Supplementary Material

Supplementary Table 1.

Supplementary Table 1. All indicators of driving factors for morphological features of buildings in a block.

Driving dimensions	Driving indicators	Indicator description	Formula
Morphological characteristics of the block	Block area (BLA)	-	
	Block perimeter (BLP)	-	
	Block shape regularity (BSR)	The degree to which the shape of the plot tends to be circular	$BSR = \frac{4\pi S}{C^2}$
Road situation	Surrounding road accessibility (SRA)	Spatial syntactic integration	
	Surrounding road network density (SRD)	The ratio of road network length within a radius of 1 km from the centroid of the plot to the plot area	$RB = \frac{\sum_{i=1}^{n} L_i}{\pi}$
	Adjacent road level (ARL)	The distance between the centroid of the block and the nearest roads at all levels, including main road, secondary road, and branch road	
Land use situation	Land use function (LU)	Public service land is recorded as A, commercial land is recorded as B, residential land is recorded as R, and industrial land is recorded as M	
	Surrounding B-class clustering level (LB)	The proportion of Class B land area within a radius of 1 km from the centroid of the plot	$LB = \frac{\sum B_{i=1}^{n} S_{Bi}}{100\pi}$
	Level of A-class clustering in the surrounding area (LA)	A-class land area within a radius of 1 km from the centroid of the plot	$LA = \frac{\sum_{Ai=1}^{An} S_{Ai}}{100\pi}$
	Surrounding R-class clustering level (LR)	R-class land area within a radius of 1 km from the centroid of the plot	$LR = \frac{\sum R_{i=1}^{n} S_{Ri}}{100\pi}$
	Level of M-class clustering in the surrounding area (LM)	M-class land area within a radius of 1 km from the centroid of the plot	$LM = \frac{\sum M_{i=1}^{n} S_{Mi}}{100\pi}$
Geographic situation	First level centre distance (DF)	The distance between the centroid of the plot and the primary centre of the nearest city	
	Secondary centre distance (DS)	The distance between the centroid of the plot and the second level centre of the nearest city	
	Third level centre distance (DT)	The distance between the centroid of the plot and the nearest tertiary centre	

Supplementary Table 2.

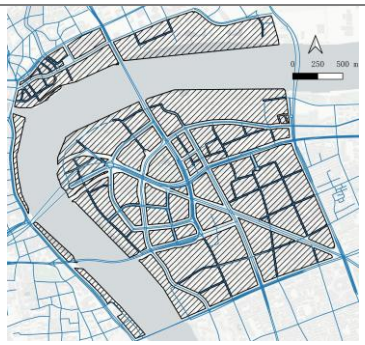
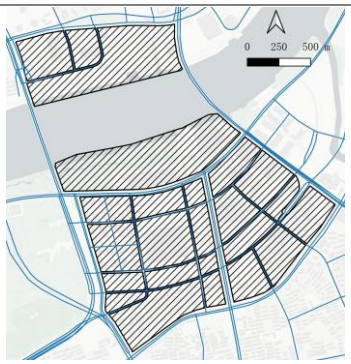
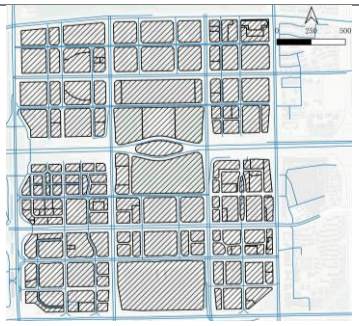
Supplementary Table 2. Detailed description of 12 morphological indicators for blocks.

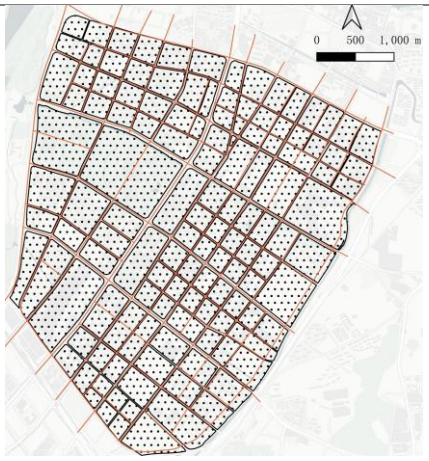
Morphological dimensions	Morphological indicators	Abbreviation	Indicator description	Formula algorithm
Planar form of buildings within the block	Building Number	BN	Total number of buildings within the block	
	Building Density	BD	Ratio of total building footprint area to block area	$BD = \frac{\sum_{i=1}^{n} S_{footprint,i}}{BLA}$
	Closeness	CL	Ratio of building perimeter to block perimeter	Offset 10 meters inward along the block boundary to form an erosion buffer zone, the proportion of building footprint area in the buffer zone
	Ratio of Building along Street	RBS	Proportion of street-facing buildings in the total number of buildings within the block	$RBS = \frac{BN_{street-facing}}{BN}$
	Average Building Footprint	ABF	Average footprint area of buildings within the block	$ABF = \frac{\sum_{i=1}^{n} S_{footprint,i}}{BN}$
Three-dimensional form of buildings within the block	Floor Area Ratio	FAR	Ratio of total building floor area to block area	$FAR = \frac{\sum_{i=1}^{n} S_{building,i}}{BLA}$
	High Building Number	HBN	Number of high-rise buildings within the block	Buildings with more than 12 floors are classified as high-rise buildings
	High Built Front Ratio	HBFR	Proportion of high-rise buildings facing the street in the total number of high-rise buildings	
	Max Building Height	MABH	Max Height of high-rise buildings	
	Average Building Height	ABH	Average height of all buildings	$ABH = \frac{\sum_{i=1}^{n} H_i}{BN}$
	Average High Building Height	AHBH	Average height of high-rise buildings	$AHBH = \frac{\sum_{i=1}^{n} HBH_i}{HBN}$
	Deviation of High Building Height	DHBH	Degree of variation in the height of high-rise buildings	$DHBH = \sqrt{\frac{\sum_{i=1}^{n}(HBH_i - AHBH)^2}{HBN}}$

Supplementary Table 3.

Supplementary Table 3. Detailed characteristics and spatial distribution of the block-level sample datasets. The table documents the city, urban new district, geographical area, block quantities, spatial overviews, and data splitting strategies, including the primary dataset (across 9 new districts) for model training and the independent out-of-city dataset (Nanjing Hexi New District) for spatial generalisation testing.

City	Urban New District	Area (km^2)	Number of Blocks	Spatial Overview	Dataset Role & Split Strategy
Beijing	Chaoyang New District	3.64	51		Primary Dataset (Random 80% Train, 20% Test)
	Financial Street District	1.23	41		
	Wangjing New District	8.51	123		

Shanghai	Pudong New Area	2.97	80	
	Expo New Area	2.43	24	
Guangzhou	Tianhe New District	5.60	66	
Shenzhen	Futian New Districts	3.95	171	
	Nanshan New Districts	4.91	276	

	Qianhai New Districts	5.09	231		
Nanjing	Hexi New District	18.59	128		Generalisability Test (100% Unseen samples)

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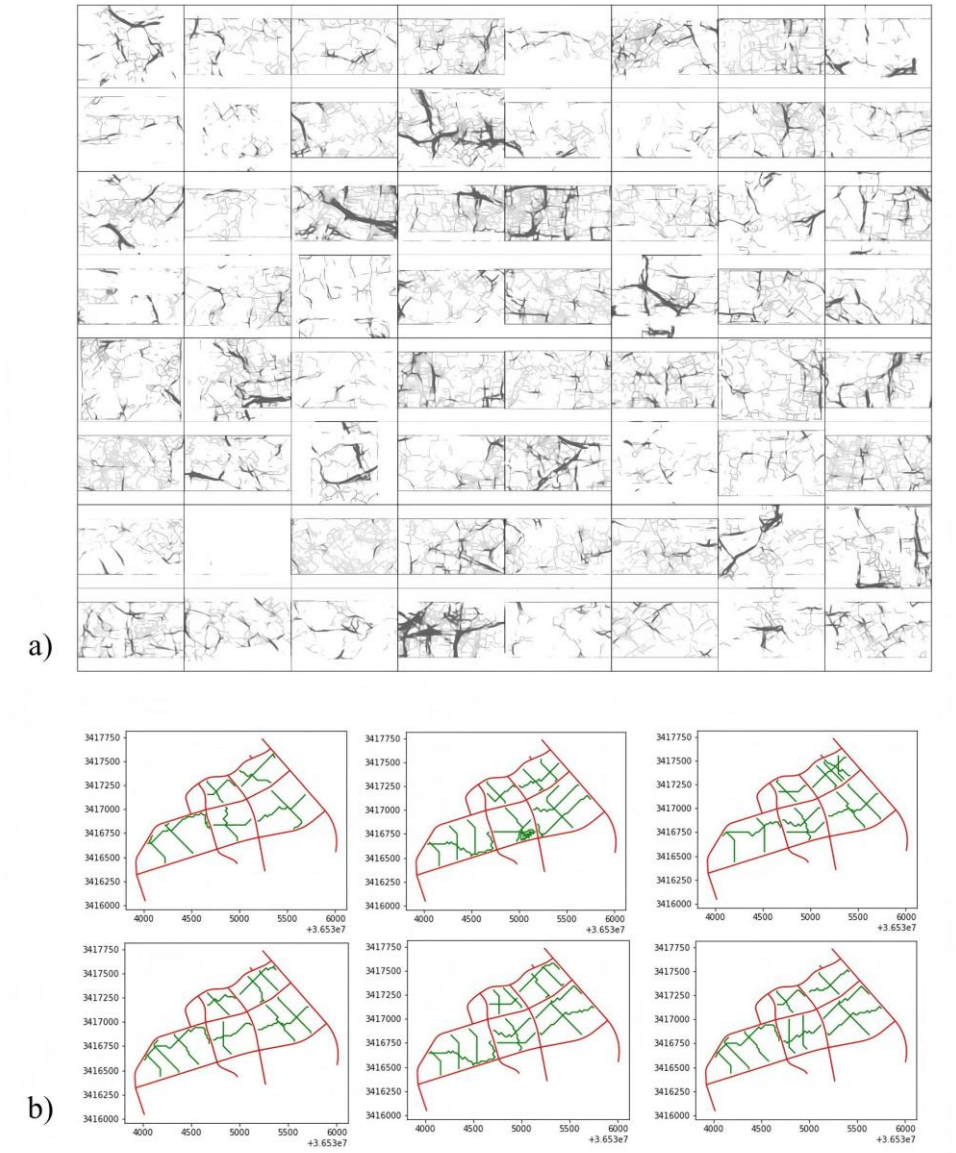
Supplementary Table 4.

Supplementary Table 4. Excerpt of the third-party evaluation report for the generative platform. This table summarises the system's objective testing results, detailing specific evaluation criteria and outcomes across five categories and eleven testing items.

Testing items	Technical requirements	Test results
System-generated elements must cover	It shall be capable of generating 20 categories of spatial elements, including: primary roads, secondary roads, branch roads, road corners, plots, corner green spaces, roadside green spaces, linear green spaces, neighbourhood commercial areas, height controls for residential land, height controls for commercial land, high-rise residential buildings, mid-rise residential buildings, multi-storey residential buildings, residential podiums, commercial podiums, high-rise commercial buildings, community green spaces, commercial plazas, and commercial green spaces.	Accord with
	It shall be able to distinguish spatial elements by means of varied colours and shapes.	Accord with
System loading and rendering	The loading time for the urban road network in a design scheme covering ten square kilometres shall be less than 40 seconds.	In this test, the loading time for the urban roads within the ten-square-kilometre design scheme was 32.63 seconds.
	The loading time for the urban spatial morphology in a design scheme covering ten square kilometres shall be less than 200 seconds.	In this test, the loading time for the urban spatial morphology within the ten-square-kilometre design scheme was 182.21 seconds.
	The loading time for the building forms in a design scheme covering ten square kilometres shall be less than 200 seconds.	In this test, the loading time for building forms within the ten-square-kilometre design scheme was 20.32 seconds.
	The total loading time for rendering the ten-square-kilometre design scheme shall be capable of being less than 6 minutes.	In this test, the total rendering loading time for the ten-square-kilometre design scheme was 3 minutes and 48.23 seconds.
The number of statistical indicators for the generated scheme	The generated scheme shall be capable of producing statistics for 50 indicators, including: total road length (m); average segment length (m); road hierarchy; number of plots; road network area density; road network connectivity; road network length density; road network non-straightness coefficient; land use type; plot area; planning orientation; total land area (ha); construction land area (ha); functional mix; average height (m); average floor area ratio (FAR); height variation; openness; green coverage rate; total green area (ha); maximum height of landmark high-rise buildings (m); number of landmark high-rise buildings; maximum building height per plot; average height of high-rise buildings; building density; land use mix degree; height intervals; height frequencies; building ID; plot ID; block indicators; land use nature; commercial floor area; residential floor area; public service floor area; public utility area; industrial floor area; total volume; total footprint area; footprint perimeter; height-to-width ratio; length-to-width ratio; total number of building masses; number of high-rise building masses; maximum plot height; maximum footprint area; maximum volume; height variation of building masses; footprint area	Accord with

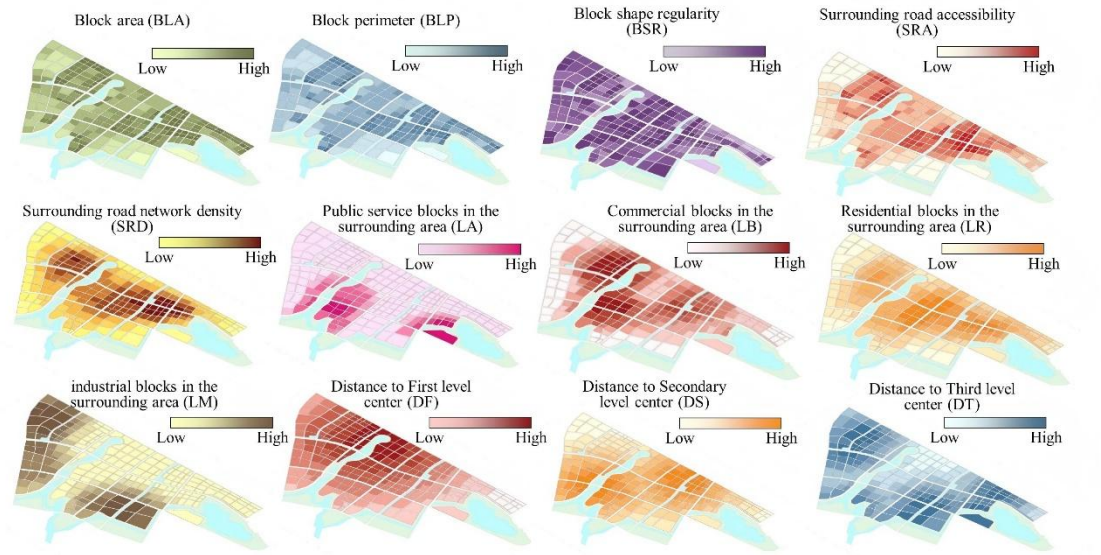
	variation of building masses; and construction potential.	
Urban design process	It shall be capable of generating urban roads, urban spatial forms, and three-dimensional forms of urban blocks based on broad land-use categories and external arterial road conditions.	Accord with
	It shall be capable of generating urban spatial forms and the three-dimensional morphology of urban blocks, based on the conditions of urban roads and land use.	Accord with
Schematic design	The system shall be capable of generating corresponding urban design schemes based on different site conditions.	Accord with
	The system shall be capable of generating multiple alternative urban design schemes for the same plot.	Accord with

Supplementary Figure 1.



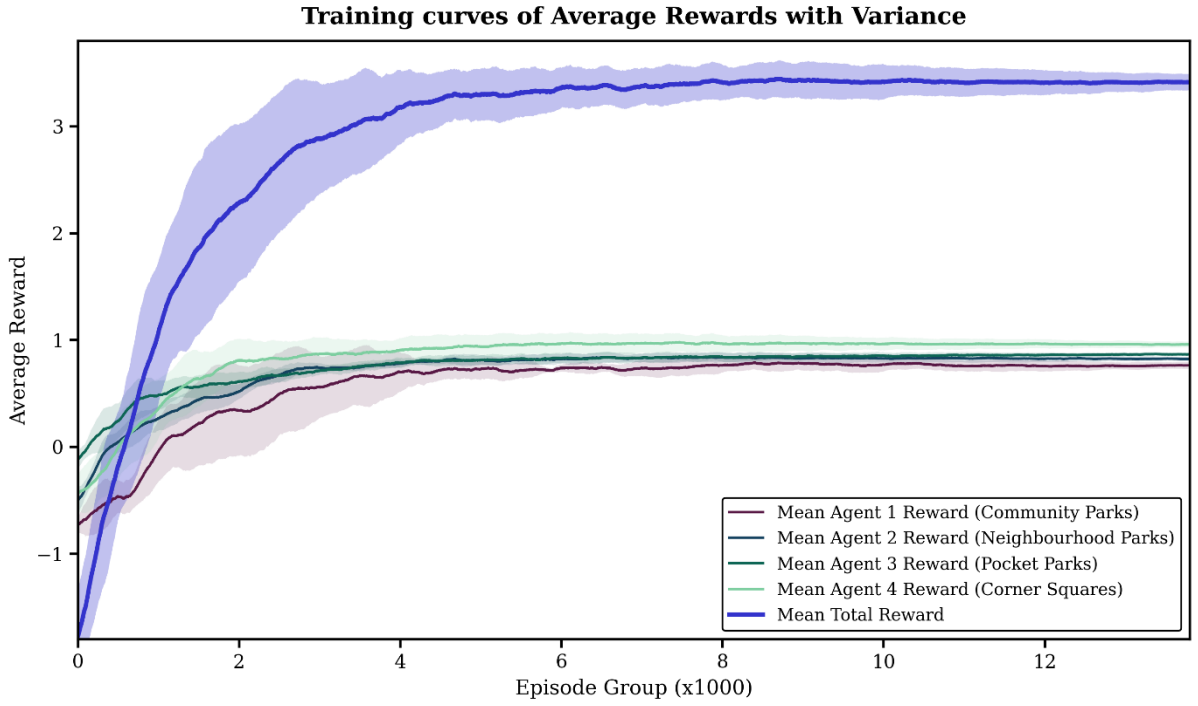
Supplementary Figure 1. Comparative evaluation of urban road network generation using Variational Autoencoders (VAEs) and Reinforcement Learning (RL). (a) Road network outcomes generated via VAEs. The model was trained on a dataset of 5400 binary images (resized to 256 × 256 pixels), representing 3000 × 3000 m urban samples extracted from OpenStreetMap. **(b)** Road network trajectories generated using an RL approach. The model utilises an Actor-Critic framework based on a Finite Markov Decision Process, where the generation of a road terminates upon the agent reaching the block boundary.

Supplementary Figure 2.



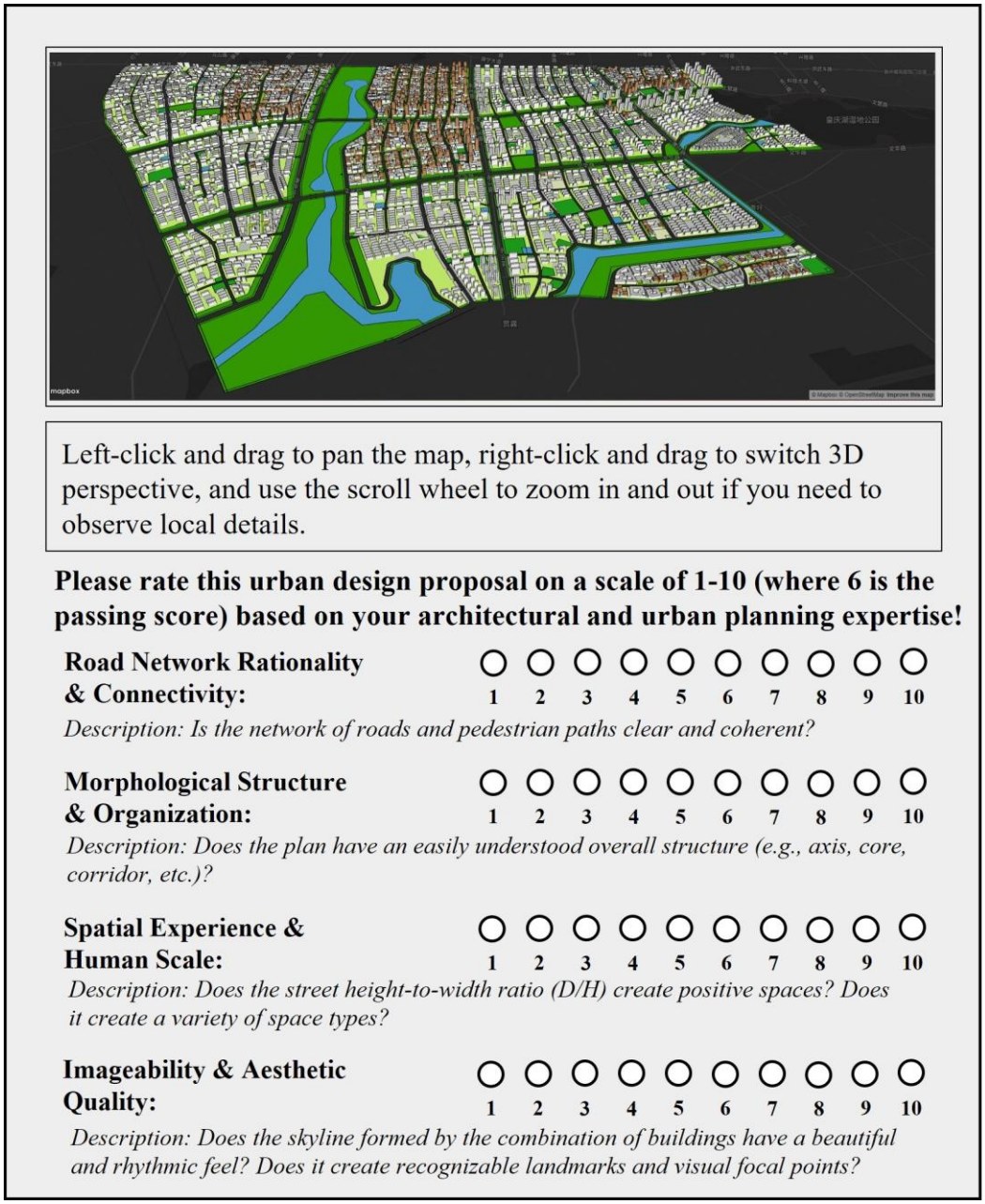
Supplementary Figure 2. Spatial distribution of 12 numerical driving factors in the case area, including BLA, BLP, BSR, SRA, SRD, LB, LA, LR, LM, DF, DS and DT

Supplementary Figure 3.



Supplementary Figure 3. Training dynamics and convergence curves of the MADDPG algorithm for point-shaped green space generation. Solid lines represent the mean episodic rewards across three independent training runs (initialised with different random seeds), while the shaded regions indicate the corresponding variance.

Supplementary Figure 4.



Supplementary Figure 4. Web-based questionnaire for professional evaluation of urban design outputs across four dimensions.