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ASSESSING COOLING AND FLOOD MITIGATION ECOSYSTEM SERVICES OF URBAN GREEN SPACES IN TASHKENT USING GIS TECHNOLOGIES

ABSTRACT

This study investigates the various types of green spaces in Tashkent, analyzes their spatial distribution, and assesses the ecosystem services they provide. The extent of green space coverage across the city was quantified using the Normalized Difference Vegetation Index (NDVI). To evaluate the cooling efficiency of green spaces, a surface temperature map was generated by processing the red, near-infrared, and thermal infrared bands from Landsat-8 satellite imagery. The InVEST (Integrated Valuation of Ecosystem Services and Tradeoffs) model was utilized to assess both the urban cooling effect and the flood mitigation capacity of green areas. The findings indicate that green spaces in multi-storey residential zones provide greater cooling and flood mitigation services than those in traditionally built neighborhoods. They also exhibit significantly higher cooling efficiency during the summer, with the maximum Heat Mitigation Index reaching 0.83. Furthermore, the flood mitigation potential of green spaces in Tashkent depends on the city's river terrace formations. The terraces of the Chirchik River correspond to A, C, and D hydrological soil groups with varying infiltration rates. Green spaces on the floodplain and terrace I (A group) exhibit the highest infiltration and thus the greatest potential for reducing flood risks, whereas terraces II and III (C group) and IV and V (D group) show lower infiltration. Additionally, green spaces on terraces II and III (C group) have higher flood mitigation potential than those on terraces IV and V (D group).

KEYWORDS: InVEST model, green spaces, ecosystem services, pluvial floods, NDVI, urban heat island

INTRODUCTION

Land use and land cover types in cities have unique characteristics. Hard, impermeable surfaces such as roads and various buildings occupy large areas, whereas green spaces usually cover only small portions [*Agonafir*, 2023; *Costadone*, 2024; *Aghaloo* et al., 2025]. These characteristics lead to several urban problems, including (a) the urban heat island effect during summer, and (b) an increased risk of pluvial flooding during the rainy season.

The following factors have the greatest impact on the formation of the urban heat island in summer: hard surfaces, such as asphalt and concrete, which occupy a large share of cities, have a high heat capacity and absorb, store, and emit thermal radiation [*Forman*, 2014; *Gao* et al., 2024; *Kumar*, 2024; *Mukhamedjanov* et al., 2024; *Sharipov* et al., 2024]. In many cities, especially in

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their central areas, surface and air temperatures are higher than in the surrounding areas. As a result, an urban heat island is formed [*Sharipov*, *Khayitmurodov*, 2024]. The urban heat island is known to have several negative consequences. In arid climates, these effects are exacerbated by water scarcity and dry air. The main problems caused by the urban heat island include: endangering the health of children and adolescents [*Tojiyeva* et al., 2024]; increasing mortality among senior citizens with cardiovascular diseases; raising electricity demand due to greater use of cooling systems; and accelerating the formation of greenhouse gases and ozone. Green spaces play a significant role in reducing summer heat in cities. Trees lower air and surface temperatures by providing shade and increase air humidity through evapotranspiration [*Ibragimova* et al., 2020]. Additionally, plants have a higher albedo than hard surfaces, reflecting more sunlight and absorbing less heat.

The purpose of this research is to analyze the spatial distribution of different types of green spaces in Tashkent and to assess their ecosystem services, particularly their contribution to urban heat mitigation and flood regulation, through the integration of NDVI analysis, surface temperature mapping, and the InVEST modeling framework.

Tashkent also experiences high temperatures in the summer. In the central areas of the city, air temperatures are 1.5–3 °C higher than in the surrounding regions, resulting in the formation of an urban heat island [*Sharipov*, *Khayitmurodov*, 2024]. The surface temperature in the city is also slightly higher than in the surrounding areas. The energy stored in hard surfaces is emitted at night, causing air temperatures to rise.

Green spaces in Tashkent are unevenly distributed. There are more green spaces in the central areas of the city and significantly fewer in the northwestern parts. This uneven distribution is influenced by the city’s historical development. While green spaces occupy a larger share around multi-storey buildings, their presence is much smaller in traditionally built neighborhoods.

In cities, impermeable surfaces such as paved roads and built-up areas significantly limit the infiltration of precipitation [*Li*, 2019; *Azadgar*, 2025; *Zhang*, 2025]. As a result, pluvial flooding of varying scales occurs in these areas during seasons with heavy rainfall. Although most of these pluvial floods are relatively small and shallow, they result in substantial direct and indirect damage to both the population and urban infrastructure. These pluvial floods can lead to traffic congestion, cause individuals to become stranded, damage roads and buildings, and disrupt the normal functioning of daily life. In Tashkent, green spaces play an essential role in providing ecosystem services, such as mitigating summer heat and retaining flood water during the spring and autumn seasons.

In several areas of Tashkent, pluvial flooding occurs during periods of heavy rainfall, leading to traffic congestion, damage to urban infrastructure, and significant disruption of daily life. The occurrence of these floods is primarily attributed to two factors: first, the inadequate planning of drainage and stormwater systems, and second, the scarcity of green spaces in the city. Additionally, the formation of flood-prone areas during heavy rainfall is influenced by the city’s topography, geological structure, and climatic conditions [*Sabitova* et al., 2021; *Fazilova* et al., 2023; *Ruziev* et al., 2024; *Sharipov* et al., 2024].

Green spaces play a crucial role in mitigating urban flooding by reducing the volume of runoff through infiltration and slowing the movement of stormwater [*Umilia* et al., 2020; *Jones*, 2022]. Proper planning of vegetated areas can significantly decrease surface runoff [*France*, 2003]. The effectiveness of vegetated infrastructure increases over time as vegetation matures and becomes denser.

RESEARCH MATERIALS AND METHODS

This research employed methods including remote sensing, geospatial data analysis using programs such as ArcGIS and InVEST, and field research.

To obtain initial results, the following maps were prepared in ArcGIS: a Land Use and Land Cover (LULC) map of Tashkent City, NDVI maps, and surface temperature maps. Satellite imagery from sources such as Sentinel-2 and Landsat-8 was used to generate these maps.

An NDVI map was created to determine the past and present distribution of green spaces in Tashkent. NDVI values range from −1 to 1; however, there is no universally fixed threshold that defines green areas [*Hashim* et al., 2019]. The value indicative of vegetation varies across regions and fluctuates seasonally.

In many studies, an NDVI index ranging from 0.2 to 1 in urban areas indicates green spaces [*Hashim* et al., 2019]. When comparing the NDVI map of Tashkent with the base map from Google Earth, it was observed that NDVI values between 0.2 and 1 correspond to green spaces (Fig. 1). The NDVI map was created based on conditions in April, a month during which Tashkent receives more precipitation and experiences frequent pluvial flooding. Additionally, by April, most trees have fully developed leaves, which enhances their ability to retain rainwater. It was deemed essential to select a month characterized by frequent flooding and the onset of tree budburst to evaluate the level of greenery.

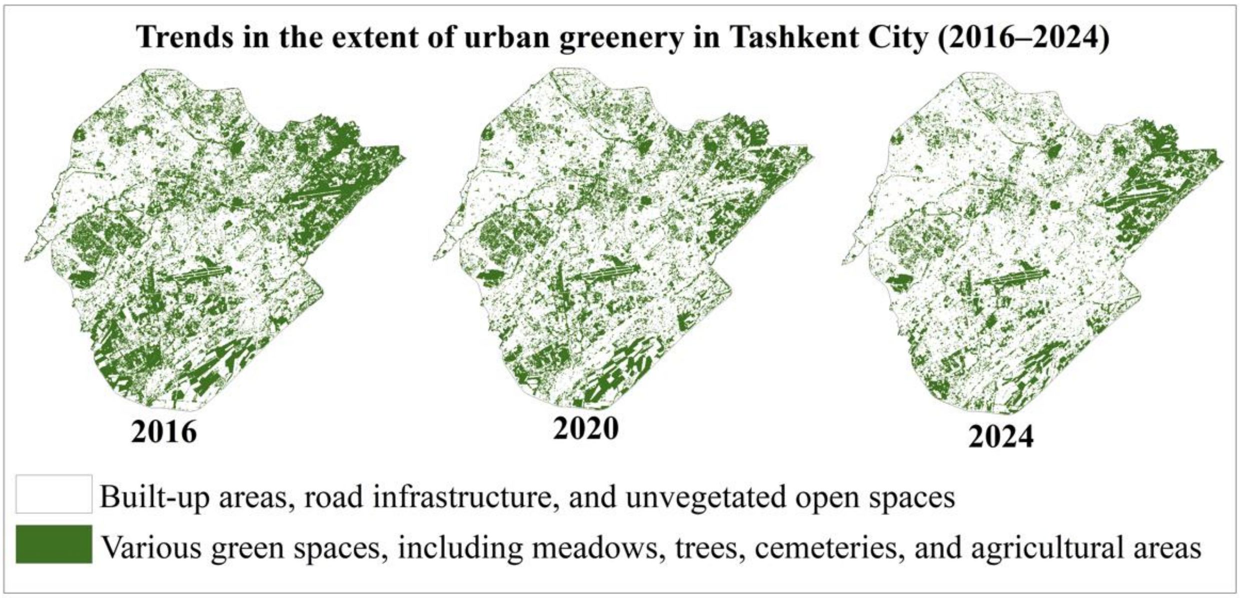

Fig. 1. Distribution of green spaces in Tashkent during the first ten days of April in 2016, 2020, and 2024

Table 1. NDVI values and greenness levels in Tashkent in April 2024

Vegetation cover	**Description**	**NDVI value**	**Percentage share (%) in Tashkent City**
Vegetation cover is absent	Build-up areas, paved roads, and non-vegetated open areas	From −1 to 0.199	76
Vegetation cover is present	Trees, meadows, cemeteries, agricultural lands, and other green spaces	More than 0.2	24

To assess the air temperature cooling effect of green areas in Tashkent, the surface temperature map, derived from the processing of red, near-infrared (NIR), and thermal infrared bands of the Landsat-8 satellite, along with the Urban Cooling model of the InVEST software[1], was utilized.

To determine the cooling effect of green spaces in Tashkent, a surface temperature map generated from the Landsat-8 dataset was utilized. These green spaces play a significant role in mitigating surface temperatures. In Tashkent, particular attention was given to the cooling effect of the following types of green spaces: (1) green spaces in traditionally built neighborhoods, (2) green spaces in residential areas composed of multi-storey buildings, and (3) green spaces along canals. In addition, the cooling effect of the city's largest green space — the Botanical Garden was also analyzed.

The InVEST program is highly effective in assessing urban ecosystem services. This program also includes a Flood risk mitigation model. InVEST requires several input datasets to obtain results (Table 2).

Table 2. Key input data for the Urban Cooling and Urban Flood Risk Mitigation models in the InVEST program

Urban cooling model		**Urban flood risk mitigation model**	
Data	**Data format**	**Data**	**Data format**
Land Use/Land Cover	Raster	Land Use/Land Cover	Raster
Reference Evapotranspiration	Raster	Rainfall Depth (mm)	Number
Area Of Interest	Vector	Area Of Interest	Vector
Biophysical Table	Csv	Biophysical Table	Csv
Reference Air Temperature (°C)	Number	Soil Hydrologic Group	Raster
UHI Effect (°C)	Number	Built Infrastructure	Vector, optional
Air Blending Distance (m)	Number	Damage Loss Table	Csv, optional
Maximum Cooling Distance (m)	Number		
Shade Weight, Albedo Weight, Evapotranspiration Weight	Numbers		

The primary input data for the InVEST program were derived from the processing of satellite imagery in ArcGIS. The most critical inputs include a Land Use/Land Cover (LULC) map, a biophysical table, and a soil hydrological group map.

Land Use/Land Cover types are important in assessing ecosystem services [*Bekanov* et al., 2020; *Naserikia*, 2023; *Chernisheva* et al., 2024; *Jumanov* et al., 2024; *Zhou* et al., 2025]. A Land Use/Land Cover (LULC) map of Tashkent City was created using the dataset collected by the Sentinel-2 satellite in ArcGIS (Fig. 2). Tashkent city was classified into seven LULC types: (1) water bodies, (2) built-up areas, (3) paved roads, (4) urban trees, (5) grasslands, (6) irrigated agricultural lands, and (7) open areas. The area and proportional share of each LULC type within the city were calculated (Table 3).

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[1] Web resource: https://naturalcapitalproject.stanford.edu/software/invest (accessed 07.07.2025)

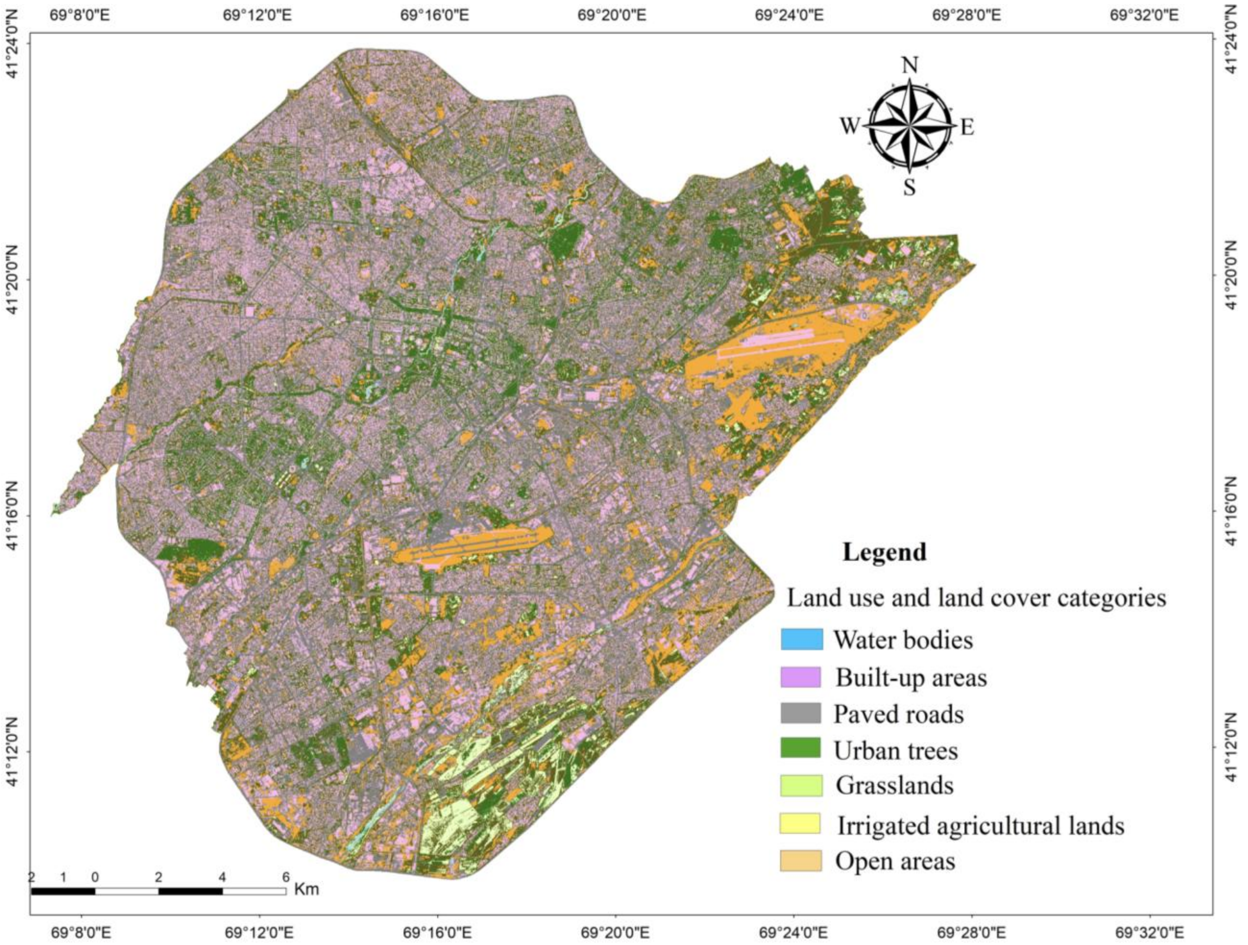

Fig. 2. Land Use/Land Cover (LULC) classification of Tashkent

Table 3. Area and proportional share of Land Use/Land Cover (LULC) types in Tashkent City

No.	Land use and land cover types	Area, km²	Proportional Share (%)
1	Water bodies	1.23	0.3
2	Buildings and structures	104.76	24.2
3	Paved roads	157.68	36.1
4	Urban trees	33.52	7.7
5	Grasslands	19.14	4.4
6	Irrigated agricultural lands	74.35	17.2
7	Open areas	43.73	10.1
Total		434.41	100

The soil hydrological groups were developed by the United States Department of Agriculture (USDA) and the Natural Resources Conservation Service (NRCS). According to this classification, soils are divided into four groups: A, B, C, and D. The hydrological groups of soils differ based on their infiltration rates [*Auerswald*, *Qiao-Lin Gu*, 2021].

To determine the hydrological soil groups in Tashkent, the Digital Soil Map of the World (GeoNetwork), obtained from the official FAO website[1], and the classification table of hydrological soil groups developed by the U.S. Natural Resources Conservation Service (NRCS) were used. Analysis of various sources revealed that the hydrological soil groups in Tashkent correspond to the terraces of the Chirchik River. Each terrace is characterized by distinct soil types, geological formations, and landforms that developed during specific geological periods.

The soils of Tashkent City belong to three hydrological groups: A, C, and D. Group A includes the stony-gravel floodplains of the Chirchik River, as well as the first terrace. This terrace slopes towards the Chirchik River, causing precipitation to flow toward the river. As a result, rainwater does not accumulate, and floods do not occur. Additionally, the stony-gravel composition of the rocks enhances the infiltration process. Group C includes the second and third terraces of the Chirchik River. In this area, a thin layer of loess overlies alluvial soils [*Abdunazarov* et al., 2020; *Abdurakhmonov* et al., 2023], which reduces the rate of infiltration. Additionally, the gentle slope of these terraces toward the river results in slow surface runoff, and in some locations, surface water does not reach the river at all. Group D includes terraces IV and V upstream of the Chirchik River. These terraces are covered with thick loess deposits, resulting in very low infiltration rates.

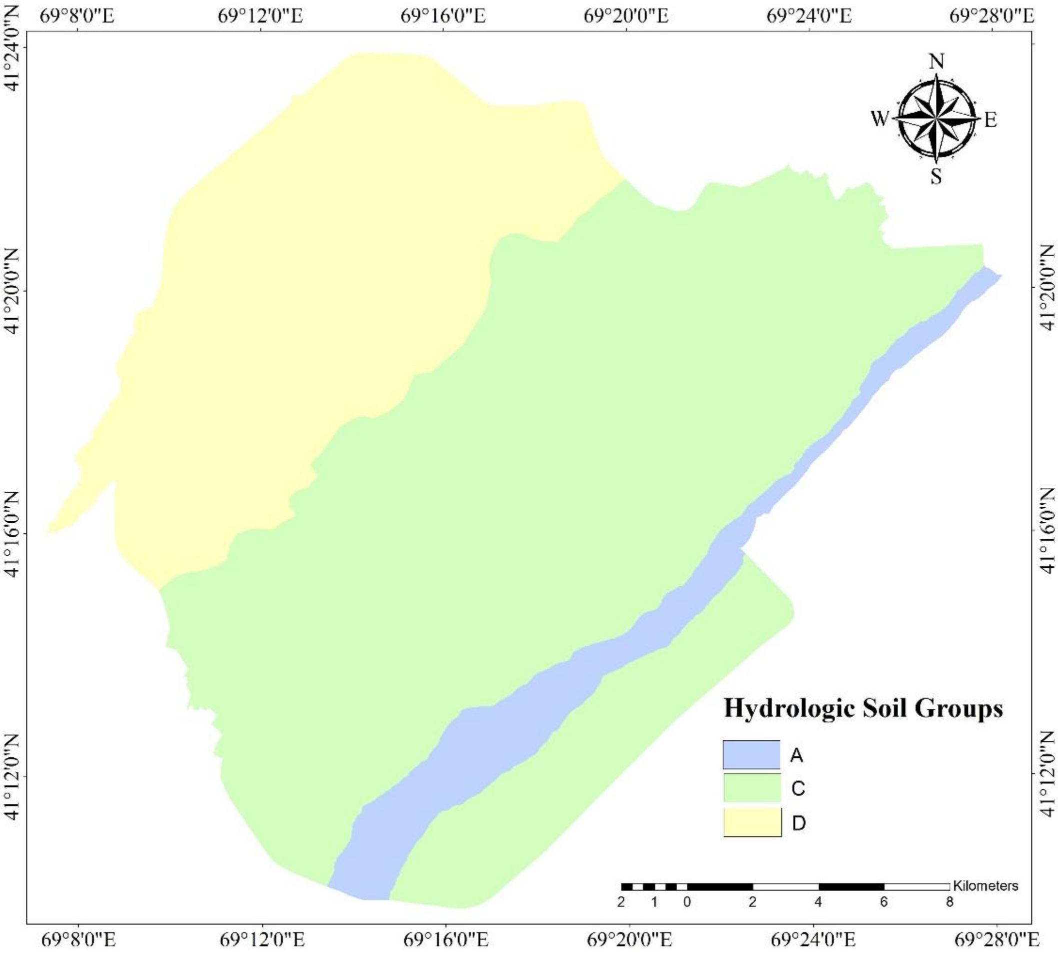

Fig. 3. Hydrological soil group map of the city of Tashkent

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[1] Web resource: https://www.fao.org/soils-portal/data-hub/soil-maps-and-databases/faounesco-soil-map-of-the-world/en/ (accessed 07.07.2025)

The biophysical table contains data specific to each land use type and varies between the Urban Cooling and Urban Flood Mitigation models. In the Urban Cooling model, the table includes parameters such as shading, albedo, vegetation cover (greenery), and building intensity for each land use category. In contrast, the Urban Flood Mitigation model uses curve numbers associated with each land use type, differentiated across the four hydrological soil groups (A, B, C, and D).

In the Urban Flood Mitigation model, precipitation input is selected based on periods during which flood events have been observed. The model allows for the specification of daily, weekly, or monthly precipitation values. For this study, daily precipitation levels in Tashkent were used. Using the InVEST model, several scenarios of flood and surface runoff formation in Tashkent were simulated based on daily precipitation levels of 10 mm, 15 mm, 20 mm, 25 mm, 30 mm, and 35 mm.

Daily precipitation data for Tashkent from 2000 to 2020 were obtained from the Center for Hydrometeorological Service (Uzgidromet). It was observed that surface runoff is minimal or does not form when daily precipitation is less than 5 mm. Therefore, only days with precipitation exceeding 5 mm were included in the analysis. Between 2000 and 2020, Tashkent experienced an average of 15.2 days per year with daily precipitation between 5–10 mm. The average annual number of days with precipitation in the ranges of 10–15 mm, 15–20 mm, 20–25 mm, 25–30 mm, and greater than 30 mm was 6.9, 3.9, 2.1, 0.9, and 0.6 days, respectively (Table 4). According to various studies [*Li*, *2020*], even intense rainfall of 10 mm in cities with low infiltration rates can cause urban flooding. Over the 20-year period, the highest number of days in a single year with daily precipitation exceeding 10 mm was 25 (recorded in 2002), while the average for the period was 14.5 days per year. This suggests that Tashkent is exposed to more than 10 potential flood events annually, primarily driven by moderate to heavy rainfall.

Table 4. Biophysical table for the urban flood mitigation model

Land use and land cover	**Land use code**	**cn_a**	**cn_b**	**cn_c**	**cn_d**
open water	1	100	100	100	100
commercial	72	86	91	93	95
roads	434	98	98	98	98
mixed forest	524	36	60	73	79
grassland	755	49	69	79	84
barren land	812	63	77	85	88
cultivated	968	62	71	78	81

Table 5. Annual number of days by precipitation intensity in Tashkent City (2000–2020)

Year	**Number of Days by Precipitation Range**					
	5–10 mm	**10–15 mm**	**15–20 mm**	**20–25 mm**	**25–30 mm**	**More than 30 mm**
2000	12	3	4	1	2	0
2001	15	7	4	2	1	1
2002	15	16	2	4	2	1
2003	14	12	7	2	2	1
2004	16	4	4	3	0	0

Year	Number of Days by Precipitation Range					
	5–10 mm	10–15 mm	15–20 mm	20–25 mm	25–30 mm	More than 30 mm
2005	12	9	4	2	0	0
2006	21	7	6	1	0	0
2007	15	11	3	2	0	0
2008	15	4	2	2	0	1
2009	15	7	4	2	0	0
2010	17	7	1	5	2	0
2011	17	7	1	1	1	3
2012	19	3	4	1	2	0
2013	11	6	7	1	1	0
2014	17	7	4	1	1	1
2015	17	5	4	4	2	1
2016	17	7	4	3	1	1
2017	17	6	1	0	2	2
2018	18	5	8	0	0	0
2019	12	5	5	3	0	2
2020	7	6	4	4	0	0
Average	15.2	6.9	3.9	2.1	0.9	0.6

RESEARCH RESULTS AND DISCUSSION

Analysis of the collected data yielded several key findings. Surface temperature maps were employed to assess the cooling effect of green spaces in Tashkent. This approach is justified by the established correlation between surface temperature and ambient air temperature [*Gao*, 2025].

In Tashkent, traditionally built neighborhoods occupy substantial areas in the northern, northwestern, and eastern parts of the city. These neighborhoods historically comprised low-rise dwellings constructed to accommodate local climatic conditions. Green spaces within these areas are characterized by a distinctive layout, with trees dispersed along narrow streets and within residential courtyards. In July, the surface temperature within these vegetated spaces averages 36 °C, which is approximately 4 °C lower than that of the surrounding urban areas.

High-rise residential areas are primarily situated in the central and northeastern regions of Tashkent, between the Bozsu and Salor canals and the Kuyi Bozsu and Ankhor canals. In these areas, green spaces are systematically planned and generally characterized by high vegetation density, with mature and sizable trees. These green areas provide ecosystem services comparable to those of cultural and recreational parks. In July, the surface temperature of green spaces in these neighborhoods averages 31 °C, offering a cooling effect of approximately 7 °C compared to surrounding urban zones (38 °C). The cooling efficiency of green spaces in these areas is 4 °C higher than that of traditional neighborhoods.

Green spaces along the canals in Tashkent also provide a notable cooling effect. These green spaces, however, are not present along all of the city's canals. They are primarily found along the Bozsuv, Kuyi Bozsuv, Ankhor, Aktepa, and Burizhar canals. The ecosystem services provided by these green spaces are closely integrated with the canals themselves. In July, the surface temperature of the trees along the Bozsu Canal averages 33 °C, which is 5 °C lower than that of the surrounding areas, where surface temperatures reach 38 °C.

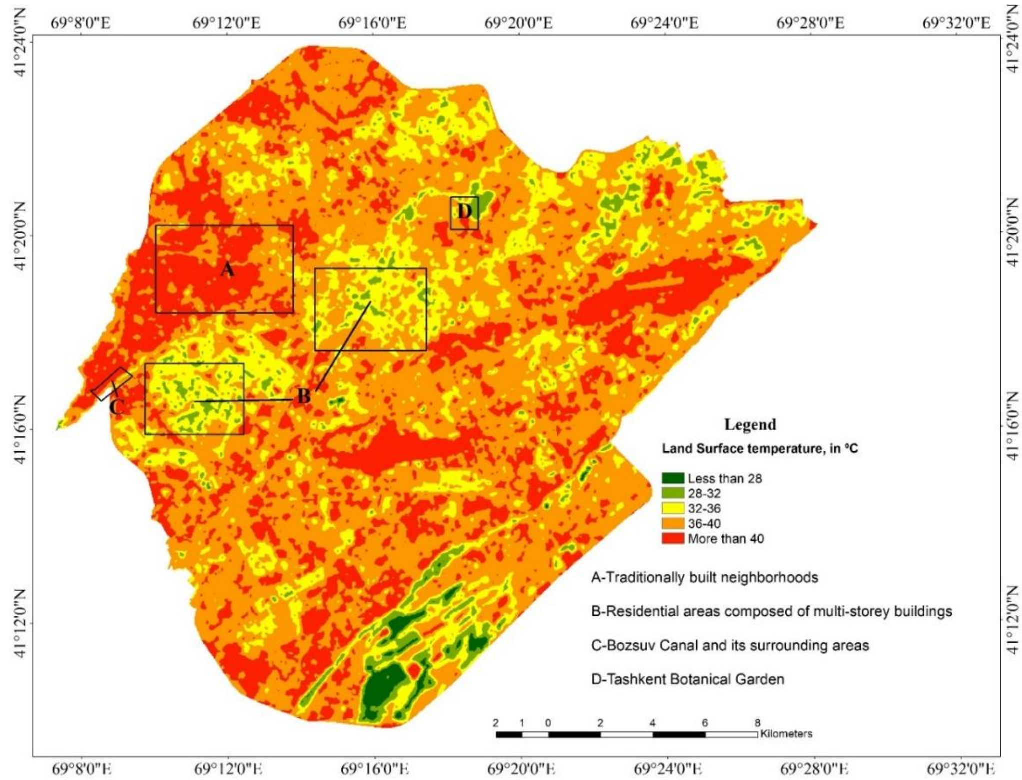

Fig. 4. Surface temperature map of Tashkent during the summer month of July

The Tashkent Botanical Garden, covering an area of over 65 ha, demonstrates a high cooling efficiency. In July, the cooling effect of the Botanical Garden is about 10 °C.

The cooling efficiency of green spaces in Tashkent varies by season, with the highest values observed during the summer. In spring and autumn, the cooling efficiency is nearly equal.

Runoff retention indicates the volume of precipitation that can be retained per square meter of surface area and is expressed in cubic meters per acre (m^3/acre).

In Tashkent, runoff retention, the Runoff Retention Index, and surface runoff depth vary across different land use and land cover types, as well as among the terraces of the Chirchik River. Using the results generated by the InVEST model and processed in ArcGIS, spatial maps of the Runoff Retention Index, surface runoff depth, and total runoff retention were produced (Fig. 6–8). These indicators show variation depending on the precipitation intensity. The calculations were performed for daily precipitation values ranging from 10 mm to 35 mm (Table 6).

The air temperature cooling effect of green spaces in Tashkent was assessed using the InVEST model. As part of this analysis, the heat mitigation index was calculated for the city. The Heat Mitigation Index (HMI) ranges from 0 to 1, where a value of 1 indicates complete mitigation of the urban heat island effect, and a value of 0 indicates no contribution to heat mitigation. The maximum value of the Heat Mitigation Index for green spaces in Tashkent was 0.83. Higher index values were observed in areas with a greater proportion of green space, particularly in the central areas characterized by high-rise residential buildings. In these areas, the intensity of the urban heat island effect was significantly reduced.

The flood mitigation services provided by green areas were evaluated using the InVEST model. Runoff generation was assessed based on the following indicators: (a) Runoff retention index (ranging from 0 to 1), (b) Runoff depth (measured in millimeters), and (c) Runoff retention amount (measured in cubic meters per acre).

Table 6. Cooling effect of green spaces in Tashkent

Types of green spaces in Tashkent	**Surface temperature cooling effect across different seasons (in °C)**				**Heat mitigation index (from 0 to 1)**
	Summer (July)	**Autumn (November)**	**Winter (February)**	**Spring (March)**	**Summer (July)**
Green spaces in residential areas composed of multi-storey buildings, and (3) green spaces along canals.	7	6	7	6	0.82
Green spaces in traditionally built neighborhoods	4	3	3	3	0.82
Green Spaces Along Canals: Bozsuv Canal as an Example	5	2	3	4	0.82
Tashkent Botanical Garden	10	3	1	3	0.83

The Runoff Retention Index is displayed on a scale from 0 to 1. When the index value is 1, all precipitation is retained on surfaces (through infiltration or interception by vegetation) and no surface runoff occurs. When its value is 0, all precipitation forms runoff, and in this case, the surfaces do not retain precipitation. When the precipitation retention index is 0.5, half of the rainwater is retained on surfaces and the other half forms runoff.

The ability of different surfaces to retain precipitation also depends on the amount of rainfall. Analysis of the Runoff Retention Index yielded several findings. In Tashkent, for instance, tree-covered areas can fully retain up to 35 mm of precipitation on terraces II and III of the Chirchik River, and up to 20 mm on terraces IV and V. When rainfall exceeds these thresholds, surface runoff begins to occur even from vegetated areas. For grasslands and agricultural lands, the retention capacity is 25 mm on terraces II and III, and 15 mm on terraces IV and V. Open areas retain precipitation without generating runoff up to 20 mm on terraces II and III, and up to 10 mm on terraces IV and V. The Runoff Retention Index is particularly high in the floodplains of the Chirchik River and its first terrace. Except for impermeable surfaces such as roads and built-up areas, the likelihood of flooding is low across all land use and land cover types. Surface runoff generated on hard surfaces is rapidly directed toward the Chirchik River due to the steep slope, which prevents flood formation in most parts of the floodplain and the first terrace.

In Tashkent, impervious surfaces account for over 76 % of the urban area (Fig. 8). These surfaces generate nearly complete surface runoff, with minimal absorption or evaporation occurring prior to surface saturation. Consequently, both the frequency and intensity of urban flooding have increased. Natural areas within the city — such as groves, lawns, agricultural lands, and open spaces — play a critical role in mitigating runoff generated by impervious surfaces.

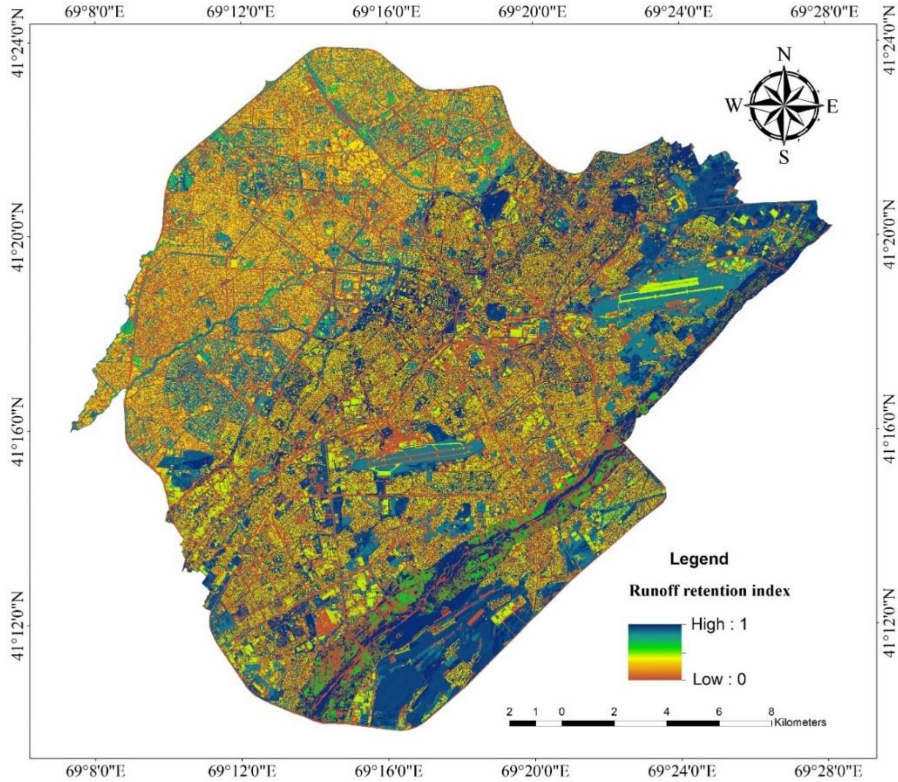

Fig. 5. Runoff retention index under a daily precipitation event of 35 mm

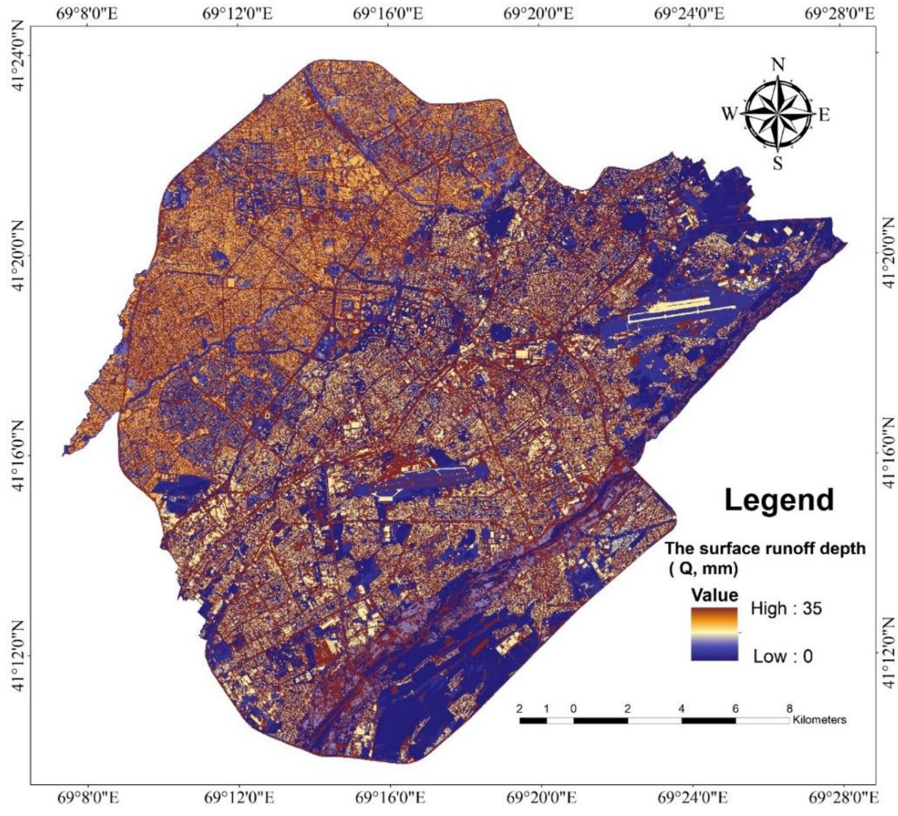

Fig. 6. Surface runoff depth under a daily precipitation event of 35 mm

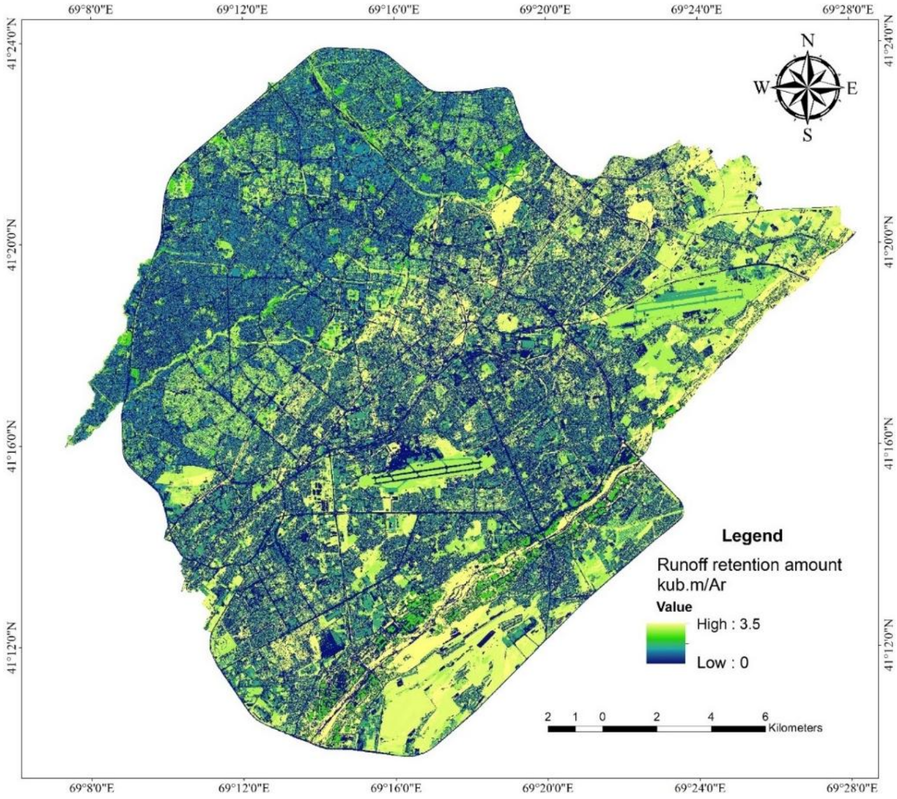

Fig. 7. Runoff retention amount under a daily precipitation event of 35 mm

Despite the significant benefits provided by green spaces, their reduction remains an ongoing issue. In many cases, the destruction of green areas has not been effectively prevented, leading to the gradual shrinkage of existing green spaces, which are increasingly being replaced by infrastructure and engineering structures. As a result of population growth in Tashkent, the densification of urban infrastructure, and changes in land use, the extent of green spaces has notably diminished over recent decades (Fig. 1 and 8). According to NDVI data, the proportion of green areas such as groves, shrubs, meadows, fields, and cemeteries has decreased from 37 % in 2016 to 30 % in 2020, and further to 24 % in 2024.

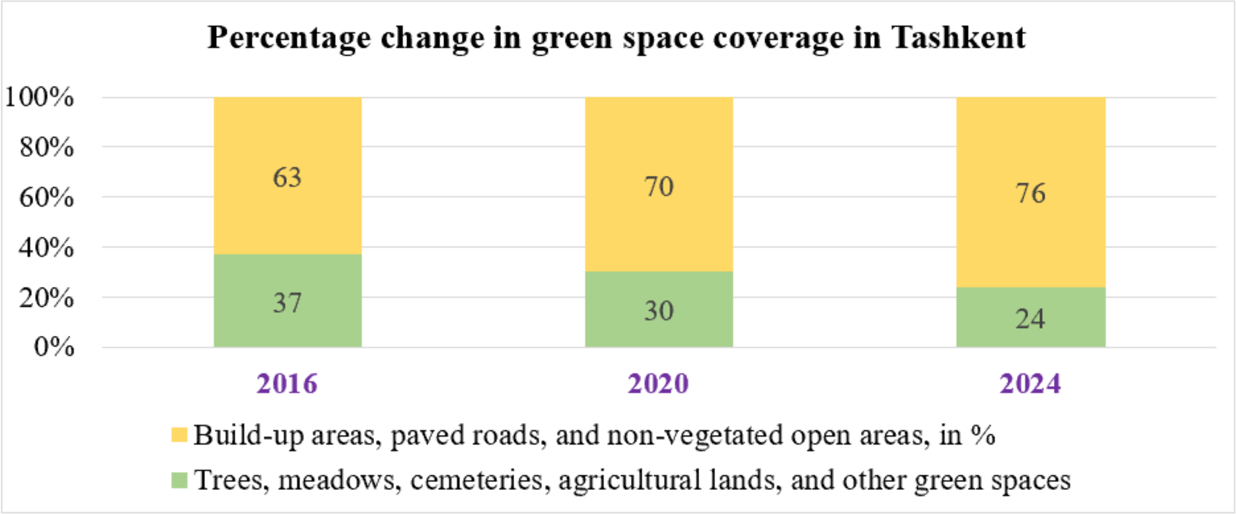

Fig. 8. Percentage change in green space coverage in Tashkent, in %

Table 7. Runoff mitigation characteristics and surface runoff depth of different land use and land cover types in Tashkent

Precipitation amount, mm	**Runoff mitigation characteristics and surface runoff depth**	**Urban trees**	**Grasslands**	**Irrigated agricultural lands**	**Open spaces**	**Build-up areas and paved roads**
10 mm	Runoff retention index, from 0 to 1	1	1	1	0.99	0.43
	Surface runoff depth, in mm	0	0	0	0.02	5.67
	Runoff retention amount, m³/acre	1	1	1	0.99	0.43
15 mm	Runoff retention index, from 0 to 1	1	0.99	0.99	0.95	0.32
	Surface runoff depth, in mm	0	0.03	0.01	0.72	10.18
	Runoff retention amount, m³/acre	1.5	1.49	1.49	1.43	0.48
20 mm	Runoff retention index, from 0 to 1	0.99	0.97	0.97	0.89	0.25
	Surface runoff depth, in mm	0.02	0.57	0.41	2.18	14.89
	Runoff retention amount, m³/acre	1.99	1.94	1.95	1.78	0.51
25 mm	Runoff retention index, from 0 to 1	0.98	0.93	0.94	0.83	0.21
	Surface runoff depth, in mm	0.38	1.67	1.38	4.22	19.7
	Runoff retention amount, m³/acre	2.46	2.33	2.36	2.07	0.53
30 mm	Runoff retention index, from 0 to 1	0.96	0.89	0.90	0.77	0.18
	Surface runoff depth, in mm	1.19	3.24	2.81	6.72	24.56
	Runoff retention amount, m³/acre	2.88	2.67	2.71	2.33	0.54
35 mm	Runoff retention index, from 0 to 1	0.93	0.85	0.86	0.72	0.16
	Surface runoff depth, in mm	2.38	5.19	4.62	9.56	29.46
	Runoff retention amount, m³/acre	3.26	2.98	3.03	2.54	0.55

CONCLUSIONS

The cooling efficiency of green spaces in Tashkent exhibits seasonal variation, with the highest values recorded during the summer months. In spring and autumn, the cooling effect is approximately equal.

In Tashkent, the cooling efficiency of green spaces is higher in areas with multi-storey residential buildings compared to traditionally built neighborhoods. This difference is primarily attributed to the greater proportion of green space typically found around multi-storey developments.

The effectiveness of green spaces in Tashkent in retaining precipitation and mitigating urban flooding is influenced by both the intensity of rainfall and the infiltration capacity of subsurface materials. These infiltration properties are largely determined by the hydrological characteristics of soils. In Tashkent, the distribution of hydrological soil groups corresponds to the terraces of the Chirchik River, resulting in terrace-based differences in the flood mitigation capacity of green spaces. Green spaces on the floodplain and terrace I of the Chirchik River exhibit the highest potential for reducing flood risks. On terraces II and III, green spaces retain more rainfall than those on terraces IV and V, primarily due to differences in infiltration capacity.

Despite the relatively high flood mitigation capacity of green spaces on terraces II and III of the Chirchik River, urban flooding occurs more frequently in these areas. This is largely due to runoff originating from terraces IV and V, which are situated at higher elevations, have steeper slopes, and exhibit lower infiltration capacities. As a result, rainwater flows downslope toward terraces II and III, increasing the likelihood of flooding.

In Tashkent, traditionally built neighborhoods have been found to contribute more significantly to urban flooding compared to multi-storey residential areas. This is primarily due to the higher proportion of impervious surfaces in these neighborhoods, which leads to a greater portion of rainfall being converted into surface runoff.

Green spaces play a crucial role in enhancing public health, improving the urban microclimate, and particularly in mitigating flooding. Tree plantations with understorey vegetation are the most effective in reducing urban flooding.

Government policies and environmental initiatives should recognize the vital role of green spaces. To improve the ecological situation and reduce flood risks in Tashkent, the following proposals and recommendations are put forward:

1. Encourage residents to cultivate natural grasslands around their homes, as these are highly effective in reducing flood risks.
2. Develop additional green spaces in the remote southeastern and northeastern areas of Tashkent, where large open spaces remain undeveloped.
3. Conduct scientific research on the implementation of green roofs in Tashkent. Increasing the number of multi-storey buildings with green roofs would reduce the likelihood of rainwater runoff and the formation of stormwater.
4. Identify unused open spaces in Tashkent, compile a register of these areas, and develop projects to transform them into green spaces.
5. Enhance the protection of valuable green spaces in Tashkent and prevent their removal for urban development.
6. Apply the 3-30-300 principle in the creation of new green spaces. This principle stipulates that at least three trees should be visible from each apartment window, tree canopy cover should occupy at least 30 % of every neighborhood, and a park or recreation area should be located within 300 m of each residence.

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