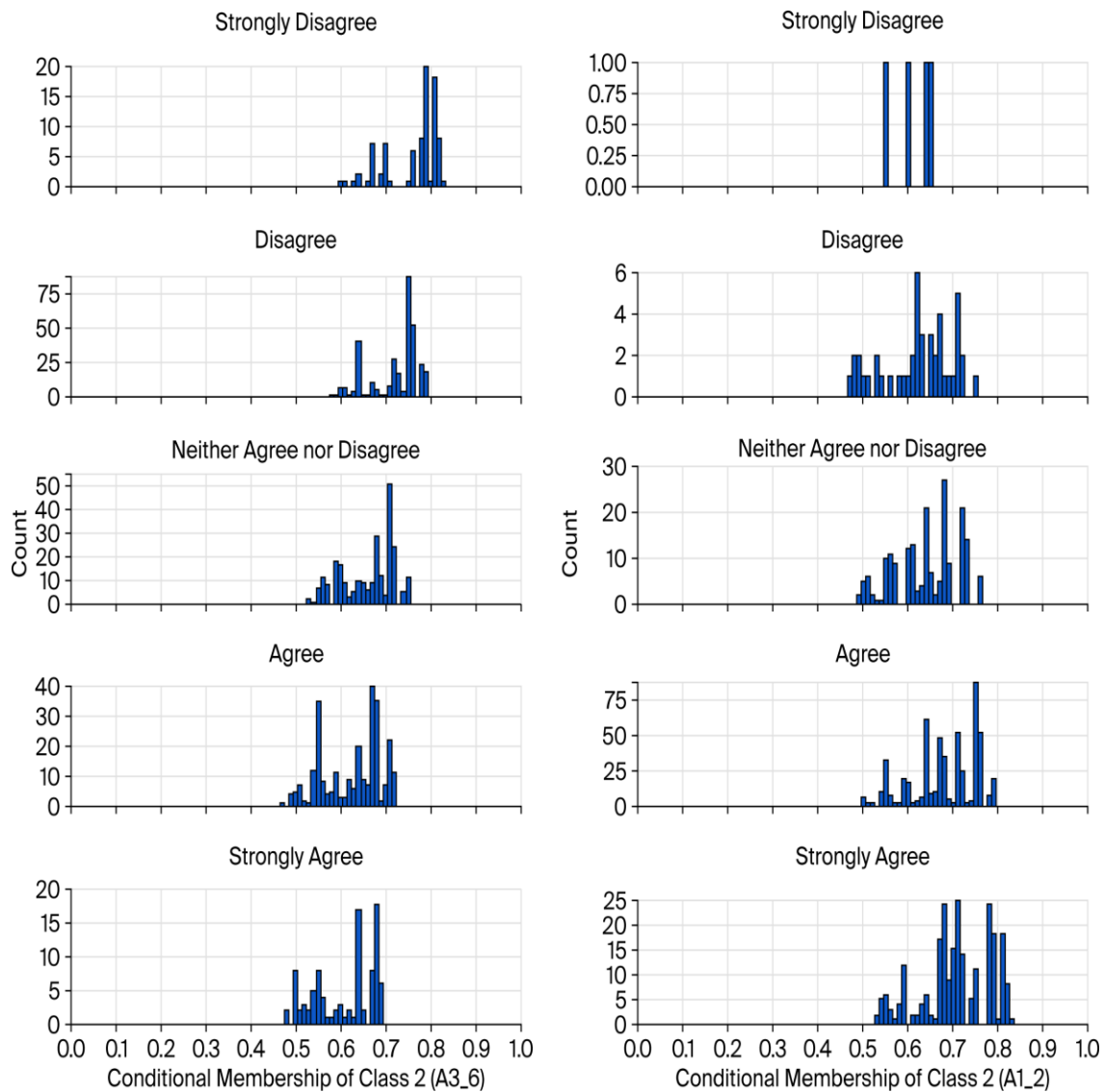


Figure A1. Distribution of conditional class membership to Class 2 for different values of A3_6 and A1_2.

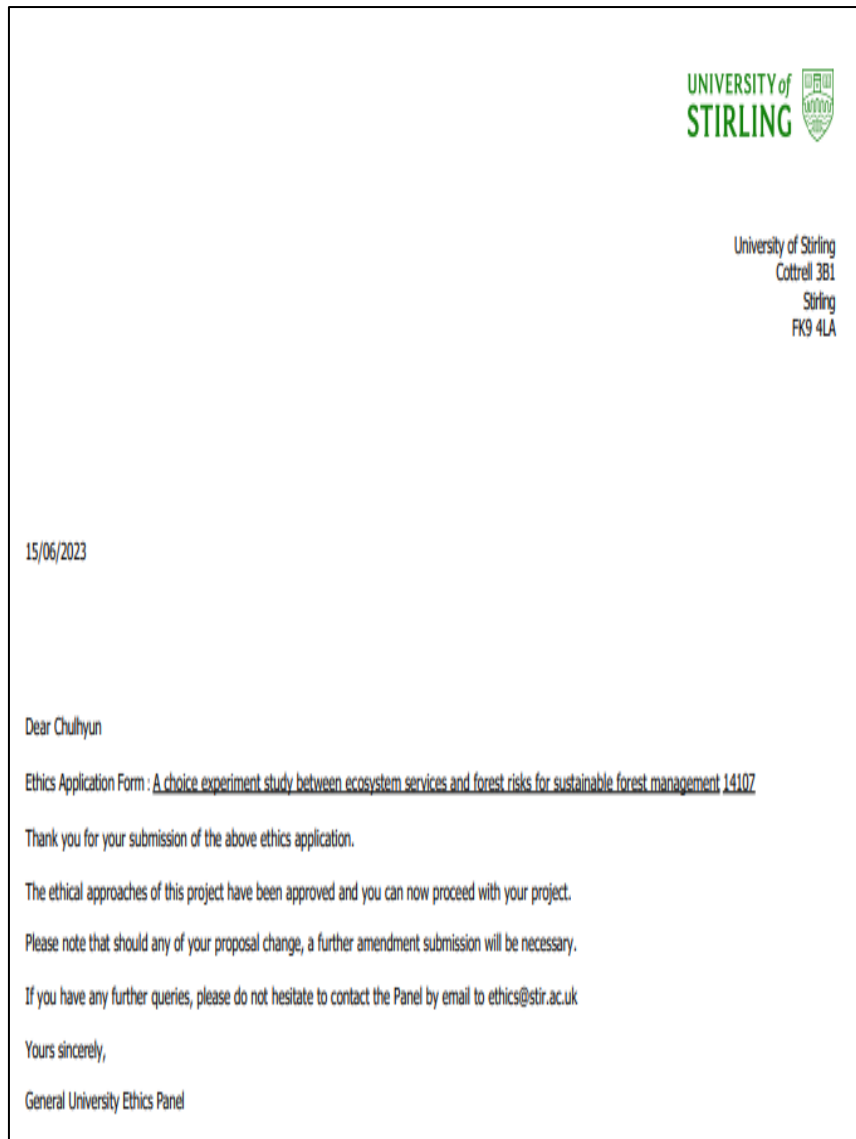
Table A7. Latent class modelling without environmental behaviour variables.

Classes	Attribute and Levels	Estimate	Rob.t.rat. (0)
Latent Class 1	b1_fire2	-0.38	-2.93 **
	b1_fire3	-0.36	-2.50 **
	b1_fire4	-0.62	-3.71 ***
	b1_pest2	-0.09	-0.85
	b1_pest3	-0.13	-1.21
	b1_pest4	-0.25	-2.04 **
	b1_restrn2	0.17	1.40
	b1_restrn3	0.04	0.36
	b1_restrn4	0.25	2.01 **
	b1_biolos2	0.00	-0.03
	b1_biolos3	-0.07	-0.59
	b1_biolos4	-0.04	-0.32
	b1_cost	-0.27	-5.92 ***
	b1_asc_A	-0.71	-2.98 **
	b1_asc_B	0.15	0.61
	b2_fire2	0.07	1.31

Latent Class 2	b2 fire3	0.05	0.82
	b2 fire4	0.02	0.42
	b2 pest2	-0.01	-0.20
	b2 pest3	-0.10	-1.70 *
	b2 pest4	0.00	-0.08
	b2 restrn2	0.11	2.24 **
	b2 restrn3	0.11	2.11 **
	b2 restrn4	0.02	0.40
	b2 biolos2	0.09	1.74 *
	b2 biolos3	0.07	1.30
	b2 biolos4	0.03	0.44
	b2 cost	-0.16	-7.97 ***
	b2 asc A	2.03	8.90 ***
	b2 asc B	2.37	11.69 ***
	c2 constant	0.80	4.25 ***
Goodness of fit (Log-likelihood, AIC, BIC)		-9345.82, 18846.93, 19071.1	

Notes: Each significant code indicates statistical significance at 0.01 “***”, 0.05 “**”, and 0.1 “*”.

Appendix C. Ethics Approval



Note: ethical approval procedures were followed, and permission was obtained from the University of Stirling for this research (15 March 2023)

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Chapter 5

(Understanding environmental decision-making in forest restoration: the role of latent attitudes, attribute non-attendance, and choice behaviour.)

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Understanding environmental decision-making in forest restoration: the role of latent attitudes, attribute non-attendance, and choice behaviour

Abstract

As forests face escalating threats from fires, pests, and disease, understanding public preferences for restoration policies is increasingly urgent. This study investigates how individuals make environmental decisions in choice experiments by examining the influence of latent environmental attitudes, attribute non-attendance, and varied choice behaviours. Using a discrete choice experiment conducted in Korea, the study applies advanced econometric models, including the independent availability logit and latent class analysis to uncover nuanced decision-making processes and heterogeneity in willingness to pay. The results reveal that respondents do not ignore entire attributes but engage in selective non-attendance at the level of attribute details. Distinct behavioural classes emerge, ranging from deterministic to probabilistic decision types. Latent attitudes significantly shape a willingness to pay for forest restoration, with some groups showing resistance to payment due to self-benefit orientation. These insights demonstrate the necessity of tailoring restoration policies and communication strategies to behavioural subgroups. By integrating behavioural realism into environmental valuation, this research offers practical guidance for designing effective and socially accepted forest restoration programs.

1. Introduction

Environmental challenges to achieve sustainable ecosystem services for our well-being that involve wide-ranging and potentially irreversible consequences are of profound importance (Mendelsohn and Binder, 2013; Binder et al., 2012). All important environmental management and policy decisions have a wide range of effects. Understanding how people make environmental choices is crucial for implementing effective management and policy decisions. When it comes to environmental policies, implementing them without knowing the relevant stakeholders' environmental attitudes and latent behaviours is highly uncertain. To reduce the uncertainty of environmental policy, therefore, among the environmental non-market valuation methodologies, the choice experiment (CE) methodology (stated preference) is a very relevant methodology for measuring changes in ecosystem services and welfare changes due to environmental policies. However, individuals differ in their preferences and final decision-making processes and influences concerning these environmental issues. This study attempts to test for the presence or absence of latent environmental decisions, environmental attitudes and types of choice-making behaviours that may influence these decisions, as well as the presence or absence of attribute non-attendance (ANA) in these choice-making processes. The choice modelling methods through economics, health, and transportation fields have increased in several research contexts over the recent decades (Mariel et al., 2021; Louviere et al., 2000). In the area of ecosystem services, environmental decisions related to them with which we were closely intertwined are directly and indirectly critical and complex, relying on a single

overarching policy component focusing on economic variables in economics is limited to understanding the public environmental behaviour.

Negative anthropogenic factors that undermine the sustainable provision of ecosystem services from healthy ecosystems, including climate change phenomena, continue to increase year and year. On the global forest issues with respect to the main anthropogenic threats, forests face pressures of deforestation and forest degradation continue to take place at alarming rates and threats from various anthropogenic causes that include forest fires, exotic invasive species (Zenni et al., 2021), and illegal logging adversely affect their health and vitality and reduce their ability to provide a full range of goods and ecosystem services. In contrast, trees, forests and sustainable forestry can help the world recover from combat looming environmental crisis such as climate change and biodiversity loss (FAO, 2022; Górriz-Mifsud et al., 2016; Torres et al., 2021). Both global forest fires and forest pests and diseases are common environmental threats in Korea as well. In recent, Korean forests have been characterized by growing large-scale forest fires and forest pest and diseases such as Pine Wilt Diseases (PWD) (Kwon et al., 2011), causing ecosystem disturbances by invasive species since it is considered a successful greening story, with a remarkable growing stock more than tripling from 38.36m³/ha in 1990 to 168.7m³ in 2021 (KFS, 2023; FAO, 1982; Brown, 2006), which has led experts to propose it as a potential model for forest restoration in developing countries. Considering the current situation in the Korean case, about twelve million pine trees have been infected by PWDs and removed to prevent the spread of disease since the 1980s, and forest fires continue to have significant impacts nationally, causing the loss of forest activities, built assets, biodiversity and habitat, production and productivity, and the disruption of livelihoods. Therefore, these threats are degrading the ecosystem's capacity to provide ecosystem services although forest benefits play critical roles in supporting various human wellbeing directly and indirectly and measuring how and what these threats that cause biodiversity losses as well as impact human welfare poses an urgent scientific challenge (Taghouti et al., 2024).

To make choice scenarios more realistic and better aligned with real-world decision-making contexts in the microeconomic foundations, our behavioural approaches will be enhanced by incorporating extensions of latent class attitudes and choice behaviours (Greene and Hensher, 2003; Weller et al., 2020; Lahoz et al., 2023; Hoedemakers et al., 2022; Lowthian et al., 2021), attribute non-attendance testing (Goncalves et al., 2022; Nguyen et al., 2015; Weller et al., 2020; Campbell et al., 2011; Espinosa-Goded et al., 2021; Weller et al., 2014), and types of choice decision behaviours (Campbell and Erdem, 2019; Frejinger et al., 2009; Campbell et al., 2012; Manski, 1977). This approach transcends comprehensive, context-specific experiments, methodological advancements, interdisciplinary studies, ethical and societal considerations, and the technological integration of discrete choice analysis in the environmental sector. The focus on environmental behaviour and choice decisions in the study is grounded in the idea that behavioural aspects have a more significant influence on environmental choices in practice than purely methodological refinements. By emphasizing this, this research aims to contribute to the improvement of discrete choice experiments, ultimately advancing the field of realistic choice-making. Based on the literature and the theoretical framework of ecosystem services, we hypothesize

that distinct latent classes will emerge, reflecting different environmental attitudes and willingness to pay for forest restoration. These latent classes will be identified through the latent class model using the independent availability logit (IAL), which is designed to uncover heterogeneity in preferences that may not be apparent using aggregate models.

This study tests the effectiveness and significance of various environmental components-such as choice decision types, attribute non-attendance and latent environmental attitudes-in influencing choice behaviour in choice experiments. These elements are assessed using 20 items of a 5-Likert scale (see Appendix 2 for specific questions), which aim to provide a realistic representation of behaviour responses within the context of choice experimental data. While the previous literature on choice experiments, due to the classical multinomial logit model has limitations, this research apply choice experiments with the independent availability logit model, which is a more realistic alternative to the previous experimental surveys, because it creates environmental conditions that are similar as possible to those in which we decide our daily lives, and in addition latent class approach using principal component analysis is conducted as well. Hence, this research considers and applies these experimental assumptions and situations for the Korean case study about sustainable ecosystem services with deforested and degraded forests and seeks to find more meaningful realistic and reasonable results. The remainder of our study is structured as follows: a literature review is presented in Section 2. Section 3 then explains the design of the study and our empirical study. Next, section 4 outlines the hypotheses to be tested in this study and the modelling approach while Section 5 presents results. Section 6 concludes with a discussion of their implications.

2. Econometric modelling for exploring decision-making choice decision behaviours

Modelling for environmental choice behaviour involving latent class, deterministic and probabilistic data to set up the most realistic scenario reflecting the main environmental threats forest fire, forest pests and diseases, and forest invasive species to sustainable ecosystem services in Asia-Pacific region (FAO, 2020; World Economic Forum, 2023), this research uses to test a three assumption relevant to types of choice behaviours based on the positive forest management policies to deforested and degraded forests in our research. When faced with complicated environmental issues, individuals may encounter various methods to make choices and environmental decisions. These can range from a heuristics approach to probabilistic and deterministic methods. However, the preferences for these methods can vary among individuals. To understand this complicated procedure, this section consists of two main parts to account for our case study. A basic understanding of the multinomial logit model (MNL) with random utility theory and latent class analysis is necessary. The first part starts with the conventional utility maximization framework, which is the most widely used framework, and we specify the utility U , where respondents n obtains from alternative i in choice situation z be denoted in the usual way as $U_{niz} = \beta_n' x_{niz} + \varepsilon_{niz}$ where niz is a vector of observed attributes, β_n is a corresponding vector of utility coefficients that vary randomly over individual respondents, and ε_{niz} is a random term that represents the unobserved component of utility. The vector x_{niz} can include 0 (zero) and 1 (one) term to allow for alternative-

specific constants and for individual attribute levels, as well as continuous attributes. The unobserved term ε_{niz} is assumed to be independent and identically distribution type I (*iid*) extreme value distribution. Under this assumption, the probability that respondents n chooses alternative i in choice situation z , conditional on β_n , is the MNL formula model (1):

$$\Pr(y_n | X_n, \beta, \lambda = 1) = \prod_{z=1}^{Z_n} \frac{\exp(\beta x_{niz})}{\sum_{j=1}^J \exp(\beta x_{njz})} \quad (1)$$

where y_n gives the sequence of choices over the Z_n choice occasions for participants n , $y_n = [i_{n1}, i_{n2}, \dots, i_{nZ}]$. However, Eq.1 is inappropriate for our study of IAL application with ANA because it is only applicable in case the basic conditions are met (Cambell et al. 2019).

These analytical approaches and outcomes demonstrate that respondents engage in diverse decision-making processes, exhibiting latent, deterministic, and probabilistic behaviours, along with attribute and level non-attendance in their choices. This variation not only enhances the model's overall fit but also significantly impacts willingness-to-pay (WTP) estimates. It suggests that respondents evaluate each attribute and alternative individually when navigating complex survey choices. However, most prior studies using IAL models have limited their scope to attribute classes alone, neglecting the influence of other variables. Our study addresses this gap by proposing an improved model with greater explanatory power, incorporating additional variables, such as latent environmental attitudes and overlooked statistical assumptions, to capture more realistic choice behaviours.

In the context of this research, traditional MNL models generally assume that all respondents evaluate every alternative, attributes, and levels presented-even those they may find unacceptable or irrelevant to their actual preference. Given this situation, several decision-making behaviours can be postulated here. Firstly, suppose some participants who tend to be unknown reasons, however, have an overwhelming preference for the status quo (SQ) of our forest issues and that any change from this SQ baseline is perceived to avoid economic and psychological loss. These respondents may only accept the SQ alternative. Conversely, the other opposite participants, for whatever reason, may have a strong dislike of the SQ (and/or opt-out), in which case they adopt a semi-compensatory choice process with the non-opt-out alternatives comprising their actual consideration set. These participants make their choice among the alternatives within this consideration set following a utility maximization compensatory rule. Given these situations, the standard consideration set assumption may be inappropriate for our research. Applying Manski's theory (1977), a probabilistic model can be formulated to explain this type of choice behaviour to help distinguish between the experimentally designed choice task that is presented to respondents and the respondents' actual consideration set (Campbell and Erdem, 2019). To gain this formulation, this study considers the IAL (Espinosa-Goded et al., 2021; Campbell and Erdem, 2019; Habib et. al, 2013). Under this specification, the choice probability is given by (2),

$$\Pr(y_n | X_n, \beta, \lambda = 1, \Phi) = \sum_{s=1}^S \phi_s \Pr(y_n | C_s, X_n, \beta, \lambda=1) \quad (2)$$

where $\Pr(y_n | C_s, X_n, \beta, \lambda = 1)$ is the conditional probability of the sequence of choice given that the consideration set is $C_s \subseteq S$, where S is the set of all subsets and ϕ_s is the unconditional probability that C_s is the

true consideration set. To be specific, S is the set of all non-empty subsets of C_S (i.e. all the latent choice subsets, which the study describes below in the context of this practical demonstration). Since a participant's true consideration set cannot be known with certainty, the model assumes that actual choice tasks are latent and vary across the S classes. While conditional on the consideration set (and hence the class) the choice probability is multinomial logit:

$$\Pr (y_n | X_n, \beta, \lambda = 1, \Phi) = \prod_{z=1}^{z_n} \frac{\exp (\beta' x_{niz})}{\sum_{j \in C_S} \exp (\beta' x_{njz})}$$

In an IAL model, the number of classes, S is determined as a function of the number of alternatives (ex. there are $2^J - 1$ possible consideration sets for a universal set with J alternatives). This research aims to explore whether some respondents' choice exhibit probabilistic or deterministic behaviour—for example, consistently choosing the status quo or other specific alternatives. In this context, deterministic behaviour refers to consistently choosing the same type of alternative regardless of attribute levels, while probabilistic behaviour reflects variability in choices that depend on the trade-offs between attributes presented in each scenario. Based on this assumption, four types of environmentally possible behaviours can be identified:

- (i) a subset ($C_{S=1}$) who always only consider the alternative A, and B deterministically.
- (ii) a subset ($C_{S=2}$) who restrict their actual choice task to only the SQ alternatives deterministically.
- (iii) a subset ($C_{S=3}$) who always only choose the alternative A, and B probabilistically.
- (iv) a subset ($C_{S=4}$) who always choose their actual choice task to the alternative SQ probabilistically.

These four patterns (i.e. $S = \{C_{S=1}, C_{S=2}, C_{S=3}, C_{S=4}\}$) can be modelled using an IAL framework with four latent classes. In this setup, each latent class represents a distinct consideration set, capturing how different groups of respondents attend to different subsets of the available alternatives. As noted above, the alternatives considered by respondents cannot be known with certainty and therefore remain latent. However, their observed choice behaviour helps us to make probabilistic statements about the likelihood of competing consideration sets being their true choice task, with the full probability per participant allocated across all S classes (i.e. $\sum_{s=1}^S \phi_s = 1$). ϕ_s can be, therefore, considered the unconditional probability associated with observing the latent behavioural rule characterized by class s .

Lastly, the latent class approach in our research is usually used to explore unobserved constructions in observed choice data. This technique uses multiple variables to identify the presence of underlying classes or groups in the data. A latent class model is performed first to understand the number of classes that generate an optimal solution for the data and analyse heterogeneous preferences by constructing multiple classes and utility functions for each class.

In our study, the following three hypotheses (assumptions 1~3) on environmental decision-making behaviour are tested using the IAL and latent class models simultaneously, and three models are estimated for three statistical assumptions and compared to search for specifications that best fit the data:

Assumption 1 (types of different choice behaviours): respondents can exhibit either deterministic or probabilistic behaviour in their preference choice. In deterministic behaviour, respondents always choose from

a specific subset of alternatives, regardless of the attribute levels. For example, (i) they always consider only Option A, Option B (class 1), (ii) they always consider only Option SQ (class 2). In probabilistic behaviour, respondents also limit their consideration to specific options, but their choices among those options vary depending on the attribute levels. For example, (iii) they consider only Option A, option B, but choose between them based on the scenario (class 3), or (iv) they consider only option SQ (class 4), but their choice is influenced by how attractive it is relative to other options.

Assumption 2 (restriction of zero parameters; attribute non-attendance or attribute level non-attendance): the parameters of attributes and/or level ignored by a respondent are restricted to zero. If the respondent ignores an attribute or levels in a choice situation, the parameter β_{ij} for that attribute and level is constrained to be zero.

Assumption 3 (effect of latent environmental behaviours): the latent environmental attitudes and behaviours of respondents are going to influence their choice decisions positively or negatively. If latent environmental class classified by principal component analysis plays a substantial effect and role in the model the parameter is not zero and has statistically significant values.

3. Empirical case study

Our questionnaire and hypothetical scenarios are designed to reflect the present status of forests in Korea as much as possible in terms of environmental threats to ecosystem services and sustainable forest management (SFM)¹⁷. Forests in Korea are highly threatened by forest fires and forest pests and diseases (KFS 2023). Therefore, it is necessary to make a good choice to match the theoretical part and realistic assumption on the realistic forest policies in Korea. In the discrete choice methods, the choice of attributes and their levels are a very important part of experimental design (Salvo et al., 2018). Too many attributes and levels are not only confusing for respondents but also have potential to reduce the efficiency of the experimental design process (Mariel et al., 2021). So, the forest policy, the status of forest fire and forest pest and diseases management, and the measurement system for those two risks are examined, with attributes and their levels tailored to address forest biodiversity loss and the negative effects of forest outdoor activities. The forest restoration cost variable is designed with a range of accounts for the various intervals of respondents. This section describes the attributes and levels selected, the pilot study, and the questionnaire design procedures (Gorriiz-Mifsud et al., 2016).

This study examines forest fire risks as an attribute, given its significant negative impacts on sustainable ecosystem services both nationally and globally. Direct and critical factors arising from these threats are selected as attributes. To improve clarity, brief definitions of each attribute are included in Table 1 alongside their corresponding levels. The forest fire risk in Korea is a growing factor to be continuously concerned with the successful growing stumpage stock simultaneously (Yoo et al., 2018). The frequency and damages of forest fires are rapidly increased recently and the main causes of them include the following Statistical Yearbook of

¹⁷ Ethical approval procedures are followed, and permission is obtained from the University of Stirling for this research (15/03/2023) (See appendix 5).

the Korea Forest Service (KFS 2023) reveals that carelessness of visitors 38.1%, weed burning 6.3%, trash burning 7.7%, cigarette littering 9.7%, visitors to ancestral graves 4.6%, children 0.9%, and building fire 5.7% of the recent wildfire incidents, while 26.9% was attributed to other causes. Even though the event number of forest fires varies slightly from year to year, the damaged area and costs are becoming larger (KFS, 2023). For instance, the area affected by the fire was 24,797ha in 2022, but it was 2,920ha in 2020, so it has surprisingly increased. Following the statistical yearbook and the literature studies, the main attributes and levels here will be described. The KFS provides 4 levels of forest fire alert systems [0(lower risks) →100(higher risk)] such as blue level (lower than 50), yellow level (51~65), orange level (66~85), and red level (higher than 86), according to the data analysis of forest fire alert system by National Institute of Forest Science (NIFoS). Secondly, forest pests and diseases risk with invasive species introduced from Japan, such as Pine Wilt diseases (PWDs)¹⁸, have been very destructive cases in Korea since 1988, because more than 12 million pine trees infected with PWDs and have been urgently removed through all the nation with a huge treatment cost. KFS have implemented a forest disease and pest outbreak index, and an alert system designed to assess current outbreak conditions and communicate the potential risk of future spread. This system categorizes risk into four levels -Interest (Blue: below 50), Caution level (Yellow: 51~65), Serious (Orange: 66~85), Very serious (Red, above 86)-based on periodic surveillance results. The index evaluates the scale of occurrence, speed of spread, and degree of damage, in accordance with Article No.4 of the Forest Pest Control Regulation.

Table 1. Attributes and levels of sustainable forest management scenario

Attributes	Level1	Level2	Level3	Level4
Forest fire risk	 (Red, 85↑)*	 (Orange, 66~85)	 (Yellow, 51~65)	 (Blue, 51↓)
Forest pests and disease risk	 (Red)*	 (Orange)	 (Yellow)	 (Blue)
Restriction on forest-related outdoor activities	 (Zero)*	 (0~1 million)	 (-1~2 million)	 (-2~5 million)
Biodiversity loss (Number of pine trees damaged)	 (-300~400k trees)*	 (-200~300k trees)	 (-100~200k trees)	 (0~100k trees)
Forest recreation fund	KW0*	KW1-KW2500wn (\$0-\$1914)	KW2510-KW3500wn (\$1922-\$2680)	KW3510-KW5000wn (\$2688-\$829)

* It represents the status-quo condition.

¹⁸ Pine wilt is a dramatic disease that typically kills affected trees within a few months. The causal pathogen is the pine wood nematode (PWN). Tree death usually progresses from the top of the tree downward. Needles change from their normal colour to a greyish green colour and finally a tan to brown colour. The disease is most serious on pine species that are not native to North America, with the greatest impact in landscape plantings and windbreaks. The age of the tree also influences susceptibility, with an increased risk of developing pine wilt when trees are greater than 10 years of age. Worldwide, the problem is epidemic in Japan and other parts of Asia, where it is the native pine forests that are at risk.

The third attribute is forest biodiversity loss as an impact directly related to and caused by the above two risk factors, where it is supposed that the number of pine trees infected by PWD is biodiversity loss once they had infected by PWD all pine trees must be chopped down, or the suspected pine trees by infection are removed together. It is represented by the number of pine trees damaged by two environmental risks, so the possible levels are 0~100 thousand trees, 100~200 thousand trees, 200~300 thousand trees, and 300~400 thousand trees. Pine trees in Korea hold a very special place in history as an evergreen tree with the symbol of a long lifespan, making it a symbol for Korean people, which is of significant economic importance worldwide.

The fourth attribute is restrictions on forest-related outdoor activities (or forest access restriction) to control and manage these two risk factors, in which the assumption about restrictions on forest-related outdoor activities is that there are currently no restrictions, which causes forest fires by human activities, and so the potential for forest fires and pests to spread is high. Therefore, the direction of forest policy is set to restrict such forest-related outdoor activities to reduce these two risks, because most forest fires are caused by human activities. Forest ecosystem services such as forest recreation activities and forest healing concerning the fourth attribute are one of the representative ecosystem services in Korea. There are more than 170 natural recreational forest facilities for national, public, and private running. The number of visitors has continuously increased from 4 million in the 2000s to more than 15 million in the 2020s, where it is about 15 million tourists on average per year to visit the forest facilities. There are four levels about zero (no restriction), 1 million negatives, 2 million negatives, and 5 million negatives. Lastly, a cost-related attribute to create a forest restoration fund (one-time payment for a year) about restoring the damaged forest and it is divided into 11 levels ranging from ₩0 up to ₩50,000 (\$38.29)¹⁹ in increments by ₩5,000 (\$3.8). For the information, a general citizen pays about ₩6,700 (\$5.13) in government taxes for the forest sector (KFS) in 2020.

The experimental design, which includes all attributes and levels, is optimized as a discrete choice model following the framework of Hensher et al. (2005). The attributes and levels were defined based on literature reviews, pilot studies, consultations with subject matter experts, and the relevant forest policies that could be implemented by the Korean Forest Service. Based on this approach, a total of 200 choice sets were generated using efficient design principles. The efficiency of the design is reflected in a D-error of 0.101, A-error of 0.192, and S-error of 9.67, aiming to minimize the variance of WTP. These values were calculated using priors from a pilot study involving 77 respondents and 770 choice responses. The research survey is divided into four sections. The first section is about an environmental attitude inventory of 20 items selected with a 5 Likert scale to understand latent environmental behaviours and environmental choices to the public (Milfont and Duckitt, 2010) because it is becoming an increasingly important part of environmental problem research. In the second part of the questionnaire, the scenarios are preferentially described in detail, providing information on forest fires, forest pest and disease damage, and forest restoration management in Korea. The respondents are then provided with detailed attributes and level descriptions and are shown an example of our choice experiment (Appendix 1). The

¹⁹ In 2023, US \$1 is equal to ₩1,305.8 Korean won (KRW) (<https://ecos.bok.or.kr/#/SearchStat>).

third section consists of 10 choice tasks and respondents are asked to choose the preferred choice alternative among depicting SQ alternatives and two forest management policies (alternative A and B) that would restore the degraded and deforested forests by these two forest risks. After selecting the choice sets, respondents answer the follow-up questions such as the reason for WTP resistances, two types of consequentiality questions, the propriety of attributes among fives, and general socio-economic questions. The attributes and levels used in the choice experiment are outlined in Table 1. Visual images are used to represent each attribute level to counter problems of low levels of literacy. In this questionnaire, a cheap talk notice is added to prevent respondents from overestimating their WTP (forest restoration fund) and to remind them of their level of their disposable income before selecting the main choice tasks (Haghani et al., 2021; Haghani et al., 2022).

This research mainly includes the first and second risk attributes of forest fires, forest pests and diseases. The third attribute is considered a restriction on forest-related outdoor activities (forest access restriction). A fourth attribute, biodiversity loss, is measured by the number of pine trees infected. Finally, choice sets include a one-time forest restoration fund contribution per household as the payment vehicle. The fund would be managed by a designated public authority (e.g. the Korea Forest Service), responsible for implementing the restoration measures. All attributes and levels are described to respondents using visual icons and readable images to enhance understanding of risks and trade-offs. Respondents were presented with ten choice tasks, each consisting of three alternatives and varying attribute levels (Appendix 1 for example). The 10 choice tasks, each containing three alternatives, are presented to respondents using the visual representations that are described to them in the second part of the survey. In each choice set, following the DCEs, respondents are asked several follow-up questions. In line with recent studies on incentive compatibility, respondents are asked several questions on their belief regarding the consequentiality of the survey on a 5-point Likert scale. The techniques applied in our research to easily understand our reasonable scenario are making the choice setting as tangible and relatable as possible for the respondent. This has enhanced graphics and pictures in presenting choice alternatives as opposed to presenting attribute levels in words or numbers.

Before designing the final questionnaire, a pilot study was conducted from August ~ September 2023 via a face-to-face survey with a portable tap book to assist our questionnaire by a professional research company in Korea. For more information on this part, see Jeon (2025). The coefficient derived from this pilot study with 67 pilot studies (670 choice data) would be used as a priori for the efficient design of the main research. As a result of the data analysis, some of the attribute and levels coefficients were statistically significant with the expected sign, while others were statistically insignificant. Therefore, the partial results were used to derive the final experimental design. Positive responses were received from respondents, indicating that the pilot questionnaire regarding the status of national forest status was not difficult, visually appealing, and well-written for ease of understanding, though some found it slightly long. To reflect the comment, we checked the overall framework of the questionnaire and some questions that were redundant in the first section were modified, and shortened the content by clarifying the lengthy information associated with the survey scenario in section B. Therefore, the questionnaire was finally modified to allow respondents to complete the survey within 15~20 minutes.

Appendix 1 is an example of a discrete choice set of experimental choice scenarios.

4. Empirical results

4.1. The Sample demographics of respondents

The sampling design followed a stratified random sampling approach to ensure demographic representation of the Korean adult population aged 20 and above. Respondents were recruited across all major administrative regions in Korea, including both metropolitan and rural areas, with quotas applied to achieve a balanced distribution in terms of gender, age, and income levels. While slightly overrepresented in metropolitan areas (e.g., Seoul and Gyeonggi), the sample includes socio-economic groups to reflect national variations.

Data were collected through in-person surveys administered by a professional survey company (ST Innovation), using a tablet-assisted questionnaire for real-time entry and quality control. A total of 1,021 individuals participated, yielding 10,210 valid choice responses, while not formally calculated, benefited from the professional fieldwork approach and face-to-face engagement. Although sampling weights were not applied in estimation, the demographic breakdown (Table 2) indicates sufficient heterogeneity to support subgroup analysis and generalizability of findings within the Korean context. Future applications of this methodology may further enhance representativeness further by incorporating probability sampling frames or longitudinal panel design (Thompson, 1987).

Of the 1,021 valid participants, 569 (55.7%) are female and 621 (60.8%) of them are aged between 30 to 49. Over 70% of respondents held a bachelor's degree, and 60% were employed full-time. Moreover, around 40% reported a monthly income exceeding US\$3,001. As the questionnaire is administered nationwide, responses were distributed across the following regions: Seoul (345,33.8%), Incheon/Gyeonggi (290, 28.4%), Busan/Ulsan/Gyeongnam (140,13.7%), Daegu/Gyeongbuk (100, 9.8%), Chungcheong (57, 5.6%), Jeonla (51, 5.0%), Gangwon (30, 2.9%), JeJu (8, 0.8%). While metropolitan areas are somewhat overrepresented, the overall distribution suggests adequate national coverage²⁰.

Table 2. Demographic characteristics of respondents (N=1,021)

Variables	Description of variables	Frequencies (Ratio)	Mean	Standard deviation
Gender	1. Male	452 (44.3%)	1.56	0.49
	2. Female	569 (55.7%)		
Age	1. 20 ~ 29	178 (17.4%)	2.6 (40.47)	1.16
	2. 30 ~ 39	352 (34.5%)		
	3. 40 ~ 49	269 (26.3%)		
	4. 50 ~ 59	140 (13.7%)		
	5. More than 60s	82 (8.0%)		
Education	1. Primary school or below	3 (0.3%)	3.96	0.57
	2. Secondary school	7 (0.7%)		

²⁰ For your information, the population distribution is added by region in Korea as below (kssc.kostat.go.kr), Seoul 19.2%, Incheon/Gyeonggi 30.1%, Ulsan/Ulsan/Gyeongnam 15.1%, Daegu/Gyeongbuk 10.0%, Chungcheong 11.2%, Jeonla 10.0%, Gangwon 3.1%, JeJu 1.3% through 2020 Korea statistics.

	3. High school	146 (14.3%)		
	4. University	732 (71.7%)		
	5. Postgraduate or above	133 (13.0%)		
Employment status	1. Students	43 (4.2%)	2.13	1.59
	2. Employed full-time	613 (60.0%)		
	3. Housekeeper	173 (16.9%)		
	4. Public officer	67 (6.6%)		
	5. Unemployment	64 (6.3%)		
	6. Others	61 (6.0%)		
Monthly income level (in USD)	1. Below ₩2000,000 (\$1,538)	112 (11.0%)	3.23	1.34
	2. ₩2000,000~₩2,900,000 (\$1,538~\$2,231)	225 (22.0%)		
	3. ₩3,000,000~₩3,900,000 (\$2,308~\$3,000)	265 (26.0%)		
	4. ₩4,000,000~₩4,900,000 (\$3,077~\$3,769)	155 (15.2%)		
	5. More than ₩5,000,000 (\$3,846)	264 (25.9%)		

4.2. Result of latent environmental attitude and environmental behaviour through latent class application

To implement and support forest restoration management policies, it is very important to understand the environmental attitudes and behaviours of the public citizens. This is because environmental issues are very closely connected with the public stakeholders. To capture latent environmental behaviour types, respondents were asked to evaluate 20 statements on a 5-point Likert scale (see Appendix 2). These items, adapted from Milfont and Duckitt(2010), inform the principal component analysis used to derive latent class structure. The 20-item environmental attitude inventory used in this survey is listed in Appendix 2. To investigate how environmental attitudes and environmental behaviour related to forest ecosystem services and forest threats influence WTP to the forest management policy.

To begin with, this section tests the reliability, validity and model fit of the structural equation model, and analyses how the latent variables derived affect actual WTP intention behaviour through latent class analysis and IAL. As a first step, a principal factor analysis with IBM SPSS statistics 28 (licensed) is conducted on the responses to the environmental attitude and behaviour questions in Appendix 2. Before a principal factor analysis employs principal axis factor analysis, it is necessary to check the data to ensure internal consistency and reliability. Cronbach's Alpha with 20 items, one of reliability statistics, shows a better fit of 0.826 than 0.7 criteria values in general, and to test the sampling adequacy the result of Kaiser-Meyer-Olkin Measure (KMO) and Barlett's Test for KMO Measure shows 0.86, and it shows very appropriate and the significance of 0.000 with Barlett's Test of sphericity of degree of freedom 190 (approximately Chi-Square 6,251.30), with proving that our data is appropriate to factor analysis. In our data and model, all test statistics are fit and over the critical values, indicating that the structural model of environmental attitudes and behaviour variables is adequate to explain the consequence of sustainable forest management and WTPs for forest ecosystem services.

Table 3. Total variance explained to environmental attitude and behaviour

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative percentage	Total	Percent of Variance	Cumulative percentage	Total	% of Variance	Cumulative percentage
1	5.13	25.66	25.66	5.13	25.66	25.66	2.75	13.75	13.75
2	2.83	14.17	39.84	2.83	14.17	39.84	2.69	13.47	27.23
3	1.40	7.03	46.87	1.40	7.03	46.87	2.32	11.61	38.84
4	1.24	6.21	53.09	1.24	6.21	53.09	2.20	11.01	49.86
5	1.03	5.16	58.25	1.03	5.16	58.25	1.67	8.39	58.25

According to Table 3, a five-factor solution appears appropriate, as the explained variance (58%) drops sharply after the fifth factor, with eigenvalues falling below 1, and factor loadings concentrated in the columns for factors 1 through 5 (Milfont and Duckitt, 2010; Everitt and Hothorn, 2010) (Appendix 3). As summarized in Table 4 (Yoon and Ahn, 2020), respondents show a tendency to prioritize personal convenience and economic interests, despite being aware of the importance of the environment and nature (A3_6, A3_4, A2_2, A2_1, A3_5, A3_3). This suggests the existence of a latent class we refer to as the "human self-benefit centred group," which places more value on practical and economic benefits than on environmental concerns. In contrast, another latent class—labelled the "environmental activity favourite group"—highly values the role of ecosystem services in providing stress relief, well-being, and happiness in natural settings (A1_3, A1_2, A1_4, A1_1). A third group, the "ecosystem sensitivity recognition group," strongly acknowledges that the planet and natural ecosystems are at risk (A2_4, A2_3, A2_5, A1_5). A fourth group, characterized as the "actively environmental protection group," expresses confidence in the potential of scientific and technological innovations to address environmental problems (A1_7, A3_7, A1_8, A1_6), indicating a pragmatic and solution-oriented mindset. Finally, a fifth group—the "passive environmental behaviour group"—recognizes the value of daily energy-saving behaviours, such as electricity conservation and adjusting heating levels, as meaningful contributions to sustainable forest management (A3_1, A3_2). While these actions are relatively low effort, they reflect a form of engagement that may span across all classes but is most distinct within this group (Appendix 4).

Table 4. Latent environmental groups derived from principal component analysis

	Component1	Component2	Component3	Component4	Component5
Question items	A3_6,A3_4, A2_2,A2_1, A3_5,A3_3	A1_3,A1_2, A1_4,A1_1	A2_4,A2_3, A2_5,A1_5	A1_7,A3_7, A1_8,A1_6	A3_1,A3_2
Ratio(N=1021)	150(14.7%)	138(13.5%)	206(20.2%)	281(27.5%)	246(24.1%)
Group characteristics	Human self-benefit centred group	Environmental activity favourite group	Ecosystem sensitivity recognized group	Actively environmental protection group	Passive environmental group

4.3. Follow-up questions

In this section, the results of responses to the main items in the second half of the questionnaire, along with

follow-up questions, are examined. These include resistance of WTP, the rank of attribute prioritization, policy consequentiality, and difficulty of the questionnaire. Firstly, in terms of WTP resistance, there are no unusual responses. For the main items related to forest government and forest policies, respondents emphasize the importance of government responsibility and show moderate response to the policy and tax instrument as a WTP payment. Secondly, respondents tend to be positive about the monetary value of forest protection and awareness of environmental threats such as forest fires, forest pests and diseases, and difficulty in preventing environmental disasters. And they were not interested in forests (Table 5).

Table 5. Results of follow-up questions

Questions	Mean	Standard Deviation
1. I cannot afford to pay.	3.31	0.99
2. I have a better option near where I would go to.	3.51	0.80
3. It is not feasible to stop the release of forest pests and bushfires.	2.76	1.02
4. I do not want to put a monetary value on protecting forests.	2.67	1.07
5. I do not recognize the risks and threats to forest ecosystem services.	2.94	1.03
6. The payment method is inappropriate.	3.01	1.05
7. I pay enough tax already. It is the government's responsibility.	3.43	0.98
8. The benefits I receive are not worth my rate increases.	3.28	0.97
9. I am not interested in forests.	2.45	1.05

4.4. Results for modelling environmental choice behaviours and WTP estimation

To support the hypothesis in Section 2, this study estimates four environmentally oriented choice behavioural models: one basic model (MNL) and three IAL models (IAL I to III), each designed to test specific behavioural assumptions. These include latent class segmentation (IAL I), and attribute non-attendance (IAL II), and resistance to cost-based attributes such as tax payments (IAL III). In the IAL II model, attribute non-attendance is explicitly modelled to identify which attributes respondents systematically ignored during the decision-making process. The results reveal that a subset of respondents tended to ignore one or more attributes (levels)-most notably, the biodiversity loss attribute. This suggests that not all attributes were considered equally in the decision process, validating the need for the IAL specification. Additionally, the estimated coefficients help to interpret behavioural responses toward risk attributes. Since both forest fire and forest pest and disease are framed as negative outcomes, a negative coefficient indicates risk-averse behaviour (Diendere and Kabore, 2023; Reynaud and Nguyen, 2016; Botzen and Bergh, 2012). These risk attributes thus represent disutility: as risk levels decrease, utility (or willingness to pay) increases, confirming an inverse relationship. The MNL model results show that the highest level of the forest fire attribute (Fire 4) is statistically significant at the 5% level, indicating that respondents are willingness to pay to achieve the safest possible fire risk reduction. In contrast, for the forest pest and disease risk attribute, respondent's willingness to pay peaks at the mid-level (Pest 3), suggesting a relatively lower valuation than fire risk. The third attribute, restriction to forest-related outdoor activities, is statistically significant across all levels, indicating that restricted access to forests as part of forest policy to manage degraded forest restoration is acceptable to respondents. It means that respondents would

accept forest access restrictions, strong or weak, to reduce forest fire and pest and disease risks. Although the forest biodiversity loss attribute is not statistically significant, the sign of the coefficient is positive, indicating a positive effect on utility. As expected, the coefficient on the forest restoration cost is negative, indicating that the probability of bid payment decreases as the bidding price increases. Finally, the highly significant and positive ASC coefficient confirms a general preference for new forest restoration policies over the status quo.

Next, the IAL I model has better model fitness values (loglikelihood -9,281.022, AIC 18,598.05) than the traditional MNL model (loglikelihood -10,715.15, AIC 21,460.31). In the model, assumptions 1 and 2 are assumed to be deterministic and assumptions 3 and 4 are assumed to be probabilistic in the environmental decision-making choice behaviour, and the results of the IAL model I show that class 2 and 4 are statistically significant at 1% level, indicating that both deterministic and stochastic behaviour exist. However, class 3 chooses only option A and B stochastically is not statistically significant, so this hypothesis cannot be rejected.

Table 6. WTP estimates by various models

Attributes, levels and variables		MNL	IAL I	IAL with ANA II	IAL with ANA III
Forest fire risk*	Fire2	¥1,346.9 (\$1.03)	¥1,668.0 (\$1.28)	¥1,698.6 (\$1.30)	¥4,558.1** (\$3.49)
	Fire3	¥2,674.4 (\$2.05)	¥3,429.8 (\$2.63)	¥3,314.9 (\$2.54)	¥7,160.2** (\$5.48)
	Fire4	¥6,589.4** (\$5.05)	¥5,856.2** (\$4.48)	¥5,773.5** (\$4.42)	¥6,634.4** (\$5.08)
Forest pest and diseases risk*	Pest2	¥1,675.3 (\$1.28)	¥3,596.8** (\$2.75)	¥3,475.5** (\$2.66)	¥6,952.5** (\$5.32)
	Pest3	¥6,513.8** (\$4.99)	¥6,891.2** (\$5.26)	¥6,767.1** (\$5.18)	¥6,011.1** (\$4.60)
	Pest4	¥3,314.9 (\$2.54)	¥3,739.7 (\$2.86)	¥3,452.8** (\$2.64)	¥4,222.2** (\$3.23)
Restriction on forest-related outdoor activities (No. tourist restriction)	Restm2	¥8,014.5** (\$6.14)	¥5,764.3** (\$4.41)	¥5,547.4** (\$4.25)	¥-664.6 (\$-0.51)
	Restm3	¥7,061.8** (\$5.41)	¥4,843.6** (\$3.71)	¥4,610.6** (\$3.53)	¥-425.7 (\$-0.33)
	Restm4	¥4,905.5** (\$3.76)	¥3,582.0 (\$2.74)	¥3,197.0** (\$2.45)	¥-2,089.4 (\$-1.60)
Forest biodiversity loss (No. of pine trees infected)	Biolos2	¥3,411.4 (\$2.61)	¥3,054.9 (\$2.34)	¥3,464.8 (\$2.65)	¥513.2 (\$0.39)
	Biolos3	¥1,295.8 (\$0.99)	¥1,484.1 (\$1.14)	¥3,075.5 (\$2.36)	¥2,280.1 (\$1.75)
	Biolos4	¥75.9 (\$0.06)	¥-667.7 (\$-0.51)	¥856.1 (\$0.66)	¥-1,239.1 (\$-0.95)
Tax payment resistance	Tare	-	-	-	¥-18,435.9** (\$-14.12)
Latent environmental attitude	A3_6	-	-	-	¥-34,807.2** (\$-26.66)

Note: * two risk attributes are given absolute values for easy explanation. ** indicates statistically significant WTP at the attribute level in Table 7.

Next is the IAL II model with ANA, which shows a lower fit than the traditional MNL model but is not significantly different from IAL I. The IAL II model is estimated by imposing zero constraints on each attribute

to test for attribute non-attendance. The results indicate no evidence of full attribute non-attendance. However, when zero constraints were applied to levels 3 and 4 of the biodiversity loss attributes in class 6 of the IAL with ANA II (Table 7), the coefficient for class 6 was not significantly different from zero, suggesting that levels 3 and 4 were characterized by attribute non-attendance. Next is the IAL III model, which is better than the original MNL model, but not significantly different from IAL I and IAL II. It includes more realistic assumptions than the original model, and the assumptions of resistance to the means of paying taxes and the latent environmental attitude group are added to the model and the results are statistically significant at the 1% level for both variables, indicating that respondents with resistance to the means of paying taxes and latent environmental attitudes of preferring to enjoy the benefits are more willing to pay negatively.

Table 7. Estimation of multinomial logit and independent availability logit model I ~ III for environmental choice behaviours

			MNL	IAL I	IAL with ANA II	IAL with ANA III
			Estimate	Estimate	Estimate	Estimate
Forest fire risk		Fire2(Orange, 75)	-0.022 (-0.552)	-0.044 (-0.832)	-0.033 (-0.631)	-0.125 (-2.459)*
		Fire3(Yellow, 60)	-0.044 (-1.024)	-0.089 (-1.569)	-0.073 (-1.28)	-0.198 (-3.578)***
		Fire4(Green, 50)	-0.109 (-2.488)*	-0.148 (-2.55)*	-0.122 (-2.089)*	-0.184 (-3.289)**
Forest pest and diseases risk		Pest2(Orange, 75)	-0.027 (-0.679)	-0.091 (-1.738)	-1.754 (-10.514)***	-0.193 (-3.729)***
		Pest3(Yellow, 60)	-0.107 (-2.374)*	-0.176 (-2.986)**	-1.813 (-11.096)***	-0.166 (-2.896)**
		Pest4(Green, 50)	-0.054 (-1.161)	-0.096 (-1.584)	-1.913 (-11.173)***	-0.117 (-1.957)
Restriction on forest-related outdoor activities (No. tourist restriction)		Restrn2(0~1 million)	0.132 (3.190)**	0.138 (2.584)**	0.161 (2.982)**	-0.018 (-0.350)
		Restrn3(1~2 million)	0.116 (2.712)**	0.118 (2.106)*	0.137 (2.432)*	-0.011 (-0.213)
		Restrn4(2~5 million)	0.081 (1.801)	0.088 (1.491)	0.111 (1.892)	-0.058 (-0.994)
Forest biodiversity loss (No. of pine trees infected)		Biolos2(100,000 ~ 200,000)	0.056 (1.317)	0.071 (1.296)	0.052 (0.973)	0.014 (0.261)
		Biolos3(200,000 ~ 300,000)	0.021 (0.489)	0.032 (0.581)	0.011 (0.215)	0.063 (1.130)
		Biolos4(300,000 ~ 400,000)	0.001 (0.028)	-0.021 (-0.362)	-0.086 (-1.503)	-0.034 (-0.445)
Forest restoration fund	Cost		-0.016 (-15.395)***	-0.024 (-16.526)***	-0.024 (-16.502)***	-0.027 (-18.277)***
Alternative option ASC	Asc-A		0.648 (9.976)***	0.207 (2.472)*	0.428 (5.337)***	0.586 (6.924)***
	Aasc-B		1.059 (16.496)***	0.8728 (10.38)***	1.085 (13.493)***	1.246 (14.181)***
Behavioural decision type	Deterministic	Class2	-	-1.232 (-7.395)***	-1.151 (-7.172)***	-1.245 (-5.149)***
	Probabilistic	Class3	-	0.151 (0.904)	-1.158 (5.051)***	0.025 (0.104)
	Probabilistic	Class4	-	0.984 (8.865)***	-0.508 (-3.239)**	1.443 (4.570)***
Attribute non-attendance assumption		Class5	-	-	0.1337 (0.759)	-0.117 (-0.480)
		Class6	-	-	0.8776 (7.723)***	-0.413 (-0.534)
Resistance of Tax payment	Tare		-	-	-	-0.512 (-2.164)*
Latent environmental attitude (A3_6)	A3_6		-	-	-	-0.966 (-4.052)***
Model fitness criteria	Log-Likelihood, AIC		-10,715.15, 21,460.31	-9,281.022, 18,598.05	-9,281.24, 18,602.48	-9,439.622, 18,923.24

Note: t-values are in parentheses. '***' denotes at 0% statistically significance level, '**' at 1% level, '*' at 5% level, and '.' at 10% level.

Table 8. Estimate results of multinomial logit, independent availability logit with environmental choice behaviours based on latent class analysis

		Multinomial logit model					Independent availability logit model (IAL) (I)					Independent availability logit with attribute non-attendance (ANA) (II)					
		Estimate					Estimate					Estimate					
Attribute and levels		Class1 (n=1290)	Class2 (n=2100)	Class3 (n=2480)	Class4 (n=1590)	Class5 (n=2750)	Class1 (n=1290)	Class2 (n=2100)	Class3 (n=2480)	Class4 (n=1590)	Class5 (n=2750)	Class1 (n=1290)	Class2 (n=2100)	Class3 (n=2480)	Class4 (n=1590)	Class5 (n=2750)	
Forest fire risk	Fire2 (Orange, 75)	0.023 (0.190)	-0.013 (-0.142)	-0.074 (-0.907)	0.031 (0.300)	-0.034 (-0.440)	-0.124 (-0.777)	-0.048 (-0.428)	-0.180 (-1.560)	0.057 (0.418)	0.615 (5.630)***	0.020 (0.138)	-0.049 (-0.463)	-0.133 (-1.249)	-0.004 (-0.035)	-1.397 (-4.307)***	
	Fire3 (Yellow, 60)	0.017 (0.134)	0.011 (0.116)	-0.158 (-1.801)	0.144 (1.319)	-0.096 (-1.138)	-0.061 (-0.362)	0.051 (0.441)	-0.432 (-3.188)**	0.191 (1.335)	0.268 (2.423)*	0.016 (0.099)	-0.127 (-1.156)	-0.332 (-2.786)**	0.114 (0.866)	-1.845 (-3.928)***	
	Fire4 (Green, 50)	0.122 (0.941)	-0.073 (-0.758)	-0.172 (-1.955)	-0.126 (-1.147)	-0.155 (-1.778)	0.045 (0.264)	-0.120 (-0.992)	-0.358 (-2.722)**	-0.136 (-0.976)	-0.173 (-1.441)	0.121 (0.736)	0.029 (0.259)	-0.281 (-2.370)*	-0.152 (-1.175)	-3.269 (-5.049)***	
	Pest2 (Orange, 75)	-0.074 (-0.620)	-0.106 (-1.175)	0.007 (0.085)	0.020 (0.189)	-0.002 (-0.024)	-0.075 (-0.481)	-0.302 (-2.715)**	-0.057 (-0.511)	-0.036 (-0.269)	-0.088 (-0.827)	-0.076 (-0.511)	-0.326 (-2.781)**	-0.718 (-2.574)*	-0.027 (-0.216)	-0.045 (-0.428)	
	Pest3 (Yellow, 60)	-0.123 (-0.923)	-0.038 (-0.378)	-0.239 (-2.594)**	-0.035 (-0.308)	-0.080 (-0.897)	-0.153 (-0.866)	-0.066 (-0.550)	-0.407 (-3.079)**	-0.082 (-0.568)	-0.311 (-2.545)*	-0.123 (-0.693)	-0.094 (-0.681)	-1.416 (-4.838)***	-0.049 (-0.362)	-0.167 (-1.390)	
Forest pest and diseases risk	Pest4 (Green, 50)	-0.289 (-2.109)*	-0.095 (-0.906)	-0.076 (-0.785)	-0.054 (-0.449)	0.110 (1.197)	-0.167 (-0.942)	-0.188 (-1.452)	-0.190 (-1.422)	-0.141 (-0.915)	-0.100 (-0.808)	-0.288 (-1.331)	-0.315 (-2.418)*	-1.308 (-4.186)***	-0.090 (-0.599)	0.098 (0.794)	
	Restrnr2 (0~1 million)	0.311 (2.559)*	-0.018 (-0.192)	0.170 (2.030)*	0.025 (0.240)	0.215 (2.669)**	0.482 (3.005)***	-0.120 (-1.050)	0.232 (1.953)	0.050 (0.365)	0.182 (1.685)	0.312 (2.180)*	0.047 (0.444)	0.254 (2.353)*	-0.012 (-0.097)	0.268 (2.455)*	
	Restrnr3 (1~2 million)	0.092 (0.751)	-0.045 (-0.486)	0.174 (1.995)*	0.097 (0.886)	0.229 (2.694)**	0.027 (0.168)	-0.089 (-0.763)	0.313 (2.461)*	0.107 (0.772)	0.257 (2.260)*	0.088 (0.599)	-0.046 (-0.422)	0.293 (2.547)*	0.056 (0.430)	0.334 (2.976)**	
Restriction on forest-related outdoor activities (No. tourist restriction)	Restrnr4 (2~5 million)	0.049 (0.376)	-0.070 (-0.708)	0.123 (1.339)	0.172 (1.514)	0.136 (1.544)	0.133 (0.763)	0.110 (0.929)	0.239 (1.750)	0.195 (1.321)	0.532 (4.285)***	0.048 (0.279)	-0.116 (-1.032)	0.280 (2.253)*	0.148 (1.046)	0.159 (1.378)	
	Biolos2 (100,000 ~ 200,000)	0.080 (0.661)	-0.153 (-1.618)	0.202 (2.276)*	-0.017 (-0.158)	0.127 (1.523)	0.105 (0.662)	0.423 (3.553)***	0.317 (2.544)*	-0.028 (-0.205)	0.087 (0.802)	0.080 (0.204)	-0.006 (-0.057)	0.237 (2.053)*	-0.038 (-0.154)	0.228 (2.075)*	
Forest biodiversity loss (No. of pine trees infected)	Biolos3 (200,000 ~ 300,000)	0.025 (0.201)	-0.117 (-1.201)	0.043 (0.482)	0.077 (0.700)	0.079 (0.929)	0.093 (0.579)	0.363 (2.962)**	0.029 (0.228)	0.147 (1.076)	0.017 (0.154)	0.026 (0.056)	-0.143 (-1.267)	-0.011 (-0.095)	0.079 (0.331)	0.092 (0.804)	
	Biolos4 (300,000 ~ 400,000)	-0.025 (-0.190)	-0.081 (-0.789)	0.117 (1.267)	-0.180 (-1.555)	0.067 (0.760)	-0.135 (-0.775)	0.508 (3.911)***	0.132 (0.980)	-0.193 (-1.341)	-0.199 (-1.571)	-0.027 (-0.057)	0.150 (1.282)	0.055 (0.452)	-0.218 (-0.910)	0.010 (0.081)	
Forest restoration fund		Cost (-3.509)***	-0.014 (-6.131)***	-0.029 (-12.832)***	-0.006 (-2.115)*	-0.016 (-7.824)***	-0.015 (-3.627)***	-0.013 (-4.540)***	-0.048 (-12.878)***	-0.005 (-1.343)	-0.029 (-9.535)***	-0.021 (-5.688)***	-0.019 (-6.516)***	-0.044 (-13.633)***	-0.015 (-4.446)***	-0.027 (-9.027)***	
Alternative option ASC	ascA	0.176 (0.934)	0.680 (4.750)***	1.340 (10.071)***	0.297 (1.810)	0.407 (3.231)**	-0.399 (-1.649)	-0.271 (-1.505)	0.897 (4.511)***	-0.475 (-2.171)*	-0.021 (-0.128)	0.161 (0.492)	0.438 (2.566)*	0.972 (5.553)***	0.156 (0.735)	0.198 (1.215)	
	ascB	0.835 (4.563)***	1.004 (7.081)***	1.584 (12.060)***	0.721 (4.446)***	0.941 (7.559)***	0.744 (3.143)**	0.229 (1.289)	1.253 (6.464)***	0.230 (1.153)	0.781 (4.745)***	0.845 (2.431)*	0.796 (4.608)***	1.284 (7.441)***	0.730 (3.434)***	1.070 (6.587)***	
Behavioural decision type	Deterministic	Class2	-	-	-	-	-0.874 (-1.921)	-0.978 (-2.680)**	-1.660 (-4.672)***	-1.014 (-1.562)	0.217 (0.568)	-0.597 (-1.086)	-0.643 (-1.275)	-0.842 (-4.035)***	-0.608 (-1.290)	-1.043 (-3.372)***	
	Probabilistic	Class3	-	-	-	-	-0.009 (-0.019)	0.100 (0.238)	0.332 (1.067)	0.456 (0.575)	0.430 (0.796)	0.951 (1.902)	0.470 (0.912)	0.036 (0.119)	0.897 (1.862)	-2.061 (-2.286)*	
	Probabilistic	Class4	-	-	-	-	1.219 (3.836)***	0.987 (3.704)***	0.539 (2.360)*	1.275 (2.366)*	1.210 (3.224)**	-0.165 (-0.331)	1.767 (4.280)***	0.468 (5.970)***	-0.047 (-0.116)	-0.648 (-1.880)	
Attribute non-attendance assumption	Class5	-	-	-	-	-	-	-	-	-	-	-0.051 (-0.086)	-0.006 (-0.008)	1.072 (7.632)***	-0.072 (-0.133)	0.111 (0.367)	
	Class6	-	-	-	-	-	-	-	-	-	-	-0.960 (-2.353)*	0.113 (0.408)	0.791 (3.014)**	-0.909 (-2.419)*	0.726 (3.316)***	
Environmental attitude		A3_6	-	-	-	-	-3.212 (-3.335)***	-0.543 (-1.681)	-3.281 (-4.726)***	-2.641 (-2.771)**	-0.388 (-0.908)	-0.907 (-1.425)	-1.566 (-1.970)*	-2.491 (-5.941)***	-0.931 (-1.805)	-8.051 (-12.019)***	
Reason for WTP resistance		Tax resistance (tare)	-	-	-	-	-3.248 (-2.283)*	-0.431 (-1.351)	-3.321 (-4.121)***	-2.729 (-2.859)**	-2.484 (-2.662)**	-0.267 (-0.489)	-1.461 (-2.748)**	-2.470 (-5.210)***	-0.314 (-0.720)	-5.761 (-2.473)*	
Model fitness criteria		Log-Likelihood	-1340.191	-2248.104	-2482.739	-1681.377	-2861.235	-1146.726	-2140.523	-2073.468	-1470.824	-2488.154	-1229.341	-2068.672	-2072.612	-1544.177	-2376.236

Table 6 reports the WTP estimates under four behavioural models, highlighting the superior fit of the IAL III : the forest fire risk attribute has a WTP of ₩4,558.1 (\$3.49) to ₩7,160.2 KRW (\$5.48), and the forest pest risk has a WTP of ₩3,452.8 (\$2.64) to ₩6,952.5 KRW (\$5.32). The forest access restriction attribute has a WTP of ₩KRW 3,197.0 (\$2.45) to ₩KRW 8,014.5 (\$6.14). Forest biodiversity loss does not have a statistically significant value and was characterized by a wide distribution of WTP. It is noteworthy that in the IAL III model, the reluctance to pay taxes shows a WTP of about ₩-18,435.9 KRW (\$-14.12), and the latent environmental attitude variable shows a WTP of about ₩-34,807.2 KRW (\$-26.66), which is the largest value among the WTP variables. The results of estimating the WTP for each attribute and level using the four models are shown in Figure 1.

Figure 1. WTP estimation of attributes and levels by MNL, IAL I , IAL II , and IAL III

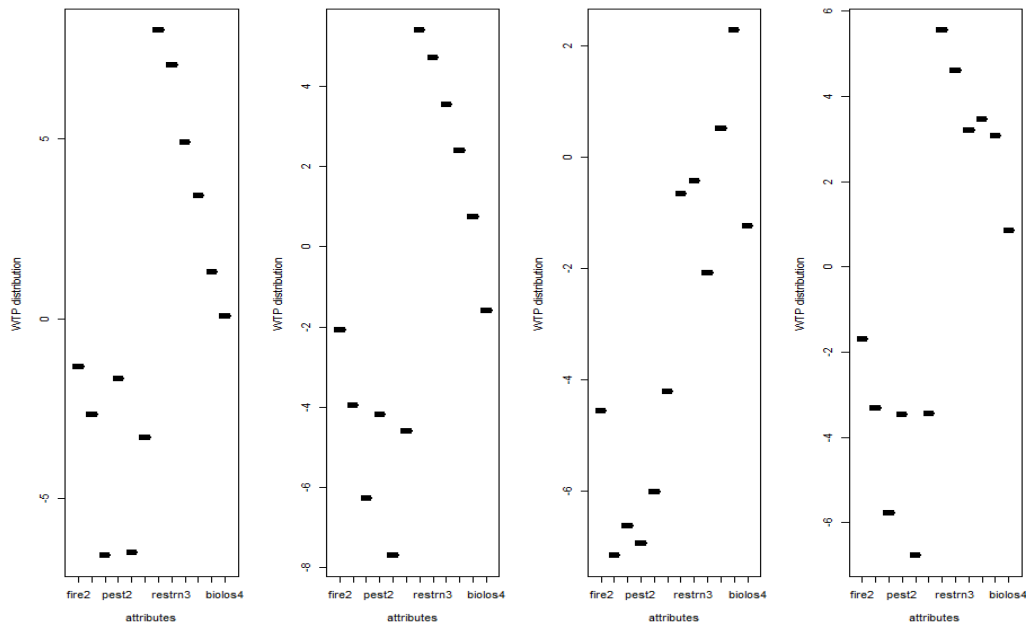
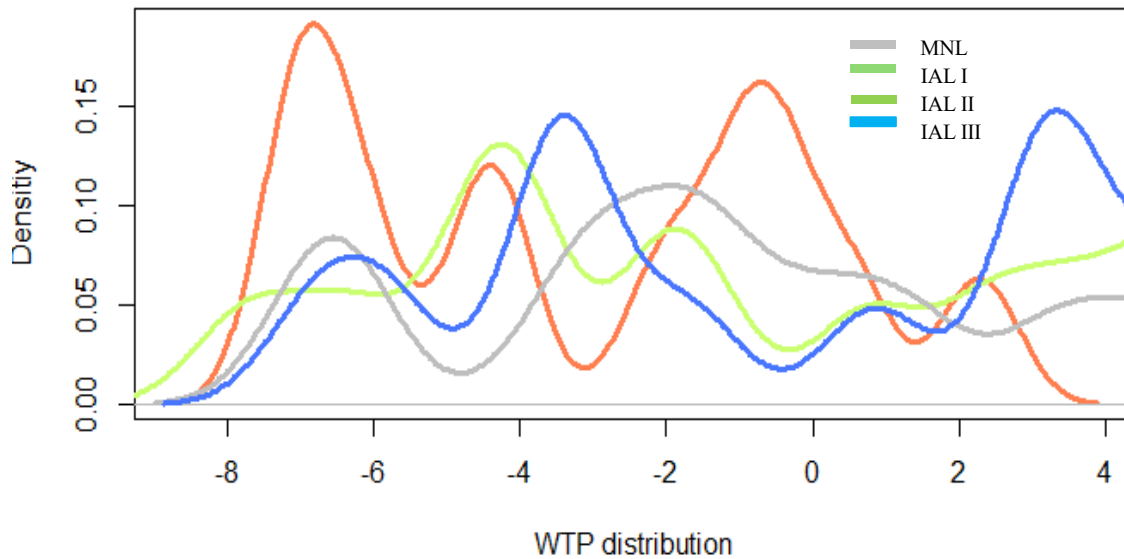


Figure 2 below shows the density distribution of individual WTPs based on the model estimation results in Table 7. The distribution reflects heterogeneity in preferences, including the presence of negative WTP values, which arise from negative utility associated with the forest fire and forest pest attributes. And Figure 2 highlights these variations, particularly the existence of negative WTP for tax payments among certain respondent classes.

Table 8 presents the estimation results for each model—MNL, IAL I, and IAL II—following the segmentation of the total sample into distinct latent environmental classes using principal component analysis. These results highlight notable differences in environmental behaviour and decision-making across latent classes. While direct comparison of model coefficients may be limited, the analysis offers meaningful insights into the diverse ways citizens approach environmental decisions on their environmental concerns, values, and preferences.

Figure 2. The density distribution of individual WTPs by different models



This research contributes by assessing public attitudes toward key policy instruments and applying advanced statistical methods to better understand and support the environmental decision-making process. The findings can inform policymakers about which groups are more responsive to certain restoration policies, payment mechanisms, or communication strategies.

Given the inherent complexity of aligning individual, national, social, economic, and cultural perspectives on environmental issues, a one-size-fits all policy approach is often ineffective. Instead, segmenting respondents' environmental attitudes and behavioural tendencies—using the latent class model and IAL models—enables the design of targeted, group-specific policies. While this approach introduces analytical complexity, it is vital for enhancing the relevance, acceptance, and overall success of forest restoration and environmental initiatives.

5. Conclusions

Understanding how individuals make environmental decisions is vital for effective policy design, especially in the context of forest restoration under increasing ecological threats. Using Korea as a case study, this research applied advanced choice modelling approaches—including independent availability logit and latent class models—to assess heterogeneous environmental attitudes, attribute non-attendance, and willingness to pay.

The findings reveal that respondents do not uniformly consider all policy attributes; instead, they selectively ignore certain information or rely on latent preferences, which significantly influence their WTP. Importantly, both deterministic and probabilistic choice behaviours were identified, and these behaviours were linked to underlying environmental attitudes. For example, individuals in the 'human self-benefit centred' group expressed significantly lower WTP for restoration, underscoring the challenge of engaging in less environmentally motivated segments of the population.

These insights have direct policy relevance. First, restoration programs should not adopt a one-size-fits-all

approach. Tailored strategies—such as targeted messaging, educational outreach, and differentiated payment schemes—should be used to engage different latent attitude groups. Second, the strong resistance to tax-based financing suggests a need to explore alternative funding mechanisms, such as voluntary contribution schemes, corporate partnerships, or ecosystem service credits. Third, the partial presence of attribute non-attendance highlights the importance of simplifying communication about policy options and using clear, relatable visuals to improve public understanding.

In sum, this study emphasizes the critical role of behavioural segmentation in environmental policy and provides a practical framework for integrating public heterogeneity into forest restoration strategies. Future research should continue to explore these dynamics in other contexts and test interventions that can shift latent preferences toward stronger pro-environmental support.

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Appendixes

Appendix 1. An example of a choice scenario.

Attributes and levels	Improved situation		Current situation
	Alternative 1	Alternative 2	Alternative 3(status quo)
Forest fire risk	 (Blue)	 (Orange)	 (Red)
Forest pests and disease risk	 (Orange)	 (Blue)	 (Red)
Restriction on forest-related outdoor activities	 (3~5million restriction)	 (Under 1 million restriction)	 (No restriction)
Biodiversity loss (No. of pine trees infected)	 (-100k~200k pine trees loss)	 (-200k~300k pine trees loss)	 (-300k~400k pine trees loss)
Forest restoration costs	 ₩ 10,000	 ₩ 10,000	₩ Zero won

Appendix 2. Respondents' results of environmental attitude and behaviour inventory (20 items).

A1. To what extent do you personally agree with the following statements?

Items	Mean	Mode	Standard deviation
1. I am the kind of person who loves spending time in wild, untamed wilderness areas.	3.55	4	0.96
2. Being out in nature is a great stress reducer for me.	3.95	4	0.79
3. I have a sense of well-being in the silence of nature.	3.99	4	0.78
4. I find it more interesting in the forest looking at trees and birds than in a shopping mall.	3.64	4	0.96
5. Nature is important because of what can contribute to the pleasure and welfare of humans.	4.15	4	0.81
6. What concerns me most about deforestation is that there will not be enough lumber for future generations.	3.72	4	1.00
7. We should protect the environment for the well-being of plants and animals rather than for the welfare of humans.	3.56	4	1.01
8. Conservation is important even if it lowers people's standard of living.	3.71	4	0.92

A2. To what extent do you personally agree with the following statements?

Items	Mean	Mode	Standard deviation
1. Most environmental problems can be solved by applying more and better technology.	3.53	4	0.91
2. Science and technology will eventually solve our problems with pollution, overpopulation, and diminishing resources.	3.54	4	0.95
3. If things continue their present course, we will soon experience a major ecological catastrophe.	4.08	4	0.82

4. The Earth is like a spaceship with very limited room and resources.	4.03	4	0.82
5. The balance of nature is very delicate and easily upset.	3.84	4	0.89
A3. To what extent do you personally agree with the following statements?			
Items	Mean	Mode	Standard deviation
1. I make sure that during the winter the heating system in my room is not switched on too high.	3.98	4	0.77
2. In my daily life I try to find ways to conserve water or power.	3.95	4	0.81
3. Even if public transportation was more efficient than it is, I would prefer to drive my car.	2.94	2	1.24
4. It is all right for humans to use nature as a resource for economic purposes.	3.08	3	1.03
5. The question of the environment is secondary to economic growth.	3.57	4	1.07
6. The benefits of modern consumer products are more important than the pollution that results from their production and use.	2.97	2	1.13
7. I would like to join and actively participate in an environmentalist group.	3.20	3	1.02

Appendix 3. The result of PCA with IBM SPSS 24 (28.0.1.1)

	Component				
	1	2	3	4	5
A3_6	0.782	-0.018	-0.108	0.189	-0.148
A3_4	0.752	0.021	-0.155	0.095	-0.096
A2_2	0.656	0.130	0.017	-0.074	0.457
A2_1	0.610	0.109	0.084	-0.047	0.492
A3_5	0.593	0.033	0.259	0.022	0.026
A3_3	0.545	0.085	-0.195	0.360	-0.203
A1_3	0.025	0.758	0.296	0.078	0.064
A1_2	0.052	0.756	0.199	0.202	0.143
A1_4	0.087	0.727	0.033	0.188	0.004
A1_1	0.096	0.689	0.051	0.238	0.102
A2_4	-0.061	0.159	0.806	0.087	0.094
A2_3	-0.073	0.188	0.724	0.167	0.143
A2_5	0.078	0.104	0.655	0.273	0.079
A1_5	-0.089	0.461	0.462	-0.073	0.230
A1_7	0.098	0.164	0.168	0.725	0.090
A3_7	0.213	0.123	0.050	0.704	0.102
A1_8	-0.081	0.344	0.183	0.624	0.195
A1_6	0.092	0.170	0.330	0.485	0.113
A3_1	-0.090	0.096	0.187	0.148	0.698
A3_2	-0.017	0.158	0.140	0.315	0.689

Note: Extraction Method: Principal Component Analysis; Rotation Method: Varimax with Kaiser Normalization; Rotation converged in 6 iterations.

Appendix 4. class-specific respondent characteristics.

	Class1(n=150)		Class2(n=138)		Class3 (n=206)		Class4(n=281)		Class5(n=246)	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
(Socioeconomic background)										
Gender	1.52	0.50	1.51	0.50	1.46	0.49	1.58	0.49	1.67	0.47
Age	37.63	8.77	41.49	12.45	36.75	11.07	42.26	12.26	42.69	11.31
Income	3.11	1.20	3.03	1.33	3.33	1.36	3.30	1.34	3.26	1.38
Education	3.95	0.41	3.75	0.62	3.99	0.56	4.01	0.58	4.02	0.58
(Environmental attitude and behaviours)										
A1 1	4.26	0.54	3.12	0.70	2.85	1.16	3.58	0.67	2.39	1.73
A1 2	4.68	0.49	3.21	0.61	3.48	0.96	3.90	0.33	3.91	0.90
A1 3	4.56	0.52	3.27	0.66	3.58	0.97	3.97	0.45	4.37	0.58
A1 4	4.36	0.67	3.17	0.70	3.05	1.17	3.65	0.65	4.40	0.58
A1 5	4.47	0.60	3.40	0.63	3.90	1.06	4.05	0.51	3.96	0.89
A1 6	4.47	0.57	3.22	0.62	3.08	1.18	3.74	0.73	4.71	0.50
A1 7	4.49	0.55	3.03	0.71	2.97	1.16	3.63	0.76	4.04	1.04
A1 8	4.50	0.51	3.07	0.65	3.00	1.10	3.72	0.58	3.72	0.98
A2 1	4.23	0.69	3.29	0.55	3.36	1.01	3.55	0.72	4.16	0.70
A2 2	4.37	0.83	3.31	0.60	3.45	1.03	3.52	0.71	3.35	1.07
A2 3	4.46	0.68	3.30	0.60	3.74	1.04	4.00	0.53	3.28	1.07
A2 4	4.38	0.65	3.28	0.59	3.68	1.06	3.93	0.48	4.68	0.46
A2 5	4.50	0.57	3.19	0.57	3.34	1.05	3.82	0.53	4.62	0.54
A3 1	4.35	0.53	3.46	0.56	3.64	1.00	3.95	0.48	4.25	0.88
A3 2	4.58	0.55	3.49	0.60	3.48	1.00	3.89	0.47	4.37	0.73
A3 3	4.44	0.78	3.22	0.68	2.74	1.25	2.89	1.00	4.28	0.75
A3 4	4.11	0.98	3.18	0.56	3.19	0.95	3.18	0.79	2.11	1.08
A3 5	4.43	0.57	3.36	0.55	3.59	1.01	3.50	0.87	2.18	0.81
A3 6	4.36	0.71	3.21	0.54	3.04	1.09	2.98	0.88	3.24	1.44
A3 7	4.13	1.16	2.86	0.71	2.54	1.07	3.31	0.69	1.91	0.79
(Follow-up questions: WTP resistance, attribute ranking, consequentiality, questionnaire relevant questions, others)										
D1 1	3.48	1.23	3.40	0.73	3.21	1.09	3.36	0.77	3.25	0.88
D1 2	3.65	1.14	3.40	0.55	3.49	0.85	3.46	0.65	3.17	1.04
D1 3	3.13	1.35	2.97	0.72	2.87	1.03	2.69	0.88	3.59	0.70
D1 4	3.13	1.33	3.04	0.66	2.67	1.12	2.63	0.92	2.39	0.91
D1 5	3.23	1.26	3.03	0.74	3.18	1.05	2.91	0.89	2.22	0.98
D1 6	3.31	1.34	3.20	0.68	3.10	1.12	2.93	0.84	2.54	0.99
D1 7	3.50	1.17	3.40	0.73	3.54	0.99	3.43	0.84	2.74	1.08
D1 8	3.50	1.21	3.34	0.69	3.43	0.96	3.22	0.81	3.33	1.07
D1 9	2.79	1.44	2.93	0.66	2.73	1.10	2.43	0.86	3.03	1.05
D2 1	2.00	1.16	1.70	1.13	2.05	1.29	1.91	1.36	1.78	0.70
D2 2	2.65	1.19	2.75	1.13	2.54	1.22	2.68	1.13	1.98	1.38
D2 3	2.91	1.28	3.08	1.13	2.88	1.16	3.03	1.20	2.64	1.15
D2 4	3.44	1.19	3.30	1.20	3.30	1.19	3.30	1.13	2.91	1.21
D2 5	4.00	1.34	4.17	1.21	4.23	1.14	4.09	1.25	3.29	1.14
D3 1	4.11	0.68	3.18	0.65	3.04	1.00	3.48	0.66	4.18	1.15
D3 2	4.19	0.72	3.10	0.62	3.08	0.99	3.36	0.73	3.35	0.89
D4 1	4.16	0.68	3.28	0.63	3.47	0.94	3.52	0.60	3.34	0.93
D4 2	4.25	0.77	3.34	0.64	3.52	0.79	3.56	0.62	3.71	0.73
D4 3	4.24	0.77	3.30	0.63	3.42	0.86	3.63	0.65	3.79	0.69
D4 4	4.04	0.86	3.26	0.68	3.33	0.98	3.34	0.75	3.88	0.78
D4 5	4.28	0.72	3.34	0.58	3.33	0.93	3.52	0.63	3.40	0.98

Appendix 5. Ethical approval



University of Stirling
Cottrell 3B1
Stirling
FK9 4LA

15/06/2023

Dear Chulhyun

Ethics Application Form : A choice experiment study between ecosystem services and forest risks for sustainable forest management 14107

Thank you for your submission of the above ethics application.

The ethical approaches of this project have been approved and you can now proceed with your project.

Please note that should any of your proposal change, a further amendment submission will be necessary.

If you have any further queries, please do not hesitate to contact the Panel by email to ethics@stir.ac.uk

Yours sincerely,

General University Ethics Panel

Chapter 6

Summary and conclusions

Summary and conclusions

MEA (2005) – “Human well-being and progress toward sustainable development are vitally dependent upon improving the management of Earth’s ecosystems to ensure their conservation and sustainable use. But while demands for ecosystem services such as food and clean water are growing, human actions are at the same time diminishing the capability of many ecosystems to meet these demands. Sound policy and management interventions can often reverse ecosystem degradation and enhance the contributions of ecosystems to human well-being but knowing when and how to intervene requires substantial understanding of both the ecological and the social systems involved. Better information cannot guarantee improved decisions, but it is a prerequisite for sound decision-making.”

6.1 Academic Contributions

This thesis has advanced the field of non-market valuation of forest ecosystem services by integrating methodological innovation with behavioural realism across five empirical studies. Each chapter has addressed distinct sources of heterogeneity in stated preferences and decision-making, thereby contributing to a more comprehensive and nuanced understanding of environmental valuation.

- **Temporal heterogeneity (Chapter 1):** The meta-analysis of 476 WTP estimates from 90 studies in Korea confirmed that willingness to pay (WTP) varies significantly across seasons, with autumn premiums of up to 67% and winter declines of up to 65%. These findings highlight seasonality as an intrinsic determinant of welfare measures that have long been neglected in non-market valuation research.
- **Methodological sensitivity (Chapter 2):** The contingent valuation of the Gotjawal’s cultural–historical resources demonstrated that single-bounded estimates were consistently higher than double-bounded estimates (by approximately 18%) and that payment vehicle choice strongly influenced outcomes. Entrance fees produced the highest WTP, followed by donations, with local taxes yielding the lowest support. These results confirm that methodological and institutional context substantially affect stated values.
- **Behavioural segmentation (Chapter 3):** Latent class modelling and principal component analysis identified five distinct groups of respondents with divergent WTP and policy preferences. This segmentation illustrates that environmental values cannot be treated as homogeneous, reinforcing the need to model attitudinal and behavioural diversity explicitly.
- **Attitude-integrated valuation (Chapter 4):** Hybrid choice modelling revealed the central role of environmental attitudes in structuring preferences. Two latent classes emerged: a risk- and cost-sensitive group valuing disaster prevention, and an ecologically oriented group prioritizing biodiversity and

recreational access. This approach provides empirical evidence of how psychometric constructs can be incorporated into discrete choice models to capture motivational structures.

- **Attribute non-attendance and latent attitudes (Chapter 5):** The analysis showed that individuals often disregard certain attributes, influenced by latent orientations such as anthropocentric versus ecocentric attitudes. These findings advance understanding of cognitive simplification processes in stated preference surveys and their implications for policy acceptability.

Taken together, the thesis demonstrates that non-market valuation outcomes are dynamic and context-dependent, shaped not only by methodological design but also by temporal, cultural, and psychological heterogeneity. This represents an important contribution to bridging economic valuation with behavioural and environmental social science.

6.2 Policy Implications

The findings also provide practical lessons for forest policy and ecosystem management.

- **Accounting for seasonality:** Seasonal WTP variation indicates that benefit–cost analyses and benefit transfer exercises should incorporate seasonal adjustment factors. Policymakers could also consider differentiated entrance fees across seasons to manage demand and stabilize revenues.
- **Selecting credible payment vehicles:** Entrance fees emerged as the most socially acceptable and politically feasible mechanism for financing forest conservation in Jeju, while tax-based approaches were strongly resisted. Trust, transparency, and governance therefore remain central to the success of conservation financing.
- **Tailoring strategies to heterogeneous groups:** Preference segmentation suggests that different groups require differentiated engagement. Highly engaged citizens could be mobilized through participatory programs, while indifferent groups may require targeted education and awareness campaigns.
- **Aligning communication with attitudes:** Risk-sensitive citizens respond best to cost-effectiveness and safety narratives, whereas ecologically motivated citizens resonate more with biodiversity and recreational benefits. Communication strategies should therefore be designed with attitudinal alignment in mind.
- **Simplifying decision environments:** Evidence of attribute non-attendance highlights the need for clear and concise policy communication, supported by visual aids and simplified decision structures to enhance public comprehension and support.

Collectively, these findings underscore that one-size-fits-all approaches are unlikely to succeed. Effective forest governance requires flexible, differentiated, and socially responsive strategies that align with behavioural realities.

6.3 Limitations and Future Research

As with all empirical research, this thesis is subject to limitations.

- The analyses are context-specific to Korea, limiting generalizability to other cultural and institutional settings.
- Stated preference methods remain vulnerable to hypothetical bias, anchoring, and framing effects, even with careful design.
- Attitudinal measures were incorporated but relied on a limited set of psychometric indicators, restricting the scope for full behavioural integration.
- Some survey samples slightly overrepresented urban respondents, raising questions of representativeness.
- Differences in WTP estimates across model specifications suggest sensitivity to methodological assumptions.

Future research should therefore:

- Pursue cross-country comparative analyses to test the universality of seasonal, cultural, and attitudinal effects.
- Apply methodological innovations such as Bayesian hierarchical meta-analysis, incentive-compatible designs, and longitudinal surveys.
- Integrate richer psychometric and sociological constructs, including trust, identity, and social norms, into hybrid choice frameworks to capture behavioural underpinnings more comprehensively.

6.4 Concluding Remark

This thesis has shown that heterogeneity—across time, methodology, attitudes, and behavioural processes—is not peripheral but central to understanding the economic value of forest ecosystem services. By combining methodological diversity with behavioural insights, it contributes to the refinement of environmental valuation techniques and offers practical guidance for the design of more equitable and socially responsive forest policies.

Korea's reforestation trajectory provides a compelling illustration of the broader principle articulated in the *World Development Report 1992: Development and the Environment* (World Bank). That report argued that environmental degradation is not an inevitable outcome of growth but can be reversed through deliberate policy and investment. Korea's success story demonstrates that economic development and environmental sustainability are not mutually exclusive but can advance together when supported by effective governance and public commitment. This reinforces the central message of the thesis: recognizing heterogeneity and aligning policy instruments with behavioural realities are indispensable steps toward sustainable ecosystem management.

References

- MA, M.E.A., 2005. Millennium Ecosystem Assessment. Ecosystems and human wellbeing: Synthesis (Island Press, Washington, DC.: World Resources Institute).
- The International Bank, 1992. World Development Report 1992 (development and the environment), the World Bank Oxford University Press.

Appendices

(Two questionnaires for chapters 2 and 3)

Questionnaires for chapters 2

Questionnaires for chapter 2

Survey location:	Date: Month Day	Weather: ①Sunny ②Cloudy ③Rain
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A survey to estimate the economic benefit of historical and cultural resources in Gotjawal

How are you?

The National Academy of Forestry Sciences is conducting a survey to promote the value of Gotjawal to the people of Jeju Island and the nation. Jeju Island's unique ecosystem is a treasure trove of biodiversity, and it is also a historically and culturally important place where we can get a glimpse of the traditional lifestyle of our ancestors (foraging, charcoal production, herding, hunting, etc.). We would like to understand the historical and cultural values of Gotjawal for its conservation and sustainable utilization.

Even if you are busy, we ask for your time to respond. Thank you.

Contact	Chulhyun Jeon, Research Associate, Institute of Tropical and Subtropical Forestry (064)730-7290 Jin-Chul Yang, Director of Future Research 064)755-0073
---------	--

- Pursuant to Article 33 of the Statistics Act (Protection of Secrets), matters belonging to the secrets of the three individuals involved in this survey are strictly protected.

✓ Residence area: ① Local residents of Gotjawal ② JeJu citizens ③ tourists ☞ Stop

I. Experience of Gotjawal forest

1. What is the frequency of your visits to Gotjawal over the past 5 years?

① Revisit ☞ Total number of visits including this one () ☞ 1-1 ② first time ☞ 1-2

1.1 How often do you visit Gotjawal?

① 1-2 times per month ② 1-2 times per year ③ 3-4 times per year ④ other

1.2 How much time do I spend in Gotjawal? (Hours Minutes)

2. Please list all the modes of transportation you used to get to Gotjawal. (Check all)

① Walking ② Car ③ Motorcycle ④ Bus ⑤ Other ()

3. How many people do you bring with you when you visit Gotjawal?

Total number (men __, women __)

4. Who do you usually come to Gotjawal with?

① Alone ② Family and relatives Friends ③ Lovers and colleagues

④ Social (religious) clubs ⑤ paid tour operator programs ⑥ Other ()

5. What activities did you spend your time in Gotjawal doing? (Check all)

- ① Walking/relaxing (meditation) ② Visiting cultural sites ③ Foraging for herbs
 ④ Observing flora and fauna ⑤ Charcoal production ⑥ Ranching and grazing ⑦ Other ()

6. What are some of the reasons why you have disturbed the Gotjawal? Please select and number three in order of importance. (1st: , 2nd: , 3rd:)

- ① Forest walking/Exercising ② Collecting herbs ③ Ingredients for daily necessities
 ④ Observing flora and fauna ⑤ Historical and cultural tours ⑥ Refreshment/relaxation
 ⑦ Educational purposes ⑧ due to lack of crowds ⑨ Other ()

7. How did you get your information about Gotjawal? (Check all)

- ① Family members and acquaintances ② TV and Radio ③ Newspapers and magazines
 ④ Internet searches ⑤ Other ()

II. Questions about the role and importance of Gotjawal

8. Which of the following do you think is most important in role as a Gotjawal?

- ① Historical and cultural spaces ② Daily life Collecting tools and materials ③ Farming
 ④ Educational purposes (space) ⑤ Exercise or walking ⑥ Living spaces ⑦ Other ()

9. How do you feel about the following statements below, please indicate where applicable.

	Strongly agree	Agree	Neither	Disagree	Strongly disagree
It is historically and culturally important.					
It has a good variety of trees.					
It provides beautiful scenery and a place to relax.					
It provides opportunities for forest and ecological education.					
The site contributes to community development.					
The site has a well-preserved nature.					

10. What are your inconveniences about using Gotjawal? (Tick all)

- ① Poor maintenance of forest roads and forests ② Illegal behaviour of users ③ Damage to natural and cultural resources ④ Lack of facilities such as restrooms ⑤ Lack of information and signs ⑥ Limitations on the number of visitors per day ⑦ Lack of information on the research ⑧ Forest lack of reservation for interpretive programs ⑨ Public transportation inconvenience ⑩ Other ()

III. Questions about historical and cultural values of Gotjawal

Historically, Gotjawal has been used for different purposes depending on the era. During the Silla period, traces of wood usage such as Nam Bang Ah (wooden utensils made of oak) suggest that the forest was dense. During the Goryeo period, the pastureland (Teuri) for horse management was established in the Gotjawal area due to Mongol invasions, and people began cultivating fields for their livelihoods. During the Joseon period, Gotjawal was used as a source of wood and pastureland until the Japanese occupation, when it was damaged by Japanese military installations and other acts of pillaging. During the April 3rd incident, it was used as a battlefield and a place of residence for the locals. Since the 1960s, it has been conserved under forest protection policies, but it has been affected by development projects such as the construction of golf courses and quarries. Currently, 20% of the Gotjawal area is damaged.

Research results of historical and cultural relics in Gotjawal showed that within an area of about 8,200 square meters, there were one charcoal kiln, twelve temporary charcoal kilns, one charcoal hut, three trap pits for deer, thirty-three pits for rooting wild vegetables, eight stone walls, and one water pond. These relics were used for different purposes during the Joseon to modern times (19th century to mid-1960s). Based on the survey results, Gotjawal's historical relics can be divided into six categories: charcoal production, residential areas, agriculture, hunting, drinking water sources, and religious sites. Therefore, Gotjawal was used as a place for livelihood activities such as charcoal burning, livestock raising, mountain cultivation, hunting, and making household utensils.

To preserve Gotjawal's historical and cultural relics, various measures are being discussed, including comprehensive academic research on Gotjawal's historical and cultural relics and cultural resources, developing ecological experience programs for sustainable use of Gotjawal's historical and cultural relics, and linking tourist resources with areas around Gotjawal.

Appendix 1. Photographs related to Gotjawal history and culture

11. In your opinion, how important is the preservation and use of the historical and cultural resources in Gotjawal?

- ① Very important ② Important ③ Neither ④ Not important ⑤ Never important

12. Given this situation above, access to the Gotjawal is presently unrestricted. However, in the event that there arises a requirement to bear expenses for the purpose of protecting and enhancing historical and cultural resources in the forest, ensuring its sustainability and providing a sustainable ecosystem service, which of the following funding sources would you favour?

- ① Donations (visitors) ② Entrance fees (visitors) ③ Government budget (local taxes) ④ Other

< It will be answered twice >

13. If you were to visit Gotjawal, would you be willing to pay a certain amount of money by the means you have selected above? (* See Appendix 2)

- ① Yes ☞ 13.1 ② No ☞ 13.2

13.1 If yes, would you be willing to pay _____ KRW?

- ① Yes ☞ 14 ② No ☞ 14

13.2 If 'no', would you be willing to pay _____ KRW?

- ① Yes ☞ 14 ② No ☞ 15

14. Please write below the amount you are willing to pay, regardless of whether you answered "yes" or "no" to the amount shown in question 13. (_____ Won)

15. If you answered, "I am not willing to pay for " what do you think are the reasons?

① I can't afford it ② I am satisfied with the status quo ③ It is the responsibility of the government or municipality ④ Lack of trust in the use of money ⑤ I don't like the payment method ⑥ Uncertainty about service improvement ⑦ there is no difference from general forests ⑧ Other (_____)

16. To characterize your answer above, if you had a total of 100% to spend on Gotjawal, how much would you allocate to each of the following?

Contents	Percent
Taking advantage of historical and cultural experiences.	
I am satisfied with the fact that Gotjawal exists.	
You feel obligated to pass it on to future generations.	
To use Gotjawal in various ways in the future rather than now	
Sum	100%

IV. General questions

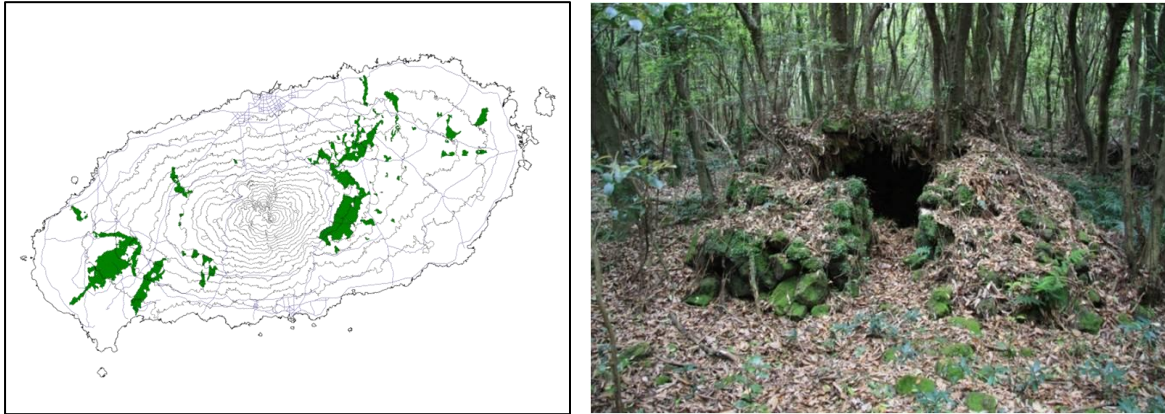
Gender	① Male ② Female
Age	① Under 20 years old ② 20s ③ 30s ④ 40s ⑤ 50s ⑥ 60+ years old
Job	① Self-employed ② Professional ③ Working in agriculture, forestry, livestock and fisheries ④ Public servant ⑤ Student ⑥ Housekeeper ⑦ Office worker (office work, sales) ⑧ Others
Education	① Middle school ② High school ③ University ④ Postgraduate or higher
Birthplace	(_____) Province/City/Gun/Gu
Monthly income	① Less than 2 million won ② Less than 2 million won ~ 4 million won ③ Less than 4 million won ~ 6 million won ④ Over 6 million won

- If you have any comments regarding Gotjawal's operation, management, or forestry policies, please write to us.

We sincerely thank you for your participation.

Appendix1. Gotjawal information for sites and resources.

Figure 1. Distribution of Gotjawal forests in JeJu and Gotjawal sites



Source: Choi et al. 2014

Figure 2. Late Neolithic streaked ceramics from Seon-hul Gotjawal Muksimul Cave Excavation



Figure 3. Recreation activities in Gotjawal forests



Appendix 2. Monthly national expenditure per household by categories in average (2015)

Expenditures by items (Won, \$dollar)		Reference level
Insurance cost	83,968(\$69.6)	
		₩80,000(\$66.3)*
Medicine	43,106(\$35.7)	
		₩40,000(\$33.1)
Cultural services	35,594(\$29.5)	
		₩30,000(\$24.9)
Dental services	28,797(\$23.9)	
		₩25,000(\$20.7)
Communication equipment	22,676(\$18.8)	
		₩20,000(\$16.6)
Other personal transportation services	13,253(\$11.0)	
		₩15,000(\$12.4)
Alcoholic beverages	12,109(\$10.0)	
		₩10,000(\$8.3)
Innerwear	9,606(\$8.0)	
		₩9,000(\$7.5)
Toys and hobbies	8,682(\$7.2)	
		₩8000(\$6.6)
Coffee and tea	7,657(\$6.3)	
		₩6,000(\$5.0)
Audio-visual equipment	5,289(\$4.4)	
		₩4,000(\$3.3)
Clothing services	3,818(\$3.2)	
		₩3,000(\$2.5)
Other medical services	2,632(\$2.2)	
		₩2,000(\$1.7)
Simple interior decorations	1,598(\$1.3)	
		₩1,000(\$0.8)

Source: Korean National Statistics (<https://kostat.go.kr/ansk/>).

* US dollar and Korean won is \$1 vs. ₩1,207.

Questionnaires for chapters 3

Questionnaires for chapter 3



University of Stirling
Cottrell 3B1
Stirling
FK9 4LA

15/06/2023

Dear Chulhyun

Ethics Application Form : A choice experiment study between ecosystem services and forest risks for sustainable forest management 14107

Thank you for your submission of the above ethics application.

The ethical approaches of this project have been approved and you can now proceed with your project.

Please note that should any of your proposal change, a further amendment submission will be necessary.

If you have any further queries, please do not hesitate to contact the Panel by email to ethics@stir.ac.uk

Yours sincerely,

General University Ethics Panel

Consent form

Research project title:

A choice experiment study between ecosystem services and forest risks for sustainable forest management

Contents	Please tick box
I confirm that I have read and understood the information sheet explaining the research project and I have had the opportunity to ask questions about the project.	
I understand that my participation is voluntary and that I am free to withdraw at any time during the study without giving a reason and without any penalty. I understand that if I withdraw no more data will be collected from me. However, any data collected up until the point that I withdraw may be kept and used in the data analysis.	
I have been given a unique identifying number and know whom to contact should I wish to withdraw my data.	
I understand that my responses will be kept anonymous, and I give permission for members of the research team to have access to my anonymised responses.	
I agree that research data collected in the study to be made available to researchers in South Korea. I understand that any data that leaves the research group will be fully anonymised so that I cannot be identified.	
I agree to take part in this study.	

Participant information sheet

Research project title:

A choice experiment study between ecosystem services and forest risks for sustainable forest management

The name and contact details of the lead researcher:

Name: Chulhyun Jeon, email: chj2@stir.ac.uk & ecoecon@korea.kr

Ethical approval:

This survey is being conducted with ethical approval under the University of Stirling.

Invitation to participants

This survey is aimed at the general public to get their opinions on forests and is being conducted by selecting local residents or foresters to get their opinions. There are no right or wrong answers to these questions, so please feel free to answer as you see fit. And Taking part in the study is entirely voluntary and that refusal to agree to participate will involve no penalty or loss of benefits to which the participant is otherwise entitled. The participant may discontinue participation at any time without penalty or loss of benefits to which the participant is otherwise entitled. If you have any questions during the survey, please ask the survey moderator.

Privacy Notice for Research Participants

The answers will be treated anonymously and protected by Personal Information Protection Act in Korea (No. 16930). This survey is for research purposes only. The results will be of great help for sustainable forest management.

If you wish to withdraw your data

You may withdraw your data by emailing Chulhyun Jeon (chj2@stir.ac.uk) using your unique identifier number located at the bottom of each page. The information sheet also contains other contact details if you have any questions about the research or any queries you wish to raise. You have the right to lodge a complaint against the University regarding data protection issues with the Information Commissioner's Office (<https://ico.org.uk/concerns/>). The University's Data Protection Officer is Joanna Morrow, Deputy Secretary. If you have any questions relating to data protection these can be addressed to data.protection@stir.ac.uk in the first instance. Once again, I would like to thank you for your participation.

(Unique ID)

Participant debriefing sheet

Thank you for participating in this research project Research.

Research project title:

A choice experiment study between ecosystem services and forest risks for sustainable forest management

Background, aims of project

This project aims to understand people's attitudes, preferences, and economic values regarding sustainable forest management. The information gathered will be used to inform future forest policies and management strategies and allow local and national authorities to better align forest planning decisions based on public preferences.

If you wish to withdraw your data

You may withdraw your data by emailing Chulhyun Jeon (chj2@stir.ac.uk) using your unique identifier number (located at the bottom of each page). The information sheet also contains other contact details if you have any questions about the research or any queries you wish to raise. You have the right to lodge a complaint against the University regarding data protection issues with the Information Commissioner's Office (<https://ico.org.uk/concerns/>). The University's Data Protection Officer is Joanna Morrow, Deputy Secretary. If you have any questions relating to data protection these can be addressed to data.protection@stir.ac.uk in the first instance.

Once again, I would like to thank you for your participation.

A choice experiment study between ecosystem services and forest risks for sustainable forest management

Welcome to this survey about forest ecosystem services and forest risks(threats) in the Republic of Korea. We will ask you some questions regarding your visits to forests, ecosystem services and your preferences for how you think they should be managed about forests and ecosystem services. We are interested in your opinion, and thus there are no right or wrong answers. Your responses help us to learn more about the public preferences of forest ecosystem services and forest risks such as bush fires, forest pest and diseases, biodiversity and recreation activities in forest. The survey is part of research collaboration with the university of Stirling (economics division) and Temperate and Subtropical Forest Research Institute, National Institute of Forest Science on sustainable forest management. The answers will be treated anonymously and protected by Personal Information Protection Act in Korea (No. 16930). Taking part in the study is entirely voluntary and that refusal to agree to participate will involve no penalty or loss of benefits to which the participant is otherwise entitled. The participant may discontinue participation at any time without penalty or loss of benefits to which the participant is otherwise entitled. If you have any questions regarding the survey, you are welcome to contact: Chulhyun Jeon (chj2@stir.ac.uk and ecoecon@korea.kr) and Ara Seol(arasole@korea.kr). Thank you for considering taking part in this research project.

* It will take approximately 15~20 minutes to fill out the questionnaire.

I agree to take part in this survey under the conditions explained to me above: Please select one.

a) Yes b) No

[Part A] Environmental Attitudes

Please indicate your level of agreement or disagreement for the following statements. There are no right or wrong answers. Each statement is measured on 5-point scale ranging from:

5-point scale: 1 = Strongly disagreement; 2 = Disagree; 3 = Neither disagree nor agree; 4 = Agree; 5 = Strongly agree

<u>Items</u>	1	2	3	4	5
I am the kind of person who loves spending time in wild, untamed wilderness areas.					
Being out in nature is a great stress reducer for me.					

I have a sense of well-being in the silence of nature.					
I find it more interesting in the forest looking at trees and birds than a shopping mall.					
Nature is important because of what it can contribute to the pleasure and welfare of humans.					
The thing that concerns me most about deforestation is that there will not be enough lumber for future generations.					
We should protect the environment for the wellbeing of plants and animals then for the welfare of humans.					
Conservation is important even if it lowers peoples' standard of living.					

<u>Items</u>	1	2	3	4	5
Most environmental problems can be solved by applying more and better technology.					
Science and technology will eventually solve our problems with pollution, overpopulation, and diminishing resources.					
If things continue on their present course, we will soon experience a major ecological catastrophe.					
The earth is like a spaceship with very limited room and resources.					
The balance of nature is very delicate and easily upset.					

<u>Items</u>	1	2	3	4	5
I make sure that during the winter the heating system in my room is not switched on too high.					
In my daily life I try to find ways to conserve water or power.					
Even if public transportation was more efficient than it is, I would prefer to drive my car.					
It is all right for humans to use nature as a resource for economic purposes.					
The question of the environment is secondary to economic growth.					
The benefits of modern consumer products are more important than the pollution that results from their production and use.					
I would like to join and actively participate in an environmentalist group.					

[Part B] Please carefully read the following information.

✓ **choice experiment questions for forest ecosystem services and environmental risks(threats)**

- Healthy forests can provide people with both direct and indirect benefits such as timber, clean air and opportunities for recreational activities, forest healing and habitat for biodiversity as well. In Korea, the tree-growing stock of forests was increased from 23.09m³ in 1980 to 165.2m³ in 2020. More than 11 million people have continuously visited the national recreation forest sites in 2020 as well (KFS 2021).
- However, there exist environmental threats and risks such as bushfires and forest pest and disease outbreaks (increasing invasive species. ex, pine wilt diseases), which impact destroy forest ecosystem and their services. For example, more than 12 million pine trees were infected with Pine Wilt Diseases, introduced from Japanese imported timbers, which have been urgently removed since 1988. These environmental threats and disturbances can hinder forest ecosystem service provision and their growth.
- If we do not take action, these environmental risks may increase. Therefore, we need appropriate measures to achieve sustainable forest management and conservation to tackle these risks. To cope with these threats and risks, the government is considering policies to alleviate the risks of forest fires and forest pests and diseases.

Description of background about the scenario

Let us describe the current status in Korea in relation to this task and attributes, according to the statistics book of the year, Korea Forest Services (2020). First, the main attributes and levels here will be described.

- **One of the most critical threats to forests in Korea is bushfires as recent trends show this is increasing.**
- **Bushfire risk index and alert system in Korea:** Korea Forest Service provides 4 levels of forest fire risk such as blue level (lower than 50), Yellow level (51~65), Orange level (66~85), and Red level (higher than 86) [0(lower risks) -> 100(higher risk)], according to the data analysis of NIFOS forecasting system.

Seriously extreme (Current level)	High level (Highly alert)	Moderate level (Caution)	Low level (Attention)
 (85↑)	 (66~85)	 (51~65)	 (↓50)

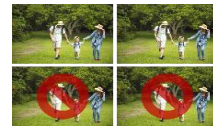
- **Pine Wilt Diseases (PWD) is currently prevalent in Korea.** More than 12 million pine trees have been infected with Pine Wilt Diseases, introduced from Japanese imported timbers. These have been urgently removed since 1988. **Pine Wilt disease:** Pine wilt is a dramatic disease that typically kills affected trees within a few months. The causal pathogen is the pine wood nematode (PWN). Tree death usually progresses from the top of the tree downward. Needles change from their normal colour to a greyish green colour and finally a tan to brown colour. The disease is most serious on pine species that are not native to North America, with the greatest impact in landscape plantings and windbreaks. Age of the tree also influences susceptibility, with an increased risk of developing pine wilt when trees are greater than 10 years of age. Worldwide, the problem is epidemic in Japan and other parts of Asia, where it is the native pine forests that are at risk.

- **Forest pests and disease outbreak index and alert level in Korea:** NIFoS (the director general) shall issue a pest outbreak alarming with four levels, Interest (Blue), Caution (Yellow), Border (Orange), Serious (Red) under the results of the surveillance investigation, based on the scale of occurrence, speed of spread, and degree of damage (through forest pest control regulation article No. 4).

Seriously extreme (Current level)	High level (Highly alert)	Moderate level (Caution)	Low level (Attention)
			

- **Restrictions on outdoor relevant activities (forest recreation activities, which is one of the representative ecosystem services in Korea).** In order to control forest fires and pest and disease, the government are thinking a controlling visitor numbers as part of their policy.

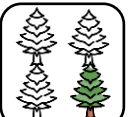
- 0 ~ -1 million people, -1 ~ -2 million people, -2 ~ -5 million people

No restrictions (Current level)	Slightly restrictions	Moderate restrictions	Highly restrictions
 (zero)	 (0~-1 million)	 (-1 ~ -2 million)	 (-2 ~ -5 million)

- **Biodiversity loss (The number of pine trees infected)**

Pine trees are one of the main trees infected with PWD. Six hundred thousand pine trees per year on average are infected by Pine Wilt diseases. Pine trees are very special images with long historical backgrounds and evergreen trees for Korean people. And it is one of the long-lived symbols.

- 0 (zero) ~ -100k, -100k ~ -200k, -200k ~ -300k, -300k ~ -400k

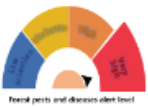
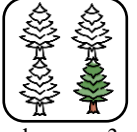
Large damages (Current level)	Moderate damages	Slightly damages	Rarely damages
 (-300k~-400k)	 (-200~-300k)	 (-100k~-200k)	 (0~-100k)

- **Costs (forest restoration fund by household)**

Forests are usually managed by the government budget and to forest policy they thus will make a one-off tax payment. For reference, the general citizen monthly pays about ₩6,019.54(£3.76), based on the annual budget of the Korean Forest Service, currently government budget per year ₩3,110,822 million in 2020. Considering the levels ₩5,000, ₩10,000, and ₩20,000 are classified. These are additional to what current policy.

Little increase (Current level)	Slightly increase	Moderate increase	Large increase
₩ Zero won~₩10,000	₩10,100~₩25,000	₩25,100~₩35,000	₩35,100~₩50,000
0			

An example of choice sets for forest management

Attributes and levels					①	②	③
Attributes	Levels				Alternative A	Alternative B	Current (SQ)
Forest fires (4 stages of alerts)	Seriously extreme (Current level)  (85↑)	High level  (66~84)	Moderate level  (51~65)	Low level  (↓50)	 (Low, ↓50)	 (Moderate, 51~65)	 (Very high, 85↑)
Forest pest & diseases (4 stages of alerts)	Very high (Current level)  Forest pests and diseases alert level	High level  Forest pests and diseases alert level	Moderate level  Forest pests and diseases alert level	Low level  Forest pests and diseases alert level	 Forest pests and diseases alert level (Low)	 Forest pests and diseases alert level (Moderate)	 Forest pests and diseases alert level (Very high)
Recreation on outdoor relevant activities (4 levels w.r.t negative impact on recreational activities)	No restrictions (Current level)  (zero)	Slightly restrictions  (0~1 million)	Moderate restrictions  (-1 ~ -2 million)	Highly restrictions  (-2 ~ -5 million)	 (Highly restriction, 2~5 million)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (4 levels of negative impact)	Large damages (Current level)  (300k~400k)	Moderate damages  (200~300k)	Slightly damages  (100k~200k)	Rarely damages  (0~100k)	 (Rarely damages, 0~100k)	 (Rarely damages, 0~100k)	 (Large damages, -300k~400k)
Forest restoration fund (Randomly distributed in 5,000 increments from ₩0 to ₩50,000)	Current level (Little increase) ₩ Zero won~₩10,000 	Slightly increase ₩10,100~₩25,000 	Moderate increase ₩25,100~₩35,000 	Very increase ₩35,100~₩50,000 	 (₩5,000won)	 (₩35,000won)	0 korean won

[Part C] Please carefully read the following information.

In the following questions, you will be presented with suggested policy options the government is considering 2 options, you will be asked which alternative you prefer or choose the status quo if neither two options.

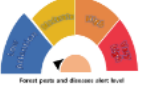
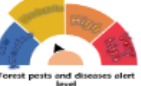
< Cheap talk >

“Remember to consider how the additional one-off tax payment will affect your household’s disposable income for other purposes. In similar surveys, it has been found that people tend to overestimate how much they would really be willing to pay.” If the prices of alternatives A and B are higher than what you think your household will pay, you should choose the current situation.

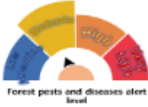
If you can choose the three alternatives, which one would you choose?

< Examples from choice tasks 1~10>

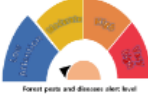
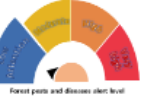
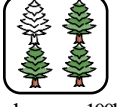
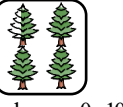
1. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Low, ↓50)	 (High, 66~84)	 (Very high, 85↑)
Forest pest and disease risk	 (Attention)	 (Caution)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Slightly restriction, 0~1 million)	 (Moderate restriction, 1~2 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Rarely damages, 0~100k)	 (Rarely damages, 0~100k)	 (Large damages, 300k~400k)
Forest restoration fund per household (Korean won)	 (₩15,000)	 (₩10,000)	0 korean won

2. Suppose the government have narrowed their policy options to following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Very high, 85↑)	 (High, 66~84)	 (Very high, 85↑)
Forest pest and disease risk	 (Caution)	 (Highly alert)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, ~2~5 million)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Moderate damages, ~200~300k)	 (Slightly damages, ~100k~200k)	 (Large damages, ~300k~400k)
Forest restoration fund per household (Korean won)	 (₩10,000)	 (₩10,000)	0 korean won

3. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Moderate, 51~65)	 (Moderate, 51~65)	 (Very high, 85↑)
Forest pest and disease risk	 (Attention)	 (Attention)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, ~2~5 million)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Slightly damages, ~100k~300k)	 (Rarely damages, 0~100k)	 (Large damages, ~300k~400k)
Forest restoration fund per household (Korean won)	 (₩5,000)	 (₩15,000)	0 korean won

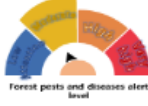
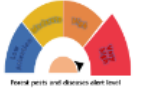
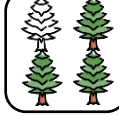
4. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Very high, 85↑)	 (Moderate, 51~65)	 (Very high, 85↑)
Forest pest and disease risk	 (Attention)	 (Highly alert)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, -2~-5 million)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Large damages, -300k~400k)	 (Slightly damages, -100k~200k)	 (Large damages, -300k~400k)
Forest restoration fund per household (Korean won)	 (₩15,000)	 (₩10,000)	0 korean won

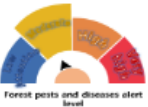
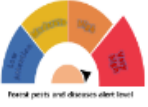
5. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Low, ↓50)	 (High, 66~84)	 (Very high, 85↑)
Forest pest and disease risk	 (Seriously extreme)	 (Seriously extreme)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, -2~-5 million)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Large damages, -300k~400)	 (Moderate damages, -200k~300k)	 (Large damages, -300k~400k)
Forest restoration fund per household (Korean won)	 (₩5,000)	 (₩10,000)	0 korean won

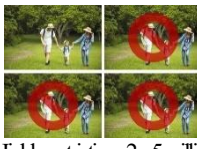
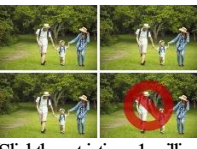
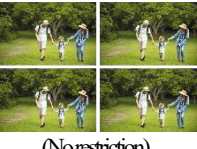
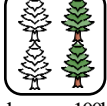
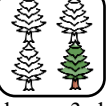
6. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Very high, 85†)	 (Very high, 85†)	 (Very high, 85†)
Forest pest and disease risk	 (Caution)	 (Seriously extreme)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, ~2~5 million)	 (Rarely restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Moderate damages, ~200k~300k)	 (Slightly damages, ~100~200k)	 (Large damages, ~300k~400k)
Forest restoration fund per household (Korean won)	 (₩15,000)	 (₩5,000)	0 korean won

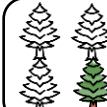
7. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (High, 66~84)	 (Moderate, 51~65)	 (Very high, 85†)
Forest pest and disease risk	 (Caution)	 (Seriously extreme)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, ~2~5 million)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Large damages, ~300k~400k)	 (Moderate damages, ~200~300k)	 (Large damages, ~300k~400k)
Forest restoration fund per household (Korean won)	 (₩5,000)	 (₩10,000)	0 korean won

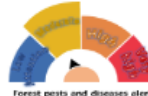
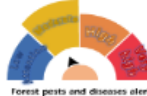
8. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Low, ↓50)	 (Moderate, 51~65)	 (Very high, 85↑)
Forest pest and disease risk	 (Attention)	 (Highly alert)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, ~2~5 million)	 (Slightly restriction, ~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Rarely damages, 0~100k)	 (Slightly damages, 100k~200k)	 (Large damages, 300k~400k)
Forest restoration fund per household (Korean won)	 (₩15,000)	 (₩5,000)	0 korean won

9. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Moderate, 51~65)	 (Very high, 85↑)	 (Very high, 85↑)
Forest pest and disease risk	 (Highly alert)	 (Highly alert)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (Highly restriction, 2~5million)	 (Highly restriction, 2~5million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Rarely damages, 0~100k)	 (Rarely damages, 0~100k)	 (Large damages, 300k~400k)
Forest restoration fund per household (Korean won)	 (₩40,000)	 (₩20,000)	0 korean won

10. Suppose the government have narrowed their policy options following options, which option do you prefer?

	Alternative A	Alternative B	Current
Forest fire risk	 (Very high, 85†)	 (Low, ↓50)	 (Very high, 85†)
Forest pest and disease risk	 (Caution)	 (Caution)	 (Seriously extreme)
Restrictions on outdoor relevant activities	 (No restriction)	 (Slightly restriction, 0~1 million)	 (No restriction)
Biodiversity loss (Loss of pine trees)	 (Large damages, 300k~400k)	 (Large damages, 200k~300k)	 (Large damages, 300k~400k)
Forest restoration fund per household (Korean won)	 (₩5,000)	 (₩50,000)	0 korean won

[Part D] Follow-up questions

(Now we have a few questions regarding the choices you made.)

A. In all choice situations, what was the main reason for this? please indicate how well you agree with the following statements.

	Strongly disagree	disagree	Neither	Agree	Strongly agree
I do not like assigning a monetary value on protecting forests.					
I cannot afford to pay.					
The payment method is inappropriate.					
I do not recognize the risks and threats to forest ecosystem services.					
I pay enough tax already. It is the Government's responsibility.					
It is not feasible to stop the release of forest pests and bushfires.					
The benefits would receive from the improvements in the forest are not worth it to me.					
I don't care about forest.					

B. Please rank the attributes (1~5) below as you thin are important to you.

Forest diseases and pests	Forest fires	Recreation activities	Biodiversity loss (Number of pine trees damaged)	Forest restoration fund
()	()	()	()	()

C. Please indicate how well you agree with the following statements.

	Strongly disagree	disagree	Neither	Agree	Strongly agree
To what degree do you believe that your responses will affect which measures will be implemented in this forest policy?					
To what degree do you believe that our responses will affect whether you will have to pay the additional cost (WTP) if the measures are implemented in this forest policy?					

D. Please indicate how well you agree with the following statements.

	Strongly disagree	disagree	Neither	Agree	Strongly agree
I am confident in my answers and choices.					
If this was real, I would make exactly the same choices.					
The environmental threats and risks above may affect your benefit from forest services.					
Do you think enough information is given this questionnaire to you?					
How difficult was it to answer the choice tasks?					

[Part E] General questions

In the first part of the questionnaire, we have a few questions about yourself. This survey is anonymous, and the information gathered will only presented in research summary form.

1. Gender: _____ (1=Female, 0=Male)

2. Monthly Income level

① ₩833,333~2,490,000 (£556~1,666)

② ₩2,500,000~4,160,000 (£1,667~2,778)

③ ₩4,170,000~5,830,000 (£2,779~3,889)

④ ₩5,840,000~8,330,000 (£3,890~5,556)

more than ₩100,000,000 (more than £5,557)

1. Education level

① Elementary school ② Middle school ③ High school ④ Undergraduate ⑤ Postgraduate

2. Age Level

① Under 20s ② 30s ③ 40s ④ 50s ⑤ 60s ⑥ Over 70s

3. Working status?

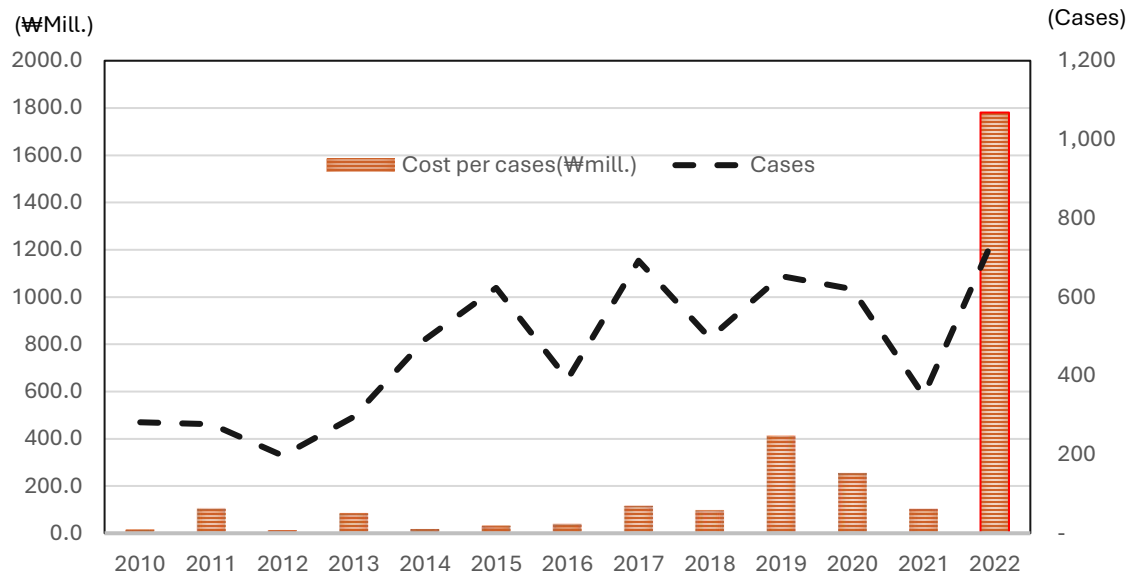
① Salaryman ② Students ③ House Keepers ④ Retired ⑤ Unemployed

⑥ Not in paid employment ⑦ Self-employed ⑧ Others ()

Thank you for your attention and cooperation!

Appendix. Forest fires and Pine Wilt diseases status in Korea

➤ Pattern of increasing forest fire frequency and rising the damage costs



➤ Status and trends of Pine Wilt diseases (North America → Japan → Busan in Korea → Spreading across the Korea country)

