



Table S1 Spatial predictor variables used in the CA–ANN simulation.

Predictor variable	Source/derivation	Spatial representation
DEM/Elevation	SRTM DEM	Represents elevation and vertical terrain position
Aspect	Derived from SRTM DEM	Represents directional orientation of terrain surfaces
Slope	Derived from SRTM DEM	Represents terrain steepness
Hill shade	Derived from SRTM DEM	Represents terrain relief and illumination characteristics
Contour	Derived from SRTM DEM	Represents spatial configuration and gradient of elevation
Curvature	Derived from SRTM DEM	Represents local convexity and concavity of terrain
Distance to Stream	Derived from stream network	Represents hydrological proximity to drainage features
Distance to Railway	Derived from railway network	Represents proximity to transportation infrastructure

Note: The predictor variables were selected on the basis of geographical and spatial-process relevance and were intended to provide complementary representations of terrain configuration, hydrological proximity, and transportation accessibility. The six terrain variables are derived from a common SRTM DEM and may therefore contain related spatial information.

Table S2 Quality-controlled verification statistics for the revised 2025 Landsat-derived LST and UTFVI surfaces used to verify the UTFVI formulation.

Statistic	2025 Summer	2025 Winter
Landsat L2SP scenes used	5	3
Valid LST pixels	502,658	504,875
Mean LST (°C)	43.0564	33.6730
Mean LST (K)	316.2064	306.8230
LST SD (°C)	2.8855	3.1605
Mean UTFVI	7.48×10^{-15}	1.62×10^{-14}
UTFVI SD	0.009125	0.010301
UTFVI minimum	-0.044466	-0.056868
UTFVI maximum	0.037757	0.063322
UTFVI P95	0.011469	0.017820
Mean absolute UTFVI	0.006529	0.007715

Note: LST was converted to Kelvin before UTFVI calculation. The mean UTFVI values are numerically close to zero because positive and negative pixel-level deviations around the study-area mean approximately cancel when averaged.