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ARTICLE

Identification of Multipurpose Greenway Networks for Ecological Resilience Using Geospatial Technology: Case Study of South Delhi District in India

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ABSTRACT

Urban greenways counter ecological fragmentation and enhance urban sustainability. This study proposes a multipurpose greenway network in South Delhi District to improve ecological connectivity and urban liveability amidst rapid urbanization. Key areas such as Asola Bhatti Wildlife Sanctuary, Hauz Khas, and Saket were identified using geospatial analysis, considering factors like land availability, road density, protected areas, demand, and topography through a Rating and Weighting (RAW) method. The findings reveal the potential of greenways to connect fragmented green spaces, integrate recreational zones, and preserve natural habitats while linking cultural and historical landmarks. Comparative analysis with greenway projects in Bangalore and Singapore highlights scalability and best practices. Bangalore's initiatives focus on linking urban lakes and parks, showcasing the use of local ecological features as anchors. Singapore's Park Connector Network demonstrates the benefits of cohesive urban ecosystems. These examples emphasize the importance of

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phased implementation and institutional support for success. The proposed greenways not only enhance biodiversity but also mitigate urban heat islands, improve air quality, and promote public health through accessible recreational spaces. Policymakers and urban planners can adopt this model to address environmental challenges, improve urban liveability, and drive sustainable development in other urbanizing regions. The research underscores greenways as a blueprint for creating ecologically and socially resilient urban environments.

Keywords: Greenwaynetworks; Urbanplanning; Ecologicalresilience; Remote Sensing; GIS; Multi-Criteria Decision Making (MCDM)

1. Introduction

Green infrastructure refers to the development of urban green areas, such as parks, rain gardens, greenways, and urban forests, to create a network of natural and semi-natural spaces that provide a range of ecological, social, and economic benefits. These areas enhance biodiversity, improve ecosystem services, and contribute to the overall quality of urban life by mitigating environmental challenges like stormwater runoff, air pollution, and urban heat islands. Urbanization refers to the shift from rural to urban living, involving changes in population distribution, land use, economic activities, and social dynamics [1]. With globalization, urbanization has accelerated significantly. In the mid-20th century, only 17.8% of the population in developing countries lived in cities. This figure has surged to over 40% in the last 50 years and is projected to reach nearly 60% by 2030 [2]. Urban areas, strongly influenced by human activities, are now major drivers of land use changes, often leading to overcrowding, unplanned settlements, environmental pollution, ecosystem degradation, and the depletion of natural resources [3]. In rapidly developing countries like India, urbanization began with industrialization in the 1950s and was further intensified by globalization in the 1990s. This led to mass migration from rural areas to urban centres, with cities like Delhi, Bangalore, and Mumbai expanding rapidly. Delhi faces significant challenges due to its haphazard expansion, resulting in the fragmentation of green spaces and the strain on urban ecosystems [3]. The push to expand urban land for development has increasingly put pressure on these green spaces, compromising the ecological balance [4].Cities around the world are actively expanding urban green spaces, which include greenways, parks, urban forests, waterfronts, and open green areas—key elements of urban infrastructure [5]. Greenways serve crucial ecological functions, especially in urban areas where habitat fragmentation and environmental degradation are common [6]. Relevant studies highlight the potential of greenways to address urban challenges. Du et al. (2012) demonstrated the use of spatial suitability analysis and the Analytical Hierarchy Process (AHP) to design greenways that balance ecological, cultural, and recreational needs. Similarly, Blob (2016) applied the least-cost path model to create greenway networks that connect urban habitats while optimizing land use. Gharaibeh (2016) emphasized the integration of physical, natural, and human systems to design greenways that enhance ecosystem connectivity and public access. These studies illustrate the versatility of geospatial methods, such as the Rating and Weighting Method (RAW), in optimizing greenway planning. However, the majority of these studies focus on developed nations, with limited application in rapidly urbanizing contexts like India. Moreover, existing approaches often prioritize single criteria, such as ecological or recreational benefits, rather than integrating multiple dimensions. This creates a knowledge gap in designing holistic greenways for urban regions like South Delhi, which face unique challenges of high population density, habitat fragmentation, and cultural diversity.

These green corridors enhance biodiversity by connecting isolated habitats, which promotes gene flow and species movement, helping mitigate the impacts of urbanization on wildlife [7]. In South Delhi, greenways are planned to integrate natural habitats, such as the Asola Bhatti Wildlife Sanctuary, with urban green spaces, allowing for wildlife passage and fostering ecological resilience. Additionally, greenways contribute to ecosystem services, such as carbon sequestration, stormwater management, and pollution reduction, by incorporating vegetation that filters air and water, stabilizes soils, and provides shade, thereby reducing urban heat islands. The development of urban green areas, such as parks, rain gardens, and greenways, is referred to as "green infrastructure". These areas offer a range of ecological and social advantages, from enhanced public health to reduced stormwater runoff[8]. Despite being marketed for its many uses, green infrastructure is usually studied and applied from the standpoint of a single advantage, often stormwater conservation[9].

Urbanization significantly impacts ecosystems, contributing to issues like increased land surface temperatures, higher runoff, loss of biodiversity, and higher greenhouse gas emissions[10]. Habitat fragmentation, driven by land-use changes, is a major threat to biodiversity and disrupts ecosystem services[11]. Greenways, which connect isolated habitats, can mitigate these effects by improving species movement and ecosystem resilience[12]. Urban greenways are also beneficial for both ecological and social outcomes, promoting wildlife coexistence and enhancing human well-being through recreational spaces[13]. Advanced spatial analysis techniques, like the Rating and Weighting Method (RAW)[14], have been used to optimize greenway planning, balancing environmental, cultural, and recreational needs[15]. By addressing these gaps, this study aims to develop a replicable methodology that integrates ecological, social, and cultural dimensions using geospatial tools like RAW and multi-criteria GIS-based analysis. These tools are well-suited for identifying suitable locations and designing interconnected greenway networks, addressing habitat fragmentation, and improving urban liveability in rapidly urbanizing areas. The study applies geospatial technologies to plan a greenway network in South Delhi, aiming to address habitat fragmentation, enhance connectivity, and provide recreational opportunities[16]. Enhancing ecological connection, restoring ecosystem services, and providing homes for a variety of plants and animals in urban environments are the objectives of urban green infrastructure. To do this, a thorough plan for the arrangement, connectivity, and biological integrity of green areas at all scales, from local locations to citywide networks is required[17]. The primary scientific goal of this work is to develop a replicable methodology for identifying and designing greenway networks that enhance ecological connectivity and urban sustainability[18]. Through a multi-criteria GIS-based approach, this study aims to create an evidence-based model for greenway planning that can be applied in other urban contexts facing similar challenges of habitat fragmentation and urban expansion[19]. By focusing on ecological resilience and human well-being, the study also seeks to contribute to sustainable urban planning practices that promote biodiversity, ecosystem health, and enhanced quality of life for urban residents[20].

2. Study Area

Delhi, India's capital, is a rapidly growing metropolitan city with a rich history. It is divided into eleven administrative districts, including South Delhi, the focus of this study. South Delhi is notable for its remaining green spaces, including the Asola Bhatti Wildlife Sanctuary, Deer Park, Rose Garden, and various smaller urban parks. These green spaces present an opportunity for connection through a planned multipurpose green corridor. This corridor aims to link natural habitats, historic monuments, pedestrian and cycling paths, recreational areas, and citywide networks, creating a seamless blend of ecological and urban connectivity.

Covering approximately 250 square kilometres, about 16.7 percent of Delhi's total area, South Delhi is located at latitude 28.55° North and longitude 77.19° East, with an average elevation of 254 meters above sea level. The district is bordered by the Yamuna River to the east, New Delhi to the north, Haryana's Faridabad to the southeast, Gurgaon to the southwest, and Southwest Delhi to the west. The terrain is mostly flat, with some areas covered by the old Aravalli Mountain ranges, which provide a natural setting for parks and wildlife sanctuariesv (**Figure 1**).

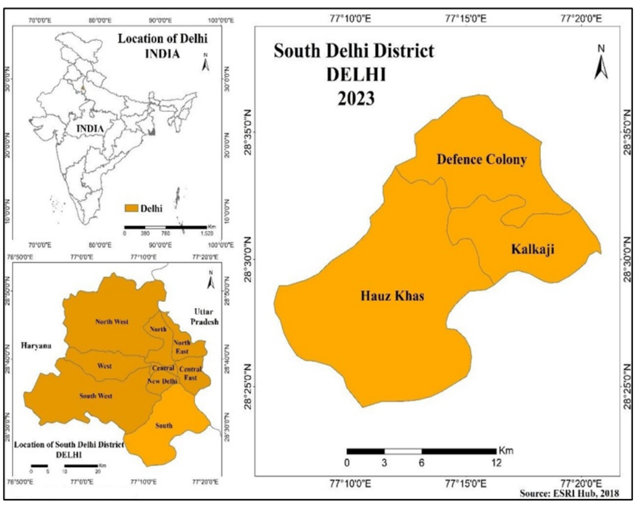

Figure 1. Location map of the studyarea.

Source: Prepared by authors.

South Delhi faces several challenges due to its fragmented layout of green spaces. The existing green areas are isolated, reducing their ecological effectiveness and limiting public access to recreational opportunities. Urban development pressures have further fragmented these spaces, making them vulnerable to encroachment and reducing their connectivity with the broader citywide green infrastructure network. The lack of connectivity between these green areas and urban hubs has also limited their ability to serve as effective ecological corridors, recreational zones, and alternative transit routes.

Predominantly urban, South Delhi includes 25 rural villages and has a population of approximately 2.73 million, with a sex ratio of 862 females per 1,000 males and an average literacy rate of 86.5 percent. The district is renowned for its tourist attractions, such as the Qutub Minar, Humayun's Tomb, and various temples like Nizamuddin Dargah and Lotus Temple. It is also home to several prestigious institutions, including the Indian Institute of Technology (IIT), All India Institute of Medical Sciences (AIIMS), and the National Institute of Fashion Technology, making it a significant cultural and educational hub. The proposed green corridor addresses these challenges by connecting isolated green spaces and integrating local locations like parks, sanctuaries, and cultural landmarks into a cohesive network. This connection not only enhances ecological resilience but also creates accessible recreational spaces for residents and tourists, promotes non-motorized transit options, and contributes to sustainable urban planning.

3. Data Sources and Research Methodology

The study relies on both primary and secondary data sources, including expert interviews, satellite data processing, and point of interest data collection using the Google Places API. The methodology follows a structured three-step process: creation of thematic layers, rating and weighting of factors, and identification of suitable areas for greenway connectivity [21]. This approach ensures a comprehensive analysis, addressing both ecological and social factors in the greenway planning process.

- Satellite Imagery: Sentinel-2 satellite imagery (from May 2022) with a 10-meter ground resolution and 13 spectral bands was processed to generate land use and land cover (LULC) maps. This imagery was crucial for identifying natural areas and built-up zones, serving as the foundation for the habitat suitability analysis. Using object-oriented classification in Cognition software enabled a more refined interpretation of imagery by incorporating spatial relationships and contextual information of image objects [22].
- Point of Interest (POI) Data: The Google Places API was employed to extract data related to points of interest, such as tourist attractions, educational institutions, parks, markets, and hospitals [23]. This data was necessary for understanding the spatial distribution of demand areas and ensuring that the greenway network connects key locations within South Delhi. The demand data was categorized into residential, commercial, recreational, and historical categories to provide a comprehensive view of the urban landscape [24].
- Expert Interviews: To refine the selection of criteria and validate the thematic layers, expert interviews were conducted with urban planners, ecologists, and GIS specialists. Their input was essential in determining the weights and ranks of various suitability factors used in the analysis [25].
- Survey of India Maps: Road and railway networks were digitized from Survey of India maps, providing a clear understanding of existing transportation routes. This data was integrated with satellite imagery to ensure connectivity between greenway corridors and existing infrastructure.

Methodological Framework

The methodology is structured around the creation of thematic layers, followed by a suitability analysis using the Rating and Weighting (RAW) method, which assigns weights based on the importance of various factors. These steps help identify the most suitable areas for establishing greenways, focusing on ecological connectivity, accessibility, and human interaction with the environment [26]. The RAW method was employed to assign relative importance to each of the thematic layers by combining expert input and literature review. Each thematic layer (e.g., land availability, road density, protected areas) was first scored based on its contribution to greenway suitability. Experts provided rankings for these layers using a structured questionnaire, which were normalized to derive weights. These weights were then used in a weighted overlay analysis to integrate the spatial layers in ArcGIS. Each factor, such as land availability, road density, and protected areas, was evaluated based on its relevance to greenway planning. Expert feedback was used to assign a relative weight (e.g., percentages) to each factor, emphasizing their importance in supporting ecological connectivity and urban liveability. These weights were applied to thematic layers, and the layers were combined using GIS-based weighted overlay analysis. For example, land availability was weighted higher for green spaces and natural areas compared to built-up zones due to their ecological benefits.

1. Step 1: Creation of Thematic Layers

The first step involves generating thematic layers to represent the different factors influencing greenway suitability. The thematic layers include primary data, such as field observations and expert interviews, complemented by secondary sources like Sentinel-2 imagery, Survey of India maps, and Google Places API data. For instance, primary data was used to validate land-use classifications derived from satellite imagery and to identify gaps in road network data. This integration ensured that the spatial layers accurately reflected on-ground conditions.

- Land Use and Land Cover (LULC): Object-oriented classification was used to categorize land into forest, wetlands, waterbodies, barren land, agricultural land, built-up areas, and industrial zones. Object-oriented classification differs from traditional pixel-based classification by considering spatial, textural, and spectral properties of image objects. In this study, classification was refined into classes by grouping similar features within a spatial hierarchy. These classes were validated through field observations and cross-verified with secondary datasets. Classification helps identify potential land for greenways, prioritizing natural and open spaces over built-up areas [12]. Object-oriented classification differs from traditional pixel-based classification by considering spatial, textural, and spectral properties of image objects. In this study, classification was refined into classes by grouping similar features within a spatial hierarchy. These classes were validated through field observations and cross-verified with secondary datasets.
- Road Network: Major highways and roads (e.g., NH 148, NH 44, NH 19, NH 48) were integrated into the analysis to ensure that the greenway system would connect key transportation corridors and improve accessibility [27].
- Topography: Elevation and slope data were extracted from Digital Elevation Models (DEMs) to determine how terrain might influence the movement of people and wildlife. Areas with less steep slopes were prioritized for greenway routes [13].
- Protected Areas: Ecologically sensitive habitats, like the Asola Bhatti Wildlife Sanctuary, were mapped and prioritized due to their ecological importance and potential influence on the greenway network [18].

2. Step 2: Rating and Weighting Method (RAW)

The RAW method was employed to assign relative importance to each of the thematic layers based on a comprehensive review of literature and expert input [28]. Expert interviews involved consultations with ecologists, urban planners, and GIS professionals. The interviews were structured around a series of weighted criteria, where participants ranked factors such as land availability, road density, and attractiveness on a scale of 1 to 5. These rankings were normalized to derive weights and ensure comparability across different criteria. Suitable areas for greenway connectivity were identified based on factors such as land availability, naturalness, proximity to demand areas, and connectivity with existing networks. These criteria were evaluated by overlaying thematic layers and scoring areas based on the weights assigned through the RAW method. Each factor was weighted based on its significance in greenway planning, as follows:

- Land Availability: Areas with more natural land, such as forests and wetlands, were weighted higher, while built-up and industrial areas were weighted lower [15].
- Attractiveness and Naturalness: Greenways that enhance urban aesthetics and recreational opportunities were prioritized. Natural areas with scenic features were given higher weights [29].
- Demand Areas: Proximity to schools, parks, markets, and other public amenities was a critical factor in the weighting scheme, ensuring that the greenway network serves densely populated and high-demand areas [10].

- Road Network: Areas with lower road density were prioritized to reduce the potential for conflict between greenway users and vehicular traffic[17].

The RAW method was applied by assigning scores to thematic layers based on expert-validated criteria. For example, land availability in green spaces like forests and parks was scored higher due to its potential for greenway integration, whereas built-up areas were scored lower. Scores for each criterion were converted into weights, reflecting their proportional significance in the overall analysis. These weighted layers were overlaid using GIS to identify areas of maximum suitability.

3. Step 3: Habitat Suitability and Site Selection

Once the layers were weighted and combined, the resulting suitability map highlighted areas most appropriate for greenway development[30]. The suitability map was refined by assessing areas for their ability to connect existing green spaces, urban landmarks, and demand nodes. For example, areas near schools, parks, and transit hubs were prioritized to maximize accessibility. The final map underwent validation by comparing the proposed greenway routes with known ecological corridors and urban transit networks.The final suitability map was produced using a weighted overlay tool in ArcGIS, integrating all factors into a single spatial layer[31]. The identified areas were then refined to ensure connectivity between key urban landmarks, natural habitats, and recreational spaces[32] (**Figure 2**).

4. Result and Discussion

To understand the spatial distribution of greenway suitability, several factors were considered in detail:

Land use land cover:The land classification from Sentinel-2 imagery was analysed to determine areas of natural and open spaces that could be incorporated into the greenway network (**Figure 3A**). Road Network:Major highways were assessed to identify possible greenway corridors that connect transportation hubs (**Figure 3B**). Topography: Slope and elevation data informed the identification of the most feasible routes for pedestrian and wildlife movement (**Figure 3C**). Protected Areas:Conservation areas, such as wildlife sanctuaries, were evaluated to determine their suitability for integration into the greenway network, while ensuring minimal disruption to their ecosystems (**Figure 3D**). Demand Areas: Demand locations were analysed and categorized into manufacturing, services, retail, recreational, residential, and historical categories. Manufacturing includes factories, services cover health facilities, educational institutions, bus terminals, and religious places. Retail consists of markets, restaurants, and malls, while recreational includes parks and theatres. Historical locations are significant tourist destinations. Categorizing these locations provides a comprehensive view of the urban landscape, which helps in effectively planning and developing the greenway network.

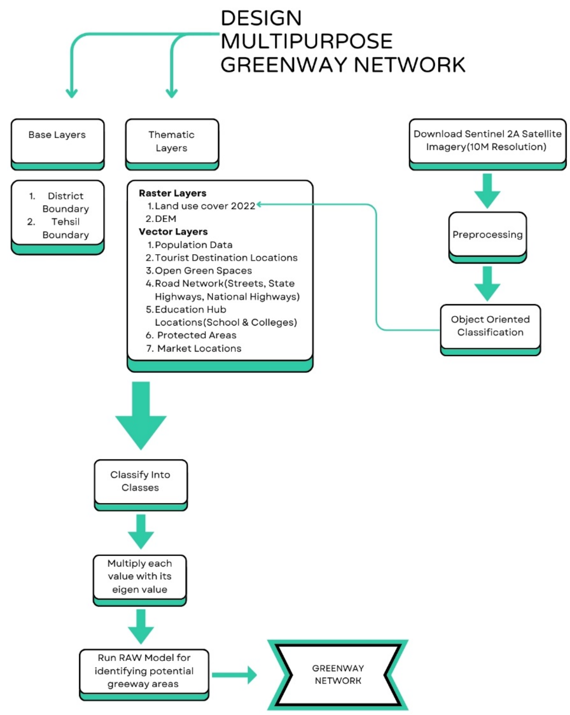

Figure 2. Methodology framework for delineating the greenwaynetwork.

Source: Prepared by authors.

The multi-step approach adopted in this study ensures a comprehensive assessment of both environmental and human factors, providing a robust foundation for greenway planning in urban contexts. Despite its strengths, the proposed greenway model faces several limitations that need to be addressed. The feasibility of implementation is constrained by land-use conflicts, such as competing demands for residential and commercial development. Political challenges, including interdepartmental coordination and resistance to land acquisition, may delay the project. Funding constraints also pose a barrier, as large-scale infrastructure projects often struggle to secure adequate resources. Addressing these challenges will require innovative solutions, such as prioritizing the use of underutilized public land, establishing public-private partnerships, and integrating greenways into broader urban policies like smart city frameworks. The findings underscore the importance of integrating greenways into urban development plans to enhance ecological resilience and urban liveability. Policymakers can designate these greenways as protected corridors within zoning regulations, ensuring their preservation amidst rapid urbanization. Additionally, linking greenways with existing infrastructure, such as transportation networks, can enhance connectivity and provide alternative transit options for residents. By integrating geospatial technology with expert knowledge and public data, the methodology addresses the need for sustainable urban development that balances ecological conservation with human well-being [33]. The use of the RAW method further strengthens the analysis, ensuring that each thematic layer is appropriately weighted, reflecting its importance in greenway planning [34]. This approach also allows for flexibility and adaptability, enabling the methodology to be applied to other urban areas with similar challenges [35].

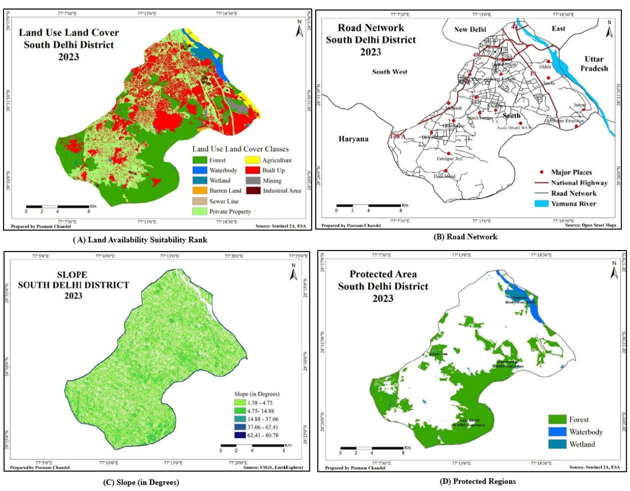

Figure 3. Spatial distribution of greenwaysuitability: (**A**) land use land cover; (**B**) roadnetwork; (**C**) slope (in degree); (**D**) protecteddregions.

Results

Suitability analysis is a common method in greenway planning, where multiple factors are evaluated and weighted, often with GIS tools, to determine suitable areas for greenway development. However, current GIS-based approaches can overlook urban design considerations and the comparison of large-scale factors such as land use, ownership, and residential density. This section addresses these gaps and emphasizes the need for a comprehensive analysis that includes both natural and urban factors.

- Assessing Suitability Factors
  Several key factors were assessed to determine suitable areas for greenway networks, including land availability, road density, attractiveness, protected areas, demand areas, and topography. Each factor was evaluated based on its potential to support a greenway, with weightages assigned using the RAW method. **Figure 4** displays suitability ranking maps, highlighting the varied weights assigned to layers according to their role in defining the greenway network. These maps illustrate areas that are most and least suitable for establishing the greenway network.
- Land Availability
  Greenways are best located in existing parks, green spaces, and areas with natural greenery. Built-up areas and privately owned lands are less suitable for greenway development (**Figure 4A**).
- Attractiveness
  Naturalness is a key factor that appeals to people in any ecosystem, including urban areas. When evaluating sections of the greenway corridor, individuals often value wild nature and emphasize the importance of protecting and restoring natural areas. In South Delhi, recreational landscapes with higher levels of naturalness, such as rivers, lakes, parks, forests, and wetlands, are considered highly suitable for greenways. In contrast, areas with significant human intervention, like central areas, streets, and commercial zones, are less suitable due to their lower naturalness (**Figure 4B**).This assessment underscores the importance of prioritizing areas with preserved natural features for greenway development in South Delhi, enhancing the natural experience for residents and visitors.
- Protected Areas
  Sensitive habitats should be prioritized and given a high suitability ranking due to their natural features. While some protected areas can enhance visitor experiences by allowing wildlife close to human activity, access should be restricted to prevent disturbance to species in their natural habitat. Preserving as much of the original environment as possible is essential. Al-

though routing the greenway through these areas can be costly, it is generally considered unsuitable to extend the greenway close to sensitive habitats (**Figure 4D**).

- Topography
  Topography greatly affects the movement of people and animals and influences where individuals choose to live and work. Therefore, it is a key factor in determining the location of a greenway corridor. The analysis focuses on identifying topographies that facilitate movement and enhance scenic spots, considering these two aspects of suitability (**Figure 4E**).
- Demand Areas
  When assessing the suitability of the greenway network, it is essential to consider activity concentrations in areas of high demand. In this factor of suitability, the classification is simplified to two ranks: "highly suitable" and "not suitable" (**Figure 4F**).
- Road Density
  Areas with a high density of roads indicate a greater length of roads per square kilometer. This circumstance limits the possibility of integrating greenways, leading to a lower suitability ranking for such areas. Accordingly, areas with lower road density and lower traffic zones are considered more suitable based on this parameter (**Figure 4C**).

The suitability assessment for greenway networks integrates multiple factors critical to establishing a well-balanced, accessible, and ecologically sensitive pathway. Key elements like land availability, road density, attractiveness, protected areas, demand areas, and topography were meticulously evaluated; different categories of the factors were assigned a weight based on their relevance to greenway development through the RAW method. Land availability is prioritized in parks and naturally green spaces, as these areas offer ideal settings for greenways, while built-up and privatelyowned lands rank lower due to limited accessibility. Attractiveness, a factor rooted in natural appeal, favors areas rich in natural landscapes such as rivers, lakes, forests, and parks; these scenic, green spaces draw people by enhancing their connection to nature. In contrast, highly urbanized zones, such as commercial and central areas, are less suitable due to their limited natural elements.

Protected areas, like wildlife sanctuaries, are given high priority for preservation, with restricted access near sensitive habitats to avoid wildlife disturbance, thus supporting a sustainable greenway design. Topography, too, plays a critical role by influencing movement and enhancing scenic spots, with favourable topographies selected to optimize accessibility and enjoyment. Demand areas, or zones with high activity levels, are marked as "highly suitable" to meet user needs effectively.

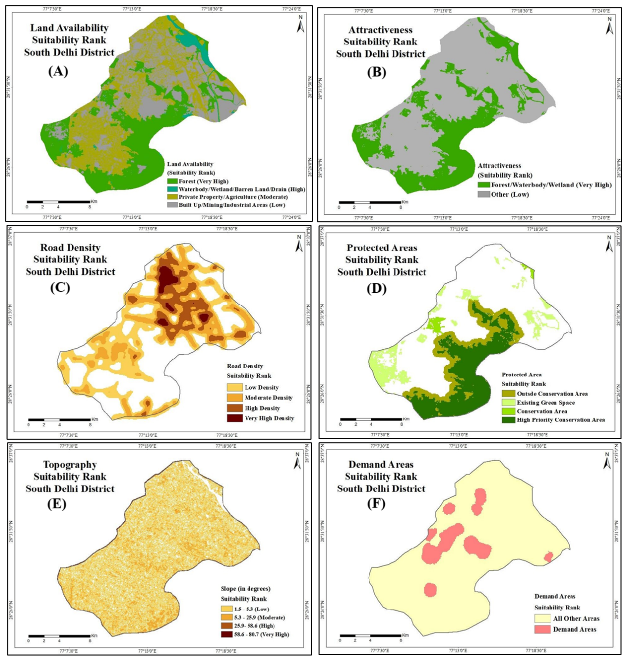

Figure 4. Suitability ranking for land use planning in SouthDelhi district based on various factors, (**A**) land availability suitability rank; (**B**) attractiveness suitability rank; (**C**) road density suitability rank; (**D**) protected area suitability rank; (**E**) topography suitability rank; (**F**) demand areas suitability rank.

Source: Prepared by authors.

Finally, areas with high road density rank lower in suitability, as dense road networks impede greenway integration, making low-density and less-trafficked zones preferable. These assessments, visualized in suitability ranking maps, collectively inform a greenway layout that fosters ecological connectivity, scenic value, and public accessibility, balancing human activity with environmental preservation. **Table 1** provides a detailed assessment of various suitability factors for the greenway network, ranking them based on how conducive they are to greenway development, their relative cost values, and the percentage weight assigned to each factor.

1. Land Availability: Different land types are categorized according to their suitability for greenways. Forested areas are considered the most favourable,

receiving a "Very High" suitability rank and a significant weight of 40%, emphasizing their critical role in greenway placement. In contrast, water bodies, wetlands, and barren or sewer line land are ranked as "High", while private property and agricultural areas are given a "Moderate" rank, indicating less feasibility for greenway integration.

2. Attractiveness: This factor considers the natural appeal of an area, which influences its suitability for greenway development. Forests, water bodies, and wetlands are given a "Very High" suitability rank, aligning with their high aesthetic and ecological value, though with a lower weight of 10% to balance other critical factors. Built-up, industrial, mining, and barren areas, as well as sewer lines, receive a "Low" rank, indicating limited attractiveness for greenways.
3. Road Density: Road density impacts greenway placement by affecting accessibility and usability. Areas with low road density are assigned a "Very High" suitability rank (10% weight), favoring less congested spaces that are easier to integrate. As density increases, the suitability rank drops, with moderate density marked as "Moderate" and high to very high densities labeled as "Low" and "Very Low", respectively, highlighting the challenges of integrating greenways in heavily trafficked zones.
4. Protected Areas: This factor evaluates conservation priorities, with existing green spaces and areas outside conservation zones ranked as highly suitable (20% weight), while areas within conservation boundaries are ranked "Moderate" to safeguard sensitive habitats. This prioritization balances the ecological sensitivity of these regions with accessibility considerations for greenway development.
5. Topography: Slope steepness greatly affects usability, with gentle slopes (1.5–5.3º) ranked "Very High" in suitability, enhancing accessibility and scenic views for greenways, assigned a 10% weight. As the slope increases (5.3–80.7º), suitability decreases from "High" to "Low", indicating greater limitations for greenway placement in steep terrains.
6. Demand Areas: Areas with high recreational or functional demand for greenways receive a "Very High" suitability rank (10% weight), emphasizing the importance of aligning greenway placement with user needs. Other areas with lower demand are rated "Low", indicating limited suitability for greenway establishment.

Each factor is systematically weighted to reflect its contribution to creating a viable greenway network, balancing ecological, aesthetic, accessibility, and user demand considerations. This ranking approach provides a structured framework for identifying ideal greenway locations, supporting both environmental preservation and community utility.

The ranking and weightage method (RAW) is a widely used approach in GIS for site suitability analysis. It involves assigning weights to different criteria or factors that are relevant to determining the suitability of a site for a specific purpose. In this study, the suitability assessment focused on six factors, following the methodology outlined by Miller and Conine. These factors included land availability, road density, attractiveness, protected area, demand areas, and topography. The spatial layers of these factors were assigned weights based on their contribution to delineating the greenway network. The weighted overlay tool in ArcGIS 10.2.2 was employed to overlay all the suitability factors, incorporating their assigned weightages. This generated a map illustrating the areas that are highly and least suitable for delineating the greenway network (**Figure 5**).

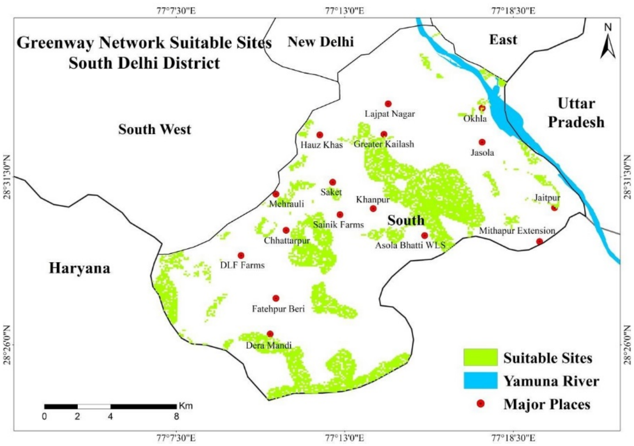

Figure 5. Suitable sites for delineatinggreenwaynetwork.

Source: Prepared by authors.

A significant portion of the district exhibits suitability for the delineation of a greenway network, primarily concentrated in the Central and South Central part of the district. Particularly, the Eastern edge of the Asola Bhatti Wildlife Sanctuary, Khanpur, and Greater Kailash areas showcase a large extent of suitability. Additionally, a smaller portion of

Table 1. Assessing suitability factors for greenway network.

Suitability	Category	Suitability	Cost Value	Factor Weight
Land availability	Forest	Very High	1	40%
	Water body, wetland, barren sewer line land,	High	2	
	Private property, Agriculture	Moderate	3	
Attractiveness	Forest, water body, wetland	Very High	1	10%
	Built up, mining, industrial area, barren land, sewer line	Low	2	
Road density	Low density	Very High	1	10%
	Moderate road density	Moderate	2	
	High density	Low	3	
	Very high road density	Very High	4	
Protected areas	Areas outside	Very Low	1	20%
	Conservation areas	High		
	Existing green	High	2	
	Conservation	Moderate	3	
Topography	Slope 1.5–5.3º	Very High	1	10%
	Slope 5.3–25.9º	High	2	
	Slope 25.9–58.6º	Moderate	3	
	Slope 58.6–80.7º	Low	4	
Demand areas	Demand areas	Very High	1	10 %
	All other areas	Low	4	

Source: Conine et al. [28]; Miller et al. [26]; Blob [27]; Donald, Alan, & Robert, 2003 [36]; Teng, M. et al. 2011 [37].

highly suitable areas can be found near the Center of the Yamuna River. Isolated sections of smaller size, such as those around Chhattarpur, Saket, Hauz Khas, and Mehrauli, are also identified as highly suitable for the greenway network. Furthermore, there is a suitable area located in the extreme North West part of the district.These sites were prioritized due to their high ecological value, accessibility, and connectivity to existing green spaces. For instance, the Asola Bhatti Wildlife Sanctuary is a critical biodiversity hotspot, while Hauz Khas and Saket offer opportunities to integrate cultural landmarks and urban recreation. However, the selection process also revealed challenges. Some other areas in South Delhi, such as residential neighborhoods with potential demand for greenways, were deprioritized due to high road density or limited land availability. Unexpectedly, certain locations near urban edges, such as Sangam Vihar, showed suitability but posed challenges due to fragmented land ownership and lack of ecological continuity.

5. Strategies and Recommendations for Greenway Network Planning

South Delhi, as a rapidly growing area in India's capital, faces substantial environmental challenges stemming from urban expansion. These greenway networks provide a blueprint for embedding ecological considerations into urban development plans, aligning with the goals of sustainable urbanization. By designating greenways as critical infrastructure within urban planning policies, municipal authorities can ensure their integration into zoning regulations, land use planning, and infrastructure development projects. This chapter explores strategies to create a cohesive greenway system that aligns with broader urban planning goals, bringing together policymakers, urban planners, ecologists, and the community. A sustainable greenway network can provide much-needed ecological support in urban development, ultimately improving the quality of life for residents and serving as a model for other expanding megacities.

5.1. Strategic Framework for Implementation

To effectively incorporate greenways into South Delhi's urban landscape, a multi-tiered framework is essential, prioritizing both ecological conservation and community benefits. Key principles within this framework include integration, connectivity, community engagement, sustainability, policy support, and phased implementation. This principle can be operationalized through strategic policy interventions, such as mandating greenway inclusion in urban master plans, incentivizing private developers to incorporate green spaces within their projects, and linking greenway development to climate adaptation and resilience frameworks. These steps not only enhance urban ecosystems but also align with global sustainability goals, such as those outlined in the UN Sustainable Development Goals (SDGs). Connectivity focuses on establishing green corridors that allow for the movement of wildlife and provide safe, accessible pathways for residents, linking neighborhoods, parks, and cultural landmarks. Urban planners can leverage these greenways to align with broader sustainability goals, such as reducing urban heat islands, mitigating air pollution, and creating inclusive public spaces. Policy frameworks should mandate the integration of greenways into urban master plans and smart city initiatives, ensuring their role as critical infrastructure for sustainable urban growth. Engaging the community in planning and maintenance builds local support, while sustainability calls for the use of native species and sustainable practices, potentially supported by ecotourism activities. To overcome feasibility issues, the proposed model should incorporate flexible land-use strategies, such as utilizing vacant or abandoned spaces, which minimizes conflicts with existing developments. Additionally, aligning greenway projects with broader environmental initiatives, such as climate adaptation programs, can help secure funding and political support. Strong policy support is critical to protect these spaces from development pressures and secure funding, and a phased implementation approach allows for manageable, cost-effective development over time.

Implementation Challenges and Strategies

Implementing greenway networks in South Delhi faces several challenges that need to be carefully addressed for successful integration into the urban landscape:

- Political and Administrative Challenges
  Coordinating between multiple government departments, such as urban planning, transport, and environment, can be complex. Conflicting priorities, such as infrastructure development versus conservation, may delay greenway projects.
  Strategy: Establish a dedicated greenway task force comprising representatives from relevant departments and local stakeholders to streamline decision-making and ensure interdepartmental coordination. Integrating greenways into the city's master plan will formalize their importance, reducing conflicts during development.
- Financial Constraints
  Limited budgets for urban green infrastructure projects can hinder the large-scale implementation of greenways.
  Strategy: Explore diverse funding sources, including public-private partnerships, green bonds, and international sustainability grants. Developers can also be incentivized to contribute through tax benefits or zoning bonuses for projects that incorporate greenway corridors.
- Logistical Barriers
  Acquiring land for greenways in densely populated areas poses a significant challenge. Fragmented land ownership, competing land use demands, and legal disputes can delay projects.
  Strategy: Prioritize the use of government-owned land, abandoned or underutilized spaces, and existing corridors like riverbanks or railway lines for greenway development. Community engagement initiatives can help negotiate land use changes by demonstrating the benefits of greenways to residents.
- Community Acceptance
  Public opposition may arise if greenway projects disrupt local businesses, housing, or daily activities.
  Strategy: Conduct participatory planning workshops to involve communities in greenway design, highlighting the potential economic and social benefits. Education campaigns and pilot projects can build trust and generate local support.
- Maintenance and Sustainability
  Long-term upkeep of greenways requires consistent funding and community involvement. Without regular maintenance, greenways risk degradation and loss of usability.
  Strategy: Establish community stewardship programs, where residents and local organizations participate in the upkeep of greenways. Partnerships with NGOs and environmental groups can also provide sustainable maintenance solutions.

5.2. Policy Recommendations

Successful greenway development in South Delhi requires robust policy support at various levels. For example, policies could establish greenways as protected corridors under municipal bylaws, ensuring their preservation amidst urban expansion. Development projects adjacent to these corridors could be required to follow buffer zone regulations to minimize ecological disruptions. Additionally, incorporating greenways into smart city initiatives would enhance connectivity between urban sustainability and technological advancements. Zoning and land-use planning regulations should designate specific corridors for greenway use, integrating these spaces into the broader urban landscape. Design standards must be established to ensure greenways are functional, environmentally compatible, and sustainable. Diverse funding mechanisms, including government allocations, green bonds, and private sector contributions, will help sustain the network financially. Community stewardship programs should be created to involve locals in greenway maintenance, fostering a sense of ownership and ensuring long-term care. Additionally, environmental impact assessments should be mandatory for all urban development projects to protect greenways and maintain transparency in planning processes.

5.3. Implementation Steps

The greenway network's successful implementation in South Delhi requires tactical, step-by-step planning. Phased development is essential, breaking the project into segments and focusing on high-impact areas to maximize resource efficiency. A multidisciplinary committee, including representatives from key stakeholder groups, should oversee the project, providing guidance and ensuring cohesive coordination. Community engagement strategies, such as surveys, workshops, and volunteer programs, can help align the network with local needs and encourage community buy-in. Technical assessments, including feasibility studies, will provide critical insights into the geographic, ecological, and social impacts of the greenway network. Small-scale pilot projects can be launched to test design concepts and gather community feedback, refining the larger network design. Monitoring and adaptive management systems should be established to track the network's usage and ecological impact, allowing for continuous improvement. Raising awareness through branding, community events, and outreach campaigns will also help promote greenway use and encourage sustainable practices. Long-term maintenance plans, potentially involving community volunteers, will ensure the network remains attractive and functional.

5.4. Enhancing Ecological Connectivity

A critical goal of the greenway network is to improve ecological connectivity across South Delhi by linking fragmented habitats and supporting local wildlife. Corridor mapping, utilizing GIS tools and ecological assessments, can help design an effective blueprint for habitat connections. Restoring natural habitats along these corridors with native plant species will attract and sustain local wildlife populations. These greenways can also act as natural buffers against climate change impacts, such as urban flooding and heatwaves. Policymakers should integrate greenways into climate adaptation strategies, ensuring they serve both ecological and infrastructural purposes.Infrastructure elements such as wildlife crossings and green bridges can facilitate safe animal movement across urban areas. Additionally, the greenway network can augment ecosystem services like pollination and water filtration through diverse plantings, contributing to environmental health. Educational initiatives along the greenways can serve as interactive spaces to foster community appreciation for biodiversity and ecological conservation.Greenways should be formalized as key ecological assets in urban resilience strategies, serving as natural buffers against climate impacts like flooding and heat waves. Policies could prioritize their expansion in high-risk urban areas to enhance both ecological and social adaptive capacities.

5.5. Urban Integration

Integrating greenways into South Delhi's urban environment requires thoughtful design that complements the city's development goals while enhancing ecological health. Accessibility should be a priority, ensuring greenways are easily reachable from neighborhoods and connected to commercial and cultural hubs. Urban aesthetics must be considered, designing greenways that align with South Delhi's unique character to create functional, visually appealing spaces. Sustainability features, such as rain gardens, permeable pavements, and native vegetation, can be included to manage urban runoff and support biodiversity. Collaborative design efforts with urban planners, architects, environmentalists, and community representatives will ensure the greenways meet diverse needs and promote a shared vision for sustainable development.

5.6. Stakeholders Engagement

Effective stakeholder engagement is vital for the long-term success of the greenway network. A structured engagement approach should involve identifying all relevant stakeholders, establishing clear communication channels, and including the community in both the design and maintenance processes. Public meetings and workshops can serve as forums to gather input and feedback from residents, businesses, and organizations, ensuring the greenways reflect community needs and preferences. Participatory planning sessions can encourage local involvement, giving residents a sense of ownership and responsibility toward the greenways. Continued engagement through volunteer programs, educational events, and regular updates will help adapt the network to evolving needs and maintain strong community support.

6. Sustainable Suggestions

- Expand Greenway Networks: Develop interconnected greenways linking parks and forests to support biodiversity and strengthen the urban ecosystem.
- Zoning and Protection Policies: Enforce zoning to protect conservation areas from urban sprawl, preserving green spaces for ecology and recreation.
- GIS-Based Planning: Use GIS and remote sensing to identify ideal sites for green spaces and areas needing environmental relief.
- Community Involvement: Engage locals in tree planting and maintenance to foster a sense of ownership and sustainable care for greenways.
- Improve Accessibility: Make green spaces accessible to all with safe pathways for exercise and social interaction.
- Sustainable Design: Use permeable pavements, urban forestry, and rain gardens to manage stormwater, reduce heat, and improve air quality.
- Replicate Model: Promote South Delhi's greenways as a model for sustainable urban planning in other cities.
- Monitor and Evaluate: Set up regular evaluations to adapt greenway management to ecological and community needs.

7. Conclusions

South Delhi, as a rapidly growing district in the National Capital Territory of Delhi, faces the challenge of balancing urban development with environmental sustainability. The district's appeal as a commercial, residential, and cultural hub has led to high demand for land and infrastructure development. Despite these pressures, South Delhi benefits from a wealth of green spaces, such as Deer Park, Rose Garden, and Asola Bhatti Wildlife Sanctuary, which are essential for maintaining ecological balance. This study underscores the importance of protecting and enhancing these green spaces through the development of greenway networks, which connect parks, forests, and natural reserves, promoting biodiversity, and improving the quality of life for residents. The findings underscore the potential of greenways to serve as a foundational element in urban sustainability frameworks, addressing issues such as heat islands, biodiversity loss, and limited recreational access. Policymakers can use these insights to integrate greenways into comprehensive urban plans, ensuring they contribute to long-term ecological and social resilience in cities like South Delhi and beyond. By strategically using GIS and remote sensing data, the study identifies areas that are optimal for ecological connectivity while considering the demands of urban infrastructure. Greenways are shown to play a multifaceted role in reducing urban heat islands, mitigating pollution, and providing recreational spaces, thus fostering a healthier urban environment in South Delhi. However, successful implementation requires overcoming challenges such as financial constraints, political coordination, and land acquisition. This study highlights potential strategies, including multi-stakeholder collaboration, innovative funding mechanisms, and participatory planning, to address these barriers. This approach presents a model for sustainable urban planning that can be replicated in other cities facing similar challenges. However, implementing the model in South Delhi requires addressing potential barriers, including land-use conflicts, political resistance, and funding shortages. Learning from successful greenway projects in cities like Bangalore and Singapore can provide a roadmap for scaling and adapting the model to different urban contexts. By leveraging these lessons, the proposed greenway network can serve as a scalable framework for sustainable urban planning in rapidly urbanizing regions. For urban planners, the integration of greenways offers practical solutions to balance development with sustainability in rapidly growing cities like South Delhi. These findings emphasize the need for proactive policies that incorporate greenways into urban frameworks, leveraging them to address challenges like habitat fragmentation, public health concerns, and urban heat islands. By embedding these networks into city master plans, policymakers can foster sustainable urban growth while ensuring ecological and social resilience.

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All authors have contributed equally to the research, analysis, and writing of this study.

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Informed Consent Statement

Not applicable, as the study did not involve humans.

Data Availability Statement

All data supporting the reported results are provided within the manuscript. Additional data can be made available upon reasonable request.

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Conflicts of Interest

The authors declare no conflict of interest.

References

[1] McGranahan, G., Satterthwaite, D., 2014. Urbanization: Concepts and trends. IIED Working Paper, Paper Number 10709IIED, 15 October 2014. Available from: http://pubs.iied.org/10709IIED

[2] Zhang, Q.X., 2015. The trends, promises and challenges of urbanization in the world. Habitat International. 54(Part 3), 241–252. DOI: http://dx.doi.org/10.1016/j.habitatint.2015.11.018

[3] Sharma, M., Kumar, V., Kumar, S., 2024. A systematic review of urban sprawl and land use/land cover change studies in India. Sustainable Environment. 10(1), 2331269. DOI: https://doi.org/10.1080/27658511.2024.2331269

[4] Song, X., Liu, Y., Zhu, X., et al., 2021. The impacts of urban land expansion on ecosystem services in Wuhan, China. Environmental Science and Pollution Research. 29(7), 10635–10648. DOI: https://doi.org/10.1007/s11356-021-16419-4

[5] Liu, T., Yu, L., Chen, X., et al., 2024. Identifying potential urban greenways by considering green space exposure levels and maximizing recreational flows: A case study in Beijing's built-up areas. Land. 13(11), 1793. DOI: https://doi.org/10.3390/land13111793

[6] Ignatieva, M., Stewart, G.H., Meurk, C., 2010. Planning and design of ecological networks in urban areas. Landscape and Ecological Engineering. 7(1), 17–25. DOI: https://doi.org/10.1007/s11355-010-0143-y

[7] Peng, X., 2018. Spatial green belt development report in China. Frontiers Research of Architecture and Engineering. 1(4), 98. DOI: https://doi.org/10.30564/frae.v1i4.247

[8] Jim, C.Y., Lo, A.Y., Byrne, J.A., 2015. Charting the green and climate-adaptive city. Landscape and Urban Planning. 138, 51–53. DOI: https://doi.org/10.1016/j.landurbplan.2015.03.007

[9] Kremer, P., Hamstead, Z.A., McPhearson, T., 2016. The value of urban ecosystem services in New York City: A spatially explicit multicriteria analysis of landscape scale valuation scenarios. Environmental Science & Policy. 62, 57–68. DOI: http://doi.org/10.1016/j.envsci.2016.04.012

[10] Baris, M., 2010. The effects of urbanization on the environment and the role of greenways. Environmental Urban Studies. 25(3), 45–58.

[11] Secretariat of the Convention on Biological Diversity, 2014. Global Biodiversity Outlook 4. Report

No. 92-9225-539-8, 6 October 2014. Available from: https://www.cbd.int/gbo4 (cited 25 December 2024).

[12] Bennett, A.F., Radford, J.Q., Haslem, A., 2006. Properties of land mosaics: Implications for biodiversity. Ecology Letters. 9(10), 1193–1204.

[13] Taylor, P.D., Fahrig, L., Henein, K., et al., 1993. Connectivity is a vital element of landscape structure. Oikos. 68(3), 571–573. DOI: https://doi.org/10.2307/3544927

[14] Tang, Z., Ye, Y., Jiang, Z., et al., 2020. A Data-Informed Analytical Approach to Human-Scale Greenway Planning: Integrating Multi-Sourced Urban Data with Machine Learning Algorithms. Urban Forestry and Urban Greening, 56, Article ID: 126871. DOI: https://doi.org/10.1016/j.ufug.2020.126871

[15] Du, X., Tang, M., Chen, W., 2012. Application of greenway planning for ecological protection: A case study of Chongming Island, China. Journal of Environmental Management. 103, 18–27.

[16] Du, Q., Zhang, C., Wang, K., 2012. Suitability analysis for greenway planning in China: An example of Chongming Island. Environmental Management. 49(1), 96–110. DOI: https://doi.org/10.1007/s00267-011-9768-3

[17] Korkou M., Tarigan A.K.M., Hanslin H.M., 2023. The multifunctionality concept in urban green infrastructure planning: A systematic literature review. Urban Forestry Urban Greening. 85, 127975. DOI: https://doi.org/10.1016/j.ufug.2023.127975

[18] Turner, M., Gardner, R., 1991. Quantitative methods in landscape ecology. Springer: New York, NY, USA. pp. 3–14.

[19] Balta, M.Ö., Yenil, H.Ü., 2019. Multi criteria decision making methods for urban greenway: The case of Aksaray, Turkey. Land Use Policy. 89, 104224. DOI: https://doi.org/10.1016/j.landusepol.2019.104224

[20] Zhang, F., Qian, H., 2024. A comprehensive review of the environmental benefits of urban green spaces. Environmental Research. 252, 118837. DOI: https://doi.org/10.1016/j.envres.2024.118837

[21] Gharaibeh, A.A. and Sawalqah, H.A., 2016. Greenway Planning; Developing A Network Methodology For Jordan. Proceedings of the Fábos Conference on Landscape and Greenway Planning. 5(1), 38. DOI: https://doi.org/10.7275/fabos.627

[22] Blaschke, T., 2010. Object-based image analysis for remote sensing. ISPRS Journal of Photogrammetry and Remote Sensing. 65(1), 2–16.

[23] Wu, Z., Cheng, S., Xu, K., et al., 2024. Ecological Network Resilience Evaluation and Ecological Strategic Space Identification based on complex network theory: A case study of Nanjing city. Ecological Indicators. 158, 111604. DOI: https://doi.org/10.1016/j.ecolind.2024.111604

[24] Gharaibeh, S., 2016. Identifying multipurpose greenway networks using spatial analysis: A model for sustainable urban planning. Journal of Urban Studies. 53(6), 1032–1045.

[25] Fabos, J.G., 1995. Introduction and overview: The greenway movement, uses and potentials of greenways. Landscape and Urban Planning. 33(1–3), 1–13.

[26] Miller, W., Collins, G.M., Steiner, R.F., et al., 1998. An approach for greenway suitability analysis. Landscape and Urban Planning. 41(5), 657–670.

[27] Blob, H., 2016. Travel-oriented greenway network planning using least-cost path modeling. Landscape and Urban Planning. 145, 123–132.

[28] Conine, A., Xiang, W.N., Young, J., et al., 2004. Planning for multi-purpose greenways in Concord, North Carolina. Landscape and Urban Planning. 68(2–3), 271–287.

[29] Vatanparast, E., ShataeeJoibari, S., Salmanmahiny, A., et al., 2024. Urban greenway planning: Identifying optimal locations for active travel corridors through individual mobility assessment. Urban Forestry & Urban Greening, 128464. DOI: https://doi.org/10.1016/j.ufug.2024.128464

[30] Searns, M.R., 1995. The evolution of greenways as an adaptive urban landscape form. Landscape and Urban Planning. 33(1–3), 65–80. DOI: https://doi.org/10.1016/0169-2046(94)02014-7

[31] Vogt, P., Ferrari, J.R., Lookingbill, T.R., et al., 2009. Mapping functional connectivity. Ecological Indicators. 9(1), 64–71. DOI: https://doi.org/10.1016/j.ecolind.2008.01.011

[32] Zhang, D., Xie, X., Zhou, C., 2023. Spatial influence of exposure to green spaces on the climate comfort of urban habitats in China. Urban Climate. 51, 101657. DOI: https://doi.org/10.1016/j.uclim.2023.101657

[33] Maantay, J., Winner, A., Maroko, A., 2022. Geospatial analysis of the urbanhealthenvironment. In: Faruque, F.S. (ed.). Geospatial Technology for Human Well-Being and Health. Springer: Cham, Germany. pp. 151–183. DOI: https://doi.org/10.1007/978-3-030-71377-5_9

[34] Belisle, M., 2005. Measuring landscape connectivity: The challenge of behavioral landscape ecology. Ecology Letters. 8(5), 879–890

[35] Chin, C., 2020. Understanding greenway habitat through species diversity and vegetation structure analysis. Ecological Applications. 30(2), 123–135.

[36] Donald, W., Alan, P., Robert, S., 2003. Time-Saver Standards for Urban Design. McGraw-Hill.

[37] Teng, M., Wu, C., Zhou, Z., et al., 2011. Multipurpose greenway planning for changing cities: A framework integrating priorities and a least-cost path model. Landscape and Urban Planning, 103(1), 1–14. DOI: https://doi.org/10.1016/j.landurbplan.2011.05.007