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The Influence of Forest Trail Usage Behavior and Spatial Characteristics on Forest Trail Satisfaction and Behavioral Intention

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Abstract

Purpose: *More and more people are seeking forests to escape the complexities of urban competition and soothe their weary minds by walking along forest trails. This study aimed to provide basic data for providing better opportunities for forest trail users by identifying the spatial characteristics and usage patterns of forest trails, as well as their satisfaction and behavioral intentions.*

Method: *Data for this study were collected from March to April 2025. The self-administered questionnaire was administered by respondents, who were asked to check their responses. A total of 300 questionnaires were collected, but 35 were excluded due to statistical limitations. A total of 265 valid questionnaires were used for analysis. The analysis was conducted using the statistical programs SPSS 28.0 and Amos 28.0, including frequency analysis, factor analysis, correlation analysis, initial probability analysis (IPA), and path analysis.*

Results: *Forest trail spatial characteristics had a positive effect on satisfaction with forest trail use, while forest trail usage behavior had no effect on satisfaction with forest trail use. forest trail usage satisfaction had a positive effect on behavioral intention, while forest trail spatial characteristics had a positive effect on behavioral intention. forest trail usage behavior did not appear to influence behavioral intention.*

Conclusion: *As significant differences were found among forest trail users' usage behavior, spatial characteristics, forest trail satisfaction, and behavioral intentions, it is expected that policy measures can be suggested to meet the expectations of forest trail users in terms of creating future forest trails and operating them appropriately.*

Keywords: ***Forest Trail Usage Behavior, Forest Trail Spatial Characteristics, Forest Trail Usage Satisfaction, Forest Trail Behavioral Intention, Hamjisan Forest Trail***

1. Introduction

With approximately 90% of the population living in cities, South Korea is projected to enter a full-blown super-aged society by 2026, with the elderly population accounting for 20.8% of the total population[1]. As modern people find themselves exhausted from the complexities of urban life and unable to cope with the burden of life's challenges, a growing number are turning to forests to soothe their weary minds[2][3]. Walking along forest trails allows them to escape the complexities of urban competition and enjoy the virtue of slowness. Furthermore, growing interest in health is driving a surge in the use of forest trails, as well as in the demand for and participation in trekking and walking[4]. The meaning of a forest trail is different from a hiking trail that simply emphasizes the role of a path, as “a path that has naturally occurred or has been artificially created by humans using the history, culture, and natural resources of the forest for a long time, or for moving between regions through the forest”[5]. A forest trail is a path

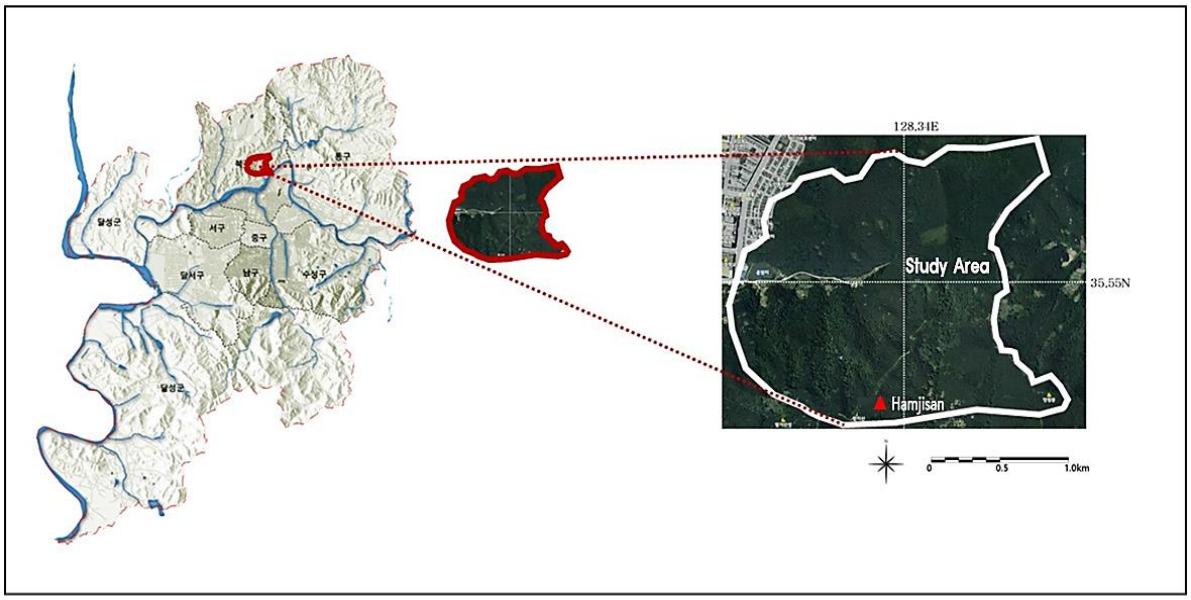
that preserves the history and culture of a local area, a path for human life, and a path that connects to the world of the forest, and is a path laid in a 'village area' inside and outside the forest[6]. According to the Forest Culture and Recreation Act (September 10, 2011), "a forest trail refers to a path created in a forest for activities such as mountaineering, trekking, leisure, sports, exploration, or rest and healing (including paths outside the forest connected thereto)"[7]. With the enactment of the Forest Culture and Recreation Act, research on forest trails has been conducted in various ways. Previous research on forest trails has consistently analyzed the usage patterns of users, their satisfaction levels, and the physical characteristics of forest trails. However, research on the spatial characteristics of forest trails and their usage patterns is insufficient[8][9][10]. Therefore, the purpose of this study is to provide basic data for providing better opportunities to forest trail users by identifying the relationships between forest trail spatial characteristics and usage patterns, satisfaction levels, and behavioral intentions.

2. Methods

2.1. Research site

To select forest trail sites for this study, we searched and investigated the Daegu City Hiking Support Basic Plan (2007-2017), each local government website, and forest trail-related websites. The results revealed that 172 forest trails, including the Hamjisan Forest Trail, were currently being developed and managed in Daegu. Hamjisan Forest Trail, a hilly mountain with an elevation of 287.7 m, represents Buk-gu, Daegu[2]. Its easy access via the Chilgok IC and Guanguk Expressway, coupled with its proximity to the city center, makes it a popular destination for residents of nearby cities and regions[11]. The area has recently seen a surge in visitors, coupled with the excavation of national heritage sites within the area. Furthermore, its proximity to the city center facilitates the efficient use of GPS for field surveys, and its location facilitates the collection of diverse opinions during surveys. Therefore, it was selected as the study site <Figure 1>.

Figure 1. Study area.



2.2. Research methods

The research method was broadly divided into a literature review and a survey. The literature review first analyzed the Hamjisan Forest Trail through the Daegu City Basic Hiking Support Plan, various reports, statistical data, and the Buk-gu Office website (http://www.buk.daegu.kr). Next, a survey was conducted, referencing prior research and academic studies. The survey for this study was conducted at 10 key locations on Hamjisan Mountain from March to April 2025. The survey was administered using a self-administered method, with respondents completing the questionnaire themselves. A total of 300 questionnaires were collected, but 35 were excluded due to statistical limitations. A total of 265 valid copies were used for analysis. The 265 collected data were processed using the statistical programs SPSS 28.0 and Amos 28.0 as follows: First, a frequency analysis was conducted to examine the general characteristics of the study subjects. Second, exploratory factor analysis was conducted to verify the validity of the measurement tool, and Cronbach's α coefficient was calculated to verify reliability[12]. Third, to examine the characteristics of forest trail spatial characteristics, forest trail use behavior, and behavioral intention, the mean and standard deviation were calculated, and skewness and kurtosis were calculated to verify normality[13]. Fourth, to examine the correlation between forest trail spatial characteristics, forest trail use behavior, and behavioral intention, a correlation analysis was conducted. Fifth, to examine the importance and satisfaction of forest trail spatial characteristics, the mean and standard deviation were calculated, and IPA analysis was performed[14]. Sixth, to verify the hypothesis, a path analysis using a structural equation model was conducted [15], and to verify the mediating effect of forest trail use satisfaction, the total effect, direct effect, and indirect effect were calculated, and bootstrapping was performed to verify the statistical significance of the indirect effect. All analyses above were verified at significance levels of $p<.05$, $p<.01$, and $p<.001$[16][17].

3. Results & Discussion

3.1. Hamjisan forest trail usage patterns

When using the Hamjisan Forest Trail, the largest number of companions were families, with 145 people (36.6%), followed by friends, with 135 people (34.1%), alone, with 63 people (15.9%), coworkers, with 30 people (7.6%), lovers and others, with 8 people each (2.0%), and members of clubs, with 7 people (1.8%). The purpose of visit was 'for health through hiking' with 154 people (38.9%), 'for mental rest and stability' with 79 people (19.9%), 'to get closer to nature' with 77 people (19.4%), 'to relieve stress' with 46 people (16%), 'to make friends' with 33 people (8.3%), and others with 7 people (1.8%). The walking section from Unamji to Sports Facility to Hamjisan Peak to Sports Facility to Unamji (4.8 km) was the most popular with 114 people (28.8%), followed by the Taebaek Interville to Hamjisan Peak to Taebaek Interville (8.8 km) with 102 people (25.8%). The time required was 2 to 3 hours with 136 people (34.3%), followed by 1 hour 30 minutes to less than 2 hours with 76 people (19.2%), 4 hours or more with 74 people (18.7%), 1 hour to less than 1 hour 30 minutes with 58 people (14.6%), and 3 to less than 4 hours with 52 people (13.1%). The walking speed was 2.01 to 3.00 km/hour with 149 people (37.6%), followed by 1.61 to 2.00 km/hour. 96 people (24.2%) drove at 1.60 km/hour or less, 57 people (14.4%) drove at 4.01 km/hour, 54 people (13.6%) drove at 3.01-4.00 km/hour, and 40 people (10.1%) drove at 3.01-4.00 km/hour.

3.2. Exploratory factor analysis and reliability analysis

The results of an exploratory factor analysis conducted to validate the forest trail spatial characteristics measurement tool are shown in <Table 1>. The factor analysis ultimately extracted seven factors. The eigenvalues of the 78 extracted factors were 1 or greater, the total explained

variance was 82.690%, and all factor loadings were 0.5 or greater. Furthermore, the KMO value was .885, which was satisfactory, and the Barlett's test of sphericity yielded a significance level of p<.000, demonstrating a good correlation between variables. Therefore, the factors were considered appropriate and valid. The seven extracted factors were named according to the nature of the items: Factor 1 ("Convenience Facilities"), Factor 2 ("Pedestrian Environment"), Factor 3 ("Guide and Rest Facilities"), Factor 4 ("View"), Factor 5 ("Natural Landscape"), Factor 6 ("Accessibility"), and Factor 7 ("Vegetation and Resources").

Table 1. Results of exploratory factor analysis and reliability analysis of the forest trail spatial characteristics measurement tool.

Item	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6	Factor 7	Cronbach's α
Amenities 14 (Toilet Location)	.906	.091	.161	.013	.040	.132	.117	.894
Amenities 13 (Number of toilet)	.844	.084	.207	-.049	.115	.177	.161	
Amenities 15 (Toilet cleanliness)	.804	.240	.224	.072	-.014	.091	.107	
Pedestrian environment 5 (Forest trail pedestrian access)	.123	.854	.165	.096	.057	.173	.167	.863
Pedestrian environment 6 (Forest trail management)	.151	.845	.246	.068	.067	.097	.151	
Pedestrian environment 7 (slope of forest trail)	.158	.693	.241	.121	.227	.312	.002	
Guide and rest facilities 11 (Milestone information)	.241	.199	.815	.116	.072	.210	.175	.872
Guidance and rest facilities 12 (Establishment of rest facilities)	.308	.320	.750	.097	.140	.032	.120	
Information and rest facility 10 (Milestone location)	.197	.232	.734	.134	.101	.328	.165	
View 3 (Surrounding view from the forest trail)	.006	.099	.110	.856	.309	.078	.058	.836
View 4 (Forest trail view)	.013	.117	.131	.845	.266	.134	.168	
Natural scenery 1 (Special features of forest trail)	.065	.119	.119	.248	.865	.151	.091	.846
Natural scenery 2 (The beauty of natural scenery)	.053	.126	.092	.372	.819	.050	.098	
Accessibility 9 (Forest trail accessibility)	.243	.278	.353	.136	.113	.732	.150	.835
Accessibility 8 (Convenience of forest trail)	.273	.393	.214	.163	.170	.699	.121	
Vegetation and resources 17 (Historical resource management around forest roads)	.141	.097	.198	.091	.025	.166	.874	.662
Vegetation and resources 16 (Vegetation management around forest trails)	.297	.267	.151	.186	.257	.007	.643	
Eigenvalues	2.685	2.558	2.315	1.810	1.804	1.448	1.438	.916
Dispersion(%)	15.791	15.048	13.617	10.647	10.611	8.516	8.462	
Cumulative variance (%)	15.791	30.839	44.455	55.102	65.713	74.228	82.690	

KMO=885, Bartlett's test of sphericity =4247.629, df=136, p=.000

The results of the exploratory factor analysis conducted to validate the tool measuring satisfaction with forest trail use and behavioral intention are shown in <Table 2>. The factor analysis ultimately extracted six factors. The eigenvalues of the six extracted factors were 1 or greater, the total explained variance was 86.508%, and all factor loadings were 0.5 or greater. Furthermore, the KMO value was .865, which was satisfactory, and the Barlett's test of sphericity yielded a significance level of p<.000, indicating a good correlation between variables. Therefore, the factors were found to be appropriate and valid. The six extracted factors were named according to the nature of the items: Factor 1, "Satisfaction with Forest Trail Use," Factor 2, "Intention to Revisit," and Factor 3, "Intention to Recommend."

Table 2. Results of exploratory factor analysis and reliability analysis of the forest trail use satisfaction and behavioral intention measurement tool.

Item	Factor 1	Factor 2	Factor 3	Cronbach's α
Satisfaction and intention to revisit 2 (Good decision to visit the forest trail)	.852	.290	.259	.812
Satisfaction and intention to revisit 1 (Overall satisfaction)	.749	.367	.279	
Satisfaction and intention to revisit 5 (Will visit soon)	.276	.886	.227	.870
Satisfaction and intention to revisit 6 (Future visit)	.369	.786	.331	
Satisfaction and intention to revisit 4 (Positive spread)	.265	.320	.874	.819
Satisfaction and intention to revisit 3 (Recommendation from others)	.596	.250	.640	
Eigenvalues	1.924	1.787	1.480	.911
Dispersion(%)	32.061	29.782	24.666	
Cumulative variance (%)	32.061	61.842	86.508	
KMO=865, Bartlett's test of sphericity =1538.739, df=15, p=.000				

3.3. Descriptive statistics

The mean and standard deviation of the measurement tools were calculated, and skewness and kurtosis values were examined to verify univariate normality. The absolute values of skewness and kurtosis for spatial characteristics, satisfaction, and intention to revisit were examined. The absolute values of skewness and kurtosis did not exceed 2 and 7, respectively, confirming multivariate normality[18][19].

In order to examine the correlation between forest trail spatial characteristics, forest trail use behavior, forest trail use satisfaction, and behavioral intention, a Pearson correlation analysis was conducted. forest trail spatial characteristics showed a positive correlation with forest trail use satisfaction (r=.702, p<.001) and behavioral intention (r=.718, p<.001), and forest trail use satisfaction showed a positive correlation with behavioral intention (r=.905, p<.001).

3.4 Hamjisan forest trail importance and satisfaction analysis (IPA analysis)

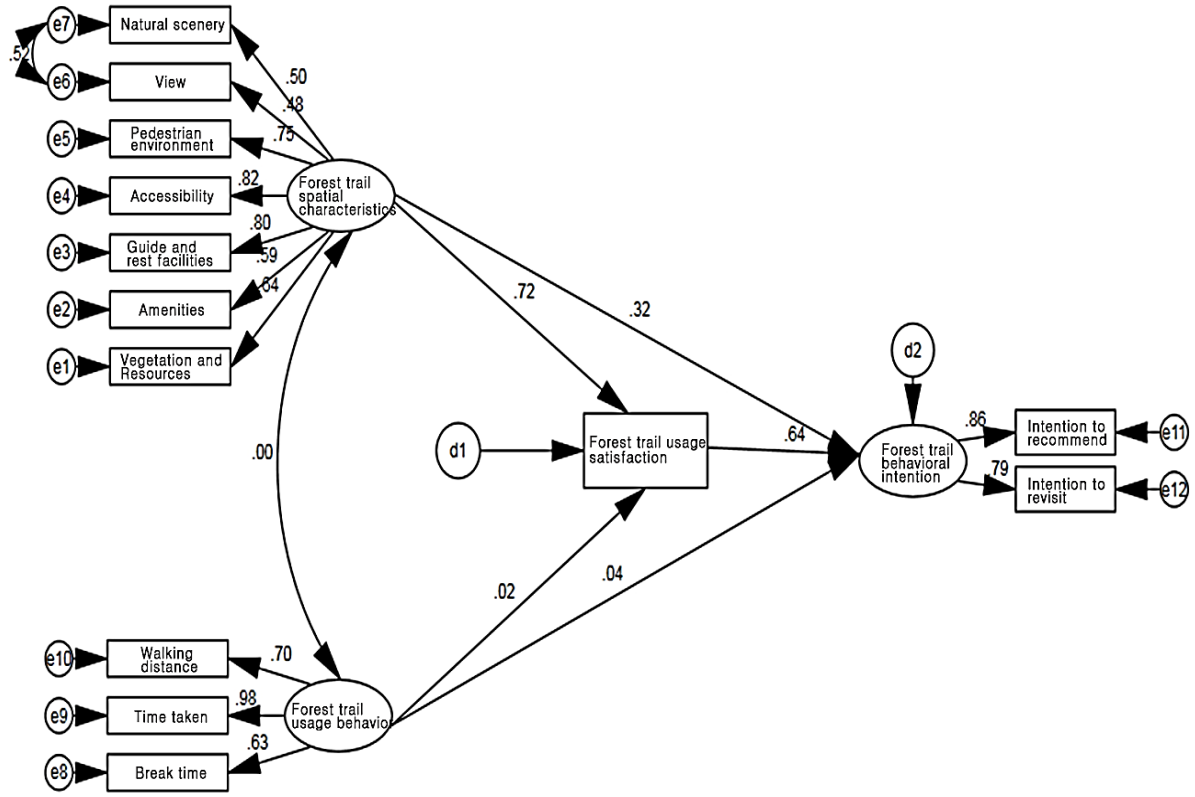
The importance and satisfaction with the characteristics of the Hamjisan Forest Trail and the differences between them showed that the importance of natural space was the highest with an average of 4.19 points, followed by the view with an average of 4.17 points, the walkability of the forest trail with an average of 4.13 points, the parking lot and the convenience of using the access road with an average of 4.07 points, the rest area such as benches in the information

and rest area and the cleanliness of the restrooms in the convenience area with an average of 4.04 points each, and the convenience of using public transportation with an average of 4.01 points. The satisfaction level was the highest for the view with an average of 3.90 points, followed by the natural scenery with an average of 3.84 points, the walkability of the forest trail with an average of 3.81 points, the surrounding vegetation with an average of 3.77 points, the rest area such as benches with an average of 3.74 points, the information facilities such as signboards and signposts with an average of 3.72 points, and the management of historical and cultural resources with an average of 3.70 points. Accordingly, the items with the largest difference in importance-satisfaction were accessibility, parking lot and access road convenience, with an average difference of 0.57 points, followed by the number of restrooms and convenience of public transportation, with an average difference of 0.49 points each, restroom location, with an average difference of 0.47 points, and restroom cleanliness, with an average difference of 0.45 points.

3.5 Hamjisan forest trails and satisfaction with forest trail use and behavioral intention

In order to examine the relationship between the spatial characteristics and usage patterns of the Hamjisan Forest Trail and satisfaction and behavioral intentions for using the forest trail, a research model as shown in <Figure 2> was established and analyzed.

Figure 2. Path of the research model.



The research model was verified according to the criteria for goodness-of-fit of the structural equation model, as shown in <Table 3> below. The research model did not meet the criteria for the x^2 and RMR values in the fit indices evaluation: x^2=172.706, p<.001), RMR=.116, GFI=.936, TLI=.948, CFI=.961, RMSAEA=.070. However, since goodness-of-fit is not an absolute criterion, it can be evaluated by integrating it with other indicators[20]. Therefore, since the fit indices such as GFI, TLI, CFI, and RMSEA meet the criteria, the measurement model can be considered valid.

Table 3. Validation of the goodness-of-fit of the research model.

Division	x^2	RMR	GFI	TLI	CFI	RMSEA
Standard	p>.05	.05 or less	.9 more than	.9 more than	.9 more than	.08 or less
Measurement model	172.706 p=.000	.116	.936	.948	.961	.070

The CR value in the path from forest trail spatial characteristics to forest trail use satisfaction was 12.093, p=.000, indicating that forest trail spatial characteristics have a positive effect on forest trail use satisfaction. In order to examine which characteristics of each sub-factor of forest trail spatial characteristics affect forest trail use satisfaction, a multiple regression analysis was conducted and the results are shown in <Table 4>. First, the VIF values were all less than 10, and the tolerance limits were all greater than .10, indicating that there was no multicollinearity problem. The regression analysis results showed that the explanatory power of the regression model for forest trail use satisfaction was 53.8%, and the F value indicating the statistical significance of the regression model was 63.531 (p<.001), indicating that this regression model was appropriate.

Table 4. The impact of forest trail spatial characteristics on forest trail user satisfaction.

Dependent variable	Independent variable	*B*	*S.E*	*β*	*t*	*p*	Collinearity statistics	
							Tolerance	VIF
Satisfaction with forest trail use	(constant)	.512	.166	-	3.075	.002**		
	Natural scenery	.216	.040	.252	5.455	.000***	.559	1.788
	View	.106	.043	.116	2.480	.014*	.542	1.845
	Pedestrian environment	.182	.042	.209	4.347	.000***	.514	1.946
	Accessibility	.072	.043	.089	1.663	.097	.414	2.418
	Guide and rest facilities	.100	.047	.112	2.137	.033*	.433	2.309
	Amenities	.022	.036	.028	.620	.536	.604	1.657
	Vegetation and Resources	.206	.045	.200	4.603	.000**	.631	1.585
R^2=.538, adj.R^2=.530, F=63.531***(p=.000)								

Note: *p<.05, **p<.01, ***p<.001.

The CR value in the path from forest trail use behavior to forest trail satisfaction was 0.508, p=.612, indicating that forest trail use behavior did not affect forest trail use satisfaction. In order to examine which characteristics of each sub-factor of forest trail use behavior affected forest trail use satisfaction, a multiple regression analysis was conducted, and the results are shown in <Table 5>. First, the VIF values were all less than 10, and the tolerance limits were all greater than .10, indicating that there was no problem with multicollinearity. The regression analysis results showed that the explanatory power of the regression model for forest trail use satisfaction was 8.9%, and the F value indicating the statistical significance of the regression model was 12.834 (p<.001), indicating that this regression model was appropriate.

Table 5. The impact of forest trail usage behavior on forest trail satisfaction.

Dependent variable	Independent variable	*B*	*S.E*	*β*	*t*	*p*	Collinearity statistics	
							Tolerance	VIF
Satisfaction with forest trail use	(constant)	3.645	.087	-	42.032	.000***		
	Walking distance	.120	.019	.409	6.156	.000***	.527	1.897
	Time taken	-.158	.040	-.297	-3.940	.000***	.410	2.441
	Break time	.002	.004	.033	.546	.585	.625	1.599
R^2=.089, adj.R^2=.082, F=12.834***(p=.000)								

Note: *p<.05, **p<.01, ***p<.001.

In the path from forest trail use satisfaction to behavioral intention, the CR value was 12.028, p=.000, indicating that forest trail use satisfaction had a positive (+) effect on behavioral intention.

In the path from forest trail spatial characteristics to behavioral intention, the CR value was 5.479, p=.000, indicating that forest trail spatial characteristics had a positive effect on behavioral intention. The results of multiple regression analysis to examine which characteristics of each sub-factor of forest trail spatial characteristics affected behavioral intention are shown in <Table 6>. First, the VIF values were all less than 10, and the tolerance limits were all greater than .10, indicating that there was no problem with multicollinearity. The regression analysis results showed that the explanatory power of the regression model for behavioral intention was 56.2%, and the F value indicating the statistical significance of the regression model was 71.002 (p<.001), indicating that this regression model was appropriate.

Table 6. The impact of forest trail spatial characteristics on behavioral intention.

Dependent variable	Independent variable	*B*	*S.E*	*β*	*t*	*p*	Collinearity statistics	
							Tolerance	VIF
Behavioral intention	(constant)	.744	.149	-	4.989	.000***	-	-
	Natural scenery	.168	.035	.214	4.748	.000***	.557	1.795
	View	.116	.038	.138	3.019	.003**	.543	1.842
	Pedestrian environment	.191	.038	.239	5.104	.000***	.514	1.946
	Accessibility	.096	.039	.129	2.483	.013*	.421	2.377
	Guide and rest facilities	.086	.042	.105	2.068	.039*	.439	2.280
	Amenities	.003	.031	.004	.093	.926	.647	1.545
	Vegetation and Resources	.179	.040	.189	4.480	.000***	.632	1.583
R^2=.562, adj.R^2=.554, F=71.002***(p=.000)								

Note: *p<.05, **p<.01, ***p<.001.

In the path from forest trail use behavior to behavioral intention, the CR value was 1.267, p=.205, indicating that forest trail use behavior did not affect behavioral intention. The results of multiple regression analysis to examine which characteristics of each sub-factor of forest trail

use behavior affected behavioral intention are shown in <Table 7>. First, the VIF values were all less than 10, and the tolerance limits were all greater than .10, indicating that there was no problem of multicollinearity. The regression analysis results showed that the explanatory power of the regression model for behavioral intention was 6.0%, and the F value indicating the statistical significance of the regression model was 8.346 (p<.001), indicating that this regression model was appropriate.

Table 7. The influence of forest trail usage behavior on behavioral intention.

Dependent variable	Independent variable	*B*	*S.E*	*β*	*t*	*p*	Collinearity statistics	
							Tolerance	VIF
Behavioral intention	(constant)	3.686	.081		45.611	.000***		
	Walking distance	.090	.018	.336	4.976	.000***	.527	1.897
	Time taken	-.094	.037	-.193	-2.522	.012*	.410	2.441
	Break time	-.001	.004	-.021	-.341	.733	.625	1.599
R^2=.060, adj.R^2=.053, F=8.346***(p=.000)								

Note: *p<05, **p<01,***p<.001.

To examine whether satisfaction with forest trail use plays a mediating role between forest trail spatial characteristics, forest trail use behavior, and behavioral intention, we calculated the total effect, direct effect, and indirect effect of the path in a structural equation model, and performed bootstrapping to verify the statistical significance of the indirect effect. When the path effect between each latent variable was decomposed into the total effect, direct effect, and indirect effect, as shown in <Table 8>, the indirect effect of forest trail spatial characteristics on behavioral intention through satisfaction with forest trail use was statistically significant at .463 (p<.05), whereas the indirect effect of forest trail use behavior on behavioral intention through satisfaction with forest trail use was statistically insignificant at .012 (p>.05). Therefore, satisfaction with forest trail use was found to have a mediating effect between forest trail spatial characteristics and behavioral intention.

Table 8. Total effect, direct effect, and indirect effect of the emotional exhaustion mediation model.

Path			Direct effect	Indirect effects	Total effect
Forest trail spatial characteristics	→	Forest trail usage satisfaction	.725*	.000	.725*
Forest trail usage patterns	→	Forest trail usage satisfaction	.019	.000	.019
Forest trail usage satisfaction	→	Behavioral intention	.638*	.000	.638*
Forest trail spatial characteristics	→	Behavioral intention	.320*	.463*	.783*
Forest trail usage patterns	→	Behavioral intention	.043	.012	.055

Note: *p<05.

4. Conclusion

This study aimed to investigate the effects of forest trail usage behavior and spatial characteristics on forest trail satisfaction and behavioral intention. The results of the study showed that forest trail spatial characteristics had a positive effect on forest trail usage satisfaction with a CR value of 12.093, p=.000 in the path from forest trail usage behavior to forest trail usage satisfaction. In addition, forest trail usage behavior did not affect forest trail usage satisfaction with a CR value of 0.508, p=.612 in the path from forest trail usage satisfaction to behavioral intention. In the path from forest trail usage satisfaction to behavioral intention, a CR value of 12.028, p=.000 showed that forest trail usage satisfaction had a positive effect on behavioral intention. In the path from forest trail spatial characteristics to behavioral intention, a CR value of 5.479, p=.000 showed that forest trail spatial characteristics had a positive effect on behavioral intention. The CR value (1.267, p=.205) in the path from forest trail usage behavior to behavioral intention revealed that forest trail usage behavior did not influence behavioral intention. The analysis results of this study revealed significant differences among forest trail users' usage behavior, spatial characteristics, forest trail satisfaction, and behavioral intention. Therefore, we expect that this will suggest policy measures to meet the expectations of forest trail users in terms of future forest trail development and desirable forest trail operation.

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6. Appendix

6.1. Author's contribution

	Initial name	Contribution
Lead Author	TK	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑
Corresponding Author*	HL	-Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑
Co-Author	CK WL	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

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A Study on the Current Status and Regeneration Directions of Rural Mountain Villages in Gyeongsangbuk-do

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Abstract

Purpose: *A mountain village refers to a settlement in a mountainous region, defined by the Forest Basic Act as an area where forest land covers at least 70% of the administrative district, with low population density and arable land ratio. Mountain villages in Gyeongsangbuk-do face challenges such as population decline and aging, with a high proportion of elderly residents exceeding the national average. Moreover, most new settlers are in their 50s and 60s, increasingly choosing these areas for their natural environment. This study aims to propose strategies for regenerating mountain villages into sustainable residential and stay environments.*

Method: *Survey results indicate a shared recognition among residents and visitors of the need for regeneration. Residents prioritize community revitalization and policies encouraging population inflow, while visitors highlight the need for improved accommodations and residential infrastructure. Based on these findings, three regeneration models are proposed: (1) the population influx model, promoting sustainable settlement and better living conditions; (2) the forest healing model, enhancing recreational and therapeutic functions of forest resources; and (3) the community happiness model, fostering economic and social sustainability.*

Results: *Each model suggests specific pilot projects. The population influx model is demonstrated by Dumari Mountain Village in Pohang, focusing on new accommodation facilities and forest-based pro-grams. The forest healing model is exemplified by Jukpari Mountain Village in Yeongyang, utilizing its birch forest for healing spaces and residential improvements. The community happiness model applies to Noryuri Mountain Village in Sangju, aiming at facility renovations and community-led economic development.*

Conclusion: *Beyond environmental improvements, mountain village regeneration must ensure economic and communal sustainability. Active support from both central and local governments, along with coordinated efforts from the Korea Forest Service and related institutions, is essential. This study pro-vides a foundation for future policies in Gyeongsangbuk-do, contributing to strategies for countering regional population decline and fostering sustainable rural development.*

Keywords: ***Rural Mountain Village, Rural Mountain Ecological Village, Rural Mountain Village Regeneration, Rural Mountain Village Resident Satisfaction, Gyeongsangbuk-do***

1. Introduction

A mountain village is generally understood as a settlement located in mountainous regions. According to the Forest Basic Act, such villages are defined as areas in which forest land accounts for more than 70% of the total administrative district, population density falls below the national average of eup/myeon units, and the ratio of arable land is also below the national average[1][2][3][4][5]. In Gyeongsangbuk-do, the share of mountain-village residents relative to the total provincial population declined from 14.9% in 2000 to 10.6% in 2021, with the proportion of residents aged 65 and above reaching 42.8%—substantially higher than the national figure of 36.7%[6]. Average household income from forestry, at 32.41 million KRW, also remains

*This study utilized a portion of the data collected from the policy research project titled "A Study on the Implementation Strategies for Pilot Models of Gyeongbuk-style Mountain Village Regeneration", conducted by the Gyeongbuk Research Institute (GRI) in 2023.

significantly below the national average of 38.13 million KRW. These indicators point to the urgent need for new policy approaches[1][2][7][8][9].

In the context of accelerating regional depopulation, Gyeongsangbuk-do must explore strategies to activate mountain villages as key bases for population attraction and improved resident satisfaction[1][6][10][11][12][13][14][15][16][17]. Technological advances and lifestyle changes emphasizing dual-residence living and nature-based wellbeing have increased the need for appealing residential spaces and forest-based healing and recreation environments[12][13][14][15][18][19]. In the short term, the establishment and implementation of pilot models are critical for demonstrating potential pathways for mountain-village change. In the longer term, diversified regional models will be needed to support a comprehensive "return-to-mountain" strategy aligned with Korea's broader regional-revitalization agenda[1][2][6][15][20][21][22][23][24][25][26].

Accordingly, the purpose of this study is to analyze the current conditions of mountain villages in Gyeongsangbuk-do and to propose foundational directions for mountain-village regeneration based on environmental conditions and resident perceptions.

2. Scope and Methods

2.1. Research scope

The spatial scope of the study is the mountain-village regions of Gyeongsangbuk-do. The temporal scope is limited to data collected from May 2023 to the present. The substantive scope includes an analysis of mountain-village conditions, a resident survey, and proposals for regeneration directions.

2.2. Methods

2.2.1. Analysis of mountain-village conditions

To examine the concepts and policy trends surrounding mountain villages, national policy documents and planning reports were reviewed, including national-level forest policies and related trends. Statistical data from national sources and internal datasets from Gyeongsangbuk-do were used to analyze detailed indicators such as the distribution of Mountain Ecological Villages, forestry households, return-to-mountain populations, and income levels.

2.2.2. Resident survey

The resident survey targeted mountain villages where both the Mountain Ecological Village Project and the Idle Forest Resource Assetization Project have been systematically implemented. The survey was administered in Dumari Mountain Village in Pohang. An explanatory session was held on June 19, 2023, followed by data collection until June 26. Since residents fall into two types—existing residents and temporary stayers—survey instruments were administered separately for each group through both face-to-face interviews and mailed questionnaires. A total of 33 valid responses were collected (22 existing residents and 11 temporary stayers), and comparative analysis was conducted using SPSS.

2.2.3. Direction for mountain-village regeneration

Based on key principles, a mountain-village regeneration model was developed by identifying critical influencing factors, including village assets, forest and leisure-policy trends, community capacity, and internal/external environmental conditions. Village assets were categorized into infrastructure, forest resources, and natural environment; forest and mountain-policy trends encompassed regional depopulation, lifestyle population expansion, forest healing, and forest welfare. Community factors included the activeness of community engagement, willingness to

interact, and latent potential of members. Internal and external environmental factors included accessibility to urban centers, linkages to nearby recreational resources, population inflow, and income-generation potential. Based on these factors, the study proposes three representative regeneration models: the population influx model, the forest healing model, and the community happiness model, along with suitable pilot strategies for each.

3. Current Conditions of Mountain Villages in Gyeongsangbuk-do

3.1. New perceptions of mountain villages

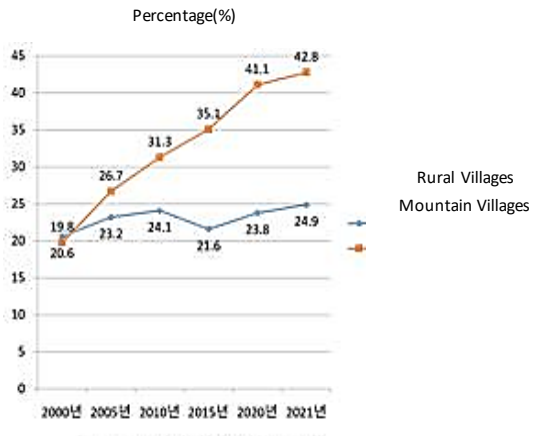
Mountain villages, traditionally considered remote settlements, are being reinterpreted as spaces for residence, recreation, and tourism. As lifestyles shift toward greater engagement with nature, interest in mountain villages as places for experience-based living has increased. The concept of mountain villages has expanded from spaces of production and ecological function to living environments that offer new opportunities through mountain-village regeneration[1][2][6][27][28][29][30].

National policies once centered solely on existing residents, but now extend to prospective return-to-mountain settlers and even urban citizens. Policy directions increasingly emphasize comfort, community, diversity, integration, public value, coexistence, recreation, healing, and stay-type living—indicating that mountain-village policy requires a multifaceted approach integrating residence, culture, economy, and ecology[2][15][31][32][33][34][35][36][37][38][39][40].

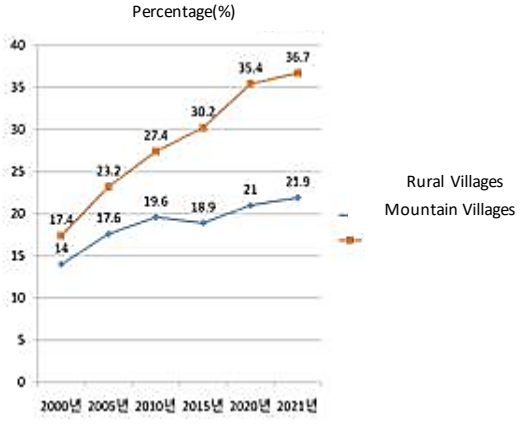
3.2. Status of mountain villages in Gyeongsanbuk-do

Gyeongsangbuk-do contains 108 mountain villages, including 33 Mountain Ecological Villages established through government support. The total project budget for these villages amounts to 52.1 billion KRW. As of January 2023, 12 operational managers are active in the province. Based on rankings of income, population, and number of visitors, Dumari Village in Pohang and the villages of Geumsu (Sungju) and Yeongcheon were consistently among the top 10 across categories. Forestry household income in Gyeongsangbuk-do (32.41 million KRW) is the second lowest after Gangwon-do.

Figure 1. Proportion of older adults (aged 65 and above) residing in mountain villages: comparison between Gyeongsangbuk-do and the national Level.



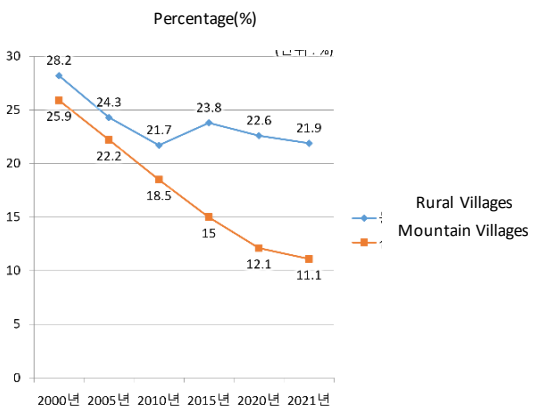
Note: Trends in the proportion of rural and mountain villages in Gyeongsangbuk-do.



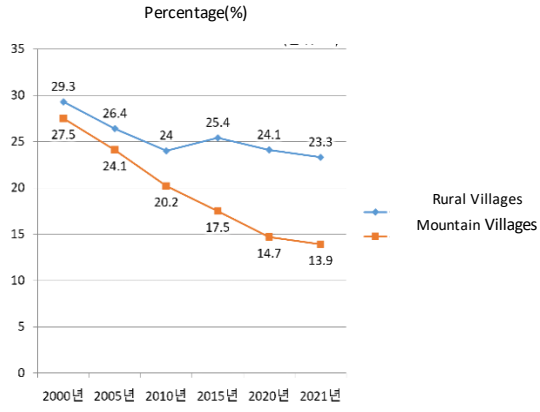
Note: National trends in the proportion of rural and mountain villages.

Mountain populations have declined continuously since 2000, while aging has intensified. Forestry households and forestry-household populations have decreased steadily since 2005. Unlike national trends in increased return-to-mountain settlement after 2015, Gyeongsangbuk-do has not experienced corresponding growth. Adults in their 60s account for 37.6% of all forestry households, and those in their 70s account for 18.7%, meaning that about 65% of forestry-household residents are aged 60 or above. Figures on page 6 illustrate the rapidly rising proportion of older residents and the declining proportion of younger cohorts in both Gyeongsangbuk-do and nationwide.

Figure 2. Analysis of the proportion of young adults residing in mountain villages: comparison between Gyeongsangbuk-do and the national Level.



Note: Trends in the proportion of Gyeongsangbuk-do.



Note: Trends in the national proportion.

The number of return-to-mountain settlers in their 50s and 60s is increasing nationwide, but in Gyeongsangbuk-do, the proportion of settlers in their 60s has surpassed that of those in their 50s since 2021. Motivations for return settlement include employment, but since 2021, natural environmental quality has emerged as a more prominent reason.

Thus, the province urgently requires strategies to regenerate mountain villages as attractive living environments, especially considering the accelerated aging and heightened interest in natural surroundings.

4. Results and Discussion

4.1. Mountain village residents survey

The purpose of the mountain-village resident survey was to collect the opinions of local residents and utilize them as foundational data for establishing regeneration directions in mountain villages across Gyeongsangbuk-do. For this study, the survey targeted residents of Dumari Mountain Village in Pohang, where the Mountain Ecological Village Project and the Idle Forest Resource Assetization Project have been systematically implemented. The survey process began with an explanatory meeting held at the Dumari village hall on June 19, 2023, during which the purpose of the study and survey procedures were introduced to residents; responses were collected until June 26.

Since residents can be categorized into two groups—existing residents and temporary stayers—the survey was conducted by distinguishing between these two groups. Both face-to-face interviews and mail-in responses were used. A total of 33 completed questionnaires were collected: 22 from existing residents and 11 from temporary stayers or individuals with prior stay

experience. The responses were analyzed using SPSS for comparative analysis between the groups.

4.1.1. Results of the existing-resident survey

Among survey respondents, the largest proportions were those in their 50s and 60s, each accounting for 31.8%, followed by those in their 70s at 22.7%. Respondents with children in their 20s or 30s accounted for 45.5%, while those with children in their 40s or 50s accounted for 22.7%. No respondents were under the age of 40, and only 9.1% were in their 40s, indicating the need for mid- and late-middle-aged population inflow to maintain village vitality.

A total of 91.7% of respondents were engaged in agriculture or forestry (particularly the cultivation of non-timber forest products). Only one respondent was employed in office/management work, and one identified as a homemaker. These results illustrate that the village economy is largely dependent on agriculture and forestry.

More than half of existing residents had lived in the village for more than 20 years, while 22.7% had resided there for between 3 and 10 years. Prior places of residence included Daegu (31.8%), Pohang urban districts (22.7%), and Seoul (13.6%). Regarding reasons for relocation, 44.4% of respondents cited "returning to their hometown," while 18.5% cited new job opportunities or potential income increases; 18.5% cited moving to the mountains as their primary reason. Additional motivations included health recovery, pursuit of a more relaxed lifestyle, and a desire to produce healthy food.

Regarding satisfaction with living conditions, 36.5% rated forest scenery and the natural environment as "good," and 22.7% rated them as "very good." However, residential environments and basic infrastructure were rated "not good" by 40.9% of respondents, and education, welfare, and cultural–leisure facilities were rated "not good" by 63.7%. When asked whether stay facilities were sufficient for population inflow, 63.7% answered "insufficient" or "very insufficient."

With respect to village management and operations, 63.7% of respondents expressed strong affection and pride in their village. Satisfaction with mutual exchange and fellowship among residents was high. More than half of respondents indicated that they actively worked toward village development, and 63.7% supported population inflow policies and exchanges with urban residents.

Regarding the perceived need for mountain-village regeneration and willingness to participate, respondents showed balanced expectations across categories such as village maintenance, creation of income sources, expansion of stay facilities for population inflow, and community activities. Only one respondent expressed a negative opinion regarding participation. Half of all respondents viewed regeneration as "very necessary," and others expressed willingness to participate—from "attempting to participate whenever possible" to "actively and proactively participating if aligned with their views."

In terms of lifestyle population inflow and the introduction of stay facilities, 77.3% of respondents stated that expanding the lifestyle population was necessary, and 81.8% responded that additional stay facilities were needed to achieve this. Preferred stay facility types included low-rise detached housing complexes with garden plots and individual housing created by utilizing vacant homes or open spaces within the village.

4.1.2. Results of the temporary-stayer survey

Among temporary stayers, 54.5% of respondents were in their 50s and 38.4% were in their 60s; thus, all but one respondent were aged 50 or older. Regarding children's ages, 72.7% reported having adult children in their 20s or 30s, indicating that typical temporary stayers were

individuals in their 50s and 60s with grown children. Five out of the eleven respondents indicated that they were retired or not currently employed, underscoring the need for hardware and software tailored to this demographic.

With respect to duration of stay, all but one respondent had lived in the village for less than one year. Previous places of residence included Suwon (3 respondents), Ulsan (2), Daegu (1), Busan (1), Seoul (1), Anyang (1), Incheon (1), and Jeju (1), showing considerable geographic diversity. More than half (63.6%) reported staying in the village with their families.

As for reasons for staying, 50% of respondents cited participation in a "live-in-the-village" experience program. Other reasons included planned return-to-the-mountain relocation (22.2%), pursuit of a relaxed lifestyle (16.5%), and health recovery (11.1%). Satisfaction with forest scenery and natural environments was extremely high: 72.7% answered "very satisfied" and 27.3% answered "satisfied." Satisfaction with housing and basic infrastructure was moderate (45.5% answered "very satisfied" or "satisfied"), while satisfaction with education, welfare, and cultural–leisure facilities was low (63.7% answered "not good").

Regarding the sufficiency of stay facilities for population inflow, 45.5% answered "insufficient" or "very insufficient." In terms of village management and operations, respondents expressed high levels of affection and pride for the village, active mutual exchange, cooperative efforts for village development, and strong support for population inflow.

Temporary stayers also emphasized the need for regeneration, highlighting stay facilities for population inflow (24.2%) and creation of income sources (24.2%) as important tasks. Community activities (18.2%) and active exchanges with urban citizens (18.2%) were also considered important. Among the 11 respondents, 10 stated that regeneration was "very necessary" or "necessary." All respondents expressed willingness to participate: 54.5% were willing to participate whenever possible, and 45.5% reported willingness to participate actively.

Regarding lifestyle population inflow and stay facility needs, 10 out of 11 respondents stated that increasing the lifestyle population was "very necessary" or "necessary," and all respondents stated that stay facilities were necessary to achieve this. Preferred stay facility types mirrored those of existing residents: low-rise detached housing complexes with garden plots (46.2%) and individual housing units developed from vacant houses or open lots (30.8%). Notably, none selected guesthouse-type accommodations.

4.1.3. Integrated findings

Most existing residents had returned to their hometown and expressed strong willingness to participate in mountain-village regeneration. Residents were highly satisfied with forest scenery, natural environments, and community management but expressed low satisfaction with basic infrastructure and cultural–leisure facilities. They strongly agreed that stay facilities were insufficient and supported population inflow strategies, including exchanges with urban residents.

Temporary stayers also showed extremely high satisfaction with forest scenery and expressed a clear preference for stay facilities that would enable lifestyle population inflow. Dissatisfaction with education, welfare, and cultural–leisure facilities was the highest. All respondents emphasized the need for stay facilities and preferred low-rise detached housing or individual units developed from vacant homes or open spaces.

4.2. Directions for mountain-village regeneration

4.2.1. Basic principles and conceptual development

Mountain-village regeneration must reflect needs shared by both existing residents and temporary stayers. The basic principle is to establish "mountain-village identity" grounded in

healthy forest resources as the foundation for regeneration in Gyeongsangbuk-do. Regeneration strategies should consider the unique characteristics of each village and follow differentiated models.

Regeneration should explore diverse points of linkage that increase lifestyle population inflow through connections with abundant forest resources. It must also support the development of community capacity so that mountain villages can evolve as active agents of local development.

Key influencing factors include village assets, forest and leisure-policy trends, community capacity and willingness, accessibility to urban areas, and linkages to nearby resources. Based on these factors, three representative regeneration models can be implemented:

(1) population influx model,

(2) forest healing model, and

(3) community happiness model.

Table 1. Key characteristics of representative mountain village regeneration models.

Model Type	Village Assets	Policy Context	Community Conditions
Population Influx Model	Well-developed village facilities; strong natural and forest resources	High demand for lifestyle migration and settlement support policies	Active community participation; good accessibility to urban centers
Forest Healing Model	Distinctive forest landscapes (e.g., birch forests); adjacent national forest land	Increasing national interest in forest healing and wellness tourism	Requires government-led support; selective resident participation
Community Happiness Model	Adequate infrastructure; potential for value-added forest product development	Aligns with community-based economic activation policies	Strong internal cohesion; willingness to establish village enterprises

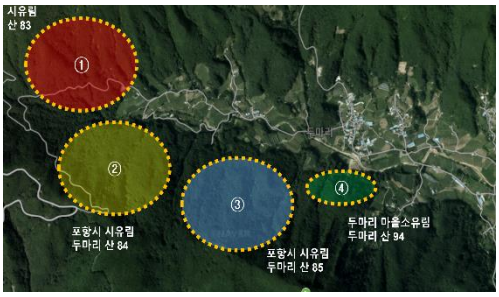
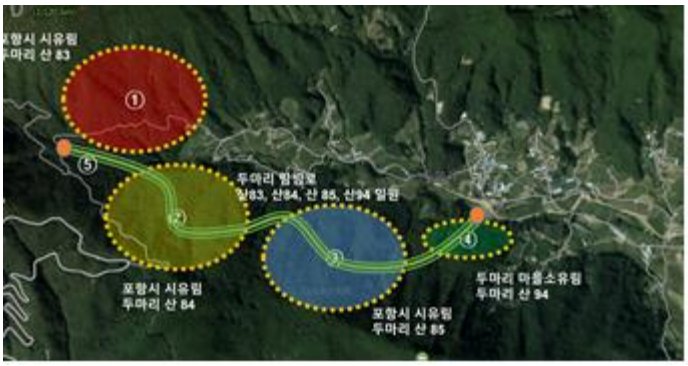
4.2.2. Proposed pilot models

(1) Population influx model: Dumari mountain village (Pohang)

Dumari Village has a population of 243, including 18 return-to-farm/forest settlers (7 households), representing approximately 7.4% of the total. Designated as a Mountain Ecological Village in 2009, the village received a project budget of 1,154,259 thousand KRW to construct facilities such as a cultural hall, sales center, and ceremonial site. These facilities are managed and operated by a village agricultural corporation in which most residents participate. A designated village manager actively collaborates with residents to implement projects and identify activation strategies.

Residents expressed strong willingness to participate in regeneration efforts and emphasized sustainable use of long-preserved village forests, rather than development that removes forest cover. Integrating city-owned forest areas with village forests may facilitate exchanges with urban residents and expand opportunities for lifestyle population inflow. Thus, a regeneration direction that combines sustainable forest-resource use with residents' willingness for regeneration is required.

Table 2. Core strategies for the population influx model: Dumari mountain village (Pohang).

	
Municipal Forests Owned by Pohang City (①②③): San 83, San 84, and San 85 in Dumari Village-Owned Forest Land (④): San 94	Village-Owned Site (⑦): Dumari 476 Resident-Owned Site (⑥): San 37
	Establishment of stay-type facilities to attract new residents, utilizing municipal forests, village-owned sites, and resident-owned land. Development of infrastructure and program concepts based on the utilization of forest assets.

(2) Forest healing model: Jukpari mountain village (Yeongyang)

Jukpari consists of 50 households (Upper and Lower Jukpari), with most residents in their 70s and five households of returnees in their 40s and 50s. Although not officially designated as a Mountain Ecological Village, Jukpari is home to the birch forest of Subi-myeon—an ecological landscape resource that has gained nationwide recognition as a representative forest-healing destination. Leveraging this distinctive resource and adjacent national forest land presents significant opportunities for increasing resident income and creating jobs.

Given the age structure and capacity of current residents, it is unrealistic for them to lead regeneration projects independently. Instead, Yeongyang-gun, Gyeongsangbuk-do, and the Southern Regional Forest Service should collaborate to develop an integrated regeneration direction based on the birch forest. Residents should participate in feasible aspects such as improving residential environments and maintaining village landscapes.

(3) Community happiness model: Noryuri mountain village (Sangju)

Noryuri has a population of 55, with 20 residents under the age of 60 and 35 residents aged 60 or older, comprising 40 households (30 farming households and 10 non-farming households). Designated as a Mountain Ecological Village in 2012, the village employs a manager who oversees facility operations and shares information on forest products with residents.

The mountain-experience center built in 2012 currently receives group visitors, but demand is low, and the facility is unsuitable for small-family groups due to spatial layout and circulation issues. Thus, remodeling is required to create separate spaces suitable for family-unit visitors.

Residents are actively exploring ways to produce, process, and distribute forest products and are preparing to establish a village enterprise. These efforts indicate a strong and exemplary

local community. For Noryuri, regeneration should focus on supporting community-led enterprises and promoting stable income generation, including the establishment of a small-scale smart nursery.

5. Conclusion

This study aimed to analyze the current conditions of mountain villages in Gyeongsangbuk-do and propose foundational directions for mountain-village regeneration based on environmental characteristics and resident perceptions. Through the review of relevant literature, analysis of national statistical data, and a resident survey, the study identified key issues and potential regeneration models.

Mountain villages in Gyeongsangbuk-do face numerous challenges requiring urgent attention. Of the 114 mountain villages in the province, 35 Mountain Ecological Villages have been established, supported by 12 operational managers. The proportion of mountain-village residents has continuously declined since 2000, and the elderly population ratio (42.8%) far exceeds the national figure (36.7%). Return-to-mountain settlers are predominantly in their 50s and 60s, with an increasing number citing natural environment quality as a reason for settlement. Thus, strategies that combine these demographic trends with the province's abundant forest resources are essential for expanding lifestyle populations and revitalizing village communities.

Survey results confirmed strong agreement among both existing residents and temporary stayers regarding the need for mountain-village regeneration. Existing residents—many of whom had returned to their hometown—demonstrated high willingness to participate and supported strategies for population inflow, including exchanges with urban residents. Temporary stayers expressed high satisfaction with forest landscapes and highlighted the need for stay facilities, particularly low-rise detached housing complexes with garden plots and individual units developed from vacant houses.

Reflecting residents' opinions and grounded in the basic principles of mountain-village regeneration, the study proposed three model types: the population influx model, the forest healing model, and the community happiness model. Dumari Village can apply core strategies such as establishing stay facilities, building forest-resource programs, and strengthening community-based governance. Jukpari Village can adopt a forest healing approach centered on birch forests, developing healing spaces and a landscape management plan. Noryuri Village can focus on facility improvements, supporting community activities, and establishing smart nurseries for income generation.

Mountain villages have long faced structural difficulties. Regeneration offers the potential to transform these villages into spaces of production, ecological stewardship, living environments, cultural succession, and experiential education. The Korea Forest Service has initiated multiple policy efforts to support mountain villages, and ongoing re-evaluation of Mountain Ecological Villages provides an opportunity for policy advancement. Mountain-village promotion should be utilized as a strategic approach to addressing regional depopulation, and linkages with related ministries' projects should be actively pursued.

It is time to ensure that mountain villages are not neglected spaces, but vibrant places where people can live, interact, and thrive. Based on this study, further development of concrete action plans for mountain-village regeneration is expected to advance the value of "mountain-village identity" and support wider implementation across the region.

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7. Appendix

7.1. Author's contribution

	Initial name	Contribution
Author	YR	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑ -Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

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Analysis and Recommendations for Ginsenoside Content according to Environmental Conditions of Wild-Simulated Ginseng in Pyeongchang, Korea

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Abstract

Purpose: *Korean Wild-simulated Ginseng is designated as a Specially Managed Forest Product by the Korea Forest Service. However, systematic research and standard cultivation guidelines often differ from the actual cultivation practices. Therefore, this study conducted an experimental study to determine the effects of ginsenoside content on the environmental conditions of wild Ginseng cultivation sites in the Pyeongchang region of Korea.*

Method: *Ten 10-year-old Wild-simulated Ginseng samples were collected from each of four Pyeongchang cultivation sites. Six factors were examined to determine the location of Wild-simulated Ginseng: slope, slope direction, elevation, tree type, diameter at breast height, and tree height. Soil physicochemical properties were analyzed according to topographic conditions, including pH, electrical conductivity, total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium, exchangeable magnesium, exchangeable sodium, and cation exchange capacity.*

Results: *Soil physicochemical properties of Wild-simulated Ginseng cultivation sites generally showed higher ginsenoside content in broadleaf areas than in coniferous areas. Statistical analysis results showed statistically significant differences between coniferous and broadleaf regions in cultivation sites A, B, and C, while cultivation site D showed little difference between coniferous and broadleaf regions. Ginsenoside content analysis revealed high levels of Re, Rb1, and Rg1, in that order, confirming the main components of Pyeongchang cultivated Ginseng.*

Conclusion: *These research results suggest that selecting cultivation sites similar to the optimal growth environment for Wild-simulated Ginseng is essential for producing high-quality Wild-simulated Ginseng. We hope that the comparative analysis of ginsenoside content across different cultivation sites presented in this study can contribute to the production of high-quality wild Ginseng and increased income for forestry workers.*

Keywords: ***Pyeongchang Area, Wild-Simulated Ginseng, Environmental Conditions Ginsenosides, Content, Korea***

1. Introduction

Korean Wild-simulated Ginseng refers to Ginseng produced by transplanting seedlings sown or nursed in the mountain area and growing them naturally in the mountain area without installing artificial structures such as shade nets. Wild-cultivated Ginseng is a specially managed forest product managed by the Forestry and Mountain Village Development Promotion Act under Article 2, Paragraph 1 of the Mountain Area Management Act. The English name is wild-simulated Ginseng, and it grows wild in the Korean Peninsula, the Maritime Province, and the Far East Asian region including Manchuria[1]. Ginsenoside refers to the main physiologically active substances contained in Ginseng and Wild-simulated Ginseng, and is known as ginsenosides, Ginseng proteins, polysaccharides, polyacetylenes, and phenolic compounds[2][3][4][5].

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Korean Ginseng is known by various names depending on its morphological characteristics and cultivation method. Sansam (山蔘) refers to Ginseng in its natural state, with no signs of domestication, and is divided into cheonjong (天種), jijong (地種), and injong (人種). Cheonjong refers to Ginseng that has grown naturally for hundreds of years without any artificial intervention. Jijong refers to Ginseng that has germinated and grown naturally from the beginning, while injong refers to Ginseng that has been collected from seeds of cheonjong and grown naturally in a forest. Sanyangsam (山養蔘: Wild-simulated Ginseng) refers to Ginseng that has been directly sown from wild Ginseng seeds and shows signs of domestication. Therefore, Wild-simulated Ginseng refers to Ginseng that has been sown in the mountains or transplanted from seedlings grown in nurseries, and can be considered injong (人種) as it is grown as close to nature as possible without pesticides[6][7].

In this study, to compare the differences in cultivation environmental conditions and ginsenoside contents between coniferous and deciduous forests, four Wild-simulated Ginseng farms in the Pyeongchang region of Korea were selected, and five samples were collected from eight locations each in the coniferous and deciduous forests of each cultivation site. Specifically, the environmental conditions of Wild-simulated Ginseng cultivation sites were divided into coniferous and deciduous forest areas within the same region, and the differences were identified through soil physicochemical properties and ginsenoside analysis.

2. Research Background

2.1. Ginseng components and effects

A scoping Currently, Ginseng in Korea is largely divided into Wild Ginseng, Wild-simulated Ginseng, and Ginseng. Wild Ginseng refers to Ginseng that grows naturally in the mountains, and Wild-simulated Ginseng refers to Ginseng that is grown in the mountains without installing artificial structures such as shade nets, as defined by the Korea Forest Service in 2011. Ginseng refers to Ginseng that is grown in fields with artificial structures installed using irrigation, pesticides, and fertilizers. Ginsenosides of Ginseng are known to be effective ingredients of Ginseng that exhibit pharmacological and biochemical actions, and are classified into protopanaxadiol (PD), protopanaxatriol (PT), and oleanane saponins according to the characteristics of their chemical structure. To date, the chemical structures of 22, 13, and 1 compound, respectively, have been identified[8][9][10][11]. Major pharmacological effects have been reported, including anticancer effects, antidiabetic effects, prevention of arteriosclerosis and hypertension, central nervous system suppression, liver function promotion and hangover relief, anti-inflammatory activity, immune enhancement, anti-fatigue and anti-stress effects, and antioxidant effects[12][13][14][15]16].

Ginsenosides, Ginseng saponins, are named according to their mobility on TLC. Their polarity is classified from ‘a’ to ‘h’ according to the number of monosaccharide residues in the sugar chain. Many ginsenosides are neutral bidesmosidic saponins (Rb1, Rb2, Rc, Rd, Re, Rg1) and some are monodesmosidic saponins (Rf, Rg2). By 1984, 18 saponins (ginsenoside Ro, Ra1, Ra2, Ra3, Rb1,Rb2, Rb3, Rc, Rd, Re, Rf, Rg1, Rg2, Rg3, Rh1, 20-glucoginsenoside Rf, notoginsenoside R1, quinquenoside R1) had been isolated from white Ginseng, and by 1986, a total of 25 had been isolated. Regarding the effects of Ginseng on the human body, the effects of 11 major ginsenosides among 36 types are as shown in <Table 1>.

Table 1. The effects of ginsenoside on the human body.

Ginsenosides	Effects
Rb1	Liver function protection, nerve cell protection, brain function improvement, mental stability, fever reduction and analgesic
Rb2	Angiogenesis, inhibition of cancer cell metastasis, improvement of hyperlipidemia, and hepatocyte proliferation
Rc	Protects liver function, has antioxidant effects, promotes protein synthesis, and improves sperm motility.
Rb	Neuroprotection, inhibition of cancer cell metastasis, immune regulation, antioxidant action,
Re	Antioxidant, antidiabetic effect
Rf	Pain-inhibiting and anti-inflammatory effects
Rg1	Improves memory, prevents aging, protects brain cells, and has anti-stress and anti-fatigue effects.
Rg2	Improves Alzheimer's disease and treats depression
Rg3	Anti-tumor, neuroprotective, skin cancer suppression, liver protection, memory impairment suppression
Rh1	Anti-inflammatory and anti-allergic effects
Rh2	Anti-obesity, tumor growth inhibition, anti-allergy, cancer cell proliferation inhibition

2.2. Growth characteristics and quality control methods of Korean Wild-simulated Ginseng

This study's The growth stages of Wild-simulated Ginseng go through the bud-budding stage, germination stage, bud-budding stage, proleaf stage, flowering stage, and fruiting stage, and although they vary depending on the elevation and region, it is known to grow from early March to early October. The average annual temperature is suitable for 0°C to 10°C, and it is said that when the temperature exceeds 30°C, photosynthesis cannot occur and nutrient consumption is high. Wild-simulated Ginseng has a very strong self-healing ability, so it can grow even if the roots fall off and only the crown part is left. However, if the environmental conditions are not right, it goes into a dormant period and grows again when the conditions are right. Each growing part of wild-cultivated Ginseng has a unique name, and each part plays a special role in growth. The above <Figure 1> shows the names of each part of wild-cultivated Ginseng.

Figure 1. Names of each part of wild-simulated Ginseng.

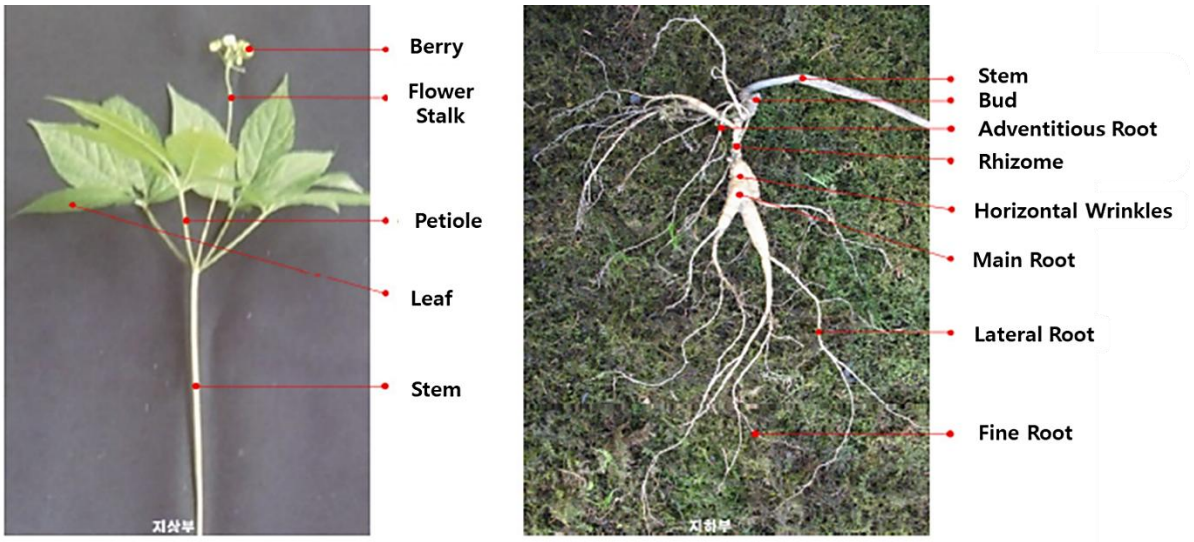

Table 2. Comparison of the differences and quality control methods between wild-simulated Ginseng and Ginseng.

Division	Wild-simulated Ginseng	Ginseng
Legal basis	Act on Promotion of Forestry and Mountain Village Development	Ginseng Industry Act
Seeds	Seeds verified in accordance with the Forestry and Mountain Village Development Promotion Act	Seeds verified under the Ginseng Industry Act
Production location	Forest	Field
Production method	Natural state	artificial shading facilities
Production Period	Long term: 4 to 20 years	Short-term: 4~6 years
Pesticide Use	Prohibited by law	Some pesticides and fertilizers are allowed
Body Shape	Slender	Bold
Fine Root Shape	Long and thick	Short and slender
Quality Inspection	Mandatory quality inspection before production	Ginseng is inspected only upon purchase after production.
Quality Labeling	Mandatory quality labeling	Ginseng does not have quality labels
Production Site Reporting	Before production, report to the Director of the Korea Forest Service the results of a soil pesticide residue test for suitability for production	Report the cultivated land area, location, planting year, etc. to the competent Ginseng cooperative
Production Process Verification System	The production process is verified by a specialized agency	Ginseng cooperative provides cultivation guidance according to standard Ginseng cultivation methods

Note: Source: National Institute of Forest Science, Korea, Standard Cultivation Guidelines for Wild Ginseng (2013), Reconstructed.

Wild-simulated Ginseng is managed and supervised from the stage of selecting the cultivation site under the "Act on Promotion of Forestry and Mountain Village Development." Therefore, it must be cultivated in the mountain area, sowing and transplanting without artificial facilities, from seeds, seedlings, planting, cultivation management, quality inspection, and distribution. Wild-simulated Ginseng refers to Ginseng that is cultivated in a natural state as much as possible and is designated as a specially managed forest product under Article 2, Paragraph 1 of the Mountain Management Act. In contrast, Ginseng is cultivated in farmland such as fields and paddies by artificially improving the soil and using facilities according to the provisions of the "Ginseng Industry Act." <Table 2> compares the quality management methods for Wild-simulated Ginseng and Ginseng.

3. Research Methods

3.1. Collection of wild-simulated Ginseng and soil samples

In this study, Wild-simulated Ginseng samples were collected from four Pyeongchang cultivation sites in June 2022, with ten 10-year-old plants collected from each site. Each site was designated A-1, 2, B-1, 2, C-1, 2, and D-1, 2. The collected samples were washed with distilled water, naturally dried at room temperature until surface moisture was removed, and then frozen at -70°C for storage. The samples were then ground into a powder that passed through an 80-mesh standard sieve and stored at -70°C for analysis. Soil samples were collected from the root zone at a depth of 10-30 cm from each of the four cultivation sites. The soil samples were dried in a cool, dry place, sieved through a 2-mm sieve, and stored at room temperature. <Figure 2> and

<Figure 3> below illustrate the soil sample collection process and photographs of the Wild-simulated Ginseng samples.

Figure 2. Wild-simulated Ginseng sample and soil sample collection.

Figure 3. Wild-simulated Ginseng sample photo.

3.2. Investigation of soil physicochemical properties in wild-simulated Ginseng cultivation areas

To investigate the soil physicochemical properties of wild-simulated Ginseng cultivation sites, the National Institute of Forest Science, Forest Medicinal Resources Research Institute, was requested for analysis, and the Comprehensive Testing Laboratory Analysis Manual published by the Rural Development Administration was referenced (National Institute of Forest Science, 2013). The hydrogen ion concentration and electrical conductivity of the soil were measured using a pH meter and an EC meter, respectively, after diluting distilled water and air-dried soil in a ratio of 5:1 and shaking for 30 minutes. Organic matter was measured using the Walkley-Black method, and total nitrogen content was measured by adding 5 mL of concentrated sulfuric acid to 1 g of soil, decomposing it using a block digester, and then using the Kjeldhal distillation method. Available phosphorus was measured using the absorbance method for 1-amino-2-naphtol-4-sulfanic acid according to the Lancaster leaching method. The cation exchange capacity was measured by the Kjeldhal distillation method for NH4+ substituted in the soil after leaching with 1 N-NH4OAc, and the exchangeable cation was measured using inductively coupled

plasma optical emission spectroscopy (ICP-OES) after leaching the soil with 1 N-ammonium acetate (NH4OAc).

3.3. Wild-simulated Ginseng sample extraction and reagents

To analyze ginsenosides in 10-year-old Wild-simulated Ginseng from the Pyeongchang region, 0.2 g of the sample was extracted with 10 mL of 70% methanol for 30 minutes using an ultrasonicator. The extract was centrifuged for 10 minutes, and the supernatant was filtered through a 0.2-μm membrane filter. The filtrate was diluted 10-fold with distilled water before use. Chroma Dex ginsenoside standards were used. Methanol, acetonitrile, and sterile distilled water used in extraction and high-performance liquid chromatography analysis were of special and HPLC grade.

3.4. Ginsenoside content analysis and data processing method

Ginsenoside analysis was performed using LC-MS, and the column used was a CORTECS UPLC C18 column 1.6μm, and the column temperature was set and maintained at 40°C. 0.1% acetic acid (HCOOH) in water was selected as the mobile phase for solvent A, and 0.1% HCOOH in acetonitrile/methanol (1:1, v/v) was selected as solvent B. The solvent conditions according to time were analyzed by gradient elution method (0-18 min, 40% B; 18-21 min, 80% B; 21-26.1 min, 99% B; 26.1-30 min, 40% B). All samples were analyzed for 30 min, with a flow rate of 0.4 mL/min and an injection volume of 1μL. After analyzing the ginsenoside standard at concentrations of 10, 25, 50, and 100μg/mL, a calibration curve was created to analyze the component content of each sample. The analyzed data values were expressed as mean ± standard error (S.E.). Statistical analysis was performed using Statistical Analysis System ver. 7.1 software. The statistical analysis of soil physicochemical properties between cultivation sites was performed using t-test to verify significance, and the least significant difference (LSD) was processed at the $p<0.05$ level.

4. Research Results

4.1. Site environment analysis results

According to the National Institute of Forest Science (2013), Wild-simulated Ginseng is suitable for cultivation in relatively cool areas below 25°C and may be damaged by high temperatures. In summer, a relatively cool area is good, and in winter, a place with accumulated snow is suitable. Accordingly, the cultivation environment of wild-cultivated Ginseng was classified into terrain, slope direction, elevation, forest type (coniferous forest, deciduous forest, mixed forest), and slope. In this study, the site environment of Wild-simulated Ginseng was investigated in six ways: slope, slope direction, elevation, tree type, diameter at breast height, and tree height, and classified into coniferous and deciduous forests with reference to the classification criteria of the National Institute of Forest Science[8]. The site environment of each cultivation site according to sample collection is shown in <Tables 3>, <Table 4>, <Table 5>, and <Table 6> below.

Table 3. Location Environment of Samples A-1 and A-2.

Class.	Slope (°)	Aspect	Altitude (m)	Tree Species (Scientific Name)	DBH (inch)	DBH (cm)	Height (m)
Coniferous	30	NE 45	698	Korean Red Pine (Pinus densiflora)	45	114.3	27
				Korean Red Pine (Pinus densiflora)	43	109.22	24
				Korean Ash (Fraxinus rhynchophylla)	11	27.94	6.5

				Korean Ash (Fraxinus rhynchophylla)	5	12.7	17.2
				White Birch (Betula platyphylla var. japonica)	17	43.18	28.5
				Korean Pine (Pinus koraiensis)	59	149.86	28.5
				Korean Pine (Pinus koraiensis)	50	127	24
				False Acacia (Robinia pseudoacacia)	16	40.64	9.4
				Oak (Quercus)	17	43.18	7
Broadleaf	28	WN 345	667	White Birch (Betula platyphylla var. japonica)	18	45.72	14
				Korean Ash (Fraxinus rhynchophylla)	62	157.48	24
				Amur Maple (Acer ginnala)	9	22.86	9.6
				False Acacia (Robinia pseudoacacia)	31	78.74	14.6
				False Acacia (Robinia pseudoacacia)	27	68.58	16.4
				Amur Maple (Acer ginnala)	9	22.86	6.4
				Korean Ash (Fraxinus rhynchophylla)	8	20.32	7
				Korean Ash (Fraxinus rhynchophylla)	8	20.32	12.8
				Painted Maple (Acer pictum subsp. Mono)	21	53.34	10

Table 4. Location Environment of Samples B-1 and B-2.

Class.	Slope (°)	Aspect	Altitude (m)	Tree Species (Scientific Name)	DBH (inch)	DBH (cm)	Height (m)
Coniferous	40	SE 110	737	Korean Pine (Pinus koraiensis)	42	106.68	16
				Korean Pine (Pinus koraiensis)	33	83.82	15
				Japanese Elm (Ulmus davidiana var. japonica)	13	33.02	3
				Korean Pine (Pinus koraiensis)	25	63.5	17
				Bumalda Bladdernut (Staphylea bumalda)	3.5	8.89	3.5
				Japanese Spicebush (Lindera obtusiloba)	3	7.62	3
				Korean Pine (Pinus koraiensis)	40	101.6	19
Broadleaf	55	NE 80	737	Korean Ash (Fraxinus rhynchophylla)	14	35.56	14
				Korean Ash (Fraxinus rhynchophylla)	12.5	31.75	16

				White Mulberry (Morus alba)	13	33.02	8
				Oak (Quercus)	19	48.26	15
				Manchurian Walnut (Juglans mandshurica)	41	104.14	16
				Korean Pine (Pinus koraiensis)	8.5	21.59	5
				Korean Pine (Pinus koraiensis)	9	22.86	6

Table 5. Location Environment of Samples C-1 and C-2.

Class.	Slope (°)	Aspect	Altitude (m)	Tree Species (Scientific Name)	DBH (inch)	DBH (cm)	Height (m)
Coniferous	50	E 45	580	Japanese Larch (Larix kaempferi)	26	66.04	21
				Japanese Larch (Larix kaempferi)	19	48.26	18
				Japanese Larch (Larix kaempferi)	27	68.58	22
				Japanese Larch (Larix kaempferi)	33	83.82	23
Broadleaf	38	NE 45	667	Linden (Tilia)	22	55.88	14
				Linden (Tilia)	22	55.88	16
				Cherry (Prunus subg. Cerasus)	34	86.36	14
				Cherry (Prunus subg. Cerasus)	21	53.34	15
				Oak (Quercus)	25	63.5	14
				Oak (Quercus)	11	27.94	12
				Dahurian Birch (Betula davurica Pall.)	22	55.88	15

Table 6. Location Environment of Samples D-1 and D-2.

Class.	Slope (°)	Aspect	Altitude (m)	Tree Species (Scientific Name)	DBH (inch)	DBH (cm)	Height (m)
Coniferous	45	ES 165	728	Japanese Spicebush (Lindera obtusiloba)	3.8	9.652	4
				Oak (Quercus)	18.5	46.99	13
				Korean Red Pine (Pinus densiflora)	32	81.28	21
				Korean Red Pine (Pinus densiflora)	44	111.76	19
Broadleaf	40	NE 50	668	Linden (Tilia)	25	63.5	15
				White Mulberry (Morus alba)	8	20.32	4

				Sand Pear (Pyrus pyrifolia (Burm.f.) Nakai)	6	15.24	3
				White Mulberry (Morus alba)	26	66.04	14
				Painted Maple (Acer pictum subsp. Mono)	7.5	19.05	4

4.2. Soil physicochemical analysis results

Analysis of soil physicochemical properties between cultivated Ginseng fields was conducted for acidity (pH), electrical conductivity, total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium, exchangeable magnesium, exchangeable sodium, and cation exchange capacity. Overall, the soil physicochemical properties of cultivated Ginseng fields showed higher contents in broadleaf areas than in coniferous areas. In addition, the results of statistical analysis showed that there was a statistically significant difference between coniferous and broadleaf areas in cultivated areas A, B, and C, while cultivated area D showed almost no significant difference between coniferous and broadleaf areas. <Table 7> shows the results of soil physicochemical properties analysis.

Table 7. Soil physicochemical analysis results.

Division	A-1(Conifers)	B-1(Conifers)	C-1(Conifers)	D-1(Conifers)
	A-2(Broadleaf)	B-2(Broadleaf)	C-2(Broadleaf)	D-2(Broadleaf)
pH[1:5]	4.078±0.024 a	4.17±0.081 b	4.226±0.072 a	4.348±0.047 a
	4.196±0.073 a	4.50±0.072 a	3.934±0.050 b	4.590±0.150 a
Total nitrogen (%)	0.5968±0.021 b	0.5048±0.03 b	0.386±0.005 b	0.3104±0.013 a
	0.8018±0.040 a	0.686±0.025 a	0.4634±0.033 a	0.3802±0.038 a
Available phosphate (mg/kg)	246.542±10.408 b	202.958±13.019 b	183.262±15.929 a	88.860±4.316 b
	337.202±14.629 a	237.574±6.877 a	136.198±11.762 b	182.064±14.557 a
Exchangeable potassium (cmol+/kg)	0.262±0.014 b	0.268±0.027 b	0.214±0.019 a	0.316±0.024 a
	0.544±0.048 a	0.390±0.030 a	0.144±0.012 b	0.302±0.025 a
Exchangeable calcium (cmol+/kg)	4.48±0.465 b	4.768±0.85 b	3.470±0.443 a	3.552±0.121 b
	6.134±0.546 a	10.768±1.436 a	1.632±0.318 b	7.868±1.622 a
Substitutable magnesium (cmol+/kg)	0.488±0.039 b	0.554±0.099 b	0.528±0.069 a	0.448±0.032 b
	0.816±0.051 a	1.212±0.118 a	0.528±0.115 a	0.776±0.162 a
Substitutable sodium (cmol+/kg)	0.110±0.011 a	0.084±0.014 a	0.066±0.007 a	0.048±0.004 a
	0.108±0.016 a	0.100±0.01 a	0.066±0.006 a	0.054±0.006 a
Cation exchange capacity (cmol+/kg)	39.014±1.398 b	33.548±1.470 b	25.23±0.864 a	22.828±0.560 a
	48.3380±2.040 a	44.612±1.434 a	26.73±1.338 a	27.954±3.191 a
Electrical conductivity [1:5](dS/m)	0.336±0.016 b	0.262±0.019 b	0.174±0.016 a	0.2400±0.011 a
	0.486±0.018 a	0.48±0.0210 a	0.236±0.008 b	0.2552±0.038 a

4.3. Results of analysis of ginsenoside content

In order to analyze the ginsenoside content among the cultivated Ginseng fields in Pyeongchang region, 10 samples of 10-year-old cultivated Ginseng were collected from 4 cultivated fields, and the content of 9 types (Rb1, Rb2, Rb3, Rc, Rd, Re, Rf, Rg1, Ro) out of 36 types of ginsenosides were analyzed. As shown in <Table 8>, the ginsenoside content of cultivated Ginseng in Pyeongchang region generally showed high contents in the order of Re, Rb1, and Rg1, indicating that these compounds constitute the main components of cultivated Ginseng.

Table 8. Ginsenoside analysis results

Division	A-1(Conifers)	B-1(Conifers)	C-1(Conifers)	D-1(Conifers)
	A-2(Broadleaf)	B-2(Broadleaf)	C-2(Broadleaf)	D-2(Broadleaf)
Rb1	4,999±1249	3,031±513	4,571±573	3,815±768
	3,419±696	2,609±348	10,756±951	7,867±1048
Rb2	1,037±154	1,027±247	1,448±429	1,373±336
	1,069±176	835±158	2,596±262	2,395±405
Rb3	365±70	297±69	409±91	380±73
	333±62	204±35	823±73	649±96
Rc	1,369±213	1,144±249	1,600±348	1,609±298
	1,279±252	1,043±111	2,467±214	2,698±361
Rd	948±95	476±90	833±147	676±73
	708±67	712±46	626±100	1,255±142
Re	5,008±701	3,827±344	5,004±857	4,366±917
	3,289±190	3,745±255	4,797±249	5,369±737
Rf	1,372±155	1,050±107	1,457±242	1,240±398
	1,005±126	1,111±163	1,273±67	1,569±203
Rg1	4,215±697	2,340±177	4,123±512	2,755±751
	3,137±363	2,941±535	4,539±557	5,839±658
Ro	1,718±280	1,570±251	2,235±248	1,393±370
	1,149±172	1,413±102	1,526±193	1,708±153

5. Conclusion and Suggestions

Wild-simulated Ginseng is designated as a special management forest product by the Korea Forest Service. However, because it has only been about 10 years since its definition was established, systematic research and standard cultivation guidelines often differ from the actual cultivation practices. Given the diverse soil types and environmental conditions of each cultivation site in Korea, multifaceted research tailored to the specific conditions of each cultivation site is necessary[17][18][19].

According to the research results of the Korea Forest Service's development of optimal cultivation technology for Wild-simulated Ginseng, the current Wild-simulated Ginseng is estimated to have been cultivated in the mountains for at least 500 years[20][21]. However, compared to

Ginseng, the cultivation period is longer, and due to concerns about theft, it has been cultivated secretly in places known only to the farmers. As a result, technology sharing and academic theory are insufficient. Compared to its long history, each farm is currently developing cultivation technology through trial and error.

The quality of Wild-simulated Ginseng varies depending on its growing environment, exhibiting various growth characteristics such as the length and weight (size) of the bud, root shape, color, taste, aroma, efficacy, and overall appearance. The Pyeongchang region of South Korea is well-suited for the growing environment of Wild-simulated Ginseng, resulting in unique growth characteristics[22][23]. Due to its geographical characteristics, the Pyeongchang region is a mountainous area with an average elevation of 700 m, experiencing four distinct seasons, with heavy snowfall and cold winters and cool summers. Furthermore, the region boasts numerous, high mountains and deep valleys, providing abundant water, and pristine forests resembling primeval forests, offering abundant cultivation sites suitable for Wild-simulated Ginseng. Wild-simulated Ginseng is a crop that prefers water but dislikes humidity, and grows well in silty loam soils with high organic matter content, good drainage, and good moisture retention[24][25].

Against this backdrop, this study examined the effects of ginsenoside content on the environmental conditions of Wild-simulated Ginseng cultivation sites in the Pyeongchang region. Ten 10-year-old cultivated Ginseng samples were collected from each of four cultivation sites. First, soil physicochemical properties were analyzed according to the topographical conditions of the Wild-simulated Ginseng sites, including topography, slope direction, elevation, forest cover (coniferous forest, deciduous forest, mixed forest), and slope. The soil properties were analyzed for acidity (pH), electrical conductivity, total nitrogen, available phosphorus, exchangeable potassium, exchangeable calcium, exchangeable magnesium, exchangeable sodium, and cation exchange capacity. Overall, the results of the study showed that the contents of Ginseng in the deciduous areas were higher than those in the coniferous areas. Furthermore, statistical analysis revealed that there was a statistically significant difference between the coniferous and deciduous areas in cultivation sites A, B, and C, while cultivation site D showed little significant difference between the coniferous and deciduous areas.

Analysis of ginsenoside content between Wild-simulated Ginseng cultivation sites in Pyeongchang, Korea. Looking at the results of the analysis of the content of 9 types of ginsenosides (Rb1, Rb2, Rb3, Rc, Rd, Re, Rf, Rg1, Ro), in cultivation site A, ginsenoside components were generally higher in coniferous areas than in deciduous areas. In cultivation site B, ginsenoside components were generally higher in coniferous areas than in deciduous areas. In cultivation site C, ginsenoside components were generally similar in both deciduous and coniferous areas. In cultivation site D, all 9 types of ginsenoside components were higher in the deciduous areas than in the coniferous areas. Wild-simulated Ginseng shows a very large difference in growth status and ginsenoside content depending on the cultivation site. The results of this study show that the ginsenoside contents of Wild-simulated Ginseng in Pyeongchang generally had high contents in the order of Re, Rb1, and Rg1, indicating that these compounds constitute the main components. Considering these research results, it can be seen that in order to produce high-quality products, Wild-simulated Ginseng must be cultivated in an environment similar to that in which wild Ginseng can grow well.

The 10-year-old Wild-simulated Ginseng used in this study was cultivated using a method based on each farm's experience. This is because the diverse and complex environments of cultivated fields make it difficult to realistically prepare samples that adhere to standard cultivation guidelines. Therefore, it appears necessary to develop new standard cultivation guidelines tailored to Korea's soil, elevation, tree species, and other cultivation environment.

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7. Appendix

7.1. Author's contribution

	Initial name	Contribution
Lead Author	SP	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑
Corresponding Author*	JL	-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑

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A Study on the Terrorism Response System in National Disasters: A Perspective on the Outbreak of War in Northeast Asia

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Abstract

Purpose: *Terrorism, such as sabotage, leads to national disasters such as war, and the response system has changed over time. As defined by William Sturgiss Lind immediately after the end of the Cold War in 1989, it has changed from people, weapons, and information to irregular threats encompassing all of these. Now, with the 4th Industrial Revolution, it is expected that false information such as videos, images, texts, and voices will be utilized through artificial intelligence (AI) deep-fake technology, and quantum computers, biotechnology and gene editing, robotics and AI drones, and artificial neural networks will develop into new threats.*

Method: *This study is an English extension of a paper published in Korean, and expands the national terrorism response system from the perspective of civilian cooperation to the perspective of war following a national disaster.*

Results: *This study first identified relative poverty and radicalization as the causes of sabotage terrorism that lead to national disasters. Furthermore, it categorized the network structure of terrorist organizations through recent Internet use into security maintenance, belief systems, support groups, and organizational structure. Second, it proposed a plan to introduce CPTED, voluntary neighborhood watch groups, and detective activities as a basis for national disaster response systems, citing beneficiary pays theory, pooling theory, and economic reductionism. Furthermore, from a Northeast Asian perspective, it discussed the need for national disaster preparedness in Northeast Asia in light of the Russia-North Korea military alliance.*

Conclusion: *First, based on the 9/11 terrorist attacks in the United States, national counterterrorism strategies are categorized into a "threat-based approach" and a "vulnerability-based approach." Second, by revisiting the case of the U.S. National Security Agency (NSA), we introduce the social conflict surrounding counterterrorism agencies' intelligence activities and the dilemma of the conflicting values of "threat intelligence" and "personal information." Third, we examine the relationship between counterterrorism agencies and domestic politics, drawing on the examples of the FBI and CIA and proposing a model for the U.S. Office of the National Intelligence Service (ODNI).*

Keywords: ***National Disasters, Sabotage, Counter-Terrorism, Civilian Cooperation, Russia-North Korea Military Alliance***

1. Background of the Study

It is said that state-sponsored responses to threats like terrorism reflect the times. Currently, they are characterized by the combination of the irregular nature of fourth-generation threats, as defined by William Lind, and advanced scientific technologies like artificial intelligence. These threats necessitate exploring solutions through civilian cooperation.

According to recent media reports in Korea, there was an instance in which fake Biden robocalls influenced the 2024 US presidential primary. The countermeasures involved robocalls

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impersonating FBI agents, and sophisticated tactics were employed, including using phone numbers from FBI offices across the US and displaying FBI numbers on caller ID. Regarding this phenomenon, Eurasia Group predicted that the top 10 threats for 2024 would not be the Ukraine-Russia or Israel-Hamas wars, but rather a chaotic US presidential election. They predicted that if the election results were not accepted, national governance would be paralyzed, and that America's adversaries would welcome this situation. South Korea is currently suffering from these social problems.

Amidst this, North Korea is the main villain in Northeast Asia, with institutions such as Kim Il-sung University of Political Science and Military Studies, Kim Chaek University of Technology, and Pyongyang University of Computer Technology offering regular cyberattack training courses. North Korea possesses the world's fourth-largest cyber power, following the United Front Department and Russia[1]. Furthermore, the United Front Department and the International Liaison Department (Cultural Exchange Bureau) are expanding their presence in China, Southeast Asia, and Central and South America[2]. Consequently, under Kim Jong-un, North Korea's cyber power has evolved into one of the three major asymmetrical forces alongside nuclear weapons and missiles[3].

Therefore, Northeast Asia should actively pursue research on this topic to provide policy recommendations. However, North Korea and China do not tolerate academic criticism of government administration, and even in Japan, there is no significant research on this topic. In Korea, the only research related to national counter-terrorism has been largely focused on the Anti-Terrorism Act. Kim Yong-ju (2013) pointed out that threats like the 9/11 terrorist attacks can occur anytime and anywhere, and that although the methods of terrorism have diversified due to technological advancements, legislation related to anti-terrorism has not kept pace with this [4], and Han Hee-won (2016) stated that the Anti-Terrorism Act should be sufficient to deal with terrorism through continuous discussion and that its purpose should be maintained [5]. Regarding the comprehensive change in the threat of terrorism, Tae-young Kim and Ho Kim (2020) suggested the need for improvement of the Anti-Terrorism Act to prevent non-traditional threats such as COVID-19 from expanding into mass casualty terrorism equivalent to war[6], and Jo (2023) stated that in most countries except for North Korea and China, due to the liberalization of overseas travel and the widespread use of the Internet, it has become meaningless to distinguish between overseas and domestic or online and offline responses to terrorism, and even soldiers and civilians are not controlled as in wartime, so the meaning of special distinctions has diminished[7]. In a direct preceding study of this study, Choi Chang-gyu and Kim Tae-young (2023) presented a plan to improve the national terrorism response system by dividing it into the concept of urban complex terrorism and the possibility of domestic occurrence, terrorism prevention stage, terrorism preparation stage, and terrorism response stage [8], and Jeon & Yun (2024) argued for the development of a plan to preemptively block terrorist threats by utilizing technologies such as AI-based terrorism prevention and response systems in line with technological advancements since the Fourth Industrial Revolution and to strengthen education and training for such changed technologies[9]. A comprehensive review of previous studies to date has shown that most of them have sought improvement measures centered on response systems by government agencies. Therefore, this study is meaningful in that it presents a terrorism response system for national disasters such as war in Northeast Asia from the perspective of civilian cooperation.

2. Sabotage Terrorism Leading to National Disaster

2.1. The origins of terrorism: relative poverty and radicalization

Maximilien Robespierre, who first used the term "terrorism," stated, "He who is a terrorist to one man is a freedom fighter to another. Just as states use violence, such as war, to achieve their goals, individuals also use terrorism"[10][11]. In this way, the national counter-terrorism system is a "mirror of the times," and distinguishing it from general crime will play a crucial role in defining the scope of counter-terrorism.

Table 1. Distinction between terrorism and crime.

Category	Terrorism	General Crime
Motives	Cause, Belief System	Personal Gain, Desire
Activities	Communication, Visibility	Secrecy, Destruction of Evidence
After the Incident	Self-surrender	Escape
Extent of Damage	Symbolic Effect	Sacrifice Through the Process

Note: Source: Jo S. Comprehensive Threats and Directions in Northeast Asia. International Journal of Terrorism & National Security, Vol. 8 (2023)[12].

Both terrorism and general crime originate from relative poverty, but terrorism is characterized by a process of radicalization, defined as violent extremism within a socioeconomic framework driven by political factors.

The general process of radicalization begins with relative poverty, and the formation of extremism begins with comparing one's level of living to that of others[13]. The OECD and EU define the relative poverty line as 40, 50, and 60% of median household income, respectively. The World Bank defines it as 1/3 of the average household income in developing countries and 1/2 of the average household income in developed countries.

Furthermore, the frustration stemming from deprivation transforms into anger, and the lacking mentality undergoes a self-rationalization process that justifies violent behavior. This justified violence and extremism, once internalized, lead individuals to seek out violent information through the internet and social media. When engaging in violence, individuals exchange the opportunity to directly or indirectly convey a message they wish to convey for the opportunity to commit violence, thus considering how their actions will be disseminated and interpreted by the media.

This negativity bias is inherent in the pre-planning of terrorist acts, as consumers perceive negative information to be more valuable. The potential negative psychological impact of a terrorist incident resulting in mass casualties can significantly overwhelm the reality of the situation. This is because terrorists seek to convey the meaning of their violent actions to the public for a symbolic effect, and media outlets recognize that consumers react more strongly to violent threats.

2.2. Structure of terrorist organizations and internet utilization

Terrorist organizations' use of the Internet has been crucial to achieving their objectives, including accessibility, lack of regulation, broad reach, and rapid information flow. Al-Qaeda, the perpetrator of the 9/11 attacks, used the Internet to expand its international network, recruit and train terrorists, manage members through remote training, and propagate their cause and belief system[14].

Table 2. Network structure of terrorist organizations.

Category	Main Contents
Maintaining Security	Details of the terrorist organization are confidential, and its members do not operate openly and disguise their identities
Belief System	Dedicated to the common cause and ideology of the terrorist organization, and organized around this common goal to maintain its strength
Support Force	Terrorist organizations have support groups, and this support maintains the organizational structure through continuous support of terrorist members
Organizational Building	Because terrorist organizations are supported and protected by the organization, terrorist incidents are perceived as being perpetrated by the terrorist organization

Note: Source: Jo S. Comprehensive Threats and Directions in Northeast Asia. International Journal of Terrorism & National Security, Vol. 8 (2023)[12].

Terrorist organizations' use of the Internet not only contributes to the formation of network structures, but also exposes them to an unspecified number of people through various media, some of whom may become supporters who agree with the terrorist organization's beliefs. In particular, individuals experiencing relative poverty within society may become single-actor terrorists, planning and executing terrorist attacks without the support or protection of any terrorist organization. Such single-actor terrorist attacks are more threatening due to the lack of support or communication, making them difficult to identify in advance. In this way, terrorist organizations are shrinking in society.

The activities of these terrorist organizations influence the development of antisocial mentalities and extremist violence in individuals experiencing relative poverty. Therefore, to maintain a social safety net, proactive intervention and countermeasures are necessary to prevent the social factors that foster relative poverty from escalating into violent extremist behavior [15].

Consequently, the US FBI established the Behavioral Threat Assessment Center (BTAC) to analyze and prevent specific individuals and groups at risk of extreme terrorism. Korea should also consider implementing similar policies. It's easy to dismiss terrorists who attack random targets as "crazy," "abnormal," or mentally unsound, but terrorists rarely suffer from mental illness. Marc Sageman interviewed and reviewed biographies of over 170 terrorists and found that his sample of terrorists had lower rates of mental illness than the general population. In other words, terrorists are not clinically mentally ill, nor do they suffer from mental illness more frequently[10][11]. Therefore, if a mysterious airplane or military aircraft crash in a specific country or region is attributed to a specific government, the question is easily understandable.

3. Civilian-Private Cooperation in the National Disaster and Terrorism Response System

3.1. Civilian-private cooperation model theory

Since the end of the Cold War, liberalization of international travel and the proliferation of the internet have led to advancements in information and communication technology and science and technology. Globalization has led to a comprehensive approach to addressing threats to humanity, encompassing the economy, culture, and health. Consequently, major countries have established procedural exceptions to laws to address violence such as terrorism, treating it differently from general criminal offenses[16].

Considering that the means and methods of terrorist threats have already evolved due to the advancement of cutting-edge science and technology, and that not only North Korea, China, and Russia, but also Japan, the United States, and the European Union are strengthening relevant laws to address new terrorist threats, it is inevitable to balance this robust legal authority with neighboring countries.

Examining relations with neighboring countries, domestic political turmoil and foreign policy failures have been linked to terrorism by national leaders and regime changes, and this domestic turmoil has led to wars with neighboring countries[17]. The Northeast Asian order is influenced by the fluidity resulting from differences in each country's growth rate and requires maintaining a balance in response to these shifts in power[18]. These forces are closely linked to domestic political circumstances, and the "transferability" observed through analysis of neighboring countries can be considered a yardstick for security strategy. This metric is analyzed based on the relational quantity (quantity) of intelligence comparison and measurement, as well as the inherent quality (quality) of the essence and meaning of a phenomenon.

However, strengthening national counter-terrorism systems in free world countries requires prior domestic political conditions and social consensus before proceeding to the legislative stage, posing limitations. Conversely, countries based on free market economies offer the potential to enhance competitiveness through free private sector cooperation. Expanding private sector cooperation in national counter-terrorism systems is closely tied to the market economy, and socialist economies like China and North Korea face structural contradictions that prevent privatization, potentially limiting the future expansion of artificial intelligence (AI) technology[7].

Table 3. The feasibility of establishing a private sector cooperation system.

Category	Main Contents
Beneficiary Pays Theory	The government's budget is limited, and the burden on the government is reduced by having users pay for some of the services necessary for the public good
Publication Theory	In a vacuum created when the government and private sectors are unable to achieve their goals, the government and private sectors complement each other to increase effectiveness and delegate a certain portion to the private sector, but the purpose is guaranteed through supervision and regulation.
Economic Reduction Theory	As threats increase, governments and businesses spend more to protect their assets (tangible and intangible), and as the economy becomes more active, governments gain more roles to respond to threats through increased tax revenue and businesses gain more roles to respond to threats through increased profit generation, ultimately making threats more effective

Note: Source: Jo S. Soft Power in Northeast Asia, Using AI in Information Warfare. Robotics & AI Ethics, Vol. 8 (2023)[7].

In this way, public-private partnerships can promote safety alongside residents in national counter-terrorism efforts. Furthermore, private sector participation fosters competition and innovation in areas requiring resource procurement, thereby reducing the government's burden.

Therefore, this study proposes solutions for responding to evolving threats and the national counter-terrorism system through private-sector collaboration. These include the systematic use of CPTED and voluntary security guards domestically, and the introduction of detective systems overseas.

3.2. CPTED and volunteer neighborhood watch

As terrorism has recently evolved into an indiscriminate form targeting soft targets, the risk of terrorism utilizing readily available tools and means, particularly vehicle ramming attacks

using passenger cars or trucks, has increased. Consequently, research on Anti-Terrorism Design (ATD) is beginning to gain traction[19].

Crime Prevention Through Environmental Design (CPTED), which already applies the principle of "visible transparency," offers a potential low-cost, high-efficiency strategy that can protect citizens from the anxiety of not only general crime but also unspecified extreme violence by designing structures that are difficult to express. CPTED consists of natural surveillance (enhancing surveillance by securing visibility), access control (controlling unauthorized access), strengthening territoriality (demarcating areas through boundary markings), and enhancing mobility (supporting the activities of volunteer neighborhood watch).

Currently, local governments recognize the importance of CPTED, and various projects are being implemented. It is now being implemented as a third-generation CPTED approach that enhances quality of life by improving residential infrastructure. While first-generation CPTED focused on defensive crime prevention by demarcating geographical areas and reducing crime opportunities within the physical environment, second-generation CPTED emphasized a non-physical surveillance system that goes beyond physical spaces and fosters connections among residents. This suggests that third-generation CPTED will also focus on how effectively it can establish its fundamental concepts of community building and collaboration with local communities as a policy model. CPTED, which incorporates non-physical elements, is expected to play a positive role in the national counter-terrorism system.

3.3. Introduction of the basis for investigative activities

Article 7 of the UK's foreign intelligence agency, MI-6 (Secret Intelligence Service Act), provides a legal basis for "no legal liability for acts carried out abroad with the permission of the Minister." Requests to apply Article 7 of MI-6 to covert operations worldwide have reportedly surged since the 9/11 attacks, with an average of 500 ministerial signatures annually. This represents a departure from the past practice of secretive and tacit operations, establishing legal grounds and standards behind closed doors[12].

This "operational authority" is used overseas in areas beyond the reach of domestic law. Intelligence service personnel, including military attachés and diplomats dispatched overseas as part of an organization's chain of command to maintain national security, are exempt from legal action under the Vienna Convention on Diplomatic Relations' diplomatic immunity. However, in this era of globalization, international connectivity is increasing in many fields, and domestic law does not apply to all incidents occurring overseas. Therefore, cooperation with the private sector, taking local characteristics into account, is required.

The case of Samsung Electronics' theft of two of the 60 OLED TVs shipped for display at IFA 2012 in Germany in August 2012, was resolved not by the German Federal Police but by a detective hired by Samsung Electronics in Germany. This demonstrates the validity of private-sector cooperation[20]. Expanding private-sector cooperation recognizes that conflicts in Northeast Asia cannot be resolved through traditional hard-power methods. Establishing an economic union, such as the "Northeast Asia EU Model," to reduce unnecessary energy waste and foster prosperity that contributes to international competitiveness could have a positive impact on peace in Northeast Asia[12].

4. The Need for National Disaster Preparedness in Northeast Asia Amid the Russia-North Korea Military Alliance[1]

International isolation following the 2022 Ukrainian-Russian War, which escalated into a full-scale war, led Russia, depleted of its resources, to conclude a military alliance with North Korea's Kim Jong-un in 2024. This forced South Korea to endure a war not only with North Korea but also with Russia, a defensive military response to North Korea's nuclear provocations. Ultimately, South Korea's dependence on its alliance with the United States has increased. Experts offer complex calculations regarding this situation, but the bottom line is that threats have increased.

Former US Secretary of State Henry Kissinger, who spearheaded the establishment of diplomatic relations between the US and China, once said, "For a relatively small country to arm itself with nuclear weapons is like entering into an implicit non-aggression pact with its neighbors." This literally signifies a "balance of terror."

The theoretical war scenarios between a nuclear power and a non-nuclear power can be summarized into four scenarios. First, if a nuclear state annihilates one or two small local cities with small tactical nuclear weapons at the start of a war, non-nuclear states lose their will to fight. Second, non-nuclear states counterattack with conventional forces at the risk of casualties, but the power of nuclear weapons inflicts near-annihilation. Third, non-nuclear states can cease the war by surrendering and submitting. Fourth, even if Russia, under international pressure, does not immediately use nuclear weapons, as in the recent Ukraine-Russia war, non-nuclear Ukraine has no choice but to resort to limited attacks. If the war continues for a long time without escalation, Ukraine's cities will be destroyed to a degree that will be difficult to recover from. Looking back on its foreign policy, resource-poor South Korea has relied on trade to sustain its national economy. Therefore, despite North Korea's repeated provocations since the Korean War, such as the bombing of Korean Air Flight 858, the sinking of the Cheonan warship, and the shelling of Yeonpyeong Island, South Korea has maintained a foreign policy of strengthening the ROK-US alliance rather than deterring war through the possession of nuclear weapons. Theoretically, this guarantees South Korea the most reliable deterrent, as any country invading South Korea would be at war with the United States, the world's most powerful military power.

However, the current Russia-North Korea military alliance poses a burden to the United States, which possesses the world's largest nuclear arsenal. Similarly, as with the US withdrawal and the fall of South Vietnam in the Vietnam War, if the US domestic political situation renders South Korea's defense incapable, South Korea's options will inevitably be questioned. In this situation, three options are presented from an international political perspective: First, South Korea can pursue a hedgehog strategy through nuclear development, risking international condemnation. Second, if South Korea fails to fully develop nuclear weapons, it will be forced to politically submit to North Korea, China, and Russia, perpetuating its existence as a vassal state. Third, it will respond to North Korea, China, and Russia through a military alliance with Japan. From an international political perspective, within the framework of protecting liberal democratic values, a military alliance with Japan is a textbook choice for South Korea. However, it is also true that collective sentiment remains unsettled due to its history of Japanese colonial rule. Therefore, now that North Korea has formed a military alliance with Russia, there is ample reason for South Korea to not only strengthen the ROK-US alliance but also explore multifaceted methods to deter any invasion.

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[1] Jo SG. Russia-North Korea Military Alliance vs. ROK-US Alliance and Independent National Defense. Korea Youth Newspaper, September 30 (2024).

5. National Counterterrorism Strategy

5.1. Threat-based and vulnerability-based strategies

National counter-terrorism strategies can be categorized into two types: a threat-based strategy, which focuses on intelligence-based approaches to predicting threats by continuously identifying pre-existing threats, organizations, attack methods, and capabilities, and a vulnerability-based strategy, which focuses on defense through investigations based on this information.

The 9/11 terrorist attacks by al-Qaeda in 2001 were a case of terrorism that defied the CIA's (Central Intelligence Agency's) precise identification of hijacked civilian aircraft and their use as air-to-ground cruise missiles. Furthermore, the ability of these two distinct strategies to coexist is a crucial challenge for national counter-terrorism strategies. In particular, al-Qaeda's successive crashes of two hijacked aircraft into the Twin Towers of the World Trade Center anticipated the destruction of the United States, which would be filmed by unspecified individuals in the vicinity and extensively covered by traditional media outlets like television news. This sophisticated strategy was creative and exceeded the capabilities of existing counter-terrorism agencies.

Table 4. Counter-terrorism strategy and response.

Category	Threat-Based Strategy	Vulnerability-Based Strategy
Scope of Response	Empirically Perceived Threats	Unlearned Creative Threats
Core Competencies	Information Power	Defense
Main Duties	Scouting	Counterintelligence
Job Scope	Investigation	Detective
Job Nature	Preemptive Action	Post-processing

Note: Source: Jo S. Comprehensive Threats and Directions in Northeast Asia. International Journal of Terrorism & National Security, Vol. 8 (2023)[12].

5.2. The dilemma of 'threat intelligence' and 'personal information'

Ultimately, the nation's counter-terrorism strategy is to dispel the public's insensitivity to safety and establish a national security response system[21]. However, despite the various efforts of government agencies, there are cases where social issues arise. For example, Google Chairman Eric Schmidt strongly criticized the National Security Agency (NSA)'s surveillance of civilians, and NSA Director Keith Alexander rebutted this in the U.S. Senate, saying, "We have prevented dozens of terrorist attacks in recent years alone through intelligence gathering, including the prevention of the 2009 New York subway bombings." This phenomenon is a common social issue in liberal democratic countries, excluding North Korea, China, and Russia, and is acting as a limitation of the national counter-terrorism system. From a Korean perspective in Northeast Asia, North Korea's nuclear weapons and China's military threats are perceived threats. South Korea's fifth-largest defense force and the ROK-US alliance deter war[22]. However, sabotage terrorism, which threatens the lives and property of citizens within the country, presents challenges for domestic law enforcement agencies, such as the police, due to its overseas connections.

5.3. Establishing the U.S. ODNI model

The distinction between foreign intelligence and domestic counterintelligence in the United States began in 1908. After the establishment of the FBI, Director John Edgar Hoover served as FBI Director for a total of 48 years from 1924 to 1972, monopolizing the position during the change of eight presidents. In 1947, President Harry S. Truman established the Central Intelligence Agency (CIA) in 1947 as the successor to the Office of Strategic Service (OSS), which was

established as an intelligence unit during World War II in 1942, and transferred foreign intelligence operations to it, thereby keeping the FBI in check. Since then, major advanced countries have applied the principle of mutual checks and balances by dividing foreign intelligence and domestic counterintelligence under the influence of the U.S. CIA and FBI [22]. However, the September 11, 2001 terrorist attacks raised questions about the US national counter-terrorism system, and the US House of Representatives' accountability investigation pointed out that the 16 US intelligence agencies failed to share information and failed to utilize the information collected competitively among intelligence agencies in a timely manner [23], and the national counter-terrorism system showed that if it missed the point of timeliness, that is, prevention in advance, it could lead to many national casualties, such as the September 11 terrorist attacks [24]. Ultimately, the US established the Office of the Director of National Intelligence (ODNI) in 2004 to maintain 'timeliness' by integrating the information collected from the 16 intelligence agencies. An integrated management structure in the national disaster and counter-terrorism system can ensure efficiency, and it is hoped that more countries and governments will take interest and look into the US ODNI model, which can be said to be a lesson from the September 11 terrorist attacks in the US.

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7. Appendix

7.1. Author's contribution

	Initial name	Contribution
Author	SJ	-Set of concepts ☑ -Design ☑ -Getting results ☑ -Analysis ☑ -Make a significant contribution to collection ☑ -Final approval of the paper ☑ -Corresponding ☑ -Play a decisive role in modification ☑ -Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑ -Participants in Drafting and Revising Papers ☑ -Someone who can explain all aspects of the paper ☑