Additional file 2

Supplementary tables and figures

Green-space design and recreational running, walking and cycling: an ecological analysis of fitness-tracking trajectories in Nanchang, China

Tables S1–S7 and Figures S1–S2

This file documents the data sources, indicator definitions, indicator screening and retention, implementation-oriented classification and the visual-landscape workflow for the analysis of 50 urban green spaces. Construct names follow the main text: internal spatial characteristics, landscape configuration and surrounding urban context. PRI = Positive Response Index.

Table S1. Multi-source data used in the study.

Category	Dataset	Temporal coverage	Data source	Analytical use
Remote sensing	Sentinel-2A imagery	2020	Copernicus Sentinel-2, via USGS EarthExplorer	Ecological-environment indicators and landscape-pattern metrics
Remote sensing	GDEM30M digital elevation model	2021	Geospatial Data Cloud	Green-space topographic characteristics
VGI activity data	Keep, Codoon, and Yuepao Circle trajectories	1 September 2020–31 December 2022	Outdoor fitness platforms	Recreational running, walking, and cycling activity records
Geographic data	Baidu Street View imagery	2022	Baidu Maps	Visual-environment indicators
Geographic data	Road network	2022	Baidu Maps	Internal and surrounding road-network characteristics
Geographic data	Points of interest	2020	Amap Open Platform API	Surrounding-environment indicators
Online service data	Housing-price data	2022	Anjuke	Mean housing price
Social-media data	Geotagged facial-expression images	2022	Publicly accessible Sina Weibo posts	Site-mean Positive Response Index (PRI)
Statistical data	Population grid	2021	WorldPop	Population-density indicator
Field survey data	Panoramic imagery	2021–2022	360-degree camera survey	Green-space environmental characteristics

Table S2. Internal-spatial built-environment indicators and calculation methods.

Subdomain	Indicator	Calculation method
Ecological environment	Green-space area	Total area of green land within the delineated green-space boundary (ha).
Ecological environment	Green ratio	Green-space area divided by total site area (%).
Ecological environment	Normalized Difference Vegetation Index (NDVI)	Calculated from Sentinel-2A near-infrared and red bands as $(\mathrm{NIR}-\mathrm{Red})/(\mathrm{NIR}+\mathrm{Red})$; site mean was used.
Ecological environment	Normalized Difference Water Index (NDWI)	Calculated from Sentinel-2A near-infrared and green bands as $(\mathrm{Green}-\mathrm{NIR})/(\mathrm{Green}+\mathrm{NIR})$; site mean was used.
Visual environment	Panoramic Green View Index (PGVI)	Area of vegetation pixels divided by total pixels across stitched panoramic images.
Visual environment	Panoramic Sky View Index (PSVI)	Area of sky pixels divided by total pixels across stitched panoramic images.
Visual environment	Panoramic Road View Index (PRVI)	Area of road and footpath pixels divided by total pixels across stitched panoramic images.
Visual environment	Panoramic Building View Index (PBVI)	Area of building and wall pixels divided by total pixels across stitched panoramic images.
Site morphology	Site area	Total area enclosed by the green-space boundary (ha).
Site morphology	Perimeter	Total length of the green-space boundary (m).
Site morphology	Area-to-perimeter ratio	Site area divided by site perimeter; lower values indicate a more elongated site.
Site morphology	Shape index	Perimeter standardized by the perimeter of a circle with the same area; higher values indicate a more irregular boundary.
Site morphology	Mean slope	Mean slope derived from the digital elevation model within the green-space boundary (degrees).
Site morphology	Elevation	Mean elevation derived from the digital elevation model within the green-space boundary (m).
Road network	Maximum loop length	Length of the longest closed route loop in the internal green-space road network (m).
Road network	Total route length	Sum of lengths of all internal road-network segments (m).
Road network	Road count	Number of internal road segments.
Road network	Road area	Total mapped area of internal roads and paths (m^2).
Road network	Mean road width	Length-weighted mean width of internal road segments (m).
Road network	Road line density	Total route length divided by green-space area ($\mathrm{m\ ha}^{-1}$).

Table S2 (continued). Internal-spatial built-environment indicators and calculation methods.

Subdomain	Indicator	Calculation method
Road network	Intersection count	Number of three-way or higher-order intersections in the internal road network.
Road network	Intersection density	Number of three-way or higher-order intersections divided by green-space area (ha^{-1}).
Road network	Line-point ratio	Number of internal road segments divided by number of network intersections.
Road network	Maximum activity straight-line distance	Maximum Euclidean distance between the endpoints of internal green-space road-network segments (m).
Road network	Activity line density	Mean Euclidean endpoint-to-endpoint distance divided by network-path length across internal green-space road-network segments; lower values indicate a more circuitous network layout.
Road network	Number of entrances	Count of publicly accessible entrances connecting the green space to the external road network.
Road network	Entrance density	Number of publicly accessible entrances divided by green-space area (entrances ha^{-1}).
Road network	Main-entrance density	Number of principal publicly accessible entrances divided by green-space area (entrances ha^{-1}). Principal entrances were identified from map records and field verification.
Supporting facilities	Park-road material buffer score	Ordinal score from 1 to 5 for surface cushioning, from cement pavement to rubberized running track.
Supporting facilities	Parking-lot size	Total number of publicly available parking spaces.
Supporting facilities	Parking-lot density	Total number of publicly available parking spaces divided by green-space area (spaces ha^{-1}).
Supporting facilities	Lighting condition	Field-assessed ordinal score from 1 to 5 for the condition of lighting facilities.
Supporting facilities	Number of toilets	Count of toilets within the green-space boundary.
Supporting facilities	Toilet density	Number of toilets divided by green-space area (ha^{-1}).
Supporting facilities	Sports-facility condition	Field-assessed ordinal score from 1 to 5 reflecting the availability and diversity of recreational and sports facilities.

Note: The main-entrance density was operationalized as a site-area-normalized count because green spaces differed substantially in size. The identification of entrances as discrete access points from map records and field verification follows established park-accessibility practice (Wang et al., 2025; doi:10.3389/fenvs.2025.1727205).

Table S3. Landscape-configuration indicators and calculation methods.

Level	Indicator	Calculation method
Class level	Forest-patch class area	Total area of forest patches within the green-space boundary (ha).
Class level	Shrub-patch class area	Total area of shrub patches within the green-space boundary (ha).
Class level	Grass-patch class area	Total area of grassland patches within the green-space boundary (ha).
Class level	Built-up-patch class area	Total area of built-up patches within the green-space boundary (ha).
Class level	Water-patch class area	Total area of water patches within the green-space boundary (ha).
Class level	Forest-patch Largest Patch Index	Area of the largest forest patch divided by total green-space area (%).
Class level	Shrub-patch Largest Patch Index	Area of the largest shrub patch divided by total green-space area (%).
Class level	Grass-patch Largest Patch Index	Area of the largest grassland patch divided by total green-space area (%).
Class level	Built-up-patch Largest Patch Index	Area of the largest built-up patch divided by total green-space area (%).
Class level	Water-patch Largest Patch Index	Area of the largest water patch divided by total green-space area (%).
Class level	Forest-patch number of patches	Count of forest patches.
Class level	Shrub-patch number of patches	Count of shrub patches.
Class level	Grass-patch number of patches	Count of grassland patches.
Class level	Built-up-patch number of patches	Count of built-up patches.
Class level	Water-patch number of patches	Count of water patches.
Class level	Forest-patch density	Number of forest patches divided by green-space area (patches km^{-2}).
Class level	Shrub-patch density	Number of shrub patches divided by green-space area (patches km^{-2}).
Class level	Grass-patch density	Number of grassland patches divided by green-space area (patches km^{-2}).
Class level	Built-up-patch density	Number of built-up patches divided by green-space area (patches km^{-2}).
Class level	Water-patch density	Number of water patches divided by green-space area (patches km^{-2}).

Table S3 (continued). Landscape-configuration indicators and calculation methods.

Level	Indicator	Calculation method
Class level	Forest-patch mean area	Mean area of forest patches (km^2).
Class level	Shrub-patch mean area	Mean area of shrub patches (km^2).
Class level	Grass-patch mean area	Mean area of grassland patches (km^2).
Class level	Built-up-patch mean area	Mean area of built-up patches (km^2).
Class level	Water-patch mean area	Mean area of water patches (km^2).
Class level	Forest-patch edge density	Total forest-patch edge length divided by green-space area (m km^{-2}).
Class level	Shrub-patch edge density	Total shrub-patch edge length divided by green-space area (m km^{-2}).
Class level	Grass-patch edge density	Total grassland-patch edge length divided by green-space area (m km^{-2}).
Class level	Built-up-patch edge density	Total built-up-patch edge length divided by green-space area (m km^{-2}).
Class level	Water-patch edge density	Total water-patch edge length divided by green-space area (m km^{-2}).
Class level	Forest-patch mean fractal dimension	Mean perimeter–area fractal dimension of forest patches.
Class level	Shrub-patch mean fractal dimension	Mean perimeter–area fractal dimension of shrub patches.
Class level	Grass-patch mean fractal dimension	Mean perimeter–area fractal dimension of grassland patches.
Class level	Built-up-patch mean fractal dimension	Mean perimeter–area fractal dimension of built-up patches.
Class level	Water-patch mean fractal dimension	Mean perimeter–area fractal dimension of water patches.
Landscape level	Total landscape area	Sum of all patch areas within the green-space boundary (ha).
Landscape level	Landscape-level number of patches	Count of all patches across land-cover classes.
Landscape level	Landscape mean patch area	Mean area of all patches across land-cover classes (km^2).
Landscape level	Landscape patch density	Number of all patches divided by green-space area (patches km^{-2}).
Landscape level	Landscape mean fractal dimension	Mean perimeter–area fractal dimension across all patches.
Landscape level	Landscape Shape Index	Total edge length standardized by the minimum possible edge length for the observed landscape area.
Landscape level	Shannon's Diversity Index	Negative sum, across land-cover classes, of each class-area proportion multiplied by its natural logarithm.
Landscape level	Shannon's Evenness Index	Shannon's Diversity Index divided by the natural logarithm of the number of land-cover classes present.

Note: Class-level indicators were calculated separately for forest, shrub, grassland, built-up, and water patches. All metrics were derived in Fragstats 4.2 from the classified landscape layers.

Table S4. Surrounding-urban-context indicators and calculation methods.

Subdomain	Indicator	Calculation method
Development intensity	Floor-area ratio	Total building floor area divided by developable land area within the 1-km buffer (%).
Development intensity	Total POI density	Number of all points of interest within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Development intensity	Land-use mix	Shannon's Diversity Index calculated from the proportional areas of land-use classes within the 1-km buffer.
Commercial facilities	Dining-service density	Number of dining-service POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Commercial facilities	Daily-living-service density	Number of daily-living-service POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Commercial facilities	Shopping-service density	Number of shopping-service POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Commercial facilities	Financial-service density	Number of financial-service POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Commercial facilities	Sports-and-leisure-service density	Number of sports-and-leisure-service POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).

Table S4 (continued). Surrounding-urban-context indicators and calculation methods.

Subdomain	Indicator	Calculation method
Public facilities	Government-institution density	Number of government-institution POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Public facilities	Education-and-training-institution density	Number of education-and-training POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Public facilities	Medical-and-health-institution density	Number of medical-and-health POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Public facilities	Tourism-and-leisure-service density	Number of tourism-and-leisure POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Road transport	Transport-facility density	Number of transport-facility POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Road transport	Transport accessibility	Traversable area divided by total area within the 1-km buffer (%).
Road transport	Public-transport accessibility grade	Ordinal grade based on the shortest network distance from the green-space site to the nearest public-transport stop.
Socioeconomic context	Mean housing price	Mean residential unit price within the 1-km buffer (CNY m^{-2}).
Socioeconomic context	Enterprise density	Number of registered enterprises within the 1-km buffer divided by buffer area (enterprises ha^{-1}).
Socioeconomic context	Residential-accommodation density	Number of residential-accommodation POIs within the 1-km buffer divided by buffer area (POIs ha^{-1}).
Socioeconomic context	Population density	Residential population within the 1-km buffer divided by buffer area (persons km^{-2}).

Note: All surrounding-urban-context indicators were calculated from data within a 1-km buffer around each green-space site.

Table S5. Built-environment indicators retained after exploratory Pearson screening and VIF filtering.

Dimension	Subdomain	Indicator	Outer loadings
Internal spatial characteristics	Ecological environment	Green-space area	0.983
Internal spatial characteristics	Ecological environment	Normalized Difference Vegetation Index	0.485
Internal spatial characteristics	Ecological environment	Normalized Difference Water Index	0.400
Internal spatial characteristics	Visual environment	Panoramic Building View Index (positive orientation)	1.000
Internal spatial characteristics	Site morphology	Site area	0.946
Internal spatial characteristics	Site morphology	Perimeter	0.966
Internal spatial characteristics	Site morphology	Shape index	0.182
Internal spatial characteristics	Site morphology	Mean slope	0.206
Internal spatial characteristics	Site morphology	Elevation	0.021
Internal spatial characteristics	Road network	Maximum loop length	0.510
Internal spatial characteristics	Road network	Total route length	0.782
Internal spatial characteristics	Road network	Road count	0.517
Internal spatial characteristics	Road network	Road area	0.825
Internal spatial characteristics	Road network	Mean road width	0.598
Internal spatial characteristics	Road network	Road line density (positive orientation)	0.747
Internal spatial characteristics	Road network	Intersection density (positive orientation)	0.763
Internal spatial characteristics	Road network	Line-point ratio	0.290
Internal spatial characteristics	Road network	Maximum activity straight-line distance	0.821
Internal spatial characteristics	Road network	Activity line density	0.035
Internal spatial characteristics	Supporting facilities	Sports-facility condition	0.748
Internal spatial characteristics	Supporting facilities	Parking-lot capacity	0.380

Table S5 (continued). Built-environment indicators retained after exploratory Pearson screening and VIF filtering.

Dimension	Subdomain	Indicator	Outer loadings
Landscape configuration	Patch type	Forest-patch class area	0.552
Landscape configuration	Patch type	Forest-patch Largest Patch Index	0.369
Landscape configuration	Patch type	Forest-patch number of patches	0.759
Landscape configuration	Patch type	Shrub-patch class area	0.791
Landscape configuration	Patch type	Shrub-patch number of patches	0.894
Landscape configuration	Patch type	Grass-patch class area	0.079
Landscape configuration	Patch type	Grass-patch number of patches	0.192
Landscape configuration	Patch type	Built-up-patch Largest Patch Index	0.398
Landscape configuration	Patch type	Built-up-patch number of patches	0.897
Landscape configuration	Patch type	Water-patch class area	0.805
Landscape configuration	Patch type	Water-patch Largest Patch Index	0.252
Landscape configuration	Patch type	Water-patch number of patches	0.847
Landscape configuration	Patch type	Water-patch mean patch area	0.295
Landscape configuration	Landscape level	Total landscape area	0.464
Landscape configuration	Landscape level	Landscape Shape Index	0.922
Landscape configuration	Landscape level	Shannon's Diversity Index	0.854
Landscape configuration	Landscape level	Landscape-level number of patches	0.831
Surrounding urban context	Development intensity	Floor-area ratio	0.912
Surrounding urban context	Development intensity	Total POI density	0.944
Surrounding urban context	Commercial facilities	Dining-service density (positive orientation)	0.967
Surrounding urban context	Commercial facilities	Daily-living service density	0.986
Surrounding urban context	Commercial facilities	Shopping-service density	0.965
Surrounding urban context	Commercial facilities	Sports/leisure-service density	0.957
Surrounding urban context	Socioeconomic context	Housing price	0.143
Surrounding urban context	Socioeconomic context	Residential-accommodation density	1.000

Note: The initial pool comprised 97 indicators. This table lists the 46 indicators retained after exploratory Pearson screening against at least one activity outcome ($p < 0.05$) and subsequent VIF filtering (VIF < 5.0; maximum VIF among retained indicators 4.679). The Panoramic Building View Index did not meet the screening threshold and was carried forward on conceptual grounds to represent the visual environment. Outer loadings are shown for transparency; the final 25 indicators are listed in Table S6. "Positive orientation" denotes reverse-coded indicators.

Table S6. Retained indicators and outer loadings of the formative measurement model.

Dimension	Retained indicator	Outer loading
Internal spatial characteristics		
	Green-space area	0.983
	Site area	0.946
	Perimeter	0.966
	Total route length	0.782
	Road area	0.825
	Road line density (positive orientation)	0.747
	Intersection density (positive orientation)	0.763
	Maximum activity straight-line distance	0.821
	Sports-facility condition	0.748
Landscape configuration		
	Forest-patch number of patches	0.759
	Shrub-patch class area	0.791
	Shrub-patch number of patches	0.894
	Built-up-patch number of patches	0.897
	Water-patch class area	0.805
	Water-patch number of patches	0.847
	Landscape Shape Index	0.922
	Shannon's Diversity Index	0.854
	Landscape-level number of patches	0.831
Surrounding urban context		
	Floor-area ratio	0.912
	Total POI density	0.944
	Dining-service density (positive orientation)	0.967
	Daily-living service density	0.986
	Shopping-service density	0.965
	Sports/leisure-service density	0.957
	Residential-accommodation density	1.000

Note: "Positive orientation" denotes indicators that were reverse-coded so that all indicators of a construct point in the same direction.

Table S7. Implementation-oriented classification of the 46 built-environment indicators retained after exploratory screening.

Classification	Meaning for practice	Indicators
More readily modifiable (18)	Potentially amenable to site design, retrofit, or routine operations. These indicators should be considered only after local feasibility and equity assessment.	Normalized Difference Vegetation Index (NDVI); Normalized Difference Water Index (NDWI); Panoramic Building View Index (PBVI); Maximum loop length; Total route length; Road count; Road area; Mean road width; Road line density; Intersection density; Line-point ratio; Maximum activity straight-line distance; Activity line density; Sports-facility condition; Shrub-patch class area; Shrub-patch number of patches; Grass-patch class area; Grass-patch number of patches.
Modifiable through longer-term planning (21)	Usually requires capital investment, staged landscape change, or coordination across green-space planning, transport, and land-use authorities.	Mean slope; Parking-lot capacity; Forest-patch class area; Forest-patch Largest Patch Index; Forest-patch number of patches; Built-up-patch Largest Patch Index; Built-up-patch number of patches; Water-patch class area; Water-patch Largest Patch Index; Water-patch number of patches; Water-patch mean patch area; Landscape Shape Index; Shannon's Diversity Index; Landscape-level number of patches; Floor-area ratio; Total POI density; Dining-service density; Daily-living service density; Shopping-service density; Sports/leisure-service density; Residential-accommodation density.
Contextual / difficult to modify (7)	More suitable for site selection, stratification, and interpretation than as intervention targets within an individual green-space project.	Green-space area; Site area; Perimeter; Shape index; Elevation; Total landscape area; Housing price.

Note: The classification is a conceptual assessment of implementation feasibility and governance. It does not represent the strength, direction, or causality of the associations, and it should not be interpreted as evidence that modifying an indicator will change VGI-recorded activity person-times or positive emotional perception.

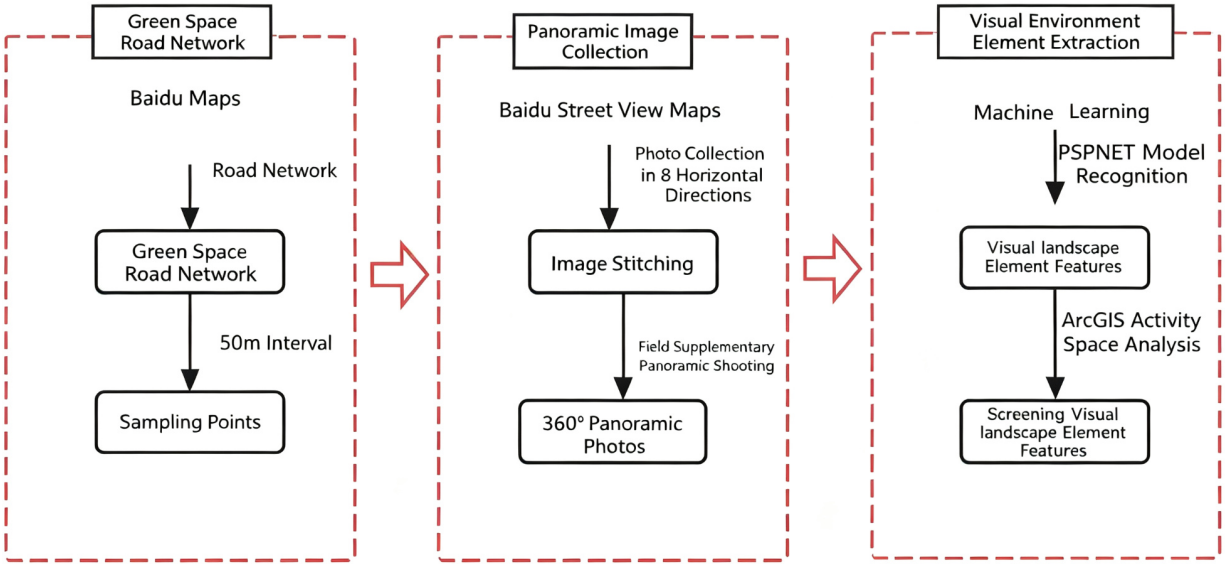
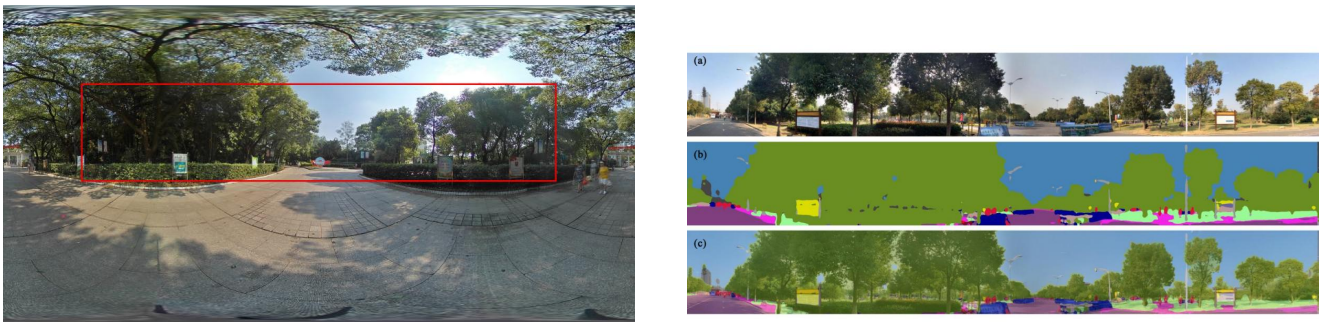


Figure S1. Visual-landscape data collection and feature-extraction workflow: sampling points every 50 m along the internal path network, panoramic image acquisition in eight horizontal directions and stitching (supplemented by field panoramas), PSPNet semantic segmentation, and extraction of site-level visual indices.



(a) Panoramic view of a green-space entrance

(b) Panorama, PSPNet segmentation and overlay

Figure S2. Example of panoramic visual acquisition and visual-element extraction.