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Understanding Urban Residents' Perceptions of Street Trees to Develop Sustainable Maintenance Guidelines in the Seoul Metropolitan Area, Korea

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Abstract: Street trees play a crucial role in improving urban environments, and their management depends on the perceptions and preferences of urban residents. This study surveyed 884 urban residents' preferences and perceptions towards street trees in a metropolitan area in Korea and proposed guidelines for their sustainable management. Urban residents were aware of the presence of street trees based on visual changes and were generally satisfied with their shape, size, and growth. They preferred trees that provide environmental and ecological services, such as offering shade, purifying the air, and preserving the ecosystem, while viewing the generation of debris from street trees as the most significant problem. Urban residents' perspectives on street tree preference and issues varied based on age, income, and housing type. Although urban residents acknowledged the need for the maintenance and management of street trees, they believed that this was the responsibility of central and local governments, not local residents. Collectively, the residents had a positive view of urban street trees and believed that maintenance and management are necessary to address problems caused by their presence. Our research findings provide valuable information to help city and landscaping experts select street tree species and establish maintenance and management strategies.

Keywords: urban greenspace; landscape architecture; social perception; tree preference; tree problem; street tree

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1. Introduction

Various city activities, such as the construction of buildings, roads, and plazas and waste disposal, are linked to climate change and increased mortality owing to the release of pollutants, such as carbon dioxide, ozone, and fine dust, through these activities [1–4]. Urbanization, which transforms agricultural land and greenspaces into high-density land-use types, such as buildings, roads, and plazas, contributes to the urban heat island phenomenon. This phenomenon is caused by various factors, including increased human-generated heat, accumulation of pollutants, and decreased evapotranspiration by vegetation [2,5,6]. High-temperature combustion of fuel in cars produces nitrogen oxide. The reaction between nitrogen oxide and volatile organic compounds creates ozone and fine dust, both of which are air pollutants [7,8]. Air pollution can have serious consequences for the urban environment. Furthermore, the expansion of impervious surfaces and the intensification and frequency of precipitation render cities more susceptible to flooding [9–12]. In particular, continued urbanization can negatively impact human health owing to the potentially increased demand for energy and water [13]. Creating greenspaces for planting, managing, and protecting trees can help promote urban sustainability and reduce the problems faced by urban populations, including several environmental issues [14–17].

Parks, urban forests, gardens, and roadside open spaces are the most important components of urban greenspaces. Artificial ground greening and wall greening are also increasing in urban areas [18,19]. The presence of vegetation surrounding an urban

landscape not only improves the aesthetic appeal of a city but also offers a range of benefits to the inhabitants, such as ecosystem services that can positively impact their quality of life [20]. Urban greenspaces offer multiple benefits, such as energy conservation [21], carbon sequestration [22,23], reduction in water runoff [24–26], urban heat island effect mitigation [27], air quality improvement [28,29], and positive impacts on human health and well-being [24,30,31]. Specifically, street trees are considered key components in enhancing the visual appeal of streetscapes [32,33].

Street trees are the most abundant and prominent form of public greenspace in cities and are easily accessible natural elements for a majority of the population [34]. Trees enhance the resilience of cities and contribute towards improving the quality of life of urban residents. They provide a variety of ecosystem services that directly and indirectly benefit human well-being [35–37]. However, perceptions of the benefits of street trees can vary depending on an individual's social characteristics. Factors such as the environment and socioeconomic status can influence urban residents' views and preferences with respect to street trees [38,39]. Urban residents have a generally positive view of street trees [40], with many residents preferring landscapes that include street trees over those that include inanimate objects [41]. In a study conducted in Mexico, residents noted the positive impact of trees on the environment, stating that they improve the quality of the environment by increasing visual appeal and that more trees should be planted in urban areas [42]. Previous studies have also examined the preferred shape and appearance of street trees, with urban residents generally preferring trees with dense canopies, small amounts of regular composition, and colorful flowers [41,43,44]. A study conducted in Mexico reported that residents preferred street trees with tall lush foliage, shading, and colorful flowers [42]. People's perception of street trees is influenced by several factors, such as their street use behavior, age, and education level, as well as the street environment, including urban structure, traffic intensity, and the length and width of streets [45]. Residents' perception of trees plays an important role in determining their planting and removal in a city [46], and this is also true for street trees, as people's perception of street trees affects their maintenance and management.

As studies have demonstrated the numerous benefits of street trees, including reducing runoff, lowering temperatures, and preserving ecosystems in cities, many municipalities have started planting more street trees. In order to reap the maximum benefits from newly planted trees, their growth should be prioritized. Appropriate maintenance and management are crucial for the healthy growth of street trees. This study aimed to provide basic data for street tree maintenance and management by investigating urban residents' perceptions of street trees and their maintenance and management needs by posing the following research questions:

Which street trees do urban residents prefer?

What are urban residents' perceptions regarding the problems caused by the presence of street trees?

What are urban residents' perceptions regarding the direction, manager, and method of street-tree management?

2. Materials and Methods

2.1. Survey Composition

Understanding public perception regarding street trees can help to plan and manage urban green infrastructure by understanding people's opinions and preferences [47]. In this study, a questionnaire survey was designed to gather information on urban residents' perceptions regarding street trees and their management, and the demographic characteristics of the participants. The questionnaire was created by reviewing published literature on street trees and urban greenspaces and ensuring the validity of its contents by referring to existing literature [34,38,42,45–52]. The questionnaire was reviewed by 10 experts, including local government officials responsible for street-tree management, landscape architects, horticulturists, and practitioners of street-tree management, in order to ensure its structural

feasibility. The questionnaire focused on understanding urban residents' perception of street trees, including their presence, preferred types, level of satisfaction, and specific aspects of satisfaction (Table 1, Appendix A). One of the questions pertained to the change in perception of the existence of street trees over time; this was a close-ended question that included multiple options based on tree growth. Another question regarding preferred street tree types offered multiple options related to their functional benefits, and respondents were requested to select up to three priorities. The questionnaire enquired about urban residents' overall satisfaction with the shape, size, growth status, and management of street trees. Respondents were asked to rate their satisfaction on a 5-point Likert scale (1: not satisfied at all, 3: average, 5: very satisfied), and the questionnaire also included questions on the perceived problems caused by street trees, the need for maintenance and management, plans for maintenance and management, and the main agents of maintenance and management. Ten problems were identified through expert consensus, based on the classification of issues caused by the presence of street trees reported in previous research (Table A1). Participants were asked to rate the need for maintenance and management of street trees on a 5-point Likert scale (ranging from 'not needed at all' to 'very necessary'). They were also asked to evaluate the severity of the problems related to street trees on a 5-point Likert scale (from 'not serious at all' to 'very much serious'). Thereafter, participants were presented with four options for addressing the problems caused by street trees and asked to select their top two priorities. Finally, respondents were asked to select the most important maintenance and management activity for street trees as a single answer in a close-ended format.

Table 1. Questionnaire and measurement scale for the satisfaction and problems associated with street trees.

Questionnaire	Details	Number of Questions	Scale	Reference
Perception of street trees	Presence of street tree	1	Close-ended question, single choice	[45,48,50,51]
	Preferred street tree types	1	Ranking scale	[42,45,48,50]
	Overall satisfaction with the shape, size, growth status, and management of street trees	5	Likert scale (Cronbach's alpha = 0.876)	[34,45,46,49,50]
Maintenance and management of street trees	Problems caused by street trees	10	Likert scale (Cronbach's alpha = 0.864)	Appendix B
	Need for maintenance and management	1	Likert scale	[47,52]
	Plans for maintenance and management	1	Ranking scale	[52]
	Main agent of maintenance and management	1	Close-ended question, single choice	[38,47,52]

2.2. Data Collection

We investigated the perception of urban residents in the Seoul metropolitan area of Korea, a large metropolitan area formed around the capital of Korea. The metropolitan area comprises Seoul Metropolitan City, Incheon Metropolitan City, and Gyeonggi-do and encompasses 12% of Korea's land area and 50.5% of its total population (Figure 1). The Seoul metropolitan area is a central hub for important aspects of Korean society such as politics, economy, and culture, and it is considered an area of great importance.

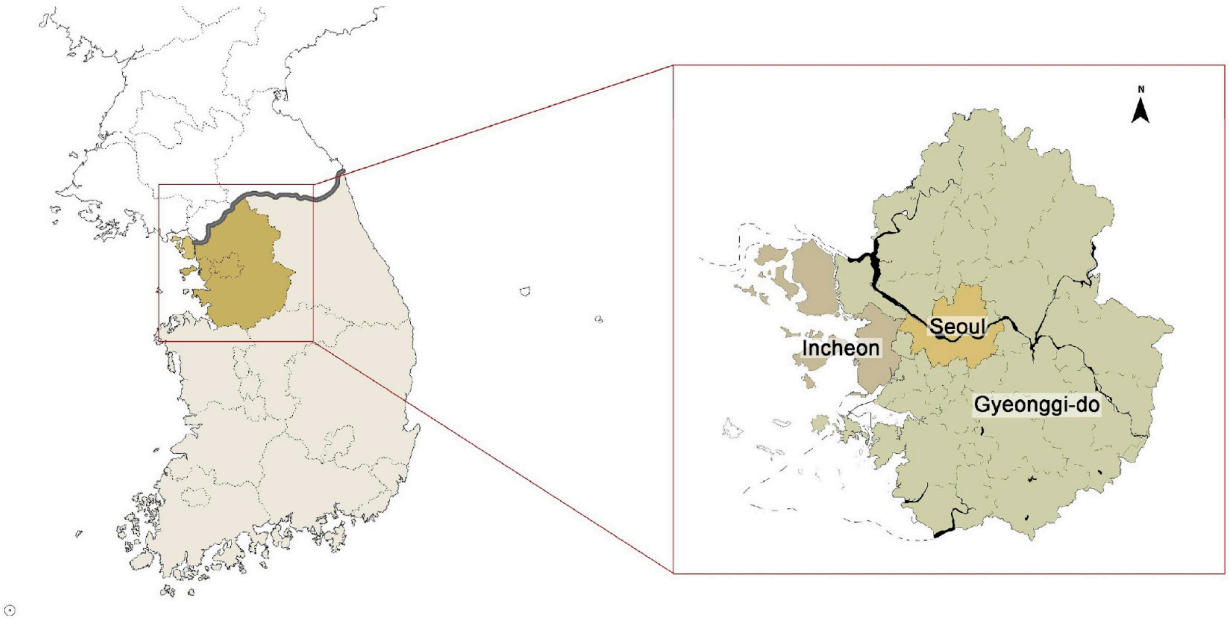

Figure 1. Location of the study area.

According to the 2021 statistics provided by the KFS [53], which manages street trees in Korea, 1,926,433 street trees have been planted across a total length of 9,889,278 m of roads in the metropolitan area (Table 2). The number of trees planted per 100 people is the highest in Gyeonggi at 8.12, followed by Incheon at 7.40, and is the lowest in Seoul at 3.22. However, the number of trees planted based on area shows the opposite trend, with Seoul having the highest number of trees at 5.02 trees per ha, followed by Incheon at 2.06, and Gyeonggi at 1.08. In terms of management, Seoul has a high proportion of pruning, whereas Incheon and Gyeonggi have a high proportion of pest control. Gyeonggi has the most diverse range of street-tree management projects, whereas Seoul's projects are relatively fragmented and focus on pruning, soil improvement, and irrigation.

Table 2. Planting and management status of street trees in the study area.

Classification		Seoul City	Incheon City	Gyeonggi-do	Sum
Planting scale	Planting distance (m)	1,701,396	1,223,479	6,964,403	9,889,278
	Number of trees planted (number of trees)	303,939	219,503	1,102,991	1,926,433
	Number of trees planted per population size (number of trees/ hundred residents)	3.22	7.40	8.12	6.26
	Number of trees planted per area (number of trees/ha)	5.02	2.06	1.08	1.37
Management projects	Total	92,014 (100%)	267,983 (100%)	947,499 (100%)	1,307,496 (100%)
	Pruning	75,016 (81.5%)	10,400 (3.9%)	115,148 (12.2%)	200,564 (15.3%)
	Pest control	-	167,482 (62.5%)	780,266 (82.4%)	947,784 (72.5%)
	Fertilizer treatment	-	26,761 (10.0%)	27,173 (2.9%)	53,934 (4.1%)
	Soil improvement	8499 (9.2%)	-	471 (0.1%)	8970 (0.7%)
	Tree surgery	-	-	2708 (0.3%)	2708 (0.2%)
	Irrigation	8499 (9.2%)	34,579 (12.9%)	9209 (1.0%)	52,287 (4.0%)
	Other	-	28,761 (10.7%)	12,524 (1.3%)	41,285 (3.2%)

The survey targeted a sample group of agri-food consumers living in the metropolitan area. The agri-food consumer panel was established to study consumer purchasing behavior and consumption trends. The sample group, consisting of 2000 households, is managed by the Rural Development Administration. The survey was conducted online in September 2022, and after being informed of the purpose of the survey, panelists were sent an e-mail that included a link for participation. The survey was closed after 1000 households participated on a first-come, first-served basis. Of the responses received, 884 were used for the analysis after disregarding those in which all questions had not been answered (Table 3). Most respondents were female (82.9%). Respondents belonged to different age groups and all age groups were represented; however, the proportion of young adults was slightly higher. Respondents' income levels were divided into quintiles based on the standard median income, which is the median income adjusted for social security purposes. Those with an income below 50% of the standard median income were classified as low-income, those with an income over 150% of the standard median income were classified as high-income, and those between 50% and 150% were classified as middle-income. Most respondents were in the middle-income group (over 50%), followed by the high-income group (36.4%). The most common type of housing was apartments (61.36%), followed by row houses (24.0%), with a high percentage of respondents living in multi-unit dwellings. Most respondents lived in Gyeonggi (over half), and 37.3% lived in Seoul, the capital city.

Table 3. Demographic attributes of respondents.

Classification		N	Ratio	Classification		N	Ratio
Total		884	100.0%	Housing type	Detached House	47	5.3%
Age group	30s	266	30.1%		Row house	212	24.0%
	40s	247	27.9%		Apartment	542	61.3%
	50s	198	22.4%		Studio	68	7.7%
	60s	173	19.6%		Other	15	1.7%
Income quintile	Low income	61	6.9%	Residential area	Seoul	330	37.3%
	Middle income	501	56.7%		Gyeonggi	469	53.1%
	High income	322	36.4%		Incheon	85	9.6%

2.3. Data Analysis

The collected data were analyzed using the statistical software SPSS 25 (IBM Corp. IBM SPSS Statistics for Windows, Armonk, NY, USA). Descriptive statistics were used to analyze the frequency of the close-ended questions and the average of the Likert scale questions. A statistical analysis was conducted for each question to compare differences in perception according to demographic characteristics such as age group, income, housing type, and residential area. Pearson's chi-square test was used to evaluate the relationship between close-ended questions and demographic factors. One-way ANOVA and *t*-tests were employed to examine the connection between satisfaction with street trees, problems with street trees as measured by the Likert scale, and demographic factors. In order to further determine the significance between groups, a post-hoc Duncan test was also performed. For items measured using a reduced ranking scale, a ranking was calculated using the reduced ranking procedure. This method considers the ranking responses when determining the ranking order between items. It involves determining a ranking based on the simple sum of the response composition ratios for first and second choices. If n_{1j} is the number of respondents who selected the j-th item as their first choice out of a total of n respondents, and n_{2j} is the number of respondents who selected the j-th item as their second choice, then the percentages of the first and second choices for each j-th item are calculated as $p_{1j} = n_{1j}/n$, $p_{2j} = n_{2j}/n$, and the item ranking is determined based on the sum

of $p_{1j} + p_{2j}$ [54]. In order to determine the factors that affect satisfaction with street trees, a linear regression analysis was conducted with overall satisfaction as the dependent variable and satisfaction with the shape, size, growth, and management of the trees as independent variables. Factor analysis was used to identify factors by examining the relationships between variables related to street trees. The Varimax orthogonal conversion method was applied to the principal axis factoring results to perform the factor analysis. The statistical significance was determined based on a significance probability of 5%.

3. Results

3.1. Street Tree Perception

Residents' awareness of street trees showed the following trend: 'when leaves start to appear' (29.6%), 'always' (27.9%), 'when flowers bloom' (17.1%), and 'when leaves turn yellow' (16.7%). Analyzing the demographic characteristics revealed no significant difference in street tree recognition by income level, housing type, or region; however, a significant difference was observed by age group ($p < 0.001$). Street tree recognition did not vary greatly; however, the frequency of the response 'always' was relatively high for those in their 50s, whereas that of 'when leaves start to grow' was relatively high in other age groups. The findings revealed that the younger the age, the stronger the recognition of the existence of street trees during the flowering period. With respect to housing type, compared to residents of other housing types, detached-house residents were more aware of the period of leafing and flowering, whereas row-house and apartment residents were relatively more aware of the presence of street trees (Table 4).

Table 4. Cross-analysis of the period of high awareness of street trees and demographic characteristics.

Classification		N	P1	P2	P3	P4	P5	P6	Sum	Pearson's X^2 (p)
Total		884	29.6	17.1	16.7	6.6	27.9	2.0	100.0	
Age group	30s	266	24.1	23.3	17.3	9.0	22.2	4.1	100.0	63.399 (0.000)
	40s	247	26.3	18.6	22.7	6.1	23.9	2.4	100.0	
	50s	198	31.3	13.6	14.1	6.6	33.8	0.5	100.0	
	60s	173	41.0	9.2	10.4	3.5	35.8	0.0	100.0	
Income quintile	Low income	61	23.0	19.7	16.4	9.8	31.1	0.0	100.0	6.988 (0.727)
	Middle income	501	31.3	17.0	15.6	6.0	28.3	1.8	100.0	
	High income	322	28.3	16.8	18.6	6.8	26.7	2.8	100.0	
Housing type	House	47	34.0	29.8	14.9	4.3	17.0	0.0	100.0	21.458 (0.371)
	Row house	212	29.2	17.5	15.6	7.1	27.4	3.3	100.0	
	Apartment	542	29.9	16.1	16.6	6.1	29.7	1.7	100.0	
	Studio	68	22.1	16.2	23.5	11.8	23.5	2.9	100.0	
	Other	15	46.7	13.3	13.3	0.0	26.7	0.0	100.0	
Residential area	Seoul	330	27.9	17.0	17.3	8.2	26.4	3.3	100.0	8.86 (0.545)
	Gyeonggi	469	30.3	17.5	16.2	5.8	29.2	1.1	100.0	
	Incheon	85	32.9	15.3	17.6	4.7	27.1	2.4	100.0	

Note: N is the number of respondents, and values are presented as the percentage. P1—'when the leaves start to appear'; P2—'when the flowers bloom'; P3—'when the leaves turn yellow'; P4—'after the leaves fall'; P5—'always'; F—other.

Residents preferred street trees that offered various environmental benefits; aspects such as providing shade (58.7%), maintaining the urban ecosystem (56.4%), purifying the air (56.4%), and producing flowers that residents can appreciate (39.4%) were emphasized (Table 5). Although no significant difference in preference was observed by age, residents

in their 30s had a relatively high preference for trees that provide shade, those in their 40s had a relatively high preference for those that produce flowers, and those in their 50s had a relatively high preference for trees that help maintain the urban ecosystem, compared to other age groups. In contrast, those in their 60s had relatively low preferences for two characteristics, 'nice tree shape' and 'does not cause discomfort owing to fallen leaves/fruits'.

Table 5. Demographic characteristics of item rankings for preferred street tree types.

Classification		Item Rank (%)						
		Produce Flowers	**Offer Shade**	**Help Purifying the Air**	**Resistance against Pests**	**Nice Tree Shape**	**Help Maintain the Urban Ecosystem**	**Do Not Cause Discomfort Owing to Fallen Leaves/Fruits**
Total		39.4	58.7	47.4	30.2	23.1	56.4	22.2
Age group	30s	40.6	62.4	64.7	29.7	28.9	51.5	22.2
	40s	41.7	59.9	68.8	26.3	23.1	55.1	25.1
	50s	35.9	53.5	71.2	32.3	21.7	63.1	22.2
	60s	38.2	57.2	78.6	34.1	15.6	58.4	17.9
Income quintile	Low income	41.0	52.5	75.4	37.7	26.2	49.2	18.0
	Middle income	40.5	59.1	70.7	30.5	21.2	56.7	21.4
	High income	37.3	59.3	68.0	28.3	25.5	57.5	24.2
Housing type	House	38.3	63.8	76.6	31.9	19.1	57.4	12.8
	Row house	37.7	58.5	69.3	29.7	23.6	57.1	24.1
	Apartment	40.4	58.9	70.1	28.8	23.1	57.2	21.6
	Studio	36.8	55.9	67.6	35.3	29.4	50.0	25.0
	Other	40.0	53.3	66.7	60.0	0.0	46.7	33.3
Region	Seoul	35.8	61.2	70.3	30.3	21.2	54.5	26.7
	Gyeonggi	40.7	56.7	69.5	30.5	23.9	58.8	19.8
	Incheon	45.9	60.0	71.8	28.2	25.9	50.6	17.6

Note: A simple summation of the ratios of the 1st, 2nd, and 3rd ranking responses according to the reduced ranking procedure.

The level of satisfaction with street trees in residential areas was evaluated using a five-point scale, with an overall satisfaction score of 3.54, and a score of 3.51 for tree shape, 3.64 for tree size, 3.59 for tree growth, and 3.62 for tree management (Table 6). The satisfaction with street trees was slightly above average (3 points). Demographic analysis showed that only housing type had a statistically significant impact on overall satisfaction ($p < 0.01$), and no other differences were found among the groups. Older residents had lower levels of satisfaction than those of younger residents. Additionally, residents in Incheon had lower satisfaction levels compared to those in Seoul and Gyeonggi. Residents of apartments and studios had higher levels of satisfaction with street trees compared to those living in detached houses. People living in detached houses who tended to their own trees were found to have relatively higher standards for satisfaction with street trees. No significant differences in satisfaction were observed with the shape of street trees based on socioeconomic factors, and satisfaction with respect to this characteristic was relatively low, ranging from 3.32 to 3.60 compared to other characteristics of street trees. However, satisfaction with the size of street trees had a statistically significant relationship with age and income level ($p < 0.001$, $p < 0.05$). Younger individuals had a higher level of satisfaction

with the size of street trees, with a significant difference observed between residents in their 30s and 40s and those in their 50s and older. Additionally, those in the middle-income group had higher levels of satisfaction with the size of street trees compared to those in the low-income group. No significant differences were observed in satisfaction with the growth and management of street trees based on socioeconomic factors.

Table 6. Demographic characteristics of satisfaction with street trees.

Classification		Overall Satisfaction	Satisfaction with Tree Shape	Satisfaction with Size	Satisfaction with Growth Status	Satisfaction with Management Status
Total		3.54 ± 0.81	3.51 ± 0.78	3.64 ± 0.74	3.59 ± 0.72	3.62 ± 0.79
Age group	30s	3.58 ± 0.83	3.56 ± 0.80	3.71 ± 0.77 a	3.66 ± 0.81	3.57 ± 0.91
	40s	3.55 ± 0.72	3.54 ± 0.71	3.74 ± 0.62 a	3.62 ± 0.63	3.66 ± 0.73
	50s	3.52 ± 0.87	3.45 ± 0.81	3.54 ± 0.68 b	3.52 ± 0.68	3.61 ± 0.72
	60s	3.51 ± 0.84	3.45 ± 0.80	3.49 ± 0.86 b	3.52 ± 0.74	3.62 ± 0.77
	F (p)	0.289 (.833)	1.155 (.326)	6.050 (.000)	2.210 (.085)	0.597 (.617)
Income quintile	Low income	3.48 ± 0.74	3.38 ± 0.80	3.39 ± 0.74 b	3.48 ± 0.79	3.46 ± 0.91
	Middle income	3.56 ± 0.80	3.54 ± 0.74	3.66 ± 0.70 a	3.60 ± 0.71	3.64 ± 0.79
	High income	3.52 ± 0.84	3.48 ± 0.82	3.64 ± 0.78 a	3.59 ± 0.73	3.61 ± 0.78
	F (p)	0.412 (.662)	1.569 (.209)	3.697 (.025)	0.843 (.431)	1.468 (.231)
Housing type	Detached house	3.30 ± 0.91 b	3.32 ± 0.89	3.60 ± 0.61	3.45 ± 0.75	3.64 ± 0.82
	Row house	3.40 ± 0.84 ab	3.42 ± 0.81	3.61 ± 0.79	3.54 ± 0.76	3.53 ± 0.88
	Apartment	3.62 ± 0.79 ab	3.56 ± 0.76	3.65 ± 0.73	3.61 ± 0.71	3.65 ± 0.77
	Studio	3.51 ± 0.80 ab	3.51 ± 0.72	3.60 ± 0.78	3.71 ± 0.71	3.57 ± 0.76
	Other	3.73 ± 0.70 a	3.60 ± 0.51	3.80 ± 0.68	3.67 ± 0.62	3.87 ± 0.35
	F (p)	4.083 (.003)	1.877 (.112)	0.372 (.829)	1.277 (.277)	1.273 (.279)
Residential area	Seoul	3.52 ± 0.81	3.48 ± 0.80	3.69 ± 0.68	3.61 ± 0.70	3.65 ± 0.74
	Gyeonggi	3.59 ± 0.80	3.55 ± 0.74	3.61 ± 0.77	3.59 ± 0.73	3.62 ± 0.81
	Incheon	3.38 ± 0.84	3.39 ± 0.85	3.55 ± 0.76	3.48 ± 0.77	3.46 ± 0.85
	F (p)	2.587 (.076)	1.896 (.151)	1.855 (.157)	1.099 (.334)	2.007 (.135)

Note: Values are presented as the mean ± standard deviation. A post-hoc test (based on Duncan test at 5% level) was conducted after the one-way ANOVA. The same lowercase letters in each column indicate no statistically significant difference ($\alpha = 0.05$).

A regression analysis was conducted to determine the specific factors that affect the overall satisfaction of urban residents with street trees (Table 7). Overall satisfaction was used as the dependent variable, and satisfaction with the shape, size, growth, and management status of trees was used as the independent variable. As a relationship between the independent variables was determined, important variables were selected through stepwise regression analysis, and three regression models were found to be significant ($p < 0.001$). Model three had the highest explanatory power at 58.5%, and indicated that satisfaction with the shape, size, and management status of trees had an effect on overall satisfaction. The factors that had the most influence on satisfaction with street trees were tree shape, followed by size, and management status. In terms of the maintenance and management practices most preferred by urban residents, tree shape was the most important, followed by an appropriate size and management status.

Table 7. Analysis of detailed factors affecting street tree satisfaction using regression analysis.

	Model	Non-Standardization Coefficient		Standardization Coefficient	T (p)	R^2	F (p)
		B	Standardization Error	Beta			
1	(Constant)	0.811	0.085		9.580 (0.000)	0.553	1091.006 (0.000)
	Satisfaction with tree shape	0.778	0.024	0.744	33.030 (0.000)		
2	(Constant)	0.447	0.096		4.635 (0.000)	0.578	603.412 (0.000)
	Satisfaction with tree shape	0.661	0.028	0.632	23.552 (0.000)		
	Satisfaction with size	0.213	0.029	0.194	7.234 (0.000)		
3	(Constant)	0.337	0.100		3.363 (0.000)	0.585	412.699 (0.000)
	Satisfaction with tree shape	0.614	0.031	0.586	20.041 (0.000)		
	Satisfaction with size	0.184	0.030	0.168	6.080 (0.000)		
	Satisfaction with management status	0.105	0.028	0.103	3.711 (0.000)		

3.2. Problems Caused by Street Trees

The problems caused by street trees were evaluated using a five-point scale in order to guide maintenance and management efforts. The higher the score, the greater the perceived problem. The issues that urban residents considered most serious were the generation of garbage owing to fallen leaves and fruit (F5), with a score of 3.48, followed by a score of 3.38 for attracting harmful birds and pests (F1), 3.21 for causing allergies (F2), 3.21 for incurring maintenance and management costs (F9), and 3.16 for reduced visibility caused by covering information boards (F7) (Table 8). Urban residents considered the 'provision of unwanted shade' (F4) the least serious issue. When the data were analyzed according to demographic characteristics, females were more likely than males to perceive all issues as serious, with statistically significant differences found in items such as F1, F2, F3, F6, and F8 ($p < 0.05$). Overall, females were more aware of problems related to walking safety and health than males. In terms of age, there were statistically significant differences in perceptions of the issues F1, F2, F3, F4, F5, and F8. People in their 30s had a lower perception of the problems with street trees compared to other age groups, whereas those in their 60s had a relatively high level of perception of all issues. People in their 30s and 50s and those in their 40s and 60s had similar levels of perception. No statistically significant differences based on income level were observed; however, higher-income individuals had a more acute perception of maintenance and management costs (F9) and resource use (F10). A statistically significant difference was observed only in F9 and F10, depending on housing type ($p < 0.05$). No significant differences were observed in the perceptions of the problems caused by street trees based on the residential area. However, Incheon had the highest score (most severe) for F5 (garbage generation), followed by Seoul, and Gyeonggi. The number of planted street trees differs depending on the residential area, which affects residents' perception of the problems caused by street trees.

Table 8. Demographic characteristics of perceived problems caused by street trees.

Classification		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10
Total		3.38	3.21	2.93	2.30	3.48	2.84	3.16	3.04	3.21	3.14
Age group	30s	3.35	3.02 c	2.82 b	2.12 c	3.42 ab	2.77	3.12	2.96 b	3.12	3.04
	40s	3.39	3.18 bc	2.93 b	2.26 bc	3.57 a	2.83	3.16	3.00 b	3.23	3.21
	50s	3.27	3.28 b	2.88 b	2.37 b	3.37 b	2.82	3.11	2.96 b	3.27	3.18
	60s	3.53	3.45 a	3.16 a	2.57 a	3.58 a	2.98	3.29	3.31 a	3.28	3.14
	F (p)	3.163 (0.024)	8.498 (0.000)	6.205 (0.000)	10.676 (0.000)	2.782 (0.040)	1.870 (0.133)	1.590 (0.190)	5.871 (0.001)	1.824 (0.141)	1.856 (0.135)
Income quartile	Low income	3.25	3.25	2.95	2.36	3.36	2.90	3.16	3.05	3.15	3.03
	Middle income	3.41	3.23	2.94	2.31	3.47	2.84	3.14	3.05	3.20	3.14
	High income	3.35	3.16	2.91	2.29	3.53	2.83	3.20	3.02	3.24	3.16
	F (p)	1.383 (0.251)	0.686 (0.504)	0.117 (0.889)	0.202 (0.818)	0.976 (0.377)	0.154 (0.857)	0.328 (0.720)	0.078 (0.925)	0.401 (0.670)	0.598 (0.550)
Housing type	Detached house	3.40	3.28	2.83	2.36	3.55	3.09	3.21	3.13	3.40 a	3.28 b
	Row house	3.41	3.28	2.97	2.30	3.56	2.78	3.19	3.05	3.16 ab	3.09 b
	Apartment	3.36	3.19	2.95	2.29	3.46	2.86	3.16	3.04	3.24 ab	3.15 b
	Studio	3.37	2.99	2.71	2.29	3.40	2.7	3.04	2.85	3.00 b	2.97 b
	Other	3.67	3.33	3.20	2.47	3.53	2.87	3.33	3.20	3.53 a	3.67 a
	F (p)	0.660 (0.620)	1.528 (0.192)	1.886 (0.111)	0.207 (0.935)	0.676 (0.608)	1.419 (0.226)	0.497 (0.738)	0.876 (0.478)	2.569 (0.037)	2.524 (0.040)
Residential area	Seoul	3.38	3.26	2.96	2.30	3.58 b	2.77	3.08	2.98	3.21	3.16
	Gyeonggi	3.38	3.19	2.91	2.29	3.38 b	2.86	3.22	3.08	3.20	3.12
	Incheon	3.34	3.09	2.93	2.39	3.67 a	2.98	3.18	3.04	3.29	3.20
	F (p)	0.094 (0.910)	1.313 (0.270)	0.272 (0.762)	0.474 (0.622)	5.779 (0.003)	1.944 (0.144)	2.229 (0.108)	1.123 (0.326)	0.419 (0.658)	0.490 (0.613)

Note: F1—attracting harmful birds and pests; F2—causing allergies; F3—damaging roadways and infrastructure; F4—providing unwanted shade; F5—generating garbage from fallen leaves and fruit; F6—posing a threat to pedestrian safety; F7—reducing visibility by covering signboards; F8—increasing the risk of traffic accidents through obstruction of view; F9—incurring maintenance and management costs; F10—consuming resources such as water and soil for maintenance and management. Values are presented as the mean. A post-hoc test (based on Duncan test at 5% level) was conducted after the one-way ANOVA. The same lowercase letters in each column indicate no statistically significant difference ($\alpha = 0.05$).

A factor analysis was conducted to group the various problems caused by street trees into homogeneous factors. The KMO sample fit was 0.849, indicating that factor analysis was possible owing to the high correlation of variables. Bartlett's sphericity test result was $p < 0.001$, confirming that factor analysis was appropriate (Table 9). Factors were largely classified into three categories; factor one had an explanatory power of 45.4%, and factors two and three had an explanatory power of 11.4% and 10.1%, respectively. Factors one, two, and three together explained 77% of the total data. In the rotated factor matrix, factor one can be interpreted as representing safety, factor two as representing economic efficiency, and factor three as representing the environmental effect.

Table 9. Classification of problems caused by street trees into homogeneous factors.

Factor	Item	Commonness	Factor		
			1	2	3
Safety	F7. Reducing visibility by covering signboards	0.734	0.844	0.117	0.093
	F8. Increasing the risk of traffic accidents through obstruction of view	0.734	0.809	0.142	0.242
	F6. Posing a threat to pedestrian safety	0.655	0.705	0.310	0.248
	F4. Providing unwanted shade	0.374	0.543	0.176	0.222
Economic efficiency	F9. Incurring maintenance and management costs	0.874	0.180	0.904	0.158
	F10. Consuming resources such as water and soil for maintenance and management	0.851	0.199	0.876	0.209
	F5. Generating garbage owing to fallen leaves and fruit	0.406	0.422	0.459	0.131
Environmental effect	F2. Causing allergies	0.736	0.239	0.070	0.821
	F1. Attracting harmful birds and pests	0.707	0.110	0.243	0.797
	F3. Damaging roadways and infrastructure	0.616	0.435	0.214	0.617
Eigenvalue			4.537	1.140	1.011
Dispersion ratio (%)			45.366	11.398	10.111
Cumulative variance ratio			45.366	56.764	77.875

Note: KMO's goodness-of-fit (MSA) test: 0.849; Bartlett's sphericity test: approximate chi-square −3692.509, degrees of freedom (df) −45, $p < 0.001$).

3.3. Considerations for the Maintenance and Management of Street Trees

(1) The need for maintenance and management of street trees

Urban residents had a high level of perceived need for the maintenance and management of street trees to preserve the various benefits that street trees provide, with an overall score of 4.53 (out of 5). Among demographic characteristics, there was no statistically significant difference observed in any of the groups.

(2) Prioritizing the maintenance and management of street trees

Respondents identified the management of diseases and pests that hinder growth (23.2%), periodic cleaning of fallen leaves and fruit waste (21.0%), irrigation management to maintain growth (19.6%), and pruning branches that obscure the visibility of important landscape features, such as roads and signboards (18.4%), as necessary (Table 10). A statistically significant difference was observed in the perceived need for the maintenance and management of street trees based on age group ($p < 0.05$). Older individuals had a higher rate of identifying irrigation management and water management as necessary, whereas younger individuals had a higher rate of identifying waste cleaning as necessary. Income level also had an impact on the issues identified, with higher-income individuals having a higher rate of identifying waste cleaning as necessary, and lower-income individuals having a higher rate of identifying pest management, pruning minimization, and tree-shape management as necessary. However, the differences were not statistically significant. Although not statistically significant, differences in the perceived need for maintenance and management of street trees were also observed by residential area. In Seoul, irrigation management (23.3%) was identified as necessary; in Gyeonggi, pest control (24.9%) was identified as necessary; and in Incheon, waste cleaning (29.4%) was identified as necessary.

Table 10. Significant factors for the maintenance and management of street trees and cross-analysis of demographics.

Classification		N	M1	M2	M3	M4	M5	M6	M7	M8	Total	Pearson's X^2 (p)
Total		884	19.7	18.4	5.3	23.2	4.9	21.0	7.2	0.2	100.0	
Age group	30s	266	15.8	17.3	5.6	25.2	4.5	26.7	4.9	0.0	100.0	35.778 (0.023)
	40s	247	18.6	20.2	5.3	20.2	4.9	24.7	5.3	0.8	100.0	
	50s	198	24.2	15.7	4.5	24.7	4.5	15.2	11.1	0.0	100.0	
	60s	173	22.0	20.8	5.8	22.5	5.8	13.9	9.2	0.0	100.0	
Income quintile	Low income	61	23.0	13.1	8.2	26.2	3.3	14.8	9.8	1.6	100.0	18.099 (0.202)
	Middle income	501	19.0	20.4	6.0	23.0	5.2	19.2	7.2	0.2	100.0	
	High income	322	20.2	16.5	3.7	23.0	4.7	25.2	6.8	0.0	100.0	
Housing type	Detached house	47	10.6	21.3	10.6	31.9	8.5	14.9	2.1	0.0	100.0	34.824 (0.175)
	Row house	212	20.3	16.0	5.7	21.2	5.2	22.2	8.5	0.9	100.0	
	Apartment	542	20.3	19.2	5.2	23.6	4.4	19.2	8.1	0.0	100.0	
	Studio	68	19.1	16.2	2.9	19.1	5.9	35.3	1.5	0.0	100.0	
	Other	15	20.0	26.7	0.0	26.7	0.0	26.7	0.0	0.0	100.0	
Residential area	Seoul	330	23.3	16.1	4.8	21.5	4.2	22.7	7.0	0.3	100.0	18.689 (0.177)
	Gyeonggi	469	18.1	20.5	5.8	24.9	5.3	18.3	7.0	0.0	100.0	
	Incheon	85	14.1	16.5	4.7	20.0	4.7	29.4	9.4	1.2	100.0	

Note: N is the number of respondents, and values are presented as the percentage. M1—irrigation management; M2—pruning branches that obscure visibility; M3—minimizing pruning to provide shade; M4—disease and pest management; M5—soil management; M6—periodic cleaning of fallen leaves and fallen fruit waste; M7—tree shape management; M8—miscellaneous.

This study found a correlation between the factors involved in the maintenance and management of street trees and the perceived seriousness of problems associated with street trees. Urban residents who felt that it was necessary to remove branches that obstructed visibility recognized that the reduced visibility (3.65) and obstruction of view (3.51) caused by street trees were serious problems (Table 11). Urban residents who felt that pest control was necessary recognized that the problems of attracting harmful birds and pests (3.59), causing allergies (3.39), and generating garbage (3.37) were serious. Urban residents who felt that tree-shape management was necessary recognized that the problems of garbage generation (3.52), incurring maintenance and management costs (3.25), and the consumption of maintenance and management resources (3.19) were serious. The group that recognized the need to clean up waste recognized the generation of garbage (3.97) as a serious problem. Overall, there was a strong relationship between the factors associated with addressing problems caused by street trees and those associated with their maintenance and management.

The perceived need for maintenance and management factors differed depending on the perception of problems associated with street trees, and a statistically significant difference was observed ($p < 0.05$). However, no statistical significance was observed for each management factor in terms of generating maintenance and management costs and resource consumption. Cost and resource consumption may be issues that are related to all aspects of management.

Table 11. Recognition of street tree maintenance and management factors and problems caused by street trees.

Classification		Recognition of Street Tree Maintenance and Management							F (p)
		M1	M2	M3	M4	M5	M6	M7	
Problems caused by street trees	F1	3.21	3.42	3.28	3.59	3.09	3.37	3.33	4.043 (0.000)
	F2	3.06	3.32	3.06	3.39	2.86	3.17	3.19	3.272 (0.002)
	F3	2.80	3.10	2.77	3.00	2.49	2.96	2.94	3.876 (0.000)
	F4	2.18	2.39	2.30	2.20	2.16	2.41	2.55	2.501 (0.015)
	F5	3.34	3.40	3.06	3.37	3.16	3.97	3.52	10.981 (0.000)
	F6	2.66	2.98	2.72	2.83	2.63	2.98	2.77	2.658 (0.010)
	F7	2.99	3.65	2.85	3.09	2.84	3.17	3.05	9.622 (0.000)
	F8	2.87	3.51	2.83	2.99	2.81	2.96	3.00	7.841 (0.000)
	F9	3.25	3.22	3.15	3.20	3.02	3.25	3.25	0.673 (0.695)
	F10	3.13	3.16	3.13	3.14	3.07	3.15	3.19	0.577 (0.775)

(3) Methods to address problems caused by street trees

Measures suggested to address the problems caused by street trees included: 'expanding research on street-tree management' (64.0%), 'increasing budgets for government and local governments' (51.2%), 'improvement in the perception of urban residents' (33.4%), and 'improvement in the perception of government and local government managers' (28.3%) (Table 12). Analyzing the data demographic characteristics revealed that both males and females ranked 'expanding research on street-tree management' highly. Males rated increasing budgets more highly compared to females; however, females rated improving the perception of urban residents and government managers more highly compared to males. There was no difference in the first-ranked measure according to age group; however, those in their 30s and 40s ranked increasing budgets more highly, and those in their 50s and 60s ranked improving government perception more highly. With respect to the socioeconomic characteristics, higher-income individuals ranked improving government perception more highly, whereas lower-income individuals ranked increasing budgets more highly. With respect to residential area, Incheon ranked relatively higher in improving the perception of urban residents compared to other areas.

Analyzing the data by item revealed that 'expansion of research for street trees management' ranked highest across all attributes, indicating a high level of perceived need for research and technology development for the maintenance and management of street trees. 'Budget expansion by the government and local governments' was ranked second in a majority of instances; however, it received relatively high rankings from the low-income studio-dwelling group. 'Improvement of user perception' was ranked low overall but received high rankings from relatively low-income studio-dwelling residents and those in the Incheon area. 'Perception improvement of government and local government managers' ranked approximately third but received relatively high rankings from the 60s age group and the high-income and apartment-dwelling groups. The lower the socioeconomic level,

the higher the importance of budget expansion in solving problems caused by street trees. In contrast, the higher the socioeconomic level of urban residents, the higher the perception that changing managers' perceptions was necessary.

Table 12. Demographic characteristics of item ranking in the solutions to the problems caused by street trees.

Classification		1st-Order Frequency (%)				2nd-Order Frequency (%)				Item Rank (%)			
		S1	S2	S3	S4	S1	S2	S3	S4	S1	S2	S3	S4
Total		29.1	39.1	14.1	17.6	22.3	25.1	19.3	10.7	51.2	64.0	33.4	28.3
Age group	30s	32.3	44.4	11.3	12.0	26.5	19.8	22.5	31.2	57.5	63.2	32.7	41.7
	40s	27.5	38.9	18.2	15.4	24.8	24.0	19.8	32.2	51.8	62.3	37.7	47.0
	50s	28.3	33.8	14.6	23.2	19.5	32.1	21.1	27.4	47.0	64.6	34.8	49.5
	60s	27.2	37.6	12.1	23.1	19.8	31.7	16.8	31.7	46.2	68.2	28.3	53.8
Income quintile	Low income	34.4	27.9	21.3	16.4	26.3	24.6	21.1	28.1	59.0	50.8	41.0	42.6
	Middle income	27.9	41.7	13.6	16.8	22.6	25.7	22.0	29.7	50.1	66.9	35.1	45.9
	High income	29.8	37.3	13.7	19.3	23.4	27.0	16.8	32.9	51.9	62.7	29.5	50.3
Housing type	Detached house	29.8	31.9	17.0	21.3	26.7	33.3	15.6	24.4	55.3	63.8	31.9	44.7
	Row house	31.6	34.9	14.6	18.9	20.8	31.2	20.8	27.2	51.4	64.6	34.4	44.8
	Apartment	27.9	41.3	14.0	16.8	22.7	24.6	18.9	33.7	50.0	65.3	32.5	49.6
	Studio	30. 9	38.2	14.7	16. 2	30.2	15.9	28.6	25. 4	58.8	52.9	41.2	39. 7
	Other	26.7	46.7	0.0	26.7	28.6	28.6	28.6	14.3	53.3	73.3	26.7	40.0
Residential area	Seoul	30.3	37.9	15.5	16.4	21.2	28.0	18.6	32.2	50.3	64.2	33.0	46.7
	Gyeonggi	29.0	40.7	12.4	17.9	24.7	25.1	20.1	30.1	53.1	65.2	32.0	47.3
	Incheon	24.7	35.3	18.8	21.2	21.7	24.1	25.3	28.9	45.9	58.8	43.5	49.4

Note: Item rank was calculated by simple summation of 1st and 2nd priority response composition ratios in the reduction ranking procedure. S1—budget enlargement; S2—research expansion; S3—improving user perception; S4—improved government perception.

With respect to street-tree management, 73.9% of respondents believed that the local government should be primarily responsible, whereas 18.6% believed that the central government should be responsible (Table 13). Therefore, the response that the government should take responsibility was very high, accounting for over 90% of the total. The high response rate for local governments being responsible for street tree maintenance was similar across age groups. However, although a relatively high proportion of those in their 30s believed that the central government should be responsible, a very low proportion believed that local residents should be responsible. Differences according to age were statistically significant ($p < 0.01$). With respect to socio-economic characteristics, the middle-income group had a higher response rate for identifying the central government as responsible, whereas the high-income group had a lower response rate for identifying local residents as responsible. However, differences in response based on income were not significant. The response rate for identifying the local government as responsible for street-tree management was relatively low among residents of detached houses and studios compared to those of other housing types. However, the response rate for identifying local residents as responsible was high among detached house residents. This may be owing to the fact that these residents have more direct interaction and experience with their own trees and therefore perceive less difficulty in managing them. The proportion of residents in the Gyeonggi area who identified the central government as responsible was relatively low and the proportion who identified the local government as responsible was high. In contrast, among residents in Incheon, the proportion identifying the local government as responsible was low and the proportion identifying local residents as responsible was

high. The differences in response based on the residential area were statistically significant ($p < 0.01$).

Table 13. Cross-analysis of the main management agent of street trees and demographic characteristics.

Classification		N	Central Government	Local Government	Local Residents	Dedicated Agency	Others	Sum	Pearson's X^2 (p)
Total		884	18.6	73.9	6.7	0.7	0.2	100	
Age group	30s	266	24.8	72.9	1.9	0.0	0.4	100	29.890 (0.003)
	40s	247	17.4	72.5	9.3	0.4	0.4	100	
	50s	198	13.1	76.8	9.1	1.0	0.0	100	
	60s	173	16.8	74.0	7.5	1.7	0.0	100	
Income quintile	Low income	61	16.4	73.8	9.8	0.0	0.0	100	13.898 (0.084)
	Middle income	501	19.6	70.9	8.2	1.2	0.2	100	
	High income	322	17.4	78.6	3.7	0.0	0.3	100	
Housing type	Detached house	47	21.3	61.7	14.9	2.1	0.0	100	21.112 (0.174)
	Row house	212	18.9	72.6	6.6	1.9	0.0	100	
	Apartment	542	17.2	76.2	6.1	0.2	0.4	100	
	Studio	68	27.9	66.2	5.9	0.0	0.0	100	
	Other	15	13.3	80.0	6.7	0.0	0.0	100	
Residential area	Seoul	330	23.0	69.7	6.7	0.6	0.0	100	31.147 (0.007)
	Gyeonggi	469	14.9	78.5	5.5	0.9	0.2	100	
	Incheon	85	21.2	64.7	12.9	0.0	1.2	100	

Among the respondents, 14.9–27.9% identified the central government as primarily responsible for managing street trees. This percentage was relatively higher among those in their 30s, studio residents, and Seoul residents. The proportion of respondents who identified the local government as responsible was 61.7–78.6%, which was high overall, particularly among high-income and Gyeonggi residents. The proportion of respondents who identified local residents as responsible was 1.9–14.9%, which was low overall, especially among those in their 30s and high-income groups. However, the proportion was relatively higher among detached house residents and Incheon residents.

4. Discussion

4.1. Street Tree Preference Characteristics of Urban Residents

Street trees can provide greenspace in urban areas that lack adequate large-scale greenspaces and are among the most accessible and familiar greenspaces for urban residents [55]. Therefore, understanding people's perceptions of street trees and considering their consensus and preferences in planning and managing urban greenspaces, including street trees, is crucial [47]. Encouraging nature-based solutions (NBS) is crucial for effective urban environmental planning and management [56]. Comprehensive citizen involvement in problem-solving is also essential to successfully apply NBS [57]. Urban residents notice street trees when they undergo seasonal changes according to their growth cycle, such as the appearance of new leaves, flowers blooming, and leaves turning yellow. The growth characteristics of street trees, such as changes in leaves and flowers, are identified as visually striking and attract people's attention. Previous studies have also suggested that changes in the flowers and leaves of street trees play an important role in attracting attention to nature and experiencing the seasons in urban areas [45,50]. Therefore, it is important to consider street tree species that have attractive features that appeal to people at each growth stage. Proper maintenance and management from the planting stage to establishment are also essential for maintaining growth.

Street trees offer a range of ecosystem services, as well as aesthetic benefits. Among the various benefits of street trees, urban residents preferred trees that provide shade and improve air quality. Trees that residents can appreciate for their flowers were the next most preferred type. A study by Camacho-Cervantes et al. [42] also found that street trees improve air quality and aesthetics in cities. Urban residents view street trees as an important part of green infrastructure, and they play a role in maintaining the urban ecosystem. As the prevalence of environmental issues such as climate change and air pollution increases, urban environmental concerns are receiving increasing attention. Therefore, although street trees were previously planted for visual and aesthetic reasons, the demand for street trees for their environmental and public health benefits has increased. In previous studies, residents also recognized the importance of the aesthetic, practical, and cultural attributes of street trees [51,58,59].

Urban residents generally have a high level of satisfaction with street trees, and their shape, size, and state of maintenance are key factors that influence overall satisfaction. In order to improve satisfaction with street trees, maintaining proper tree shape and size and continuously managing them is important. Street-tree management includes not only the trees themselves but also creating a pleasant environment where street trees are planted (mainly sidewalks). An analysis of residents' perceptions in different residential areas shows that satisfaction with street trees is lower in Incheon compared to that in Seoul and Gyeonggi. According to a survey conducted by the National Statistical Office, the positive response rate for the 'satisfaction degree of the green environment' was highest in Seoul, followed by Incheon and then Gyeonggi. [60]. Additionally, Incheon has a lower implementation rate for greenspace creation (1.7%) and park creation (30.97%) compared to that of other areas [61], indicating a lack of urban greenspaces, including street trees. Incheon residents' satisfaction with street trees may also be low as a result of the lack of parks and greenspaces and may explain the lower overall satisfaction with the urban green environment. Furthermore, satisfaction with street trees varied depending on the housing types. The experience of managing trees and plants varies based on the type of dwelling. Urban residents living in detached houses, wherein landscaping is mandatory, have a higher frequency of experience with growing and managing trees. Publicly managed street trees may be less well-maintained and managed in comparison to privately managed garden trees. As a result, urban residents living in detached houses tend to have a lower satisfaction with street trees than those living in other types of housing. This suggests that direct experience in growing and managing trees directly impacts satisfaction with street trees.

4.2. Perception of the Problems Caused by Street Trees and the Need for Maintenance and Management

Many studies have documented the various benefits provided by street trees. As the significance of street trees is increasingly recognized, cities around the world are setting goals for expanding roadside tree populations and developing plans and strategies to support them [62]. In order to achieve the desired outcomes from planting street trees, it is essential that the trees are established and reach maturity [63,64]. Urban street trees face several challenges for survival and growth, including limited soil volume, soil compaction, and impervious surfaces [65–67]. Therefore, human management is crucial for their survival. The maintenance and management of street trees includes watering, mulching, and removing debris from planting beds and sidewalks after they are planted. Increasing the survival rate of street trees is important because maintenance and management are necessary to ensure the continuity of benefits provided by street trees [68]. This study also found that urban residents recognize that maintenance and management are necessary to maintain the benefits provided by street trees.

Maintenance and management of street trees not only includes managing the growth of street trees but also addressing any problems they cause. In this study, among the various issues caused by street trees, waste generation from fallen leaves and fruits was

identified as the most significant problem. Street trees are living organisms and produce various types of waste depending on the species. Garbage is generated from fallen flowers after flowering, fallen leaves after autumn, and fallen fruits after fruition. As the growth period differs depending on the type of roadside tree, waste generated by street trees is produced throughout the year, leading to a high problem perception among urban residents. A study by Moskell and Allred [52] also reported that cleaning fallen branches, leaves, and fruits/nuts/sap was a common issue concerning street trees. Certain problems caused by street trees are not owing to their presence but rather from a lack of proper maintenance and management. A study by Camacho-Cervantes et al. [42] also reported that urban residents dislike unmanaged street trees that cause garbage the most and pointed out that this problem was caused by a lack of maintenance. Urban residents perceived the cost of maintenance and management of street trees as a problem, with an above-average score. In particular, detached-house residents were relatively more concerned about maintenance and management costs. This may be owing to the fact that residents of detached houses are aware that street trees incur maintenance and management costs because they directly manage their gardens. In contrast, in the case of apartment houses and townhouses, the exterior landscaping is jointly managed, and residents do not manage it directly. Additionally, there was a high level of concern regarding safety issues arising from decreased visibility caused by tree branches, leaves, and crowns, such as the obstruction of information boards and signboards by street trees and an increased risk of traffic accidents owing to obstructed views.

Street trees are known to be unevenly distributed from city to city and within cities [69,70]. Similarly, in Korea, the scale of street-tree formation differs in the metropolitan areas of Seoul, Gyeonggi, and Incheon. This difference is owing to variations in the social environment of the city, the policy direction of the local government, and economic factors. Differences in the distribution and diversity of street trees lead to variations in urban residents' perception of them by region. Depending on the residential area, residents of the Gyeonggi area have a lower perception of the various problems caused by street trees compared to those in Seoul and Incheon. This is likely because the Gyeonggi area has comparatively fewer street trees planted. This explains the low awareness of the problems caused by street trees among residents of the Gyeonggi area.

Urban residents prioritized the management of pests and irrigation, which impact plant growth, for the maintenance and management of street trees. They also had high demands for waste treatment that affects the landscape, sanitation, and walking. In maintaining and managing street trees, urban residents require that they fulfill environmental functions and have an aesthetic appearance, while also ensuring visibility and pedestrian safety, by considering the morphological and ecological characteristics of the street trees. The growth status of the plants is a key factor in achieving the environmental and aesthetic functions of street trees. In order to maintain an appropriate tree shape and growth cycle, it is essential to manage water, nutrients, and pest control. Pruning is an important maintenance practice that creates the desired shape of street trees, promotes a proper growth rate, and helps prevent pests. In particular, pruning is essential for maintaining visibility and safety. Urban residents called for various studies to identify the causes of problems incurred by street trees to find solutions. They also believed that the budget for the maintenance and management of street trees needs to be expanded and the perception of users and managers needs to be improved, since the continuity of maintenance and management after planting street trees is poor. Urban residents had a strong belief that the central and local governments should manage street trees. Another study conducted by Moskell and Allred [52] found that urban residents generally believe that the government should be responsible for managing urban trees and that their opinions on tree management can vary depending on their individual characteristics. Younger respondents tended to prefer government-led management, whereas older respondents believed that local residents or dedicated agencies should be in charge. In terms of regions, residents of Seoul and Incheon preferred government management more than those in Gyeonggi. In particular,

Incheon residents had the lowest satisfaction with street-tree management and felt that the government's efforts were necessary. Overall, urban residents generally believed that the central and local government were fully responsible for caring for street trees, regardless of the demographic characteristics.

5. Conclusions

Few studies have been conducted on the perceptions of urban residents in Korea regarding street trees, especially compared with research on the environmental and ecological effects of street trees. Additionally, research on understanding users' preferences for street trees is lacking. This study investigated the preferences and perceptions regarding street trees among 884 urban residents in a metropolitan area in Korea. We found that most respondents were aware of the visual changes in street trees, such as the appearance of leaves and flowers, and some were always aware of their presence. The study also found that recognition of street trees varied by age, and older respondents were more likely to recognize street trees consistently or notice them when new leaves emerged as part of their growth characteristics. Street trees provide several benefits. Respondents valued the environmental and ecological benefits provided by street trees, such as shade, ecosystem maintenance, and air purification. They were also satisfied with the shape, size, growth, and management status of street trees. However, satisfaction with the size of street trees varied according to age and income level, and a difference in overall satisfaction was observed according to housing type. This demonstrates that the perception of street trees among urban residents differs based on demographic characteristics. Urban residents' perception of street trees is influenced by their satisfaction with the tree's shape, size, and management state. The main problem identified with street trees was the generation of garbage owing to fallen leaves and fruits. The perception of the problems caused by street trees varied by age, housing type, and residential area. The study concluded that maintenance and management of street trees, including growth management, pruning, and waste management, are necessary to maintain their benefits. The results also indicate that urban residents called for more research and budget allocation for street-tree management, and believed that the central and local governments, and not local residents, were responsible for managing street trees, as they are public property.

Based on the findings of this study on urban residents' preferences and perceptions of street trees, the following management recommendations are presented. Essential actions include pruning for safety and minimizing inconvenience to residents, soil and irrigation management to support tree growth and prevent root damage, and maintenance and management that considers public health, such as reducing pollen and insect allergens. Given the importance of the environmental benefits provided by street trees, the convenience they offer residents, and their potential to adapt to future environmental changes, this study demonstrates that further research and financial investment in maintenance and management are necessary.

Our study focused on urban residents in the metropolitan area; therefore, it may not be fully representative of all urban residents. However, metropolitan areas are an important hub for politics, economy, and culture in Korea, with a large population and a higher priority for policy implementation than in other regions. Thus, the results of this study can inform the selection of tree species, planting methods, and prioritization of maintenance and management practices when planning for street-tree planting, maintenance, and management and can provide valuable information to policymakers and executors, landscape architects, urban designers, and other stakeholders in their efforts to expand green infrastructure, including street trees.

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Appendix A. Survey Instrument

When do you become aware of the existence of street trees?
What type of street trees do you prefer?
Are you satisfied with the street trees in your area?
Are you satisfied with the shape of the street trees in your area?
Are you satisfied with the size of the street trees in your area?
Are you satisfied with the growth of the street trees in your area?
Are you satisfied with the management of the street trees in your area?
What do you think of the problems caused by street trees?
What do you think is the most important thing for street tree maintenance and management?
Do you think street tree maintenance and management is necessary?
What do you think is the way to solve the problems caused by street trees?
Who do you think is responsible for managing street trees?

Appendix B

Table A1. Problems caused by street trees reported in previous studies.

Previously Reported Problems with Street Trees	A	B	C	D	E	F	G
Goods and property damage	○	○		○	○	○	○
Allergy risk	○			○	○		○
Sunlight blocking	○				○		
Decreased visibility	○		○		○		○
Risk to individual integrity	○	○			○		○
Litter/garbage generation	○		○	○	○	○	○
Feelings of insecurity	○					○	○
Increased risk of traffic accidents			○				
Unpleasant view	○				○		○
Maintenance costs and issues	○			○	○		
Occupy too much space		○			○		
Nuisance animals and bugs			○	○	○		
Cause bad odor			○		○		

A: Graça et al. [34]; B: Fernandes et al. [45]; C: Koyata et al. [51]; D: Moskell and Allred [52]; E: Kirkpatrick et al. [46]; F: Camacho-Cervantes et al. [42]; G: Flannigan [58].

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