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Identifying the Planning Priorities for Green Infrastructure within Urban Environments Using Analytic Hierarchy Process

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Abstract: Urban environmental issues such as declining air quality and increasing urban heat island effects can be managed by the effective use of urban green spaces. Consequently, the importance of green infrastructure (GI) has rapidly increased over time. While the various functions of GI have been investigated in numerous studies, limited research has focused on prioritizing those factors which impact the planning and development of GI. This study used literature reviews, expert surveys, and an analytic hierarchy process methodology to identify and prioritize the critical factors influencing GI during the design and construction process to enhance the role of GI in urban areas. Experts were asked to prioritize four primary (ecological, landscape, usability, and economic factors) and 16 secondary aspects of GI design. Respondents strongly agreed on the importance of the ecological aspects of GI, while the government sector also highlighted the importance of economic concerns, such as ongoing maintenance. Results indicated that the priorities for creating GI require further analysis and mediation between stakeholders. Further empirical evidence should be accumulated regarding the functions of GI for policy implementation in design and construction.

Keywords: green infrastructure; urban open space; analytic hierarchy process; air quality; holistic planning approach

1. Introduction

Artificial structures are predominantly present in modern cities, making the varied roles of green infrastructure (GI) vital to the community. GI is the network of natural and semi-natural features within and between villages, towns, and cities, including street trees, green roofs, green walls, and private gardens in parks, woodlands, and surrounding rivers [1]. Elements of GI can be found in existing cities to varying degrees [2].

GI benefits the surrounding environment by improving naturalness and aesthetics. At the same time, GI benefits the community by providing amenity space. GI can be a driving force for improving quality of life and for the development of local communities. As environmental issues associated with urban areas have emerged (e.g., urban heat island effects and increased concentrations of ultra-fine particulates in the air), it is necessary to reconsider the role of GI.

In addition to providing a connection between people and their surroundings, GI also serves important ecological and socio-economic functions. For example, it enhances naturality and increases the aesthetic value of urban open spaces, where artificial materials, such as concrete, comprise the majority of the landscape. Due to its varied role in urban infrastructure, the creation of GI requires many considerations, including cost, maintenance, and economic factors. On account of these varied, and often competing, considerations, it is important to determine the critical elements of GI creation, and to prioritize these factors during the planning and construction stages.

Previous studies have evaluated the social, economic, and psychological values provided by GI [3–5]; however, there is a lack of research regarding the factors that are considered to be important when creating GI. While the importance of GI has been clearly demonstrated, there are many aspects to consider when creating GI, including financial availability and maintenance. Aditionally, comprehensive consideration is necessary for the creation of GI's function, such as reducing air pollution and climate change adaptation, to be effective [6]. Hence, it is important to understand which factors should be considered when creating GI, to harmonize those elements of high importance, especially at the policy establishment, design, and construction stages.

GI research continues to increase with new concepts regarding the role and value of GI being developed continuously. However, there are still ambiguities in the GI concepts, terms, and effects [7]. For GI to be applied in planning and field, and to achieve the target effect, a thorough understanding of the role of GI is required. Therefore, this study aims to develop the understanding of GI through a holistic approach and priority derivation. As the complexity of the role of GI continues to develop, we aim to derive the role of GI that is currently used by experts, and discuss the role of GI in the future.

Creating urban GI requires theoretical, planning, and maintenance expertise. In reality, most GI is created by local planning authorities and landscape professionals in consideration of environmental issues, health trends, aesthetic judgment, and user opinion. Consequently, many professionals play a key role in creating GI. The aim of this study is to identify the critical factors that are important for the creation of urban green space by interviewing experts related to the field and drawing on policy limits and policy outlooks. We achieve this by using an expert survey and analytic hierarchy process (AHP) methodology.

2. Literature Review

2.1. Baseline Study on GI

Modern cities face a number of serious environmental issues, including urban heat island effects, heat waves, lack of green open space, and the deterioration of air quality. The concept of GI has emerged in response to this environmental degradation [8,9]. GI is defined as the network of open space, natural, and semi-natural features within towns and cities that provides ecological value and amenity to the community [1,10]. Previous studies have shown that the benefits of GI are immense. For example, GI provides the ecological benefits of enhanced air quality, adaptation to climate change, improved urban microclimates, biological habitats, species diversity, and ecological connectivity [11–13]. Furthermore, the landscape benefits of GI include the presence of natural scenery in the city, providing shades, and aesthetic pleasure [14–17], while the social benefits include health promotion, stress reduction, recreational opportunities, and increased social cohesion [5,13,18–20]. The multifunctional characteristics and versatility of GI warrants a comprehensive approach to GI planning and design [21,22].

Many studies have been conducted to provide a conceptual framework for GI. For example, Norton et al. [23] presented the urban GI (UGI) framework to improve the urban climate through microclimate cooling through UGI. The framework includes five stages: (1) Neighboring priorities are derived (e.g., vulnerability to urban heat island effects), (2) existing UGI is identified, (3) the cooling effects from the existing UGI are maximized, (4) city roads vulnerable to solar exposure are identified, and (5) recommendations for future UGI are made. Using these five steps, a hierarchical decision framework was proposed to utilize street canyons for temperature mitigation. A study by Matthews et al. [12] redefined the concept of GI for climate change adaptation. Using existing research and semi-structured interviews, they showed that GI can provide multiple climate benefits. This study highlighted the importance of academic institutions in GI planning.

Studies have also shown that the effectiveness of GI is heavily dependent on a comprehensive planning approach [23–25]. In a study of GI to manage stormwater, Porse [26] found that land use planning and the monitoring of ecological processes over time was necessary to create GI with both ecological and recreational benefits. Furthermore, Kumar et al. [11] found that citywide sustainable development was possible through effective planning considering both social and ecological effects. They also highlighted the necessity of a holistic approach to policy and decision-making in urban planning. The need for a holistic approach to sustainable GI has been reinforced in numerous studies [27,28].

Several studies have investigated the factors which are important when planning and creating a comprehensive GI strategy. For example, Haq [29] described the role of urban green space by classifying it in terms of its ecological, social, and psychological benefits. They found that, from a user perspective, accessibility and optimal quantity and quality were required to satisfy social and psychological needs. Furthermore, they found that a comprehensive approach was important for solving urban sustainability problems, and stressed the need for comprehensive research through the cooperation of stakeholders at various levels. A study by Lovell and Taylor [13] proposed the use of a multifunctional landscape framework for sustainable GI planning to optimize the functional aspects of urban green space. They considered the potential of GI in terms of social and ecological aspects, and suggested the use of specific decision-making tools during the planning process. Furthermore, they showed that considering multiple ecosystem services simultaneously could help community members, investors, and decision-makers come to some agreement regarding the best land use for a specific site. They also noted the importance of a cost-benefit analysis in the evaluation of ecosystem services in future studies. Hansen and Pauleit [28] proposed a framework considering the multifunctionality of GI. They investigated, synthesized, and evaluated the ecological and social perspectives of previous studies to develop priorities for future policy and action. These priorities can be used to improve the versatility of the GI network; therefore maximizing the benefits it provides. They concluded that the use of a quantitative approach would provide more accurate information in future studies.

2.2. Critical Elements for the Creation of GI

A keyword analysis of current research and guidelines revealed that considerations for the creation of GI could be divided into four categories (Table 1). Preservation, ecological connectivity, and climate control were the major keywords related to ecological aspects of GI [9,13,28,30,31]. There were few studies regarding the landscape aspects of GI; however, visual factors and visual quality were the main keywords used [13,29,30,32]. Usability related keywords included accessibility, social opportunity, and amenity [29–31,33,34]. In terms of economic aspects, maintenance and economic value were the main keywords [29,30,34]; however, the factors related to the cost for creating GI were rarely considered [30].

Considering all the elements of GI in an integrated approach is a complex process with practical difficulties. Accordingly, it is necessary to prioritize which aspects should be considered and planned for [14]. While the many functions and benefits of UGI have been identified, limited research has focused on prioritizing the relative importance of individual elements. In this study, we present an efficient planning framework for GI using a holistic approach. We identify factors affecting planning and UGI creation and prioritize these elements using survey data and AHP methodology. In particular, we ascertain the most important elements for creating effective UGI from landscape planning, design, and research experts, with the ultimate aim of enhancing the role of GI within urban areas.

Table 1. Green infrastructure (GI) keywords.

Literature	Keywords			
	Ecological	**Landscape**	**Usability**	**Economic**
EPA, 2010	Site Preservation protection plan Ecological Connectivity Climate change	Visual connectivity	Public participation Accessibility Public Health improvement	Choosing Material Synthetic Turf Maintenance Planning
Shah Md, 2011	Absorbing pollutant preservation	Visual screen Commuting and recreation place	Diversity of land uses Contribution to health and active life styles in cities Social opportunity	Production and supply New job creation Increasing economic value
Lovell and Taylor, 2013	Plant Biodiversity Microclimate control Soil infiltration Carbon sequestration	Visual Quality	Physical Activity Social Capital	Production
Hansen and Pauleit, 2014	Connectivity			
Martinelli et al., 2014			Fruition and accessibility Bioclimate comfort	Intervention cost Maintenance requirement
Alida Alves et al., 2018	Water quality Biodiversity Temperature reduction Groundwater Recharge Air quality improvement Stormwater infiltration		Amenity and aesthetics Recreation and health Food security	Rainwater Harvesting Saving Energy Pumping and treatment reduction Real estate value
Ahern et al., 2014	Water quality Habitat provisioning Air quality Urban climate Carbon storage and sequestration		Public recreation Cultural service provision Education service potential	Food security
Mell, 2009		Creating attractive places	Accessibility Exercise and recreational place Social cohesion Access to education Regeneration Linking people to local heritage	

3. Research Methodology: AHP

We employed the AHP method to prioritize the elements impacting GI planning and implementation. The AHP method can reflect the multiple layered structures of the decision-making process and is commonly used for analysis in unpredictable situations requiring multiple evaluation standards. The AHP method is used for research that requires a mixed understanding. For example, Xu et al. [35] applied the AHP method for proper multiple criterion evaluation of green and gray infrastructure. Yang et al. [36] used the AHP method to set the criteria for selecting the key infrastructure needed to build an effective U-City. Haider et al. [37] used the AHP method to set the priorities and appropriate criteria for a flood risk management. The assessment criteria for AHP comprised a pairwise comparison matrix with coexisting technical and normative models for interpretation. The AHP was established by Saaty [38,39], and is a flexible method used to analyze multi-criteria problems by building a hierarchy for decision-making through establishing priorities [40].

The AHP process involves creating objects, choosing evaluation criteria, expert evaluation, validation, and establishing weighed values for the various elements in the GI creation process. Data for the AHP were derived from literature reviews and expert interviews. Table 2 shows GI planning elements in two tiers, primary and secondary, based on literature reviews and expert interviews. The primary tier (Tier 1) includes ecological, landscape, usability, and economic elements. Each primary category was then further classified into four secondary (Tier 2) categories.

Secondary ecological factors include climate control, air quality improvement, stormwater runoff, and ecological conservation. Secondary landscape factors include creating a featured landscape, harmonizing with the surrounding environment, providing natural elements within an urban setting, and screening. Secondary usability factors include accessibility, leisure and amenity, educational functions, and shelter. Finally, secondary economic factors include groundwork, planting, paving and other works, and maintenance cost.

Data collection was carried out over two weeks, between 1–15 September 2019. Interviewees were experts in the fields of urban planning and landscape architecture. Interview candidates were contacted by telephone to request their participation, and 60 experts were then emailed a link to the online questionnaire. In total, 57 completed questionnaires were received. Interviewees were from government organizations, the private sector, and academia, and had experience in policy, research, design, and construction. Table 3 provides a summary of the age, experience, and expertise of the respondents.

Table 2. Evaluation criteria for creating GI.

Primary Criteria (Tier 1)	Secondary Criteria (Tier 2)	Description
Ecological	Climate control	Reducing urban heat island effects, controlling seasonal temperature and humidity
	Air quality improvement	Reducing air pollutants such as fine and ultra-fine particulates
	Stormwater runoff	Stormwater infiltration and filtration, reducing runoff
	Ecological conservation	Habitat creation and protection, soil conservation
Landscape	Creating a featured landscape	Providing urban landmarks and aesthetic features
	Harmonizing with the surrounding environment	Matching GI with surrounding buildings, roads, and the environment
	Providing natural elements within an urban setting	Naturalness within gray concrete structures
Usability	Screening	Creating spaces and screening effects using planting
	Accessibility	Ease of community access to the GI
	Leisure and amenity	Supporting leisure activities such as walking and exercising
	Educational functions	Educational programs such as working with school groups
	Shelter	Protection from natural hazards such as flash flooding and landslides, providing shelter
Economic	Groundwork	Cost for groundworks
	Planting	Cost for planting
	Paving and other works	Cost for roads, street furniture, and facilities, etc.
	Maintenance	Entire maintenance cost

Table 3. Demographic characteristics of the interviewees.

Category		No. of Respondents	Percentage
Total		57	100
Sex	Male	35	61.4
	Female	22	38.6
Age	20s	13	22.8
	30s	17	29.8
	40s	19	33.3
	50s	8	14.0
Organization	Government	11	19.3
	Academia	13	22.8
	Private Sector	33	57.9
Subject	Environment	11	19.3
	Architecture	1	1.8
	Landscape	38	66.7
	Forestry	3	5.3
	Policy	2	3.5
	Other	2	3.5
Experience	Under 5 years	18	31.6
	6–10 years	10	17.5
	11–15 years	10	17.5
	16–20 years	6	10.5
	More than 21 years	13	22.8

Evaluation using AHP was based on pairwise comparisons between Tier 1 and 2 questions. The total number of evaluations for Tier 1 and 2 questions was 6 and 24, respectively. The evaluation scale was a normally applied 9-point scale [41], as shown in Table 4.

The AHP pairwise comparison method can be negatively impacted by the provision of inaccurate data by the interviewees. To address this, the consistency ratio (CR) was used to validate the data. Commonly, a CR value below 0.1 is considered to be consistent, and a CR of 0.1–0.2 is acceptable [42]. Data were only used in this study if the CR was below 0.2. Following data validation, the importance of each criteria was ascertained based on responses from the pairwise comparisons. The geometric mean was then applied after the relative importance of each criteria was determined to reflect the opinions of the experts [43].

Table 4. Significance of the pairwise comparisons based on Song and Lee [41].

Scale	Definition	Description
1	Equal	Two activities have equal contribution.
3	Weak	One activity is mildly preferred over the other based on experience and judgment.
5	Strong	One activity is strongly preferred over the other based on experience and judgment.
7	Very strong	One activity is very strongly preferred over the other based on experience and judgment.
9	Extreme	One activity is extremely preferred over the other based on experience and judgment.
2, 4, 6, 8	Median	Median comparison value based on experience and judgment.

4. Results and Discussion

4.1. Tier 1 Evaluation

Figure 1 shows that ecological aspects (0.387) were the most important Tier 1 criteria, highlighting the importance of providing natural elements when creating UGI. Landscape aspects (0.266) were the second most important, followed by usability (0.214) and economic aspects (0.133).

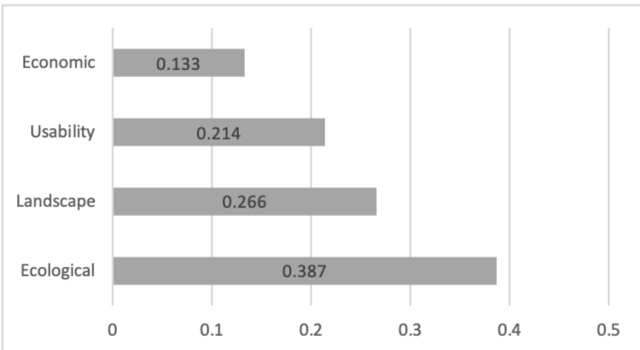

Figure 1. Relative importance of Tier 1 criteria based on survey data.

There was no difference in the ranking of Tier 1 criteria between male and female respondents (Table 5). However, more female respondents stressed the importance of ecological aspects compared to male respondents. All age groups indicated that ecological aspects were the most important consideration for UGI; however, respondents in their 20s and 30s also recognized the importance of landscape and usability aspects. In comparison, older respondents favored ecological aspects more heavily.

Respondents from academia and the private sector found that ecological aspects were the most important Tier 1 criteria, while government respondents also stressed the significance of economic factors. This reflects the importance of cost and ongoing maintenance to government respondents, who are generally responsible for the ongoing management and maintenance of UGI. Differences were also apparent based on the professional backgrounds of the respondents. For example, experts in the field of landscaping stressed the importance of both landscape and ecological aspects, while experts in environmental and other fields favored usability aspects. Importantly, respondents with more experience stressed the importance of ecological aspects. Respondents with fewer than five years of experience considered all factors equally, while those with 6–10 years of experience felt that usability was the most important consideration.

Table 5. Relative importance of Tier 1 criteria based on respondent demographics.

Category		No	Ecological	Landscape	Usability	Economic
Total		38	0.387	0.266	0.214	0.133
Sex	Male	23	0.362	0.281	0.224	0.133
	Female	15	0.426	0.242	0.199	0.133
Age	20s	7	0.273	0.237	0.247	0.243
	30s	11	0.315	0.272	0.279	0.133
	40s	14	0.477	0.258	0.163	0.102
	50s	6	0.445	0.269	0.180	0.106
Organization	Government	4	0.369	0.154	0.148	0.328
	Academia	8	0.376	0.240	0.266	0.117
	Private Sector	26	0.384	0.291	0.207	0.118
Area	Policy/Research	12	0.387	0.215	0.227	0.171
	Design/Construction	26	0.384	0.291	0.207	0.118
Subject	Environment	6	0.470	0.184	0.194	0.151
	Landscape	27	0.366	0.296	0.211	0.127
	Other	5	0.394	0.219	0.247	0.140
Experience	Under 5 years	8	0.293	0.217	0.225	0.265
	6–10 years	8	0.283	0.285	0.338	0.094
	11–15 years	8	0.450	0.234	0.185	0.131
	More than 16 years	14	0.457	0.282	0.159	0.102

4.2. Tier 2 Evaluation

Of the Tier 2 categories relating to ecological aspects, air quality improvement (0.307) was the most important criteria, followed by climate control functions (0.269), ecological conservation (0.230), and stormwater runoff management (0.194), as shown in Table 6. We attribute the high importance of air quality improvement to recent interest in reducing carbon emissions and fine particulates in urban areas. Moreover, respondents considered that the ecological aspects of UGI help to control urban climate issues, such as reduction of urban heat island effects.

Table 6. Evaluation of Tier 2 ecological criteria.

Tier 1 Criterion	Importance (Based on Tier 1 Evaluation)	Tier 2 Criteria	Importance (Based on Tier 2 Evaluation)
Ecological	0.387	Climate Control	0.269
		Air Quality Improvement	0.307
		Stormwater runoff	0.194
		Ecological conservation	0.230

Of the Tier 2 categories relating to landscape aspects, providing natural elements within an urban setting was considered to be the most important factor (0.407), followed by harmonizing with the surrounding environment (0.282), creating a featured landscape (0.161), and screening (0.151), as shown in Table 7. This indicates that respondents valued 'naturalness' within artificial urban settings.

Table 7. Evaluation of Tier 2 landscape criteria.

Tier 1 Criterion	Importance (Based on Tier 1 Evaluation)	Tier 2 Criteria	Importance (Based on Tier 2 Evaluation)
Landscape	0.266	Creating a featured landscape	0.161
		Harmonizing with the surrounding environment	0.282
		Providing natural elements within an urban setting	0.407
		Screening	0.151

Of the Tier 2 categories relating to usability aspects, accessibility (0.307) was the most important factor, followed by leisure and amenity (0.305), shelter (0.224), and educational functions (0.164), as shown in Table 8. This underscores the importance of UGI as a highly functional community space that needs to be easily accessible and amenable.

Table 8. Detailed evaluation of Tier 2 usability criteria.

Tier 1 Criterion	Importance (Based on Tier 1 Evaluation)	Tier 2 Criteria	Importance (Based on Tier 2 Evaluation)
Usability	0.214	Accessibility	0.307
		Leisure and amenity	0.305
		Educational functions	0.164
		Shelter	0.224

Of the Tier 2 categories relating to economic aspects, the planting cost (0.356) was the most important factor, followed by maintenance (0.312), groundwork (0.191), and paving and other works (0.137), as shown in Table 9. The relative importance of planting and maintenance highlights the importance of these two factors in terms of the functionality and effectiveness of UGI. In particular, maintenance cost affects the continuity and long-term usability of UGI.

Table 9. Detailed evaluation Tier 2 economic criteria.

Tier 1 Criterion	Importance (Based on Tier 1 Evaluation)	Tier 2 Criteria	Importance (Based on Tier 2 Evaluation)
Economic	0.133	Cost for groundworks	0.196
		Cost for planting	0.356
		Cost for Paving and other works	0.137
		Maintenance cost	0.312

When all of the Tier 2 elements were considered together, air quality improvement (0.119) was the most important factor, followed by providing natural elements within an urban setting (0.108) (Table 10). These factors illustrate the significance of conventional UGI values, such as the provision of natural elements within an urban setting. At the same time, survey respondents also acknowledged the functional benefits of UGI, such as improving air quality.

Table 10. Priority rankings of Tier 2 evaluation criteria.

Tier 2 Criteria	Weighed Value	Priority
Air quality improvement	0.119	1
Providing natural elements within urban settings	0.108	2
Climate control	0.104	3
Ecological conservation	0.089	4
Stormwater runoff	0.075	5
Harmonizing with the surrounding environment	0.075	5
Accessibility	0.066	7
Providing leisure and amenity	0.065	8
Shelter	0.048	9
Planting cost	0.047	10
Creating a featured landscape	0.043	11
Maintenance cost	0.042	12
Screening	0.040	13
Providing educational functions	0.035	14
Groundworks cost	0.026	15
Paving and other works cost	0.018	16

The importance of the Tier 1 ecological criteria is recognized in the relative importance of Tier 2 ecological factors such as ecological conservation (0.089) and improving stormwater runoff

(0.075). Furthermore, the landscape criteria, harmonizing with the surrounding environment (0.075), accessibility (0.066), and leisure and amenity were also important. Economic aspects were the least important Tier 1 criteria, and this was reflected in the relatively low importance of the Tier 2 criteria of groundwork (0.026) and paving and other works (0.018).

Analyzing the weighted values of the Tier 2 categories revealed some interesting results. For example, as highlighted in Table 11 below, based on the age and field of survey respondents, air quality improvement was important to respondents in their 40s (0.155) and 50s (0.158), with an environment background (0.137) and over 16 years of experience (0.168). Survey respondents with more experience had higher expectations with respect to improving urban air quality using GI.

Government respondents and those with 11–15 years of experience valued the climate control aspects of UGI highly (0.136 and 0.147, respectively), while private sector respondents valued providing natural elements within an urban setting (0.117). Accessibility (0.119) and leisure and amenity (0.104) were considered important by respondents with 6–10 years of experience, and maintenance cost was important to government respondents (0.157). The high importance of the maintenance cost within this group are expected given that the government sector is responsible for the ongoing maintenance of UGI.

As mentioned above, the GI priorities considered important among experts were almost similar, but there were differences in the detailed factors depending on age, gender, and occupation. It is expected that the derived priority results will support UGI planning and design decisions more quickly. However, due to the nature of GI, it may be difficult to generalize the results for application in any location [44]. Depending on the area, climate, and size where the GI is created, the applied priorities may differ, and this should be specified and developed through further research.

Table 11. Detailed evaluation of Tier 2 aspects based on respondent demographics.

Category		N	Ecological				Landscape				Usability				Economic			
			Climate control	**Air quality improvement**	**Stormwater runoff**	**Ecological conservation**	**Featured landscape creation**	**Suitable with surrounding environment**	**Providing natural elements within urban areas**	**Improving landscape by screening**	**Accessibility by citizens**	**Providing leisure and amenity activities**	**Educational function**	**Shelter function**	**Cost for groundworks**	**Cost for planting**	**Cost for paving and etc.**	**Maintenance cost**
Total		38	0.104	0.119	0.075	0.089	0.043	0.075	0.108	0.040	0.066	0.065	0.035	0.048	0.026	0.047	0.018	0.042
Sex	Male	23	0.097	0.115	0.062	0.088	0.046	0.082	0.112	0.041	0.071	0.073	0.038	0.043	0.022	0.050	0.017	0.044
	Female	15	0.115	0.124	0.098	0.089	0.038	0.065	0.101	0.038	0.058	0.054	0.031	0.056	0.033	0.043	0.020	0.037
Age	20s	7	0.083	0.064	0.073	0.053	0.055	0.055	0.080	0.047	0.069	0.069	0.033	0.075	0.055	0.057	0.040	0.091
	30s	11	0.083	0.096	0.063	0.074	0.032	0.084	0.108	0.048	0.093	0.084	0.043	0.059	0.025	0.055	0.024	0.030
	40s	14	0.122	0.155	0.078	0.122	0.038	0.067	0.120	0.032	0.045	0.054	0.031	0.034	0.015	0.040	0.010	0.037
	50s	6	0.117	0.158	0.079	0.091	0.054	0.089	0.095	0.031	0.064	0.050	0.029	0.037	0.032	0.032	0.012	0.030
Organization	Public sector	4	0.136	0.080	0.091	0.063	0.014	0.039	0.067	0.034	0.045	0.039	0.013	0.052	0.059	0.078	0.034	0.157
	Academic	8	0.101	0.104	0.085	0.087	0.033	0.076	0.095	0.036	0.081	0.068	0.056	0.062	0.020	0.041	0.014	0.042
	Private sector	26	0.098	0.127	0.068	0.092	0.053	0.080	0.117	0.041	0.063	0.067	0.034	0.042	0.024	0.044	0.017	0.033
Parts	Policy/Research	12	0.116	0.099	0.090	0.081	0.026	0.064	0.088	0.037	0.070	0.059	0.036	0.062	0.030	0.053	0.020	0.068
	Design/Construction	26	0.098	0.127	0.068	0.092	0.053	0.080	0.117	0.041	0.063	0.067	0.034	0.042	0.024	0.044	0.017	0.033
Subject	Environmental	6	0.089	0.137	0.111	0.133	0.036	0.040	0.084	0.025	0.069	0.048	0.025	0.053	0.044	0.037	0.027	0.044
	Landscape	27	0.106	0.114	0.067	0.079	0.048	0.088	0.114	0.046	0.064	0.066	0.036	0.045	0.023	0.049	0.015	0.040
	Other	5	0.105	0.116	0.078	0.094	0.027	0.060	0.101	0.031	0.065	0.082	0.045	0.054	0.026	0.046	0.025	0.042
Experience	Under 5 years	8	0.080	0.076	0.072	0.064	0.049	0.050	0.075	0.043	0.067	0.056	0.030	0.072	0.061	0.063	0.046	0.095
	6–10 years	8	0.069	0.083	0.072	0.058	0.033	0.091	0.112	0.049	0.119	0.104	0.056	0.059	0.018	0.038	0.013	0.025
	11–15 years	8	0.147	0.111	0.045	0.146	0.027	0.053	0.122	0.031	0.053	0.062	0.029	0.041	0.020	0.051	0.020	0.039
	More than 16 years	14	0.109	0.168	0.090	0.089	0.051	0.090	0.107	0.035	0.047	0.050	0.030	0.033	0.021	0.039	0.011	0.032

5. Conclusions

UGI plays a key role in modern society by improving the quality of life of communities and enhancing social cohesion. However, there has been limited research regarding the methods and considerations needed to create effective UGI in today's rapidly evolving societies. Instead, UGI development has been focused on location, scale, and cost rather than developing a systematic approach to better serve the community. This study aimed to identify the most important considerations when developing UGI and to prioritize these considerations to create an effective urban environment.

The AHP method reflects the multi-layered structure of complex decision-making and can be applied in uncertain conditions or where several assessment criteria are required. In this study, questionnaires were employed using AHP methodology to examine the decision criteria of GI experts in terms of design priorities. Four primary criteria and 16 detailed subcategories were derived from a review of current literature. Questionnaires were completed by 57 experts, who evaluated the weight of each category using a 9-point scale. The categories were than ranked based on their relative order of importance.

Results showed that ecological functions were considered by most experts to be the key priority for UGI development. This was followed by air quality improvement, providing naturalness within urban areas, climate control, conservation of urban ecology, and stormwater management. Harmonization with the surroundings, accessibility, and leisure and recreation were also identified as important criteria. Generally, economic factors were not given a high priority in UGI development because experts tended to focus on the benefits of UGI as opposed to construction and maintenance costs. Respondents that prioritized planting and maintenance cost tended to work in the government sector.

In this study, we prioritized aspects of the UGI design and construction process using a literature review, expert interviews, and a hierarchal analysis. Our results provide a roadmap to facilitate more rapid decision-making for UGI development by underscoring the key priorities for UGI. Furthermore, we hope that our findings will help to facilitate a holistic approach to UGI planning and development in the future. Opportunities for further research include ongoing analysis and mediation between experts, as well as potential field applications. To achieve this, additional empirical evidence on the effects of GI would be necessary for policy implementation in the design and construction phases.

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