We used the following landscape metrics to quantify the spatial pattern of the simulated urban landscape: number of patches (NP), contiguity index (CONTIG), Euclidean nearest-neighbor distance (ENN), patch cohesion index (COHESION), and aggregation index (AI). Below are simplified descriptions of how these metrics are calculated in the Fragstats software, and more details of these indices are referred to the user manual of the software [1].

NP measures the degree of fragmentation of the urban landscape. Its value range is NP≥1, and a larger value of NP means a higher degree of fragmentation.

CONTIG measures the spatial contiguity of pixels within an urban patch . The formula for this index is as follow:

$$\text{CONTIG} = \frac{\left[\frac{\sum_{r=1}^{z} c_{jr}}{a_j^*}\right] - 1}{v - 1}$$

where C_{jr} means contiguity value of pixel r of the urban patch j, a_j^* is area of urban patch j in terms of number of cells, v means sum of the values in a 3-by-3 cell template. The CONTIG index is in the range of [0, 1], and it approaches the upper limit of 1 as patch connectedness increases.

ENN quantifies patch isolation degree based on the Euclidean nearest-neighbor distances between urban patches. It is calculated using the following formula:

$$\text{ENN} = h_{ij}$$

where h_{ij} means the nearest distance from the urban patch i to urban patch j, based on edge-to-edge distance.

COHESION is the measurement of the physical connectedness of all the urban patches. It is calculated as follow:

$$\text{COHESION} = \left[1 - \frac{\sum_{j=1}^{n} p_j^*}{\sum_{j=1}^{n} p_j^* \sqrt{a_j^*}}\right] \times \left[1 - \frac{1}{\sqrt{Z}}\right]^{-1} \times (100)$$

where P_j^* is the perimeter of urban patch j, a_j^* represents the area of urban patch j, Z means the total number of urban pixels. The value range of COHESION is [0, 100], and a larger value indicates a better connectedness between urban patches.

AI measures the aggregation or adjacency of the urban patches. It is quantified as follow:

$$\text{AI} = \left[\frac{g_i}{max - g_i}\right] \times (100)$$

where g_i means number of like joins between pixels of urban patches, max - g_i is maximum number of like joins between pixels of urban patches. The value range of AI is [0, 100]. The larger of the AI the higher of the aggregation between urban patches.

1. McGarigal, L.; Marks, B. FRAGSTATS: Spatial pattern analysis program for quantifying landscape structure. General Technical Report PNW-GTR-351. U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station, Portland, OR, USA: 1995; pp. 122.