

MODELLING URBAN GREEN SPACES FOR SUSTAINABLE CITY DEVELOPMENT USING A WEB-BASED GEOGRAPHIC INFORMATION SYSTEM (GIS) TO SUPPORT SUSTAINABLE DEVELOPMENT GOALS (SDGS)

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Abstract

This study models urban green spaces to support sustainable city development through a web-based geographic information system. We combined spatial analyses of accessibility, safety, amenities, and maintenance with community perception surveys and stakeholder interviews. Spatial mapping identified patterns of distribution and gaps in inclusive access; qualitative and quantitative evidence captured satisfaction, use, and priorities. Results showed that residents valued recreation, health, and aesthetics, yet parks frequently underperformed on maintenance, disability access, and night-time safety. Correlations between perceived benefits and observed functionality indicated that cleaner, better-equipped, and easier to reach parks were used more and rated higher. These relationships matter because functionality conditions the public value delivered by green spaces and, therefore, the effectiveness of urban investments. The model demonstrates how integrative WebGIS and perception data can direct targeted upgrades, inform equitable siting, and strengthen participation. The approach provides planners with actionable insight for resilient, inclusive, and health-promoting cities globally. This study supports sustainable development goals (SDGs).

Keywords: Geographic information system (GIS), Public perception, Sustainable city development, Urban green spaces (UGS), Web-based GIS.

1. Introduction

Urban green spaces (UGS) are essential components of sustainable city development due to their ecological, social, and cultural contributions. Many reports regarding sustainable cities have been well-documented [1-3]. These spaces, especially public parks, promote public health, enhance environmental quality, and foster social cohesion. Their optimal use and management are critical in rapidly urbanizing areas. However, the functional quality of many green spaces often falls short of public expectations, resulting in underutilization. Therefore, aligning public perception with actual functionality is vital to ensure that UGS meaningfully supports broader sustainability goals [4]. This study investigates the potential of web-based geographic information systems (GIS) to assess and model UGS by offering a detailed spatial analysis of accessibility, ecological value, and usability.

While research on UGS has expanded, most studies tend to focus either on technical assessments or on public perceptions separately [5]. Accessibility barriers, poor maintenance, and limited amenities continue to undermine their intended benefits [6]. In addition, uneven spatial distribution exacerbates social inequality and environmental challenges such as urban heat islands and degraded air quality [7]. Although prior work acknowledges the importance of both perception and functionality, few studies offer integrated frameworks that combine community input with advanced GIS tools to support evidence-based urban planning.

Web-based GIS platforms have transformed the way UGS are monitored and evaluated. These tools support real-time data collection, interactive mapping, and complex spatial analyses related to UGS functionality [8]. WebGIS enables planners to visualize attributes such as accessibility, safety, ecological performance, and user amenities. Although GIS has been widely applied to analyse park accessibility and distribution [9], its integration with community perception remains limited, particularly in medium-sized cities in developing nations. This study addresses this gap by integrating objective spatial data with subjective public assessments to provide a more holistic understanding of UGS roles in urban sustainability.

Tasikmalaya, a city in West Java, Indonesia, serves as a relevant case study. While the city has invested in several green public spaces, persistent challenges remain concerning accessibility, user safety, and amenity quality. Reports highlight public dissatisfaction stemming from inadequate maintenance, limited infrastructure, and weak safety provisions [10]. These issues hinder the full utilization of UGS and limit their potential contribution to long-term urban sustainability. Understanding how public perceptions align with or diverge from observed functionality is thus crucial for guiding urban development.

This study aims to bridge the research gap by focusing on the relationship between public perception and UGS functionality in Tasikmalaya through a web-based GIS lens. Employing a mixed-methods approach, the study integrates spatial mapping with survey data to assess key UGS attributes. GIS was applied to evaluate accessibility, safety, and facility quality, while public surveys provided insights into user satisfaction and behaviour. The novelty of this research lies in three areas: first, it combines subjective perceptions with objective spatial evaluation; second, it employs a comprehensive set of indicators; and third, it provides empirical evidence from a medium-sized Southeast Asian city, contributing to global sustainability discourse. The findings are expected to inform both academic inquiry

and policy-making by offering strategic insights for enhancing UGS accessibility, quality, and equity.

Ultimately, this study demonstrates how web-based GIS combined with community feedback can improve the planning and management of urban green spaces. This integrated approach enables planners to develop green spaces that are efficient, inclusive, and aligned with public needs. The results hold practical implications for policymakers, planners, and urban designers seeking to create resilient, liveable, and sustainable cities, especially in rapidly growing regions. This study supports sustainable development goals (SDGs).

2. Literature review

2.1. Urban green spaces and their role in sustainable city development

UGS encompasses various open areas within cities that function as natural spaces, including parks, green corridors, public open fields, and green streets. These areas are fundamental in enhancing ecological balance, promoting social well-being, and supporting economic development in urban settings [11]. From an ecological perspective, UGS help reduce air pollution by absorbing carbon dioxide and releasing oxygen, while simultaneously mitigating the urban heat island effect through shading and ambient cooling. Moreover, they promote biodiversity by offering habitats for diverse plant and animal species, thereby improving the ecological resilience of urban ecosystems [12].

Socially, UGS provide accessible spaces for recreation and physical activity, which contribute significantly to the physical and mental health of urban residents [13]. Activities such as walking, jogging, and cycling in these environments are associated with reduced stress and an enhanced quality of life. Economically, green spaces increase surrounding property values, stimulate local economies, and attract visitors through tourism and leisure activities. As community hubs, they also support the growth of small businesses and service industries, contributing to sustained economic vibrancy [14].

Urban green spaces are directly aligned with the goals of the sustainable development goals (SDGs), particularly SDG 11, which aims to create inclusive, safe, resilient, and sustainable cities [15]. To meet this target, cities must ensure the equitable distribution and proper management of green spaces that can improve air quality, offer secure and welcoming environments, and help buffer the effects of climate change. Enhancing the quality and accessibility of UGS enables cities to become more adaptable to environmental challenges while promoting public health and social equity.

Furthermore, green spaces play a vital role in fostering economic sustainability. They provide low-cost recreational alternatives, create employment opportunities, and increase the attractiveness of cities for investment and tourism. When properly maintained, these spaces also strengthen social integration by offering venues for communal interaction and cultural expression. In this way, UGS contribute not only to environmental goals but also to economic advancement and inclusive urban development [16].

Several studies have explored the impact of UGS on urban sustainability. These spaces help mitigate the adverse effects of rapid urbanization, particularly issues

like air pollution and the intensification of the urban heat island phenomenon, both of which directly influence urban liveability [17]. Research has shown that improving UGS quality can significantly reduce urban temperatures and lower health risks associated with climate extremes. Equitable access to green spaces is also paramount, as accessibility strongly influences how effectively these spaces support community well-being [18].

Figure 1 illustrates a flowchart of the key benefits of UGS, categorizing them into ecological, social, and economic dimensions. This visual representation underscores how UGS contribute to ecological sustainability by enhancing biodiversity and reducing air pollution. Nevertheless, many urban areas struggle with ineffective green space management and inequitable distribution. For instance, access remains limited in overcrowded or socioeconomically disadvantaged neighbourhoods [19]. In addition, poor maintenance and suboptimal usage reduce the ability of green spaces to fulfil their intended sustainability roles. These challenges highlight the need for comprehensive evaluations of UGS quality and functionality to ensure their positive impact on sustainable urban development.



Fig. 1. Flowchart of the key benefits of urban green spaces.

2.2. Public perception of urban green spaces and its impact on utilization

Public perception plays a critical role in shaping the use and management of UGS [20]. How citizens perceive these spaces (whether as valuable, accessible, and safe) substantially influences both the frequency and the nature of their usage. Several factors determine this perception, including accessibility (the ease of reaching and navigating the space), safety (both actual and perceived security), maintenance (cleanliness and upkeep), and the availability of amenities such as benches, playgrounds, and restrooms. Parks that are poorly maintained and lack adequate facilities often foster negative perceptions, which in turn discourage public use. In contrast, well-maintained, easily accessible, and safe environments encourage frequent visits and foster activities (such as social interaction, physical exercise, and community engagement). These public evaluations directly influence not only usage patterns but also managerial decisions regarding UGS development and improvement [21].

Beyond influencing individual behaviour, public perception significantly informs urban planning policy, particularly in determining where and how to allocate resources for the creation or improvement of green spaces [22]. Planners and municipal authorities often rely on public feedback gathered through surveys, interviews, and community consultations to better understand the population's expectations. These insights help guide decisions on where new parks should be established, which existing spaces require upgrades, and what types of amenities are most in demand [23]. For example, if survey results reveal safety concerns in a particular park, local governments may prioritize installing improved lighting, security systems, or increasing patrol visibility. Likewise, public demand for more

inclusive and amenity-rich parks may shape budget allocations and development priorities. By aligning urban planning with public preferences, cities can enhance the quality of life, increase green space utilization, and ensure that investments reflect the needs of local communities.

Numerous studies have confirmed the strong link between public perception and the actual functionality of green spaces. Perceived accessibility and quality of amenities are among the strongest predictors of park usage [24]. Research shows that user satisfaction increases when parks are comfortable, well-equipped, and easy to access, particularly in lower-income neighbourhoods where such amenities may be limited. Additionally, demographic characteristics such as age, gender, and socio-economic background influence how different groups experience and value green spaces [25]. For instance, younger populations may emphasize recreational and sports facilities, while older residents may prioritize peaceful environments and seating areas. These diverse needs underscore the importance of inclusive planning approaches. Moreover, perceptions of safety and cleanliness have been shown to directly affect how frequently parks are visited, highlighting the need for consistent maintenance and effective management strategies [26].

2.3. Geographic information systems (GIS) in urban planning and green space management

GIS play an essential role in contemporary urban planning by providing robust tools for spatial analysis, land-use mapping, and green space management. GIS enables planners to process and analyse geospatial data, recognize spatial patterns, and generate detailed visual maps to support evidence-based decision-making [27]. In the context of urban green spaces, GIS is widely used to model their distribution, accessibility, and overall quality. Through spatial visualization, urban planners can assess the proximity of green areas to residential zones and identify underserved regions that lack adequate access to public parks or well-maintained green spaces [28]. These insights help prioritize which areas require intervention, expansion, or renovation. Moreover, GIS is instrumental in simulating future green space development scenarios and projecting the effects of urban growth on existing green infrastructure [29].

GIS also supports the ongoing management and maintenance of green spaces by offering tools to monitor their condition and functionality [30]. Urban managers can use GIS to track critical indicators such as accessibility, environmental quality, and the presence of key facilities. For instance, transportation routes and pedestrian pathways can be mapped to ensure that parks are accessible to all user groups. Ecological indicators, including air quality and soil health, can be integrated into GIS platforms to evaluate the environmental sustainability of green areas [31]. Furthermore, GIS supports the identification of maintenance issues (such as damaged infrastructure, cleanliness concerns, or outdated facilities) allowing city officials to address them proactively [32]. This comprehensive, data-driven approach enhances the strategic management of green spaces and contributes to their long-term functionality and appeal.

With recent advancements in digital technology, web-based GIS has emerged as a transformative tool in urban planning and green space management [33]. Unlike conventional GIS systems that require specialized desktop software and technical expertise, web-based platforms are internet-accessible and offer real-time

data visualization, often with collaborative editing features. These interactive platforms can be used by urban planners, policymakers, and even the general public to view, analyse, and contribute to spatial data, thus promoting inclusive decision-making [34]. One major advantage of web-based GIS is its ability to democratize access to spatial data, enabling broader stakeholder participation and ensuring transparency in urban development processes [35]. However, several challenges persist, including reliance on stable internet connectivity, data security vulnerabilities, and limitations in spatial resolution when compared to high-powered desktop systems [36]. Despite these limitations, the accessibility, ease of use, and collaborative features of web-based GIS render it an indispensable tool for sustainable urban development.

Figure 2 presents the core applications of GIS in the planning and management of urban green spaces, emphasizing three interrelated functions: spatial analysis, land use mapping, and green space monitoring. These functions illustrate how GIS tools can facilitate targeted interventions in areas with inadequate green space provision and promote adaptive planning based on environmental and social metrics.

Several studies further support the role of web-based GIS in advancing green space development, especially in resource-constrained urban settings. Research has demonstrated that web-based GIS platforms can effectively monitor the distribution and quality of green infrastructure across cities, helping planners identify spatial gaps and prioritize investment in underserved neighbourhoods [37]. In addition, participatory GIS tools allow community feedback-collected through online platforms-to be directly integrated into decision-making processes. This integration enhances the responsiveness of urban planning efforts and ensures that green spaces are designed and managed in accordance with community needs and preferences [38]. Collectively, these developments underscore the growing importance of web-based GIS in supporting inclusive, data-informed, and resilient urban green space planning.

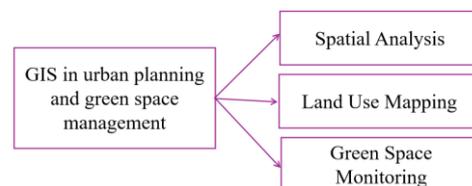


Fig. 2. Applications of GIS in urban planning and green space management.

2.4. Integrating public perception and GIS in modelling urban green spaces

The integration of public perception data with GIS offers a holistic approach to modelling UGS, combining both qualitative and quantitative dimensions [39]. Public perception, typically captured through surveys or interviews, provides insights into how residents evaluate the safety, accessibility, cleanliness, and overall quality of green spaces (factors that may not be fully evident through spatial data alone). By merging subjective feedback with objective GIS-based assessments, urban planners can construct more comprehensive models that account for both the physical characteristics of UGS and the lived experiences of local communities [23]. This hybrid approach enhances understanding of how citizens interact with green spaces and reveals spatial patterns that influence usage, satisfaction, and community engagement.

Incorporating public perception into GIS analysis presents several advantages for urban green space planning and management [40]. Notably, it enables planners to design interventions that are not only spatially targeted but also socially responsive. By identifying issues such as perceived insecurity, inadequate maintenance, or lack of inclusivity, planners can prioritize areas for improvement based on actual community concerns.

For instance, green spaces that are physically accessible but perceived as unsafe may require lighting upgrades or increased surveillance rather than structural redesigns. Moreover, this integrative approach can help detect spatial disparities (neighbourhoods with low satisfaction often coincide with areas lacking high-quality green infrastructure). As a result, combining GIS with perception data ensures that planning decisions are both data-informed and community-centered.

A variety of methodological approaches have been employed to operationalize the integration of public perception and GIS in previous research. One widely used technique is spatial overlay analysis, in which perception-based survey results are mapped alongside GIS layers representing environmental attributes, such as land cover, park distribution, and accessibility networks [41]. Tools like buffer analysis and proximity mapping are often utilized to assess how distance to green spaces influences satisfaction and frequency of use.

In parallel, statistical regression methods are used to explore correlations between perception variables (such as safety, aesthetics, or recreational value) and spatial indicators like park size, density, and facility availability. Additionally, thematic analysis of qualitative feedback can be geocoded and linked with spatial data to highlight recurring issues across different neighbourhoods. These diverse methods provide a robust framework for integrating human experience into spatial models, offering a richer understanding of UGS performance and community needs.

Empirical studies have demonstrated the effectiveness of this integrated approach in improving green space planning. For example, some researchers [42] combined public surveys with GIS spatial analysis to assess the relationship between park usage and community satisfaction. Their findings revealed that feedback related to safety and facilities helped identify underutilized parks, often located in areas with poor accessibility or infrastructure gaps.

Similarly, other researchers [43] used GIS models enriched with perception data to map zones of low public satisfaction, which often corresponded with insufficient green coverage or lack of amenities. These examples underscore the potential of integrating qualitative insights with spatial data to inform equitable and strategic green space development. Ultimately, this approach enables planners to make more inclusive, informed, and adaptive decisions that enhance the sustainability and usability of urban green environments.

3. Methods

This study adopted a mixed-methods approach to comprehensively assess the functionality of UGS and the public's perception of their use in the city of Tasikmalaya. The research design integrated both quantitative and qualitative techniques, allowing for a multi-dimensional understanding of spatial, environmental, and social factors influencing UGS. A web-based GIS was utilized

to analyse the spatial distribution and physical functionality of UGS, while a public perception survey was employed to collect community-based insights.

GIS mapping focused on key parameters, including accessibility, maintenance, and safety, particularly in relation to park proximity to residential areas and public transportation networks. Meanwhile, the survey captured data on usage patterns, satisfaction levels, and perceived quality, using a series of Likert-scale items designed to evaluate opinions on park amenities, safety, ecological value, and overall user experience.

The survey was administered to a sample of 300 residents, ensuring demographic diversity across age, gender, occupation, and residential location. To complement the quantitative data, in-depth interviews were conducted with 15 key informants, including park managers, urban planners, and community leaders. These qualitative inputs provided contextual perspectives on park governance, infrastructure conditions, and strategic development challenges.

Data collection included several instruments: structured questionnaires for park users, field observations for assessing the physical condition of park elements (e.g., pathways, signage, lighting, and amenities), and semi-structured interviews for stakeholder insights. In addition, secondary data were gathered from municipal reports and planning documents, offering background on Tasikmalaya’s urban development trajectory and green space policy frameworks.

The quantitative data from the survey were processed using SPSS version 25. Descriptive statistics (including means, frequencies, and standard deviations) were computed to summarize public perception responses. To explore the relationship between perception indicators and observed functionality, multiple regression analysis was applied. The reliability of the survey instrument was verified through Cronbach’s Alpha, and construct validity was assessed using exploratory factor analysis (EFA).

On the qualitative side, data from interviews and observations were analysed thematically, identifying patterns related to accessibility, ecological performance, and park management practices. Ultimately, findings from both the quantitative and qualitative components were integrated, offering a well-rounded understanding of how urban green space functionality aligns with public expectations and urban sustainability goals in Tasikmalaya.

4. Results and Discussion

4.1. Public perception of urban green open spaces

Table 1 presents descriptive statistics reflecting residents' perceptions of Tasikmalaya’s city park, including satisfaction, usage frequency, and perceived benefits.

Table 1. Descriptive statistics of public perception.

Indicator	High (%)	Moderate (%)	Low (%)
Overall Satisfaction	18	62	20
Frequency of Visit	47 (weekly)	28 (monthly)	25 (rarely)
Health Benefits	65	25	10
Recreational Benefits	71	19	10
Aesthetic Value	58	30	12
Social Interaction	42	35	23

The survey findings indicate diverse levels of satisfaction and engagement, revealing how urban residents experience and interact with green spaces [44]. A majority of respondents (62%) reported being “satisfied” with park facilities, while 18% expressed “high satisfaction,” and 20% were “dissatisfied.” Regarding usage, 47% of respondents visited the park weekly, 28% monthly, and 25% rarely. These patterns confirm the park’s role as a central recreational and social space in the community.

Perceived benefits were mainly recreational (71%), followed by health-related outcomes such as physical activity and mental relaxation (65%), and aesthetic enjoyment (58%). Social interaction was noted by 42%, indicating the park’s value as a community gathering space. These findings suggest that the park serves multiple functions, though it does not yet fully meet all public expectations [45].

Qualitative responses further enriched this understanding. Many respondents highlighted the park’s value as a stress-relief environment, emphasizing its accessibility for activities like jogging and walking. Improved air quality was also associated with the park’s greenery, reinforcing its perceived health benefits. Recreationally, the park was described as an affordable and accessible leisure space for families [46].

From a social and cultural standpoint, respondents viewed the park as inclusive and supportive of interaction across age groups and social backgrounds. Aesthetic appreciation focused on landscaped greenery and tree cover, though several participants expressed concerns about inconsistent maintenance and outdated design features [47]. Overall, the park was perceived not only as a physical amenity but also as a representation of Tasikmalaya’s urban environmental identity.

Table 2 summarizes the thematic analysis of public perception data. Key themes such as health, recreation, aesthetics, and social interaction are illustrated through representative quotes. While the park was highly valued in terms of health and recreation, concerns remained regarding maintenance and inclusivity. These findings mirror patterns observed in Southeast Asian cities, where green spaces are valued for promoting physical activity and social cohesion [48]. Unlike other urban contexts such as Bogotá, where safety dominates public concern, Tasikmalaya’s residents placed greater emphasis on maintenance quality.

Table 2. Thematic analysis of public perception.

Theme	Key Insights (Sample Quotes)	(%)
Health	“Jogging here keeps me healthy and stress-free.”	63
Recreation	“It is the best free leisure space for families.”	58
Aesthetic	“The trees and flowers make the city feel alive.”	46
Social Interaction	“I often meet neighbours and new friends here.”	39

4.2. Functionality and suitability of urban green open spaces

Table 3 provides a summary of field observations assessing park functionality, including facilities, cleanliness, accessibility, and safety.

Observational assessments of Tasikmalaya’s city park revealed mixed results in meeting its intended functions. While the infrastructure (such as benches, jogging tracks, and playgrounds) was generally operational (70% functional), several features showed signs of wear and required maintenance. Cleanliness scored lower (65%), particularly due to inadequate waste management during peak visitation hours.

Accessibility received a relatively positive score (75%), attributed to the park's central location and walkable pathways. However, inclusive access remained limited, especially for individuals with disabilities, due to the absence of ramps and tactile paving. Safety was rated lowest (60%), with concerns primarily related to insufficient lighting and lack of visible security patrols, particularly affecting female visitors during the evening [49].

These findings suggest that while the park fulfils its basic role as an urban green space, gaps in maintenance and inclusivity limit its overall effectiveness. In comparison with international guidelines (such as WHO recommendations for green space standards and UN-Habitat principles on universal accessibility) the park falls short in achieving equitable design and continuous upkeep [50].

Table 3. Observational analysis of park functionality.

Indicator	Score (%)	Evaluation Notes
Facilities	70	Functional but partially degraded
Cleanliness	65	Waste bins insufficient at peak times
Accessibility	75	Good location, but limited disability access
Safety	60	Poor lighting and minimal patrols

4.3. WebGIS and spatial analysis of park functionality

Figure 3 illustrates the spatial analysis of Tasikmalaya's park functionality using satellite imagery and GIS mapping, focusing on accessibility, amenity distribution, and coverage across urban zones.

Beyond field observation and survey data, this study employed a Web-based geographic information system (WebGIS) to spatially analyse the distribution and functionality of urban green spaces in Tasikmalaya. The application of WebGIS enabled a detailed examination of park coverage, amenity distribution, and proximity to residential areas, supporting a broader understanding of park utilization and spatial equity in green infrastructure [51]. Through WebGIS, key park features were mapped, and visitor access patterns were traced to evaluate whether the city's green spaces aligned with local settlement patterns and development zones.

The integration of WebGIS began with the collection and preprocessing of spatial data, including information on park size, geographic location, and existing amenities such as benches, playgrounds, and lighting infrastructure [52]. This geospatial data was further enriched with survey and observational inputs that captured usage patterns, demographic characteristics of park visitors, and perceived accessibility. The spatial overlay of these datasets allowed planners to identify underserved neighbourhoods, recognize clusters of underutilized parks, and detect accessibility gaps that might otherwise be overlooked in non-spatial analyses.

Using buffer analysis and proximity tools within WebGIS, the study evaluated the walkability and service radius of green spaces, highlighting areas where interventions-such as new park development or pathway improvements-were most needed. These visual outputs provided city officials and urban planners with actionable insights into where to prioritize investment and how to improve the alignment between green space provision and urban growth. By transforming static survey responses and field notes into dynamic, spatially referenced maps, WebGIS

emerged as a decision-support tool that facilitates transparent and participatory urban green space planning.

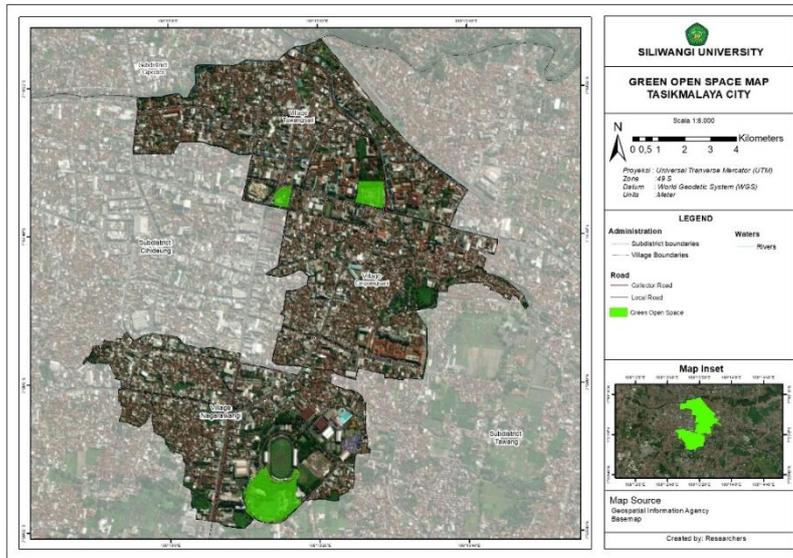


Fig. 3. Observational analysis of park functionality using satellite imagery.

The second stage of this study involved the development of a WebGIS platform to integrate the collected spatial and perception data into an interactive, user-friendly mapping system. This platform enabled real-time visualization of urban green spaces and provided analytical tools to assess accessibility, connectivity to public transportation, and proximity to residential zones. It also allowed planners to identify underserved areas, where green space availability was limited or absent, and to model future urban expansion scenarios. Through this functionality, the WebGIS platform facilitated strategic integration of green infrastructure into broader urban development plans, thereby supporting sustainable and inclusive city growth [53].

To understand the technical development process of the WebGIS system, Table 4 outlines the sequential stages involved. These stages begin with data collection, followed by system design, spatial analysis, and integration into planning frameworks. The table describes the tools, methods, and outputs associated with each phase, ensuring that green space parameters (such as accessibility, ecological function, and user needs) are comprehensively considered in the modelling process [38].

Figure 4 further illustrates the WebGIS integration process in a flowchart format, simplifying the overall workflow. It highlights key milestones such as geodatabase construction, map visualization, and data-driven urban planning. This visual aid complements the procedural explanation in Table 4 by offering a streamlined representation of how spatial data are translated into actionable insights for planning decisions [54].

Importantly, the WebGIS system allows for continuous monitoring of urban green spaces. Planners can track dynamic variables such as usage trends, accessibility fluctuations, and environmental conditions over time. This real-time

feedback loop strengthens long-term sustainability by informing updates to park management strategies and enabling predictive modelling for urban expansion [55]. As a result, WebGIS serves as both a planning tool and a monitoring framework, ensuring that green spaces evolve in alignment with community needs and environmental priorities.

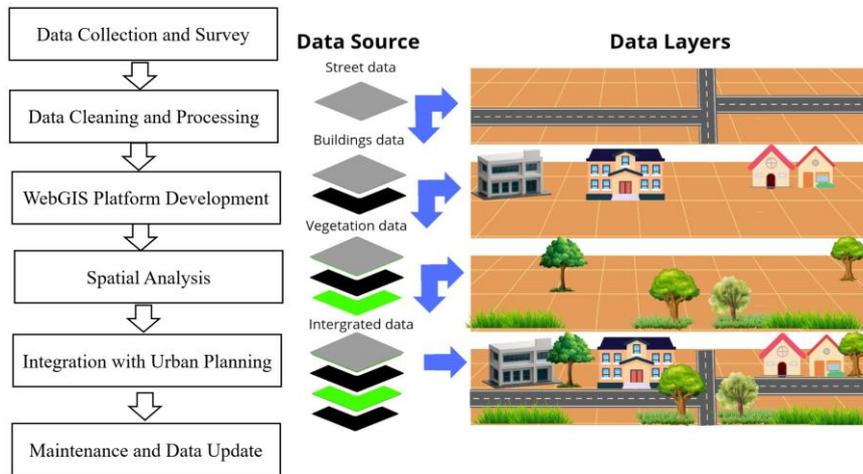


Fig. 4. Flowchart of the Stages of WebGIS integration for urban green spaces.

To guide the technical implementation of the WebGIS platform for modelling urban green spaces, Table 4 presents the sequential stages of development. This structured framework includes six key stages (ranging from data collection to system maintenance), each addressing critical components of the GIS workflow. The table also identifies the specific methods and technologies applied at every step, ensuring the system’s reliability and adaptability for long-term urban planning purposes.

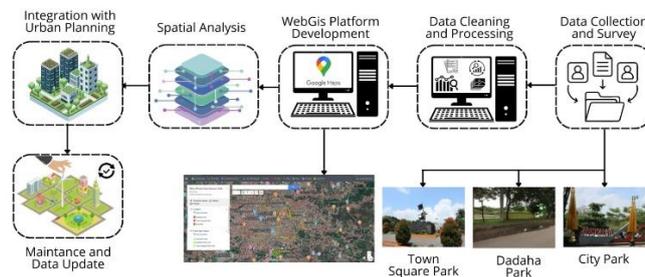
Figure 5 further demonstrates the integration of spatial data into the WebGIS platform. This integration enables interactive visualization of core urban features, such as park locations, residential densities, road networks, and public transportation routes. By overlaying multiple data layers, urban planners are able to analyse spatial relationships between green space distribution and factors such as accessibility and connectivity [56].

The platform’s capability to incorporate real-time data updates allows planners to respond dynamically to environmental and infrastructural changes. It also facilitates ongoing monitoring of green space functionality, such as tracking expansion areas, assessing new development impacts, or measuring improvements in accessibility. In addition, WebGIS fosters collaborative planning, as the system can be accessed and utilized by multiple stakeholders-including urban authorities, environmental managers, and community members. This openness contributes to a more transparent, participatory, and inclusive urban development process.

Ultimately, WebGIS serves not only as a diagnostic and planning tool, but also as a policy support mechanism, aligning with broader sustainability goals by ensuring that green spaces are equitably distributed, effectively managed, and continuously improved.

Table 4. Stages of developing a webgis for urban green space modelling.

Stage	Description	Methods/Technologies
1. Data Collection	Collect spatial data (e.g., topographic maps, city boundaries, green open space [GOS] locations) and attribute data (e.g., park facilities, accessibility features).	Remote sensing, field surveys, existing GIS datasets; data from government agencies or independent sources.
2. Data Cleaning and Processing	Clean and process the collected data to ensure it is accurate, complete, and consistent for analysis.	Data validation, removal of duplicates, standardization of attribute data to match GIS standards.
3. WebGIS Platform Development	Develop the WebGIS platform to visualize and interact with the collected data.	HTML, CSS, JavaScript (Leaflet, OpenLayers, ESRI API), GIS servers (GeoServer, QGIS).
4. Spatial Analysis	Perform spatial analysis to assess the distribution, accessibility, and inclusivity of green open spaces.	Analysis of accessibility, user density, and inclusivity using WebGIS functionalities.
5. Integration with Urban Planning	Integrate the WebGIS system into urban planning efforts to align green space development with urban growth.	Visualization of urban planning scenarios, decision-making support based on spatial analysis.
6. Maintenance and Data Updates	Maintain and update the WebGIS system with the latest data on green spaces, environmental changes, and urban development.	Regular updates of spatial data, continuous monitoring of urban development changes.

**Fig. 5. WebGIS Integration for green space mapping and accessibility analysis.**

Figures 6 and 7 present the results of the GIS-based spatial analysis of green spaces in Tasikmalaya, highlighting patterns of foot traffic, accessibility gaps, and underutilized park zones.

This analysis provided a clear visualization of zones with both high and low usage, derived from proximity to residential areas, park entrance locations, and accessibility via public transportation networks. Areas with high foot traffic were often located near dense residential clusters and major transit routes, underscoring the importance of connectivity in promoting park utilization. Conversely, underused

areas were identified in peripheral locations, where access to public transit was limited and pedestrian pathways were poorly connected to green space entrances.

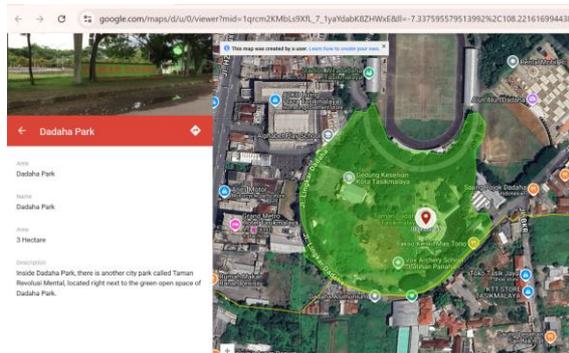


Fig. 6. GIS analysis of green space functionality and accessibility in Tasikmalaya city (high magnification).

In addition to mapping usage trends, the analysis revealed deficiencies in disability access, such as the lack of ramps, tactile paving, and universally designed entry points. These findings emphasized the need for inclusive infrastructure upgrades, especially in parks intended to serve all population groups, including the elderly and people with disabilities [57].

Moreover, the GIS model showed that parks located near transport hubs experienced higher visitation rates, suggesting that improved transit connectivity could directly influence green space engagement in underutilized regions. This spatial insight is critical for urban planners in prioritizing infrastructure investments, ensuring equity in access, and aligning park development with sustainable mobility goals.

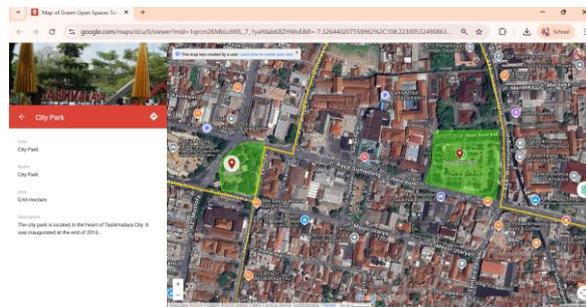


Fig. 7. GIS analysis of green space functionality and accessibility in Tasikmalaya city (low magnification).

4.4. Linking perception and functionality

Table 5 presents the results of the correlation analysis between public perception indicators and observed park functionality, using Pearson’s correlation coefficient.

The analysis revealed statistically significant relationships between how residents perceived urban green spaces and their actual functional conditions. The

strongest correlation was observed between perceived recreational benefits and facility conditions ($r = 0.68, p < 0.01$), indicating that when amenities are functional and well-maintained, users are more likely to experience recreational satisfaction. A similarly high correlation was found between health perception and cleanliness ($r = 0.59, p < 0.01$), suggesting that hygienic conditions contribute significantly to the perceived health benefits of park use.

Accessibility also showed strong associations with aesthetic perception ($r = 0.46, p < 0.05$) and frequency of visitation ($r = 0.52, p < 0.01$), emphasizing that parks that are easy to reach and navigate tend to receive higher engagement and positive visual appraisal. These results support the idea that tangible features such as clear pathways, cleanliness, and lighting substantially influence how parks are perceived and used [58].

In addition, parks with stronger ecological features, such as green coverage and visible biodiversity, were often linked with higher aesthetic appreciation and social interaction. This suggests that design considerations must go beyond functionality and incorporate sensory and environmental quality to fully meet community expectations. The correlation data underscore the need for urban planners to view public perception not merely as feedback but as an indicator of green space performance.

Table 5. Correlation Between Perception Indicators and Park Functionality.

Perception Indicator	Facility Condition	Cleanliness	Accessibility	Safety
Recreation	0.68 ($p < 0.01$)	0.41 ($p < 0.05$)	0.35 ($p < 0.05$)	0.22 (ns)
Health	0.39 ($p < 0.05$)	0.59 ($p < 0.01$)	0.28 (ns)	0.31 ($p < 0.05$)
Aesthetic	0.34 ($p < 0.05$)	0.46 ($p < 0.05$)	0.46 ($p < 0.05$)	0.19 (ns)
Social Interaction	0.42 ($p < 0.05$)	0.33 ($p < 0.05$)	0.38 ($p < 0.05$)	0.29 ($p < 0.05$)

Note: ns = not significant

4.5. Implications for sustainable city development

The findings from the analysis of Tasikmalaya's city park offer direct insights into achieving the targets of SDG 11 (sustainable cities and communities). Urban green spaces can only contribute to inclusiveness, resilience, and quality of life when their functional attributes are aligned with both community needs and international urban sustainability benchmarks [59, 60]. The observed alignment between public perception and park functionality reinforces the importance of integrating user feedback into the operationalization of SDG 11 [61]. To ensure that green spaces genuinely serve urban communities, three core policy directions should be prioritized:

- (i) Upgrading core park functionality, especially access, lighting, safety features, and inclusive infrastructure.
- (ii) Institutionalizing community participation in park design, planning, and ongoing maintenance, leveraging local knowledge and fostering civic ownership.

- (iii) Securing sustainable financing, both for capital investments and for routine maintenance, to ensure continuous improvements over time.

The challenges identified in Tasikmalaya’s green space management are not isolated but reflect broader trends in medium-sized cities across rapidly urbanizing regions. However, with community-responsive planning and institutional support, local governments can effectively bridge the gap between public expectations and functional realities. This integrated approach not only enhances the sustainability of urban green spaces but also ensures their relevance and equity in the face of future urban growth. This study adds new information regarding SDGs, as reported elsewhere (Table 6).

Table 6. Previous studies on SDGs.

No.	Title	Ref.
1	Sustainable development goals (SDGs) in engineering education: Definitions, research trends, bibliometric insights, and strategic approaches	[62]
2	Sustainable packaging: Bioplastics as a low-carbon future step for the SDGs	[63]
3	Production of wet organic waste coenzymes as an alternative solution for environmental conservation supporting SDGs	[64]
4	HIRADC for workplace safety in manufacturing: A risk-control framework and bibliometric review to support SDGs	[65]
5	Techno-economic analysis of production ecobrick from plastic waste to support SDGs	[66]
6	Techno-economic analysis of sawdust-based trash cans and their contribution to Indonesia’s green tourism policy and the SDGs	[67]
7	Definition and role of sustainable materials in reaching global SDGs completed with bibliometric analysis	[68]
8	Bibliometric insight into materials research trends and innovation to support SDGs	[69]
9	Physical adaptation of college students in high-altitude training to support SDGs	[70]
10	Enhancing job satisfaction through HRIS and communication: A commitment-based approach to SDGs	[71]
11	Enhancing innovative thinking through theory-based instructional model to support SDGs	[72]
12	Influence of self-efficacy on affective learning outcomes in social studies education toward achieving SDGs	[73]
13	Enhancing occupational identity and self-efficacy through self-education in art/design aligned with SDGs	[74]
14	Integrating generative AI-based multimodal learning in education to enhance literacy aligned with SDGs	[75]
15	Dataset on Sulawesi schools and cultural implications to support SDGs	[76]
16	Enhancing professional readiness in vocational education aligned with SDGs	[77]
17	School feeding program and SDGs in education: Linking food security to learning outcomes	[78]
18	Influence of eco-friendly packaging on consumer interest to meet SDGs	[79]
19	SDG 12 implementation through lemon commodities and waste reduction	[80]
20	Mediterranean diet patterns and sustainability to support SDGs	[81]
21	Education on food diversification through infographic to improve SDGs	[82]
22	Safe food treatment technology to achieve SDG zero hunger and optimal health	[83]
23	Student awareness of sustainable diet and carbon footprint reduction to support SDGs 2030	[84]

5. Conclusions

This study integrated spatial analysis through WebGIS with public perception data to assess the functionality, accessibility, and inclusivity of urban green spaces in Tasikmalaya, Indonesia. Using a mixed-methods approach, the research revealed that public satisfaction is closely linked to tangible aspects of park infrastructure (particularly facility conditions, cleanliness, and accessibility). Perceived benefits, such as recreation, health, and aesthetics, were strongly correlated with actual park functionality, highlighting the importance of aligning physical infrastructure with community needs. WebGIS proved to be a valuable planning tool, enabling spatial visualization of accessibility gaps, underused areas, and infrastructure deficiencies. The integration of perception data with GIS models offered a holistic understanding of green space performance and supported data-driven urban planning. The study also emphasized the need for inclusive design and consistent maintenance, particularly for marginalized groups such as people with disabilities. These findings reinforce the role of green spaces in achieving SDG 11, especially in medium-sized cities facing rapid urbanization. Urban planners and policymakers are encouraged to prioritize participatory planning, dedicated funding, and continuous monitoring to ensure that green spaces are accessible, equitable, and responsive to the evolving needs of urban residents.

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