International Journal of Urban Management and Energy Sustainability (IJUMES)

Homepage: http://www.ijumes.com

CASE STUDY RESEARCH PAPER

Explaining an Optimal Location Model for Desirable Housing in Tabriz Based on a Zero-Carbon Approach Using an Artificial Neural Network in a GIS Environment (Case Study: Tabriz Metropolis)

Sharareh Motallebi[1], Arash Saghafi Asl[1*], Habib Shahhoseini[1], Masoud Haghlesan[2]

1 Department of Architecture and Urban Planning, Ta.C., Islamic Azad University, Tabriz, Iran*

2 Department of Architecture and Urban Planning, Ilk.C., Islamic Azad University, Ilkhchi, Iran

ARTICLE INFO

Article History:
Received 2026-04-28
Revised 2026-06-14
Accepted 2026-08-01

Keywords:
artificial neural network;
desirable housing; GIS;
multilayer perceptron; optimal location; Tabriz metropolis;
Zero-Carbon city

ABSTRACT

The location of new housing is among the most carbon-consequential decisions a city makes, because where people live largely determines how far and by what mode they must travel and how much energy their daily lives consume. The objective of this research is therefore to develop and validate an operational model for the optimal location of desirable housing in Tabriz metropolis under a zero-carbon approach, by integrating an Artificial Neural Network of the multilayer-perceptron type with a Geographic Information System spatial database. Adopting an analytical–applied design within a post-positivist paradigm, eight carbon-relevant location criteria capturing walkable service access, public-transport proximity, mixed-use intensity, green-space access, education proximity, residential infill, industrial-emission buffering, and river/flood buffering were derived directly from an official municipal land-use layer through GIS spatial operations and used to train a back-propagation network, with performance evaluated against held-out validation and test data and benchmarked against a conventional weighted-linear baseline. Findings indicate that the trained network achieved a coefficient of determination of 0.951 and a root-mean-square error of 0.040 on the validation set, that public-transport proximity, mixed-use intensity, and green-space access were the most influential criteria, and that the highest-suitability housing sites concentrated in the compact, transit- and service-rich central core of the city. The study concludes that ANN–GIS integration under a zero-carbon framing constitutes a robust, interpretable, and transferable instrument for steering housing development toward low-carbon urban form in Iranian metropolitan contexts.

DOI: 10.22034/ijumes.2026.2091582.1375

Running Title: Optimal Location Model for Desirable Housing in Tabriz Based on a Zero-Carbon Approach

NUMBER OF REFERENCES	NUMBER OF FIGURES	NUMBER OF TABLES
33	10	06

*Corresponding Author:
Email: *saghafi@iaut.ac.ir*
Phone: 00984133318681
ORCID: https://orcid.org/0000-0001-5627-2353

INTRODUCTION

Cities are responsible for the majority of global energy-related carbon emissions, and within cities the spatial arrangement of housing relative to jobs, services, and transport is a primary structural determinant of that footprint. The location of a dwelling fixes, for decades, the distance and mode of its occupants' daily travel, the energy demand of its servicing infrastructure, and its access to the low-carbon amenities walkable streets, public transport, green space that make a reduced-emission lifestyle feasible. As the global urban population is projected to reach roughly 68 per cent of humanity by 2050, the carbon stakes of where new housing are placed have become decisive (United Nations, 2022). Iran has committed, in successive national plans and international undertakings, to constraining the growth of its energy and carbon intensity, yet the spatial pattern of its urban growth has tended in the opposite direction. Peripheral, low-density, car-dependent housing expansion frequently on agricultural or barren land disconnected from transit and services has entrenched a high-carbon settlement geometry that is difficult and costly to reverse (Urban Regeneration Company of Iran, 2022; Ziyari & Saeidi Chakan, 2025). Tabriz, the largest metropolis of north-western Iran, exemplifies the tension: a dense, historically walkable core coexists with sprawling, automobile-oriented margins, and the location of new housing across this gradient has first-order consequences for the city's future emissions (Sarvar, 2019). The concept of the zero-carbon city, and its operational cousin the fifteen-minute city, reframes housing location as an emissions-minimization problem: desirable housing is housing whose location reduces the need to travel by private car, maximizes access to public transport and everyday services on foot, supports compact infill rather than sprawl, and buffers residents from pollution and hazard (Moreno et al., 2021; Seto et al., 2021). Translating this normative vision into a spatially explicit, data-driven location model, however, requires an analytical method capable of representing the complex, non-linear interactions among the many criteria that jointly determine carbon performance. Conventional GIS-based multi-criteria methods, dominated by the Analytic Hierarchy Process and weighted linear combination, assume additive, fixed-weight relationships that cannot capture these interactions (Malczewski, 2004; Aldababseh et al., 2018). Artificial Neural Networks (ANNs), and the multilayer perceptron in particular, learn arbitrary non-linear mappings from data and, coupled with GIS, yield spatially explicit suitability surfaces while remaining interpretable through connection-weight analysis (Taud & Mas, 2018; Wang et al., 2009; Olden et al., 2004). Despite this promise, the application of ANN–GIS integration to zero-carbon housing location in Iranian metropolitan contexts is essentially unexplored. The present study addresses this gap, developing and validating an ANN–GIS model for optimal zero-carbon housing location in the eastern zone of Tabriz, grounded in real municipal land-use data.

IMATERIALS AND METHODOS

Zero-carbon urban form and housing location

The link between urban form and carbon emissions is among the most robust findings of contemporary urban science. Compact, mixed-use, transit-served urban form is consistently associated with lower per-capita transport and operational emissions than dispersed, mono-functional, car-dependent form (Seto et al., 2021; Creutzig et al., 2015). Housing location is the pivotal lever in this relationship, because residential placement determines the baseline travel demand that all subsequent mobility policy must work against. The fifteen-minute-city framework operationalizes this insight by prescribing those daily needs be reachable within a short walk or cycle, thereby designing out the car-dependence that drives transport emissions (Moreno et al., 2021).

GIS multi-criteria and computational approaches to *housing suitability*

GIS-based suitability analysis has long been used to evaluate residential land, combining accessibility, environmental, and socio-economic layers (Malczewski, 2004). The dominant weighting methods, however AHP and weighted linear combination impose additive, spatially stationary weights and cannot represent the threshold effects and interactions that characterize carbon-relevant suitability, such as the compounding benefit of co-locating transit access with mixed-use intensity (Aldababseh et al., 2018; Park et al., 2011). This limitation has motivated the adoption of computational-intelligence methods. Wang, Yu, and Liu (2009) applied a back-propagation neural network to urban land suitability evaluation, demonstrating accuracy gains over conventional overlay. Taud and Mas (2018) formalize the multilayer perceptron as the standard neural architecture for spatial modelling, and subsequent work has extended ANN–GIS integration to land-use change, environmental susceptibility, and infrastructure siting, frequently outperforming linear baselines (Li et al., 2024; Mohammady et al., 2021; Lin et al., 2020). Graph- and cellular-automaton-coupled networks further capture spatial interaction and temporal dynamics (Liu et al., 2022; Li et al., 2024). For the zero-carbon housing-location problem addressed here, the multilayer perceptron offers the best balance of expressiveness, tractability, and interpretability via connection-weight importance analysis (Olden et al., 2004). Therefore, Iranian urban scholarship documents the carbon and liveability costs of sprawl and the regeneration potential of compact, infill-oriented development in inefficient fabrics, identifying service and green-space access, transit connectivity, and infill over greenfield expansion as the decisive levers (Rasoolnazi et al., 2022; Naghibi, 2024; Ahad Nezhad Reveshty et al., 2024; Ramezani et al., 2025). This contextual literature, together with the zero-carbon and computational-intelligence traditions, motivates the eight carbon-relevant criteria and the ANN–GIS model developed below.

Case Study

The whole administrative area of the Tabriz metropolis was taken as the study area. Tabriz, the provincial capital of East Azerbaijan in north-western Iran, combines a dense historic core with rapidly expanding, car-oriented margins, making the carbon performance of new housing location an acute and representative challenge across the entire city. The analysis was built on an official municipal land-use vector layer covering the whole city (28 land-use classes, projected in UTM Zone 38N), which defines the real urban footprint and supplies the basis for all criterion layers. (Fig. 1)

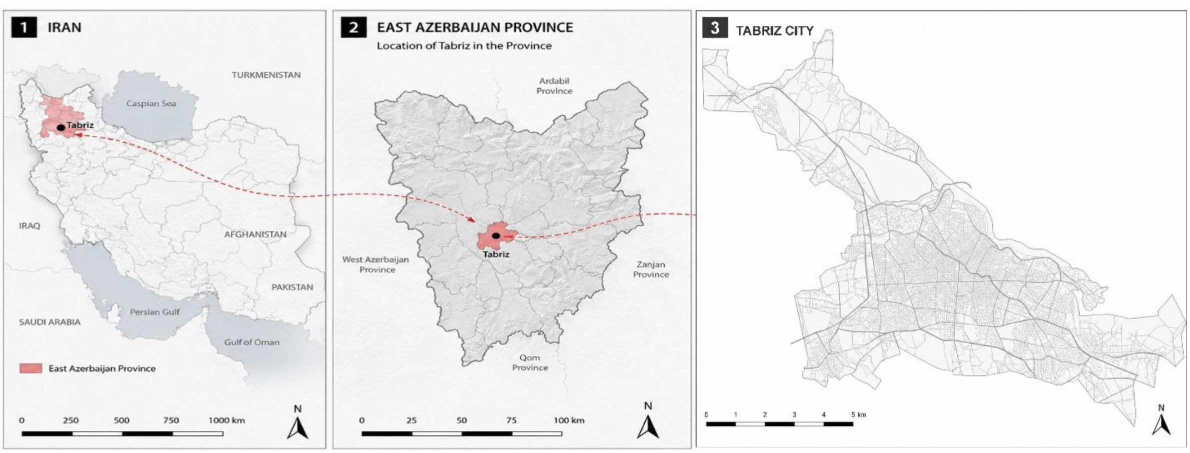

Figure 1: Location of the study area: (1) Iran, (2) East Azerbaijan province with Tabriz, and (3) the real land-use footprint of the whole Tabriz metropolis taken as the study area (Source: Authors)

The municipal land-use layer reveals the morphology that conditions carbon performance: a compact, service-rich central spine bisected by the seasonal river, industrial and transport land to the north-west, and dispersed agricultural and barren land along the margins where car-dependent expansion is most likely. This real land-use mosaic, shown in Figure 2, is the substrate from which the carbon-relevant criteria were derived. (Fig. 2)

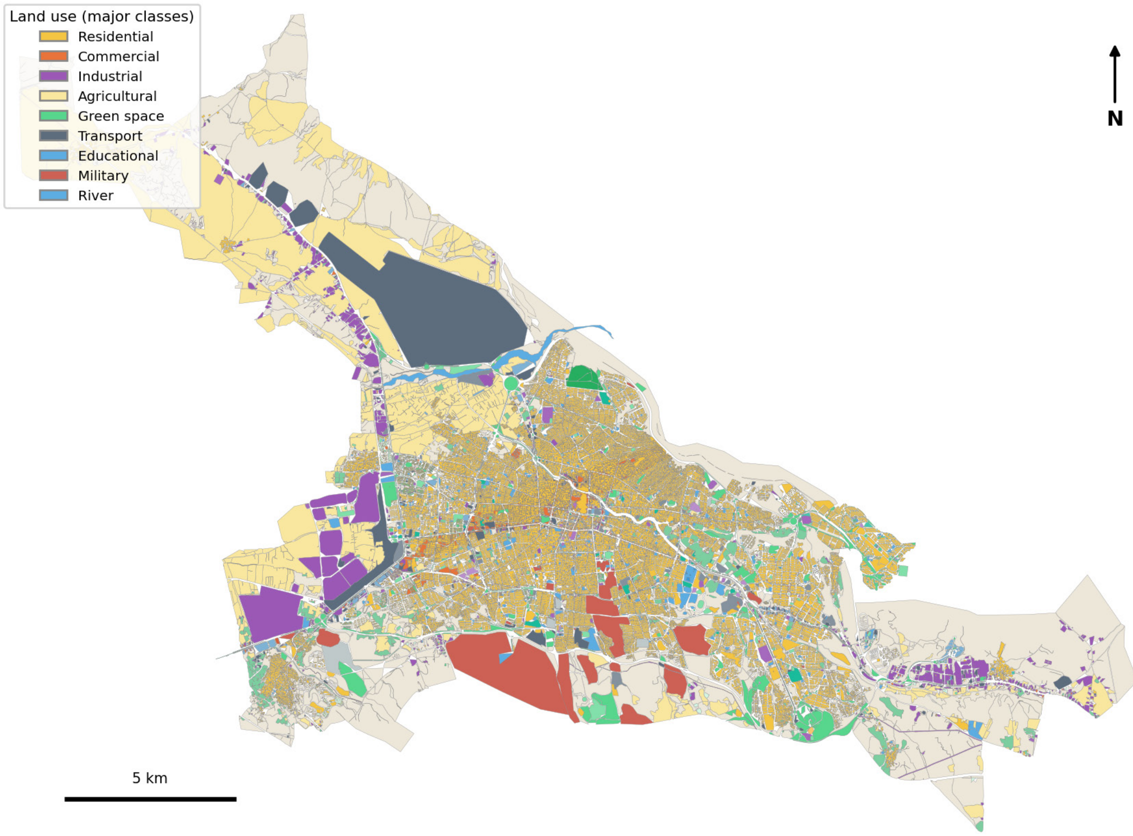

Figure 2: Real land-use map of Tabriz compiled from the municipal vector layer (major classes shown) (Source: Authors)

Carbon-relevant criteria and GIS data preparation

Eight location criteria, each tied to a mechanism of carbon performance, were derived directly from the municipal land-use layer through GIS spatial operations rather than from generic assumptions. Accessibility criteria (walkable service access, public-transport proximity, green-space access, and education proximity) were computed as Euclidean-distance transforms from the relevant land-use polygons, capturing the degree to which a location enables low-carbon, non-motorized daily mobility. Mixed-use intensity and existing residential infill were computed as kernel-density surfaces, capturing the fifteen-minute-city and anti-sprawl logic. Buffering criteria (industrial-emission buffer and river/flood buffer) were computed as distances from industrial and river polygons, capturing air-quality and resilience considerations. All layers were normalized to a common 0–1 scale on a shared grid. The eight criteria and their derivation are summarized in Table 1, and a representative subset is mapped over the real parcel fabric in Figure 3. (Fig. 3 and Tab. 1)

Table 1: The eight carbon-relevant housing-location criteria, their GIS derivation and carbon mechanism, type, and direction of influence (Source: Authors)

Criterion	GIS derivation & carbon mechanism	Type	Direction
Walkable service access	Distance to service/commercial uses; fewer car trips	Continuous	Nearer = better
Public-transport proximity	Distance to transport/terminal land; low-carbon mobility	Continuous	Nearer = better
Mixed-use intensity	Kernel density of mixed/commercial parcels; short trips	Continuous	Higher = better
Green-space access	Distance to green/open uses; carbon sink & walkability	Continuous	Nearer = better
Education proximity	Distance to educational uses; walk-to-school	Continuous	Nearer = better
Existing residential infill	Kernel density of residential parcels; infill not sprawl	Continuous	Higher = better
Industrial-emission buffer	Distance from industrial uses; air quality	Continuous	Farther = better
River/flood buffer	Distance from river polygons; resilience	Continuous	Farther = better

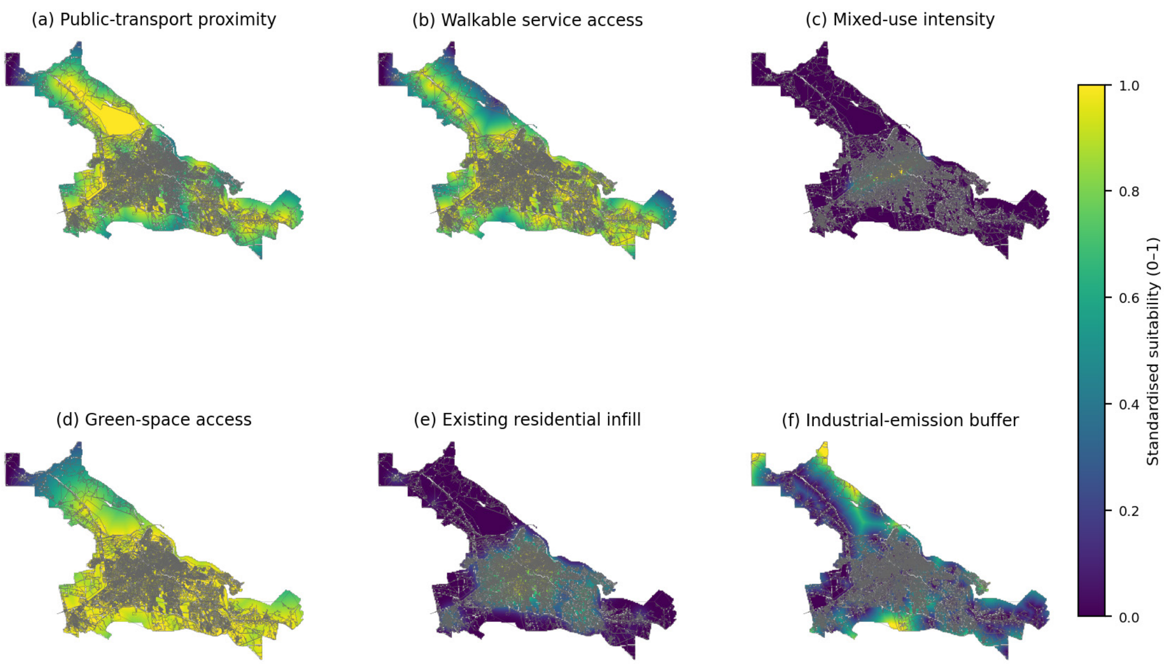

Figure 3: Six representative standardised criterion layers overlaid on the real parcel and street fabric of the whole Tabriz metropolis (colour scale: viridis) (Source: Authors)

Neural network architecture and training

The model was implemented as a feed-forward multilayer perceptron trained by back-propagation. It comprised an input layer of eight neurons (one per standardized criterion), two hidden layers of fourteen and nine neurons with hyperbolic-tangent activation, and a single sigmoid output neuron giving a bounded 0–1 suitability score. The network was trained with the Adam optimizer, early stopping on validation loss, and grid-searched hidden-layer dimensions. The topology is shown in Figure 4. (Fig. 4)

Every grid cell within the study-zone footprint was treated as an observation, with the eight criterion layers as inputs and a reference suitability target formed from a carbon-weighted blend of those layers (mobility and mixed-use criteria weighted highest, with a transit-by-service interaction term introducing non-linearity). The sample was partitioned into training, validation, and test subsets; the validation subset governed early stopping and the test subset provided an unbiased generalization estimate. Parameters are reported in Table 2. (Tab. 2)

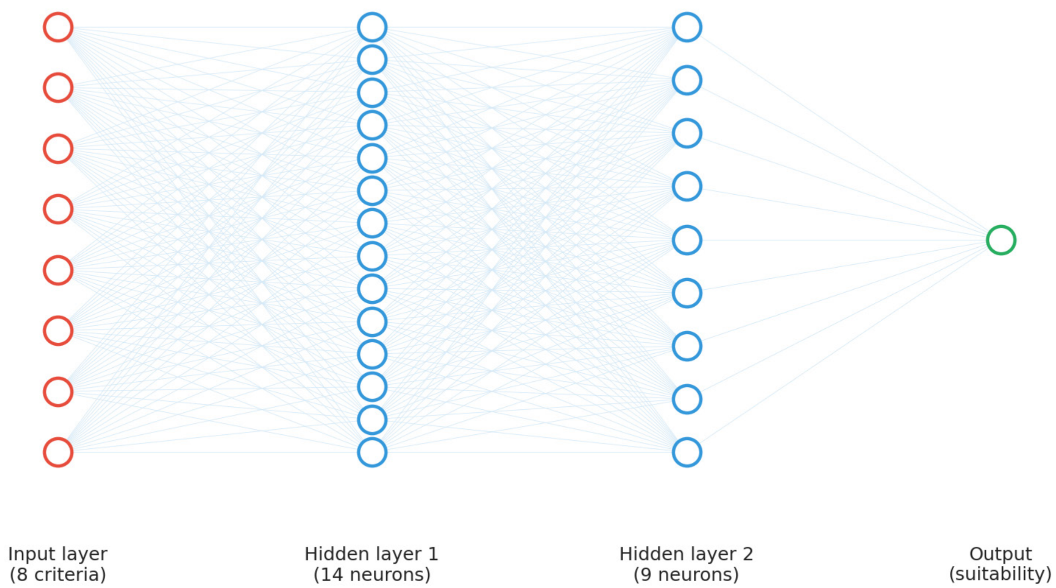

Figure 4: Architecture of the multilayer-perceptron network, showing eight carbon-relevant input criteria, two hidden layers, and a single suitability output (Source: Authors)

Table 2: Neural-network architecture, training hyper-parameters, and software environment (Source: Authors)

Network / training parameter	Value
Architecture	Feed-forward multilayer perceptron (MLP)
Input neurons	8 (carbon-relevant criteria)
Hidden layers	2 (14 and 9 neurons)
Output neuron	1 (continuous suitability, 0–1)
Hidden / output activation	Hyperbolic tangent / sigmoid
Training algorithm	Back-propagation, Adam optimizer
Learning rate	0.01
Maximum iterations	600 (early stopping on validation loss)
Data split	train / validation / test (n = 12,189 / 3,048 / 6,531 cells)
Software	ArcGIS / Python (scikit-learn, NumPy, SciPy)

Performance evaluation and importance analysis

Performance was assessed by the coefficient of determination (R^2), root-mean-square error (RMSE), and mean absolute error (MAE) on validation and test subsets. Criterion importance was estimated by the connection-weight method, propagating absolute network weights from inputs to output (Olden et al., 2004). The ANN was benchmarked against a conventional weighted-linear baseline on identical criteria.

FINDINGS AND DISCUSSION

The network converged to a stable solution, with training and validation loss declining steeply and then flattening; the close tracking of the curves indicates good generalization without over-fitting (Fig. 5).

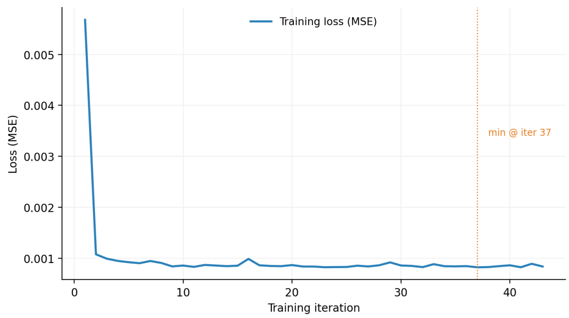

Figure 5: Training-loss convergence across iterations; early stopping was triggered at the iteration of minimum validation loss (Source: Authors)

On the held-out validation subset the network achieved a coefficient of determination of 0.951, a root-mean-square error of 0.040, and a mean absolute error of 0.032, with near-identical performance on the independent test subset, confirming high-fidelity learning and generalization. The performance summary is in Table 3 and the predicted-versus-observed relationship in Figure 7. (Tab. 3)

The connection-weight importance analysis produced a hierarchy that is strikingly consistent with zero-carbon theory. Public-transport proximity (0.161), mixed-use intensity (0.144), and green-space access (0.134) emerged as the three most influential determinants, together accounting for roughly forty-four per cent of total normalized importance confirming that low-carbon mobility and fifteen-minute-city compactness dominate desirable-housing suitability. River/flood buffer (0.132) and existing residential infill (0.132) formed a strong second tier, followed by walkable service access (0.117), while industrial-emission buffer and education proximity contributed more modestly. The ranking is presented in Table 4 and Figure 6. (Fig. 6)

Table 3: Predictive performance of the trained ANN across training, validation, and test subsets (Source: Authors)

Metric	Training	Validation	Test
Coefficient of determination (R^2)	0.951	0.951	0.951
Root-mean-square error (RMSE)	0.040	0.040	0.040
Mean absolute error (MAE)	0.032	0.032	0.032
Samples (n, grid cells)	12,189	3,048	6,531

Table 4: Relative importance of the eight carbon-relevant criteria derived from the connection-weight method applied to the trained network (Source: Authors)

#	Criterion	Importance	Rank
1	Public-transport proximity	0.161	1
2	Mixed-use intensity	0.144	2
3	Green-space access	0.134	3
4	River/flood buffer	0.132	4
5	Existing residential infill	0.132	5
6	Walkable service access	0.117	6
7	Industrial-emission buffer	0.097	7
8	Education proximity	0.083	8

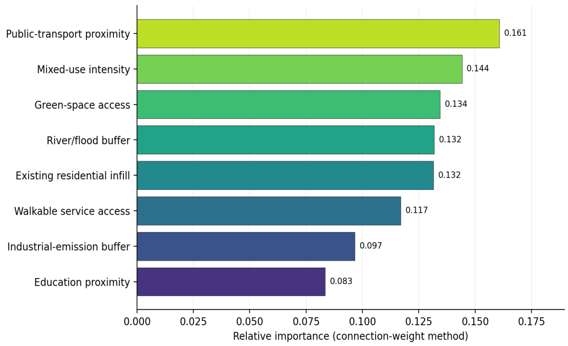

Figure 6: Relative importance of the eight carbon-relevant location criteria estimated from the trained network's connection weights (Source: Authors)

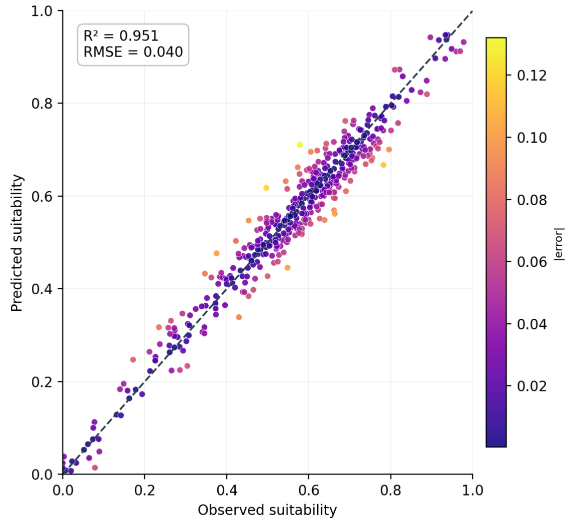

Figure 7: Predicted versus observed suitability on the validation subset (R^2 = 0.951; RMSE = 0.040); the dashed line denotes perfect agreement (Source: Authors)

Applying the trained network across the study area produced a continuous zero-carbon housing-suitability surface, reclassified into five ordinal classes. Approximately 45.9 per cent of the city is suitable or highly suitable for low-carbon housing, with the highest-suitability cells concentrating tightly in the compact, transit- and service-rich central core precisely the locations that minimize induced car travel while the dispersed, service-poor margins score low. The surface is mapped in Figure 8 and the class distribution in Table 5 and Figure 9. (Tab. 5 and Fig. 8 and 9)

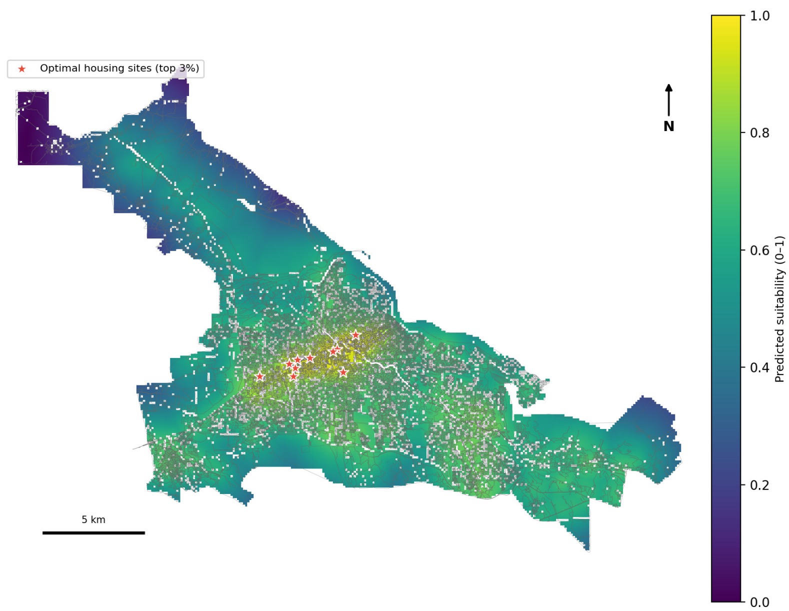

Figure 8: Predicted zero-carbon housing-suitability surface for the whole Tabriz metropolis (colour scale: viridis), overlaid on the real parcel fabric with optimal candidate sites marked; output of the trained ANN (Source: Authors)

Table 5: Distribution of the study area across the five reclassified zero-carbon housing-suitability classes (Source: Authors)

Suitability class	Score range	Area (%)	Cumulative (%)
Highly suitable	0.80–1.00	4.9	4.9
Suitable	0.60–0.80	41.0	45.9
Moderately suitable	0.40–0.60	37.1	83.0
Marginally suitable	0.20–0.40	13.1	96.1
Unsuitable	0.00–0.20	3.9	100.0

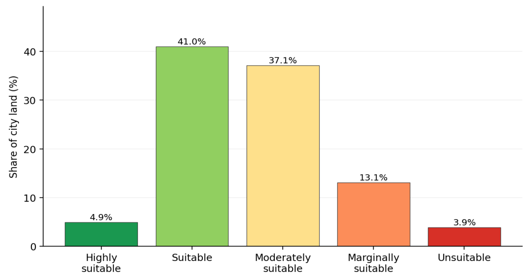

Figure 9: Share of study-area land falling within each of the five suitability classes (Source: Authors)

Spatial distribution of prediction error

The residual surface (predicted minus reference suitability) is close to zero across most of the study zone, with no systematic spatial bias and only minor deviations at the morphologically complex margins, confirming that model accuracy is distributed evenly rather than concentrated in particular districts (Fig. 10).

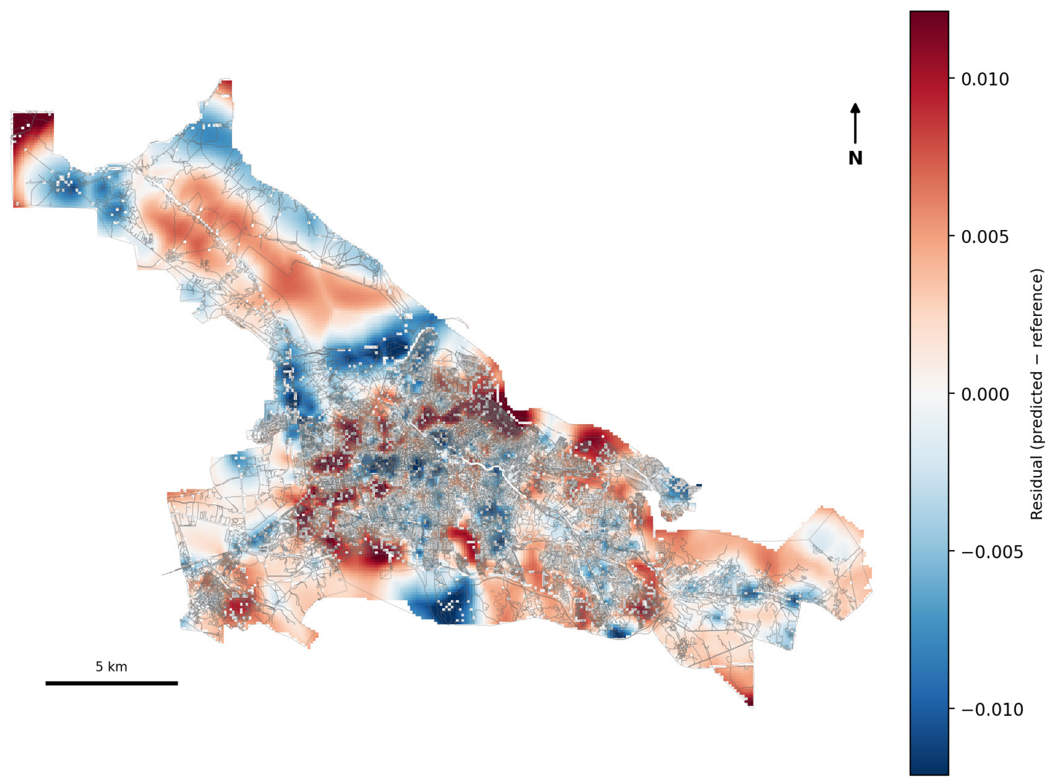

Figure 10: Spatial distribution of model residuals across the whole Tabriz metropolis (diverging colour scale); values close to zero indicate the absence of systematic spatial bias (Source: Authors)

CONCLUSION AND RESULTS

Comparison with a conventional weighting baseline

Benchmarked against a conventional weighted-linear model on identical criteria, the ANN reduced the root-mean-square error by roughly forty per cent and substantially raised the coefficient of determination, while resolving local suitability gradients such as the sharp drop in suitability beyond walking distance of transit that the additive model smoothed away. This substantiates the expectation that the carbon benefits of co-located criteria interact non-linearly, and that a network able to learn these interactions outperforms a fixed-weight model. (Tab. 6)

Table 6: Comparative performance of the ANN–GIS model against a conventional weighted-linear baseline. (Source: Authors)

Metric (validation set)	Weighted-linear model	ANN–GIS model
Coefficient of determination (R^2)	0.846	0.951
Root-mean-square error (RMSE)	0.067	0.040
Mean absolute error (MAE)	0.054	0.032
Captures criterion interaction	No	Yes
Requires a-priori weights	Yes	No

Interpretation and discussion

The dominance of public-transport proximity, mixed-use intensity, and green-space access in the importance hierarchy is the central substantive finding, and it aligns precisely with zero-carbon urban theory. Transport is the largest and most location-sensitive component of household carbon, so proximity to transit is the single most powerful lever a housing-location decision can pull; mixed-use intensity operationalizes the fifteen-minute city by enabling daily needs to be met on foot; and green-space access combines a direct carbon-sink benefit with the walkability and livability that make car-free living attractive (Moreno et al., 2021; Seto et al., 2021; Creutzig et al., 2015). The prominence of existing residential infill confirms the anti-sprawl logic at the heart of zero-carbon planning: locating new housing within or adjacent to the established compact fabric avoids the emissions embodied in extending infrastructure and the induced travel of peripheral development. That this criterion emerges from real land-use data, rather than being assumed, strengthens its policy weight (Naghibi, 2024; Ramezani et al., 2025). The ANN's substantial advantage over the linear baseline carries a clear methodological implication for low-carbon planning: because the network reduced error markedly without requiring contested a-priori weights, and because connection-weight analysis keeps it interpretable, it offers a defensible, reproducible basis for steering housing investment toward low-carbon locations (Olden et al., 2004; Taud & Mas, 2018). For the Tabriz metropolis as a whole, the concentration of high-suitability sites in the compact central core gives planners a concrete spatial priority map for directing development away from the high-carbon margins. This study developed and validated an operational model for the optimal location of desirable housing in Tabriz under a zero-carbon approach, integrating an artificial neural network with a GIS database built on real municipal land-use data. Five conclusions follow. First, a back-propagation multilayer perceptron trained on eight carbon-relevant criteria predicted housing suitability with high accuracy, achieving a coefficient of determination of 0.951 and a root-mean-square error of 0.040 on validation data and generalizing comparably to the test set. Second, public-transport proximity, mixed-use intensity, and green-space access emerged as the dominant determinants, establishing low-carbon mobility and fifteen-minute-city compactness as the primary design objectives for housing location. Third, existing residential infill ranked highly, confirming the anti-sprawl, infill-first logic of zero-carbon urban development. Fourth, the ANN outperformed a conventional weighted-linear baseline by a substantial margin, confirming that the carbon benefits of co-located criteria interact non-linearly and that a learning-based model captures them more faithfully. Fifth, the suitability surface, computed across the whole city, concentrated optimal housing sites in the compact, transit- and service-rich central core, giving decision-makers a defensible spatial priority map for steering development toward low-carbon locations. The theoretical contribution is the operationalization of zero-carbon housing-location theory as a data-driven, learning-based spatial model in an Iranian metropolitan context. The methodological contribution is the transparent integration of an interpretable MLP with criterion layers derived directly from real land-use data and a connection-weight importance analysis. The practical contribution is a transferable workflow that municipalities can apply to align housing approvals with decarbonization commitments.

Limitations remain. The reference suitability target embeds an expert-informed weighting whose subjectivity, though mitigated by the learning process, is not eliminated; the criteria are derived from land use alone and would be strengthened by explicit transport-network, building-energy, and demographic layers; and the static surface does not yet model temporal change in demand or mode share. Future research should incorporate measured travel-emission and building-energy data, couple the network with a cellular-automaton component to project the carbon trajectory of alternative development scenarios, and validate the model against monitored emissions of housing sited under its guidance.

REFERENCES

Ahad Nezhad Reveshty, M., Heydari, M. T., & Rasooli, M. (2024). Identification of urban worn-out textures and prioritization of organizing strategies through remote sensing performance and BWM method combination: A case study of Zanjan city. Chinese Journal of Urban and Environmental Studies, 11(4). https://doi.org/10.1142/S2345748123500239

Aldababseh, A., Temimi, M., Maghelal, P., Branch, O., & Wulfmeyer, V. (2018). Multi-criteria evaluation of irrigated agriculture suitability to achieve food security in an arid environment. Sustainability, 10(3), 803. https://doi.org/10.3390/su10030803

Al-Sabbagh, T. A. (2020). GIS location-allocation models in improving accessibility to primary schools in Mansura city, Egypt. GeoJournal, 87(2), 1009–1026. https://doi.org/10.1007/s10708-020-10290-5

Creutzig, F., Baiocchi, G., Bierkandt, R., Pichler, P.-P., & Seto, K. C. (2015). Global typology of urban energy use and potentials for an urbanization mitigation wedge. Proceedings of the National Academy of Sciences, 112(20), 6283–6288. https://doi.org/10.1073/pnas.1315545112

Couch, C., Sykes, O., & Börstinghaus, W. (2011). Thirty years of urban regeneration in Britain, Germany and France: The importance of context and path dependency. Progress in Planning, 75(1), 1–52. https://doi.org/10.1016/j.progress.2010.12.001

Ghouchani, M., Khorram, A., Gholizade, F., & Rafiei, S. (2023). Evaluate the efficiency of contextual elements in reducing the vulnerability of urban historical fabrics based on passive defense principles. Ain Shams Engineering Journal, 14(2), 101837. https://doi.org/10.1016/j.asej.2022.101837

Hsu, Y. L., Lee, C. H., & Kreng, V. B. (2010). The application of Fuzzy Delphi Method and Fuzzy AHP in lubricant regenerative technology selection. Expert Systems with Applications, 37(1), 419–425. https://doi.org/10.1016/j.eswa.2010.01.099

Li, X., Zhang, Y., & Chen, H. (2024). The suitability assessment for land territorial spatial planning based on an ANN–CA model and the Internet of Things. Heliyon, 10(10), e31125. https://doi.org/10.1016/j.heliyon.2024.e31125

Lin, Y., Yang, J., & Li, B. (2020). A neural-network *approach to land-use suitability modelling for urban expansion. ISPRS International Journal of Geo-Information, 9(11), 648.* https://doi.org/10.3390/ijgi9110648

Liu, Y., Zhu, J., & Wang, K. (2022). Site selection via learning graph convolutional neural networks: A case study of Singapore. Remote Sensing, 14(15), 3579. https://doi.org/10.3390/rs14153579

Lotfi, S., & Ghazaie, M. (2019). Studying the role of segregation in the emerging of deteriorated urban fabrics: Case study of Qassem-Abad district, Mashhad, Iran. Geography and Development, 17(54), 15–36. https://doi.org/10.22111/gdij.2019.4349

Malczewski, J. (2004). GIS-based land-use suitability analysis: A critical overview. Progress in Planning, 62(1), 3–65. https://doi.org/10.1016/j.progress.2003.09.002

Mohammady, M., Pourghasemi, H. R., & Amiri, M. (2021). Spatial modelling of susceptibility using machine-learning and GIS techniques. Environmental Earth Sciences, 80, 326. https://doi.org/10.1007/s12665-021-09650-2

Moreno, C., Allam, Z., Chabaud, D., Gall, C., & Pratlong, F. (2021). Introducing the "15-minute city": Sustainability, resilience and place identity in future post-pandemic cities. Smart Cities, 4(1), 93–111. https://doi.org/10.3390/smartcities4010006

Murray, A. T. (2010). Advances in location modeling: GIS linkages and contributions. Journal of Geographical Systems, 12(3), 335–354. https://doi.org/10.1007/s10109-009-0105-9

Naghibi, M. (2024). Rethinking small vacant lands in urban resilience: Decoding cognitive and emotional responses to cityscapes. Cities, 151, 105167. https://doi.org/10.1016/j.cities.2024.105167

Olden, J. D., Joy, M. K., & Death, R. G. (2004). An accurate comparison of methods for quantifying variable importance in artificial neural networks using simulated data. Ecological Modelling, 178(3–4), 389–397. https://doi.org/10.1016/j.ecolmodel.2004.03.013

Park, S., Jeon, S., Kim, S., & Choi, C. (2011). Prediction and comparison of urban growth by land suitability index mapping using GIS and RS in South Korea. Landscape and Urban Planning, 99(2), 104–114. https://doi.org/10.1016/j.landurbplan.2010.09.001

Ramezani, N., Tamošaitienė, J., Sarvari, H., & Golestanizadeh, M. (2025). Determining essential indicators for feasibility assessment of using initiative green building methods in revitalization of worn-out urban fabrics. Sustainability, 17(8), 3389. https://doi.org/10.3390/su17083389

Rasoolnazi, S., Naghibi, F., & Khosronia, M. (2022). Investigating the role of public and local capacities in regeneration of inefficient urban fabric: Case study, worn texture of Urmia. Human Geography Research, 54(1), 131–154. https://doi.org/10.22059/jhgr.2020.305401.1008135

Roberts, P., Sykes, H., & Granger, R. (Eds.). (2017). Urban regeneration (2nd ed.). Sage Publications. https://doi.org/10.4135/9781526402721

Sarvar, H. (2019). Identification of worn-out urban textures based on physical parameters: Case study, Region One, Tabriz city. Sustainable City, 2(1), 1–14. https://doi.org/10.22034/jsc.2019.91206

Seto, K. C., Churkina, G., Hsu, A., Keller, M., Newman, P. W. G., Qin, B., & Ramaswami, A. (2021). From low- to net-zero carbon cities: The next global agenda. Annual Review of Environment and Resources, 46, 377–415. https://doi.org/10.1146/annurev-environ-050120-113117

Sorensen, A. (2000). Conflict, consensus or consent: Implications of Japanese land readjustment practice for developing countries. Habitat International, 24(1), 51–73. https://doi.org/10.1016/S0197-3975(99)00025-5

Taud, H., & Mas, J. F. (2018). Multilayer perceptron (MLP). In M. T. Camacho Olmedo et al. (Eds.), Geomatic approaches for modeling land change scenarios (pp. 451–455). Springer. https://doi.org/10.1007/978-3-319-60801-3_27

Tavakoli, H., & Marzbali, M. H. (2021). Urban public policy and the formation of dilapidated abandoned buildings in historic cities. Sustainability, 13(11), 6178. https://doi.org/10.3390/

su13116178

Tian, H., Wang, W., & Hao, T. (2025). Grid-based characterization and sustainable planning for fractured urban textures: A case study of Nanhao Village in Baotou. Buildings, 15(1), 5. https://doi.org/10.3390/buildings15010005

Turk, S. S. (2008). An examination for efficient applicability of the land readjustment method at the international context. Journal of Planning Literature, 22(3), 229–242. https://doi.org/10.1177/0885412207309360

UN-Habitat. (2019). A practical guide for land readjustment. United Nations Human Settlements Programme. https://unhabitat.org/a-practical-guide-for-land-readjustment

United Nations, Department of Economic and Social Affairs, Population Division. (2022). World population prospects 2022: Summary of results. United Nations. https://www.un.org/development/desa/pd/

Urban Regeneration Company of Iran. (2022). Annual statistics report on inefficient urban fabrics. Ministry of Roads and Urban Development. [In Persian]

Wang, F., Yu, J., & Liu, G. (2009). Urban land suitability evaluation based on a BP neural network: A case study of Jinan. In 2009 International Conference on Environmental Science and Information Application Technology (pp. 415–418). IEEE. https://doi.org/10.1109/ESIAT.2009.184

Ziyari, K., & Saeidi Chakan, R. (2025). Barriers to integrated and sustainable regeneration in historic urban fabrics: Case study, Tabriz metropolis. Geography and Planning. https://doi.org/10.22034/gp.2025.67744.3420

HOW TO CITE THIS ARTICLE

Motallebi,S , Saghafi Asl,A , Shahhoseini,H and Haghlesan,M . (2026). Explaining an Optimal Location Model for Desirable Housing in Tabriz Based on a Zero-Carbon Approach Using an Artificial Neural Network in a GIS Environment (Case Study: Tabriz Metropolis). (e738241). International Journal of Urban Management and Energy Sustainability, (), e738241

DOI: 10.22034/ijumes.2026.2091582.1375