

ASSESSMENT OF URBAN PARKS AND RECREATIONAL AREAS IN SAMARKAND CITY USING GEOSPATIAL TECHNOLOGIES

Samarqand Davlat Universiteti
Geografiya mutaxisligi 1-bosqich magistranti

Ergashev Bahodir Abdusattor o'g'li
bahodirergashev77@icloud.com

Abstract

Urban parks and recreational areas are essential elements of sustainable urban development because they provide ecological, social, cultural, and public-health benefits. In rapidly urbanizing historic cities, however, the distribution, accessibility, quality, and ecological condition of green spaces may vary significantly among neighborhoods. This study assesses urban parks and recreational areas in Samarkand City, Uzbekistan, through the application of geospatial technologies. The research combines Geographic Information Systems (GIS), remote sensing, satellite imagery, spatial database development, Normalized Difference Vegetation Index (NDVI) analysis, land-use mapping, buffer analysis, and network-based accessibility assessment. OpenStreetMap data, Sentinel-2 satellite imagery, Landsat imagery, municipal planning documents, and publicly available geographic data were used to identify and evaluate the location, size, vegetation condition, accessibility, and recreational potential of parks.

Keywords: urban parks; recreational areas; GIS; remote sensing; NDVI; accessibility; green infrastructure; Samarkand City; urban planning; sustainable development.

Introduction

Urban parks, gardens, public squares, green corridors, and recreational areas are increasingly recognized as critical components of sustainable cities. They improve air quality, reduce surface temperatures, provide shade, support biodiversity, create opportunities for physical activity, and contribute to residents' psychological well-being.[1] In addition, green spaces are important public places where people can socialize, rest, walk, exercise, and participate in cultural activities. Their value is especially significant in cities with hot and dry climatic conditions, where vegetation can reduce heat stress and improve the microclimate.

Samarkand City is one of the most important historical, cultural, and tourist centers of Uzbekistan. It contains internationally recognized architectural heritage, dense residential neighborhoods, transport corridors, commercial areas, educational

institutions, and expanding urban zones. The city's historical identity is closely connected with gardens, irrigation systems, tree-lined streets, and landscaped public spaces. Nevertheless, population growth, tourism development, road construction, housing expansion, and commercial development can place pressure on existing green and recreational areas.

Recent planning initiatives demonstrate that green infrastructure has become a major issue for Samarkand. The Samarkand Master Plan to 2045 identifies the expansion of green areas and the establishment of a large green belt as strategic priorities. According to public information on the plan, Samarkand currently has approximately 9,461 hectares of green areas, including public parks, restricted-access green territories, and protected natural zones. The plan proposes an additional 11,000 hectares of green areas and an 18,000-hectare green belt around the city.[2] These figures demonstrate the importance of systematic green-space assessment before new projects are implemented.

The European Bank for Reconstruction and Development has also supported the development of a Green City Action Plan for Samarkand. The initiative aims to identify environmental challenges, locate areas with environmental problems, and develop projects that can improve urban sustainability.[3] Such initiatives require accurate spatial data. Traditional descriptive approaches are not sufficient for identifying where parks are located, which neighborhoods lack access, how vegetation quality changes over time, and which recreational areas require investment.

Geospatial technologies offer effective tools for solving these problems. GIS enables the collection, storage, visualization, and analysis of spatial information. Remote sensing allows researchers to monitor vegetation cover, land-use change, surface temperature, and environmental conditions using satellite imagery. The combination of GIS and remote sensing can therefore support evidence-based urban planning and management.[4]

In Uzbekistan, GIS-based studies have increasingly been applied to environmental monitoring, land-cover analysis, tourism mapping, and urban green-space assessment. Research on urban green spaces in Uzbekistan has emphasized that parks, gardens, street trees, forests, riparian vegetation, and green corridors play an important role in creating healthier and more resilient cities.[5] Previous research has also shown that GIS technologies can be used to monitor urban green zones in Uzbek cities, including the assessment of spatial distribution and vegetation condition.[6]

However, there remains a need for a focused assessment of parks and recreational areas specifically within Samarkand City. The present study addresses this gap by applying geospatial technologies to evaluate the spatial distribution, vegetation condition, accessibility, and recreational potential of urban parks. The study has four main objectives:

1. To identify and map urban parks and recreational areas in Samarkand City;
2. To assess vegetation density using satellite-based NDVI analysis;
3. To evaluate residents' accessibility to parks through buffer and network analysis;
4. To propose GIS-based recommendations for sustainable park planning and green-infrastructure development.

Study Area

Samarkand City is located in the central part of Uzbekistan, within the Zarafshan River basin. The city is characterized by a continental and relatively dry climate, with hot summers and cold winters. These climatic conditions increase the importance of trees, parks, water features, and shaded recreational areas for thermal comfort and environmental quality. Samarkand is a major administrative, educational, cultural, and tourism center. Its urban structure includes the historic core, tourism zones, residential neighborhoods, industrial territories, transport infrastructure, public institutions, and expanding suburban settlements. The city has experienced significant modernization and infrastructure development in recent years. Therefore, balancing urban growth with environmental protection and public access to green space is an important planning challenge.

The city's green infrastructure includes formal parks, gardens, boulevards, roadside tree corridors, public squares, river and canal-side vegetation, sports grounds, and neighborhood recreational spaces. The Samarkand urban-development strategy has emphasized the need to reconstruct existing parks, develop green public areas, and create a connected green belt around the city.[7]

Methodology

Research Design

This research uses a mixed geospatial approach combining GIS mapping, remote sensing, spatial analysis, and descriptive assessment. The methodological framework consists of five stages:

1. Collection of spatial and statistical data;
2. Mapping and classification of parks and recreational areas;
3. Vegetation analysis using NDVI;
4. Accessibility analysis using buffer and road-network methods;
5. Interpretation of results and formulation of planning recommendations.

Data Sources

The study uses several categories of spatial data:

- Sentinel-2 multispectral satellite imagery;
- Landsat satellite imagery;
- OpenStreetMap road and land-use data;
- Google Earth imagery for visual verification;
- municipal planning documents;
- publicly available administrative boundary data;
- scientific literature on urban green-space assessment;
- field-based visual interpretation where possible.

Sentinel-2 imagery was selected because it provides multispectral data with a spatial resolution of 10 meters for visible and near-infrared bands. This resolution is suitable for identifying large parks, green corridors, tree-covered areas, and urban vegetation patterns. Landsat imagery was used as supplementary data because it provides a longer historical record for observing vegetation change over time. OpenStreetMap was used to obtain road networks, public facilities, land-use features, and park-related geographic objects. Open geographic data are increasingly valuable for urban analysis because they can be integrated with satellite imagery and official planning data in GIS platforms.[8]

Indicator	Description
Park name	Official or commonly used name
Type	Park, garden, square, boulevard, sports area, recreation zone
Area	Total area in hectares
Vegetation condition	Low, medium, or high vegetation density
Accessibility	Distance from residential zones and roads
Facilities	Walking paths, benches, lighting, playgrounds, sports facilities, water features
Recreational potential	Low, medium, or high

NDVI Analysis

Vegetation condition was assessed using the Normalized Difference Vegetation Index (NDVI). NDVI is one of the most commonly used remote-sensing indicators for measuring the density and health of vegetation. It is calculated using the following formula:

$$[NDVI = \frac{NIR - Red}{NIR + Red}]$$

Where:

- **NIR** is near-infrared reflectance;
- **Red** is red-band reflectance.

High NDVI values generally indicate dense and healthy vegetation, while low values indicate sparse vegetation, built-up surfaces, bare soil, or degraded green areas.[9]

Accessibility Analysis

Accessibility is a central indicator in evaluating the social value of parks. A park may have high ecological quality but limited public benefit if it is difficult to reach. In this study, accessibility was assessed through buffer analysis and road-network analysis.

Three walking-distance buffers were created around each identified park:

- 300 meters: approximately 5 minutes of walking;
- 500 meters: approximately 7–10 minutes of walking;
- 1,000 meters: approximately 15 minutes of walking.

These distances are commonly used in urban green-space studies to evaluate whether residents can reach parks on foot.[10] Residential areas located within these buffers were classified as having high, medium, or low access to public parks.

Recreational Potential Assessment

The recreational potential of parks was evaluated using a weighted scoring method. Five criteria were selected:

1. Park size;
2. Vegetation density;
3. Accessibility;
4. Availability of facilities;
5. Proximity to residential areas and public transport.

Results

Spatial Distribution of Parks and Recreational Areas

The GIS mapping process identified several categories of urban green and recreational spaces in Samarkand:

1. Large public parks;
2. Historical gardens and landscaped tourism zones;
3. Neighborhood parks and public squares;
4. Sports and recreation facilities;
5. Roadside green corridors and boulevards;
6. Canal-side and water-related green spaces;
7. Institutional green spaces near universities, schools, hospitals, and government buildings.

The results are consistent with wider urban-planning research, which shows that green spaces are often more concentrated in central or economically important districts, while peripheral areas may experience lower access to public parks.[11]

Vegetation Condition Based on NDVI

The NDVI analysis revealed significant variation in vegetation density across Samarkand City. Major parks, irrigated gardens, tree-lined streets, and canal-side zones generally showed moderate to high NDVI values. These areas contain mature trees, lawns, shrubs, and irrigated vegetation.

High NDVI values were particularly associated with:

- large public parks;
- historical garden zones;
- tree-lined boulevards;
- areas near canals and water infrastructure;
- institutional campuses with landscaped grounds.

The NDVI results confirm that satellite imagery can identify vegetation inequality within the urban landscape. Similar studies in Central Asian cities have demonstrated that remote sensing and GIS are effective for monitoring the fragmentation, decline, and spatial variation of urban green zones.[12]

Park Accessibility

Buffer analysis showed that residents living in central and tourism-oriented areas generally have better access to public parks and landscaped recreational spaces. A considerable proportion of the central population lives within a 500-meter walking distance of at least one park, public garden, or green public space.

Recreational Potential Index

The Recreational Potential Index classified parks and recreational areas into three main categories:

Category	Characteristics
High potential	Large size, dense vegetation, good access, multiple facilities, public transport proximity

Category	Characteristics
Medium potential	Moderate size and vegetation, limited facilities, acceptable accessibility
Low potential	Small size, sparse vegetation, poor maintenance, limited access, few facilities

High-potential recreational areas are generally located in central parts of the city and in zones connected with tourism, culture, and public institutions. These areas have stronger landscaping, better pedestrian infrastructure, and more diverse facilities.

Green-space connectivity is important because it supports pedestrian movement, biodiversity, shade provision, and climate adaptation. A connected green network can also improve the visual quality of the city and strengthen the relationship between historical sites, residential neighborhoods, and public spaces.[13]

Discussion

The results demonstrate that Samarkand has substantial potential to develop a more sustainable and equitable urban green-space system. The city already possesses important assets, including historical gardens, public parks, irrigated landscapes, tree-lined streets, cultural tourism zones, and planned green-belt initiatives. However, the analysis also identifies challenges related to uneven distribution, insufficient neighborhood parks, limited pedestrian access, fragmented green corridors, and differences in vegetation condition.

The current Samarkand Master Plan to 2045 provides a major opportunity for green-infrastructure expansion. The proposed additional green areas and green belt could improve ecological conditions, reduce urban heat, and provide new recreational opportunities if implemented through spatially targeted planning.[14] GIS should be used to identify priority locations for new parks based on population density, lack of existing access, low NDVI values, heat exposure, and distance from public recreational facilities.

The Green City Action Plan process also creates an institutional basis for using geospatial data in environmental management. The identification of environmentally stressed locations and planned green projects should be supported by a regularly updated GIS database.[15] Such a database could include park boundaries, tree

inventories, irrigation systems, pedestrian routes, public facilities, maintenance status, NDVI values, and citizen feedback.

Conclusion

This study assessed urban parks and recreational areas in Samarkand City using GIS, remote sensing, NDVI analysis, spatial mapping, buffer analysis, and accessibility assessment. The research demonstrates that geospatial technologies are effective tools for identifying the location, size, vegetation condition, accessibility, and recreational potential of urban green spaces.

The main findings are as follows:

1. Samarkand contains a diverse but unevenly distributed system of parks, gardens, public squares, green corridors, and recreational spaces.
2. Central and tourism-oriented districts generally have better access to formal parks and landscaped public areas.
3. Peripheral residential zones have fewer large, high-quality, and easily accessible recreational spaces.
4. NDVI analysis shows higher vegetation density in major parks, irrigated gardens, canal-side zones, and tree-lined streets.
5. Built-up and recently urbanized areas generally have lower vegetation density and may require additional green infrastructure.
6. Green spaces are fragmented in several parts of the city, highlighting the need for connected green corridors.
7. GIS-based planning can help identify priority locations for new parks, neighborhood green spaces, pedestrian corridors, and tree-planting programs.

In conclusion, Samarkand's future green development should be based not only on increasing the total area of vegetation but also on ensuring that parks are accessible, connected, safe, ecologically healthy, and useful for all residents. Geospatial technologies provide a practical and scientifically reliable foundation for achieving these goals.

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