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Research article

Evaluating urban environmental quality using multi criteria decision making

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ABSTRACT

In the urban environment, the quality refers to the capacity that provides and fulfills the material and spiritual needs of inhabitants. In order to improve the quality of urban life and standard of living for their citizens, planners and managers strive to raise Urban Environmental Quality. The objective of this study is to evaluate the quality of urban environment through the spatial analysis of a multi-criteria decision making (MCDM) method utilizing CRITIC. This research is conducted in district 4 and district 2 of the Tabriz Metropolis Municipality. In order to determine the quality of an urban environment, air pollution, vegetation coverage, land surface temperature, production of waste, population density, noise pollution, health care per capita, green spaces per capita, recreational spaces per capita, and distance from fault lines are used. After evaluating and producing environmental quality maps in two separate districts, 10 indicators were tested for significance and a comparative evaluation of two districts was conducted in order to determine which district was in better condition based on a statistical analysis of the T-test results. In accordance with the CRITIC method, there are significant differences between averages of waste production, population density, noise pollution, distance from fault lines, Land Surface Temperature, Normalized difference vegetation index, and distance from fault lines between the two districts. It appears that recreational space, air pollution, health care per capita, and green space per capita are not meaningfully different on averages. The preparation of environmental quality maps reveals the importance of meaningful indicators at the neighborhood level in two urban districts. In both districts by strengthening the continuity of the landscape through the development of ecological corridors and an increase in per capita can contribute to the improvement of the quality of the urban environment.

1. Introduction

Urban populations surpassed rural populations for the first time in 2007 and have been growing modestly ever since, and they will comprise almost two-thirds of the world's population by 2050 [1]. Since urbanization has become a global trend, many urban regions have expanded physically and have replaced natural surfaces with impervious manmade surfaces [2,3]. It has decreased

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evapotranspiration, polluted the environment, and increased energy demand [4–6]. With the growth of urban populations and the expansion of infrastructure-based economies, there is an increasing need for land to accommodate the growing infrastructure [7,8]. There are many pressing concerns facing planners and municipal authorities in the nation today, including economic and social development, poverty alleviation, promoting and sustaining income and employment opportunities, and building democratic and harmonious societies [9–11]. Emissions from industrial sources, congestion in transportation, and pollution are just a few examples of environmental concerns [12–14]. It should be noted that the urban environment throughout Iran is deteriorating, which threatens the future of the cities, particularly large urban centers [15,16]. Rapid population and economic growth will negatively impact the environment regardless of whether cities are or are not at their ecological carrying capacity [17–19]. As a consequence of urbanization, a number of environmental issues have been exacerbated, including loss of natural vegetation, loss of wetlands, open spaces, and wildlife habitats, changes in local and regional climate, and an increase in water, electricity, and infrastructure demand [20–24]. It is essential to have timely information on the temporal and geographic patterns of urban environmental quality in order to develop new policies that support environmental sustainability and smart growth [12]. It is necessary to conduct assessments of urban environmental quality in order to plan and manage urban areas more effectively [25]. UEQ is an index which summarizes a city's environmental, social, and economic characteristics [26]. The concept of UEQ encompasses indicators that relate to physical, social, spatial, and economic dimensions [13,27,28]. In addition to urban planning, infrastructure services, economic implications, policy making, and social science research, UEQ might impact a wide range of governmental domains [29,30]. A useful tool for measuring urban environmental quality is to construct an Urban Environmental Quality Index (UEQI) [31]. In order to gain a better understanding of environmental threats and vulnerabilities, this index may be applied to other locations. In addition, city administrative units may be able to determine which interventions should be prioritized in regions that are experiencing significant environmental, social, and economic issues by recognizing the multiple dimensions of urban environments.

Urban overpopulation has induced particular socio-economic changes as well as unequal access to urban resources. These factors are without doubt significant contributors to the quality of life in urban settings. As a multidisciplinary concept, urban quality of life (UQoL) addresses economic, social, political, environmental, physical, and psychological aspects of a city [32]. A major determinant of UQoL is urban environmental quality (UEQ) [33,34]. In terms of UEQ, it can be characterized as multidisciplinary and complex, with spatial and temporal variations [31]. Therefore, it has proven to be an effective tool for studying and planning urban environments in a multidimensional manner [35]. There are other bio-geochemical processes in urban environments that can result in a variety of pollution-related problems across a range of ecological scales (such as air pollution, noise pollution, and climate change) [36,37]. In other words, urban environmental quality is an assessment of a city's suitability for human habitation [38]. Urban environments have been studied extensively, but most have explored UEQ in relation to changes in variables at local and small scales [34,39,40]. A seasonal change in urban environments seems to be another effective factor to consider when assessing dynamism and change [41–44]. The latest studies incorporate socio-economic data into UEQ calculations [45–47]. UEQ analysis has also been conducted using geohazard potential [48,49]. Even though UEQ is a spatial-temporal index for urban management and planning, there are several examples of spatial models being implemented without regard to time. For modeling and mapping UEQs, most studies utilize principal component analysis (PCA) and weighted layer overlays in GIS. It was reported by Refs. [50–54] For spatial mapping and analysis of environmental issues in urbanized areas, different experimental methods, geostatistics, and change detection techniques were proposed. It is common practice to use multi-criteria decision making (MCDM) methods in environmental planning, since it provides a broader outlook on a problem [55–59]. When human intervention in processing and evaluation of variables is not necessary, CRITIC is an effective method in assessing Urban Environmental Quality. This method is an objective method for determining the weight of criteria that involves the intensity of conflict and incompatibility between the components of a decision problem [60]. It is common for decision makers to perform multivariate analysis based on their experience, knowledge, and understanding, so their subjective point of view affects the weight of the criteria. As the number of criteria increases, the possibility of human error increases, which raises concerns about the reliability of the results [61]. A numerical valuation approach is used in the CRITIC method to overcome such problems, which eliminates the need for personal judgments. By using CRITIC model, this study attempts to model UEQ for two districts of Tabriz by comparing parameters related to physical environment, built-up area, and natural hazards (i.e. 2 and 4). We deliberately chose districts that run west-to-east, because they closely reflect the city's environmental conditions. As one of the largest cities in Iran with a population of 1.7 million [62], Tabriz suffers from severe environmental conditions [63–65], the continuation of which will, no doubt, cause severe consequences within the next few years.

2. Materials and methods

2.1. Study area

The study area includes two districts of Tabriz including, district 2 with a population of 196,507 spanning over 2104 ha; district 4 with a population of 315,183 and a territorial span of 2529 ha (Fig. 1 (a – c)). Environmental, demography, economic, institutional, and land-use characteristics have been taken into consideration when selecting the districts that represent the greater urban area of Tabriz [66].

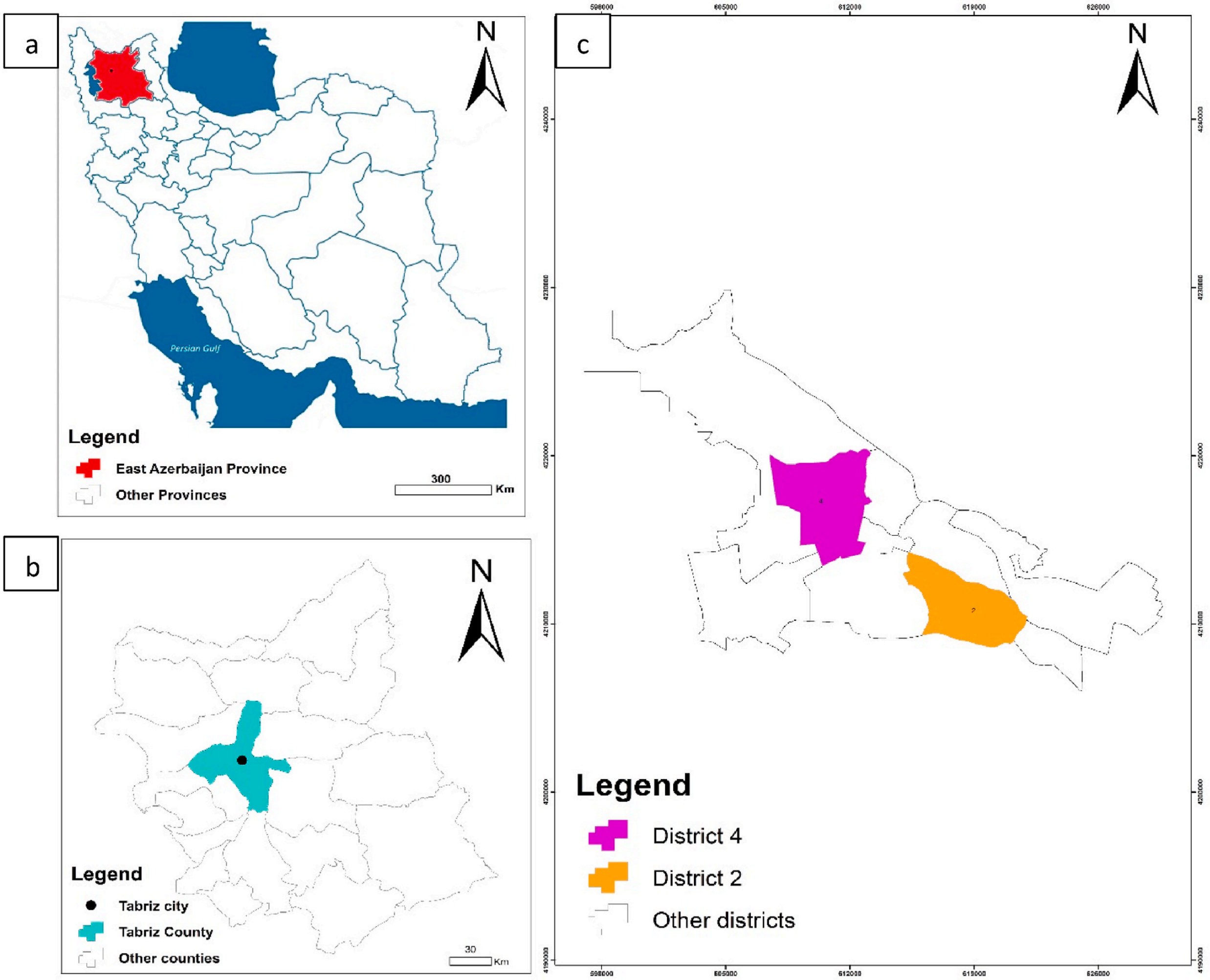


Fig. 1. The study area consists of 2 and 4 districts from west to east of Tabriz (c), Tabriz (b) is located in the East Azerbaijan province of Iran (a).

2.2. Methodology

Fig. 2 illustrates the steps involved in Urban Environment Quality calculation: extraction of Urban Environment Quality indicators, preparation of GIS layers, Standardization, Urban Environment Quality mapping, and Comparative comparison.

2.3. Measurement of UEQ by developing indicators

Cities have a physical environment domain that contains indicators related to natural characteristics (air pollution, vegetation cover, and Land Surface temperature) whereas the built-up domain contains indicators related to construction (production of waste, population density, noise pollution, health care per capita, green space per capita, recreational space per capita) and natural hazards (distance from Fault). Based on these categories, UEQ modeling can be conducted for the major domains of the city (Table 1).

Industrialized and densely populated districts often have higher levels of air pollution [48] and is largely caused by traffic, resulting in adverse health effects on respiratory systems [76]. The effects of air-land interactions are reflected in surface parameters such as LST [77,78]. In urban districts, temperatures tend to be higher than in their surrounding areas, which contributes to energy consumption, greenhouse gas emissions, a rise in heat-related diseases, and poor water quality [79–81]. The distance to a fault is the most important and rated model in evaluating earthquake vulnerability [82]. The generation of municipal solid waste (MSW) is an inevitable consequence of human activity [83]. A majority of urban MSW comes from settlements, businesses, and small industries [84]. Mixed with MSW, these wastes pose a health threat as well as a possible environmental threat [85]. In addition, it threatens the groundwater resources and soil [86]. Pollutants from solid wastes negatively affect soil physico-chemical properties, resulting in low vegetation production [87]. By absorbing pollutants and releasing oxygen, urban green space (UGS) provide numerous benefits to urban residents [88–90], assist in maintaining the city's natural urban environment by providing clean air, water, and soil [90,91]. Another parameter

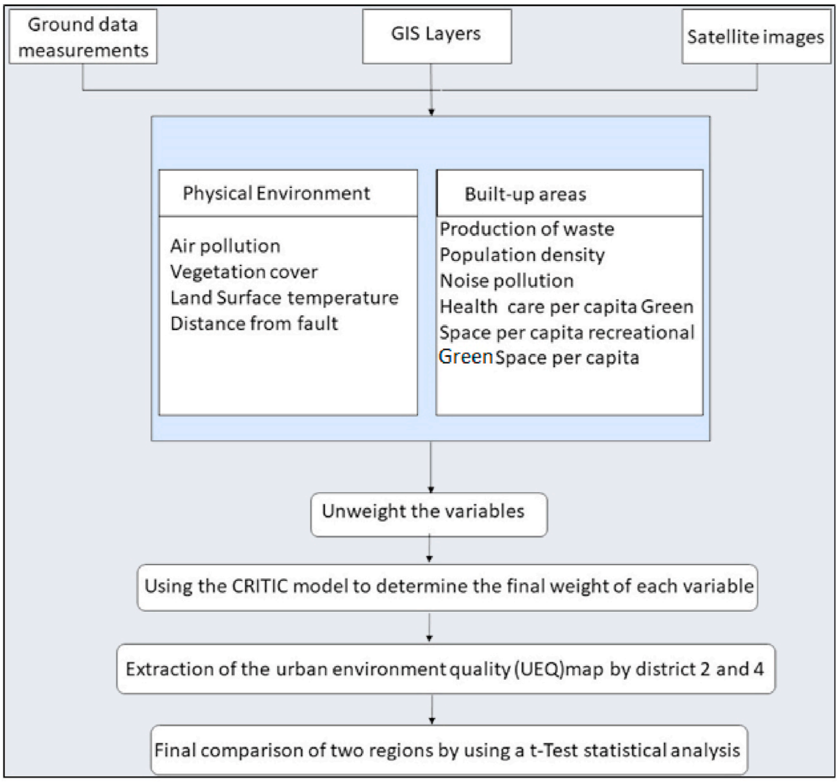


Fig. 2. Step by step procedure for spatial UEQ modeling.

of interest is population density, or the number of people per unit area [92], which has an impact on the physico-chemical properties of soils and dust, including metal concentrations and speciations [93]. Noise pollution is also a major contributor to environmental pollution that poses a threat to the health of humans and living things [94], it causes aggression, petulance, and lack of concentration, as well as hearing loss and mental disorders [95]. Health care coverage on a per capita basis at the neighborhood level improves access to the health system for citizens and improves the quality of urban environments by reducing travel for therapeutic purposes [96]. Urban green space per capita is considered to be the most important quantitative indicator of urban green infrastructure [97]. UGS per capita should be at least 9 m2 and 50 m2 for good urban environmental quality, according to the World Health Organization [98]. It is common for urban residents to interact with the natural environment as part of recreational activities [99]. As part of UEQ assessments, recreation encourages physical activity and active lifestyles, potentially reducing health risk factors such as obesity and cardiovascular disease [100]. Moreover, recreational activities promote social interaction, empower individuals, and foster social cohesion [74]. Urban expansion and high-quality development require an assessment of geotechnical seismic vulnerability in districts with seismic activity [101]. Indicators for UEQ calculation have been derived from GIS data, satellite images, and ground data. In accordance with the spatial resolution of Landsat data, a 30-m pixel size was selected for the selected data sets.

In order to conduct a literature review, the most influential variables from various land sources, official statistics, remote sensing techniques and geographic information systems were collected and analyzed. Since citizens have access to water in the same manner as before purified water was used for domestic purposes, water quality was not considered in the model. A significant part of the urban transportation index is based on the absence of an efficient public transportation system in Tabriz, which reflects in the AQI index the reliance on personal vehicles as a means of transportation. The authors acknowledge that more indicators could have been examined, but they have still assessed and quantified the most significant and influential indicators.

2.4. Criteria importance through intercriteria correlation (CRITIC)

When using MCDM, multiple options are examined and the best option is selected based on a variety of factors [102]. The evaluation of UEQ and the selection of the optimal option of neighborhoods is a typical, critical, and highly influential MCDM problem [103]. A key element in MCDM is attribute weights, which have a major influence on the results of the decision-making process [104]. For determining attribute weights, numerous approaches have been utilized [60]. CRITIC is a common objective approach to measuring criteria importance by correlating them with other criteria [105]. As part of the CRITIC method, the contrast intensity and contradictory nature of the assessment criteria are considered [106]. The CRITIC method relies solely on the decision matrix for determining the relative importance of indicators [107]. In this method, the weights are determined based on the contrast intensity and conflict evaluation of the decision problem. Additionally, human intervention is not required for the evaluation process [108]. The

Table 1
Indicators obtained from various sources were used for the calculation of UEQ.

Domain	Indicator	Equation	Equation elements	Data source	Reference
Physical environment	Air Quality Index)AQI (	$AQIap = \frac{AQIuc - AQIlc}{BPuc - AQIlc}(Cap - BPlc) + AQIlc$	AQI_{ap} is the index for given air pollutant (ap); AQI_{uc} and AQI_{lc} are the values corresponding to upper and lower of each breakpoint category (BP), respectively; C_{ap} is the concentration of each air pollutant; BP_{uc} and BP_{lc} are, respectively, the upper and lower concentrations of air pollutants at each breakpoint category.	Tabriz air quality measurement stations	[67]
	Normalized Difference Vegetation Index (NDVI)	$NDVI = \frac{RNir - Rr}{RNi + Rr}$	*RNir* and *Rr* are, respectively, the spectral reflectance of Landsat-8 OLI bands 5 and 4.	Landsat 8	[68]
	Land Surface temperature	$Ts = \frac{1}{C10}\{a(1 - C_{10} - D_{10}) + [b(1 - C_{10} - D_{10}) + C_{10} + D_{10}]T10 - D_{10}T_a\}$	*Ts* is LST; *T10* is brightness temperature of Landsat 8 band 10; *Ta* is mean atmospheric temperature; *a* and *b* are the constants used to approximate the derivative of the Planck radiance function for the TIRS band 10, *C10* and *D10* are the internal parameters for the Mono-Window algorithm	Landsat 8	[69]
	Distance from Fault line	$Deuc = (\sum_{i=1}^{p}(xi - yi)2)^{1/2}$	If x and y are two points in the p component, The Euclidean distance between these two can be calculated.	Digitizing the fault line from the geological map and applying the Euclidean distance function	[70]
built-up Environment	Production of waste	$Wp = pop \times ADWPP$	Production of waste equlals Average daily waste production per person (ADWPP) multiplied by the population	Census data	[71]
	Population density	$Popdensity = \frac{Pi}{Ai}$	Popdensity is population density per pixel, p_i is population in pixel, A_i is area (hectare).	Census data	[34]
	Noise pollution	$NdB = 10\log10 \times (P2P1)$	Ndb is the ratio of the two-power expressed in deciBels, dB P2 is the output power level P1 is the input power level. Sounds above 85 dB are harmful.	Definition of 200 × 200-m grid and maximum sound measurement in two areas separately with the Light Weight Noise Meter GM1357 Digital Handy Sound Level Meter for Sound Quality Control	[72]
	Health care space per capita (m)	$H_{pc} = \frac{HAi}{Pi}$	Health care space per capita is the division of *HAi* (m^2) to population.	Census data	[73]
	Recreational space per capita	$H_{pc} = \frac{RSAi}{Pi}$	Recreational space per capita is the division of *RSAi* (m^2) to population.	Census data	[74]
	Green space per capita	$GS_{pc} = \frac{GSAi}{Pi}$	Green space per capita is the division of *GSAi* (m^2) to population.	Census data	[75]

steps of the method can be described as follows.

i. The decision matrix is normalized using the following equation [109]:

$$a_{ij}^{+} = \frac{a_{ij}\text{-}a_{ij}^{worst}}{a_{j}^{best}\text{-}a_{j}^{worst}} \tag{1}$$

where *a*+ *ij* denotes the normalized value of the *i*th design on the *j*th response.

ii. The following multiplicative aggregation equation is used to determine the amount of information contained in the *j*th response [109]:

$$C_j = \sigma_j \sum_{k=1}^{n} \left(1\text{-}r_{jk}\right) \tag{2}$$

where *_j* denotes the standard deviation of the *j*th response and *rjk* represents the correlation coefficient between two different responses.

iii. The objective weights (*wj*) are determined by using the following equation [109]:

$$w_j = \frac{C_j}{\sum_{k=1}^{m} C_k} \tag{3}$$

As a result, this method assigns a high value of weights to those responses with high standard deviation and low correlation with other responses [109].

3. Results

A comparison map of indicators for calculating UEQ by two districts is shown in Fig. 2. There is a significant concentration of Normalized Difference Vegetation Index (NDVI) in the southern part of district 2, whereas it is mainly located in the northern part of district 4. Across district 2, the land surface temperature has been increasing from east to west, with barren and construction areas showing high values. In district 4, LST shows higher values in the southern and northern parts, and decreases with the increase in greenery areas in the middle districts. Population density determines the waste production index, which is produced more in district 2 in the southeast, and increases in district 4 in the south to the center. Based on a population density index, district 4 has a higher population density than district 2, and the eastern parts are more populous than the western parts. This has some effect on environmental quality. As a result of population density and increased urbanization, there is considerable noise pollution in district 2. In district 4, the airport and small industries and production workshops contribute to high noise pollution. In district 2, health care space per capita index is primarily concentrated in northwest and southeast neighborhoods. It is lower in district 4 compared to district 2 and more concentrated in the central neighborhoods. In district 2, parks in the south and Tabriz University green spaces in the north lead to a higher index of green spaces per capita. While district 4 has a lot of green space, the value decreases rapidly in the other neighborhoods as we move away from the north. District 2 has an unfair distribution of recreational space per capita on a local scale, but the situation is improving in the southern districts. In contrast, District 4 lacks this index severely, but the northern districts are more capable of improving it. The safety index for District 2 is higher than for District 4 because of its distance from fault lines; however, District 4 has the most worn tissue, making it more challenging to maintain safety (Fig. 3 (a – j) and Fig. 4 (a – j)).

3.1. Spatial analysis of UEQ

Using the methods described in Table 1, the maps prepared by the methods described in Fig. 2 for the two districts reveal that the investigated variables differ in terms of average, minimum and maximum parameters, which indicates that this question requires a comparative assessment from a perspective of environmental quality. According to Critic model implementation procedure, the environmental quality map is generated in two steps. First, ten indicators are prepared and normalized (Fig. 5(a–j) and Fig. 6 (a – j)) and then a correlation matrix is calculated between them (Tables 2 and 3).

Second, using the contrast matrix generated by subtracting one from the correlation, we have determined the final weights separately for each variable in the two districts by multiplying the average of each variable in its standard deviation and dividing this answer by its sum (Tables 2 and 3). Weighted linear combinations of urban environmental quality maps have been generated for districts 4 and 2 using standardized layers and associated weights obtained through the CRITIC model based on following equations (Fig. 7) (Equations 4 and 5). (4)

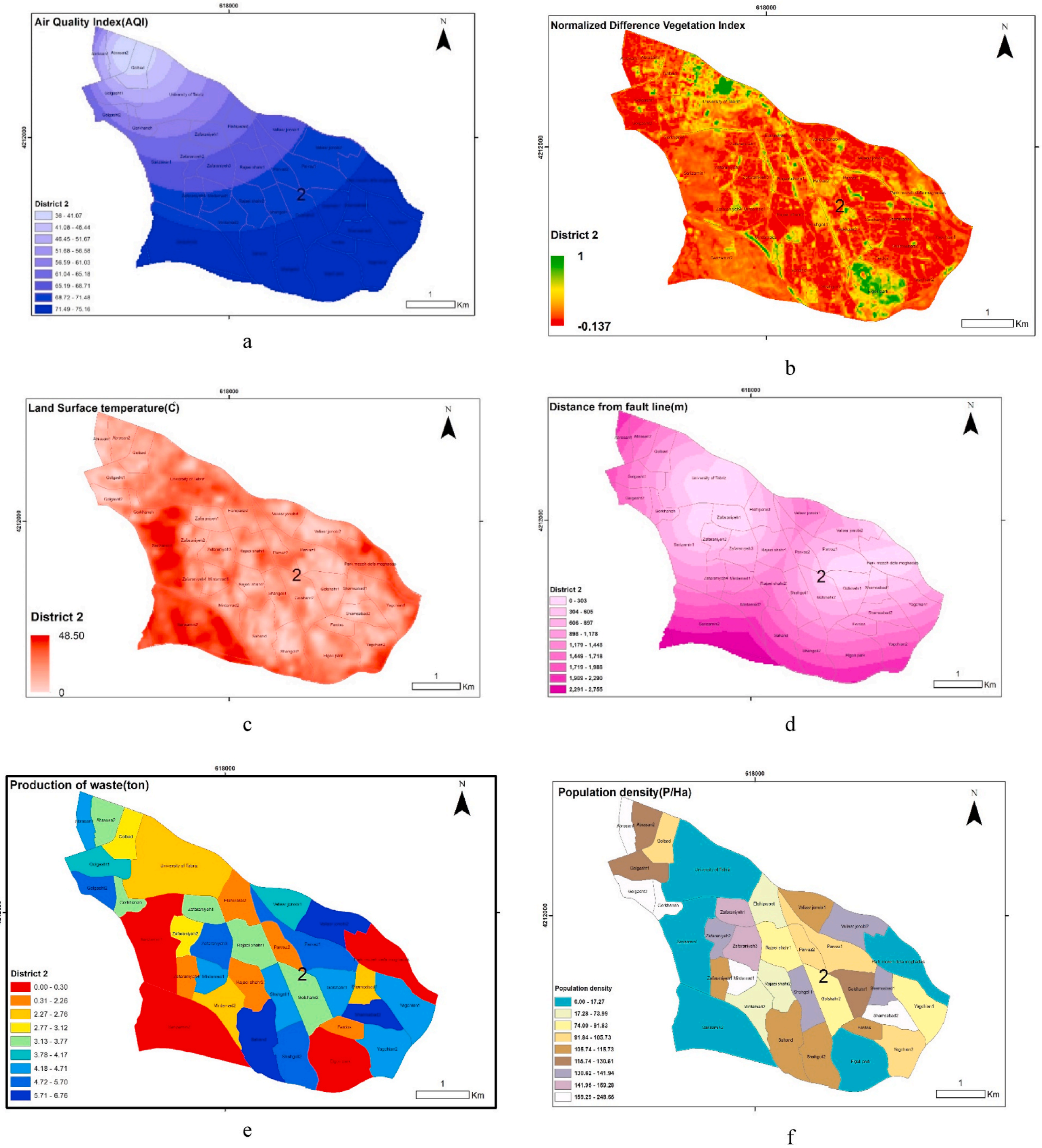


Fig. 3a. Indicators for calculation of UEQ in district 2. (**a**). Air Quality Index (AQI).

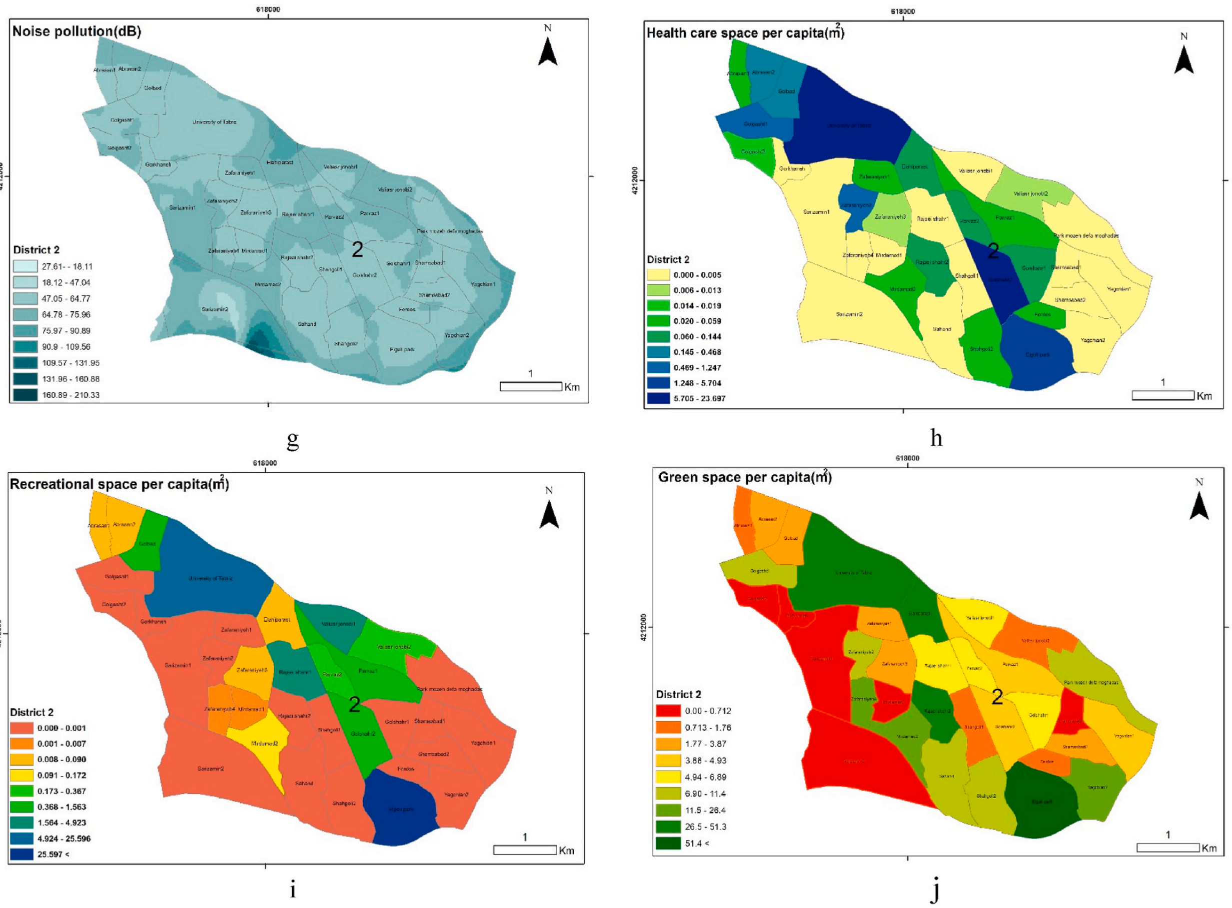


Fig. 3b. (**b**). Normalized Difference Vegetation Index (NDVI), (**c**). Land Surface temperature (c○), (**d**). Distance from fault line(m), (**e**). Production of waste (ton), (**f**). Population density, (**g**). Noise pollution (dB), (**h**). Health care space per capita (m^2), (**i**). Recreational space per capita (m^2), (**j**) Green space per capita (m^2). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

UEQ[1]$_{D4}$ = 0.129AQI[2]+ 0.099NP[3]+ 0.119LST[4]+ 0.101NDVI[5]+ 0.111PD[6]+ 0.078POW[7]+ 0.062RSPC[8]+ 0.110HCSPC[9]+ 0.062GSPC[10]+ 0.128DFFL[11] (5)

$$UEQ_{D2} = 0.132AQI + 0.101NP + 0.129LST + 0.061NDVI + 0.118PD + 0.116POW + 0.064RSPC + 0.084HCSPC + 0.065GSPC + 0.130DFFL$$

According to the comparison of the final urban environment maps (Fig. 5), there is a significant difference in the quality of the urban environment between different neighborhoods both within the districts and between the districts. The final map of UEQ in district two shows that Abersan, Golgasht, Tabriz University in the north, and Golshahr and Eel Goli in the south, have a better UEQ. These neighborhoods are better suited to political ecology with more green space per capita, more recreational spaces per capita, therapeutic facilities, and less air and noise pollution and low temperature. There are several districts in district four that offer better

1 Urban Environmental Quality.
2 Air Quality Index(AQI).
3 Noise pollution(NP).
4 Land Surface temperature(lst).
5 Normalized Difference Vegetation Index(NDVI).
6 Population density(PD).
7 Production of waste(POW).
8 Recreational space per capita(RSPC).
9 Health care space per capita(HCPC).
10 Green space per capita(GSPC).
11 Distance from Fault line(DFFL).

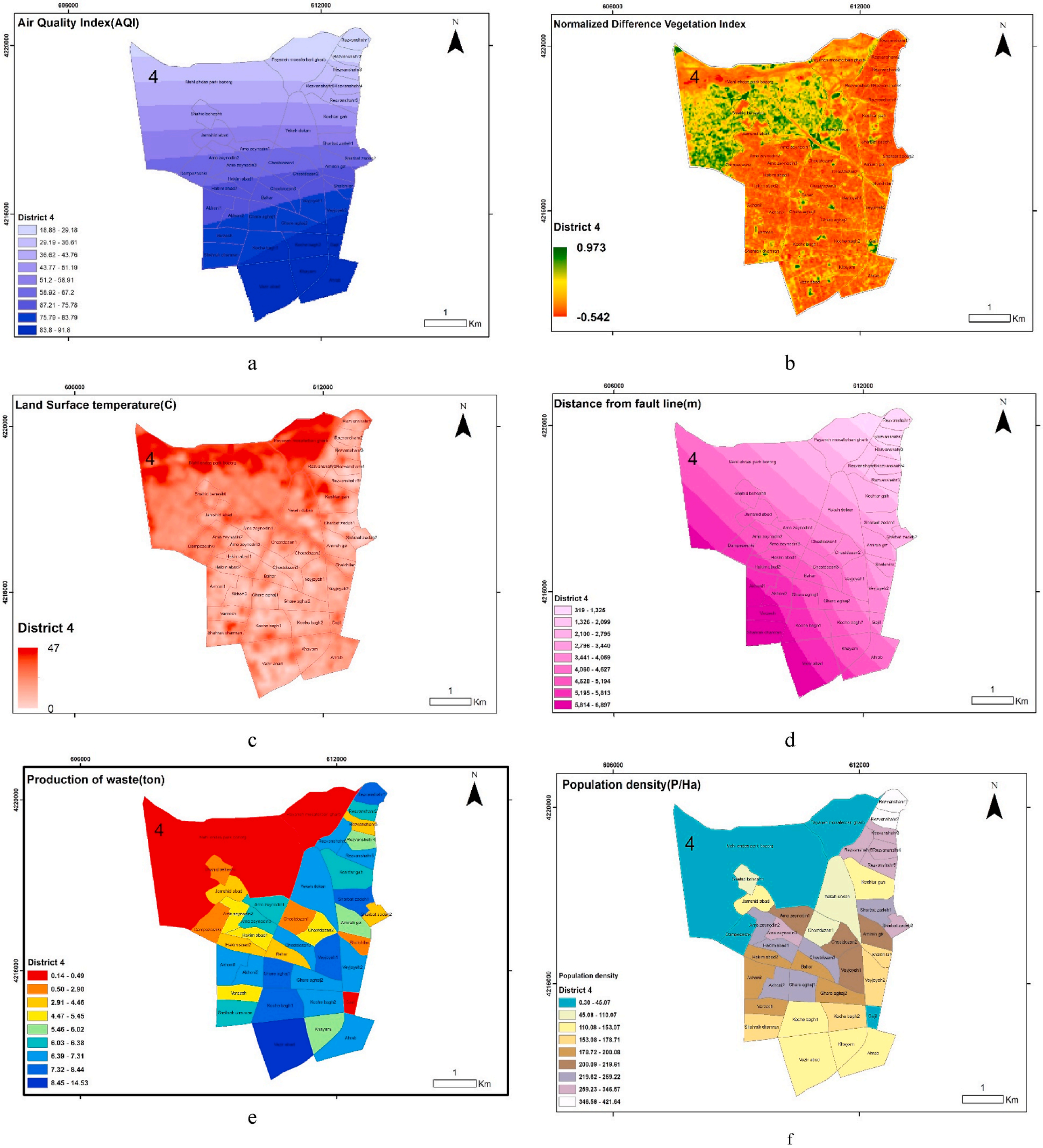


Fig. 4a. Indicators for calculation of UEQ in district 4. (**a**). Air Quality Index (AQI).

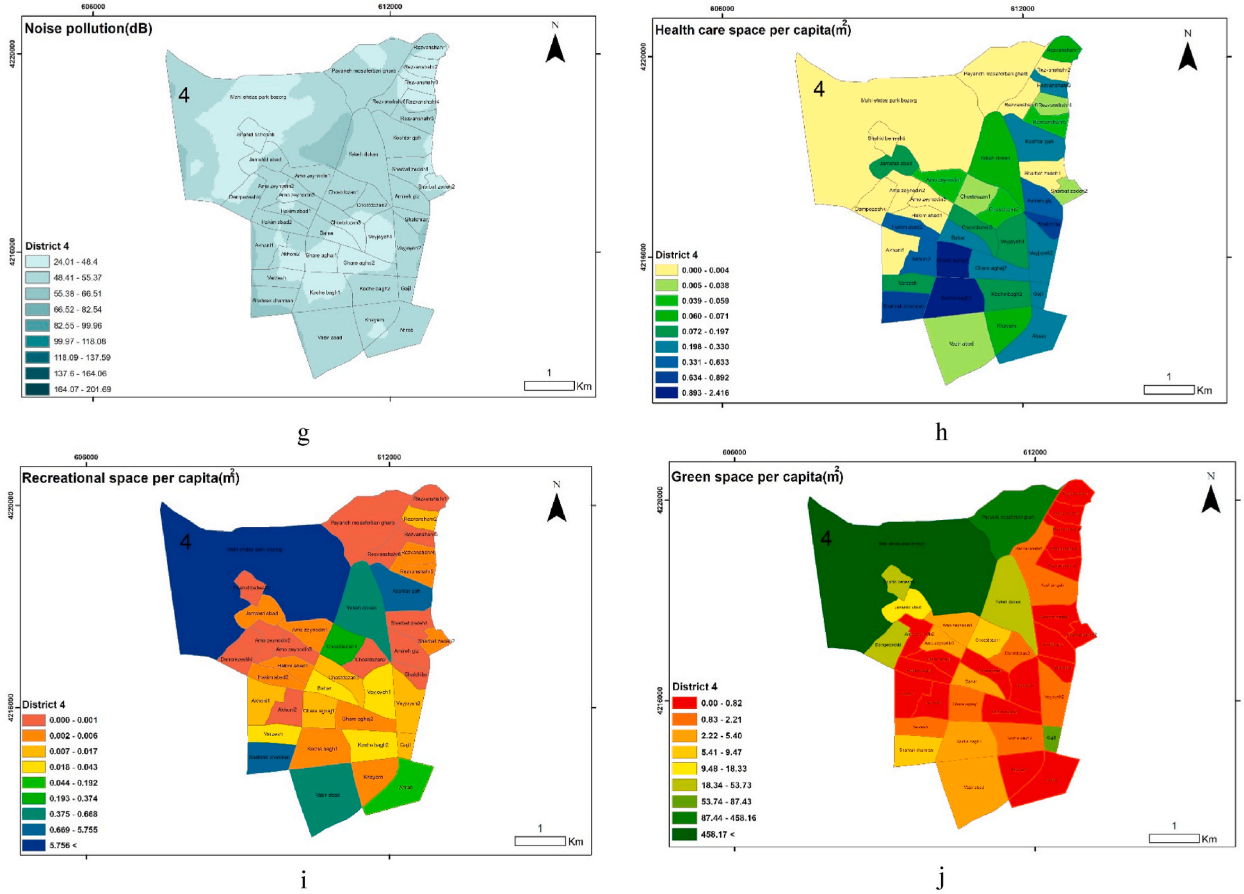


Fig. 4b. Normalized Difference Vegetation Index (NDVI), (**c**). Land Surface temperature (c∘), (**d**). Distance from fault line(m), (**e**). Production of waste (ton), (**f**). Population density, (**g**). Noise pollution (dB), (**h**). Health care space per capita (m^2), (**i**). Recreational space per capita (m^2), (**j**) Green space per capita (m^2). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

environmental conditions than other districts in the area, including Mahale Ehdas Park Bozorg, Rezvanshahr, Qara-Aghaj and Gajil (adjacent to Golestan Park).

3.2. Model evaluation by implementation of the statistical T test

When comparing the average of two groups or the average of a group with a default value, the T test is used to determine whether there is a significant difference. An independent-samples *t*-test is used to determine whether there are significant differences in averages between groups organized separately from each other in two independent groups [110]. According to Table 4, the results for two independently selected groups, districts Four and Two, show that six of ten indicators are significantly different in the two districts (Table .4).

It is evident that the averages of the two districts differ significantly with respect to waste production, population density, sound intensity, proximity to fault lines, land surface temperature, and vegetation difference index, but there are no significant differences between the other indicators. Consequently, the indicators' direct and indirect contributions to achieving the environmental quality map are summarized as follows. The four indicators sound intensity, distance from fault line, land surface temperature, and normalized difference vegetation index provide high quality in district 4 in comparison to two indicators waste production and population density in district 2. Therefore, a comparative comparison of districts two and four indicates that district two is environmentally superior.

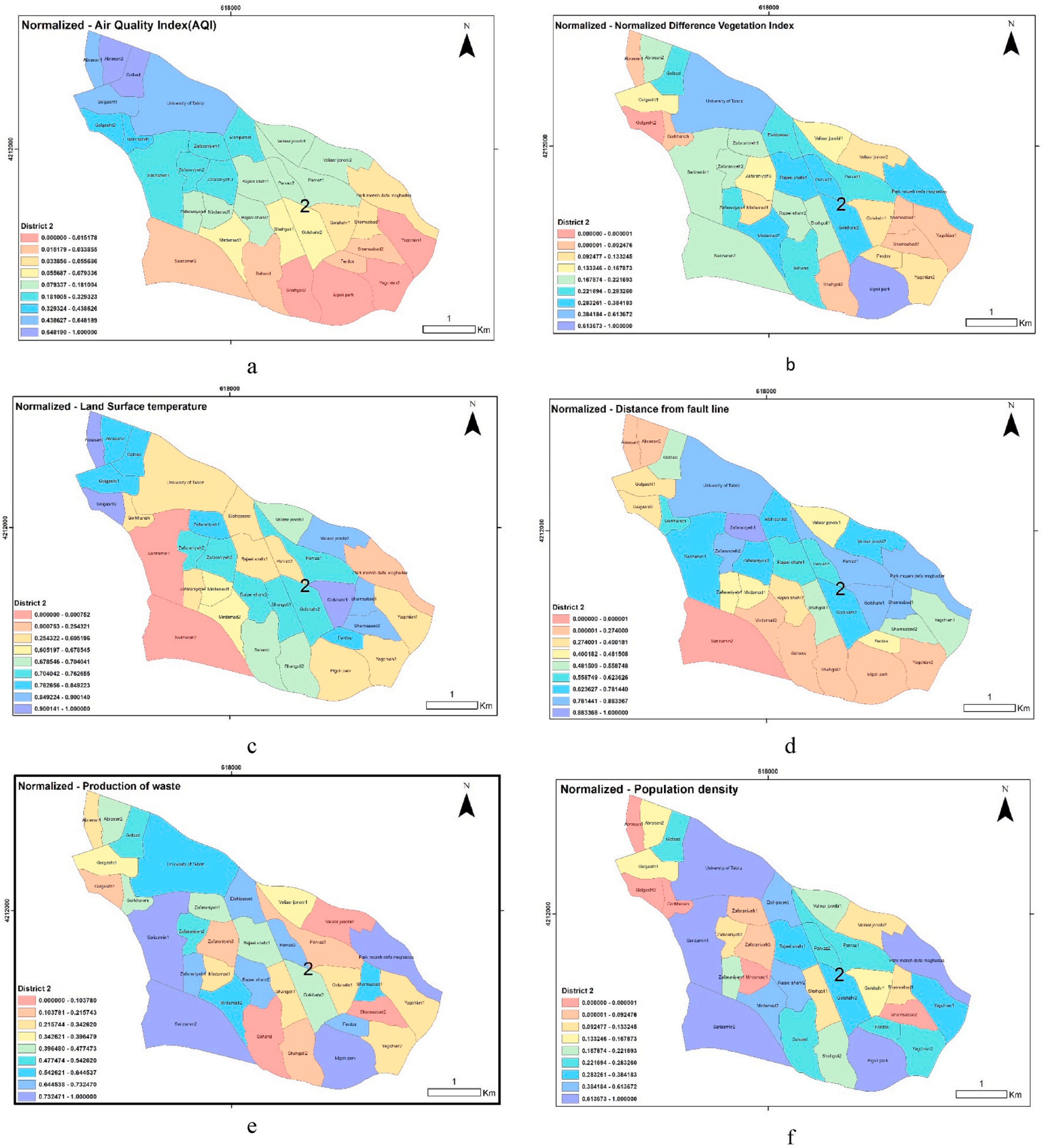
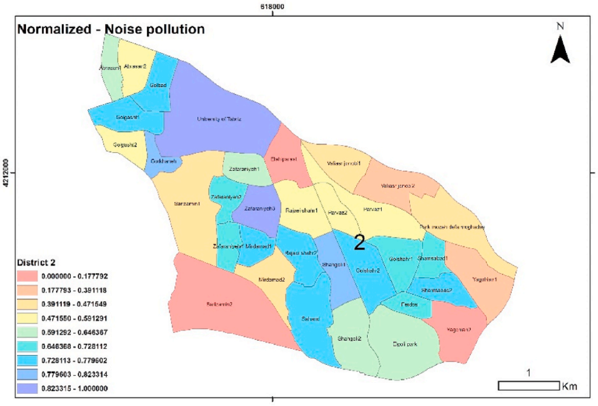


Fig. 5a. Maps of the normalized variables for the districts of 2, (**a**). Air Quality Index (AQI).



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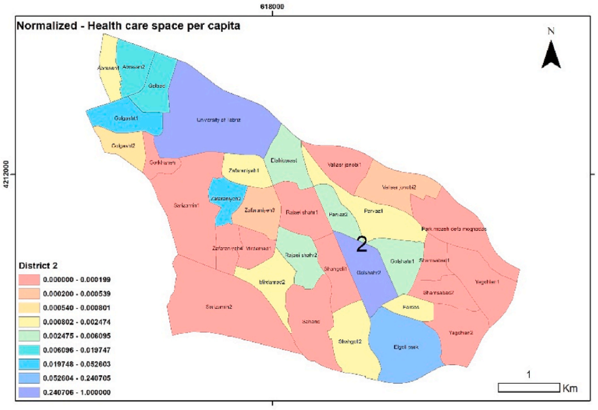

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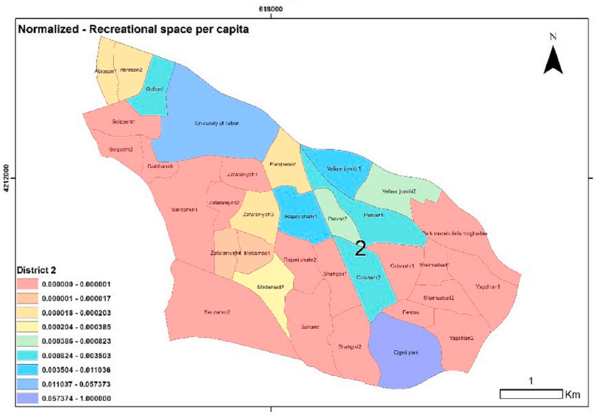

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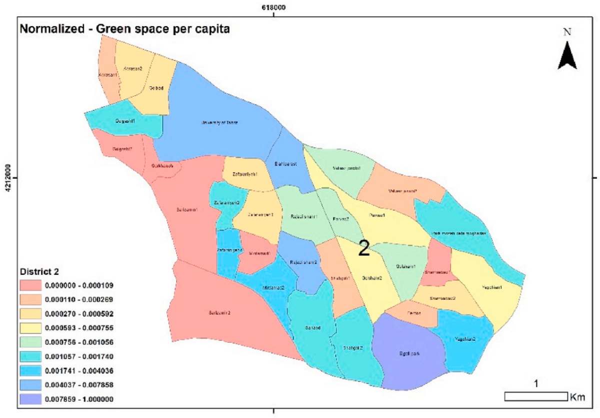

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Fig. 5b. Normalized Difference Vegetation Index (NDVI), (**c**). Land Surface temperature (c○), (**d**). Distance from fault line(m), (**e**). Production of waste (ton), (**f**). Population density, (**g**). Noise pollution (dB), (**h**). Health care space per capita (m^2), (**i**). Recreational space per capita (m^2), (**j**) Green space per capita (m^2). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

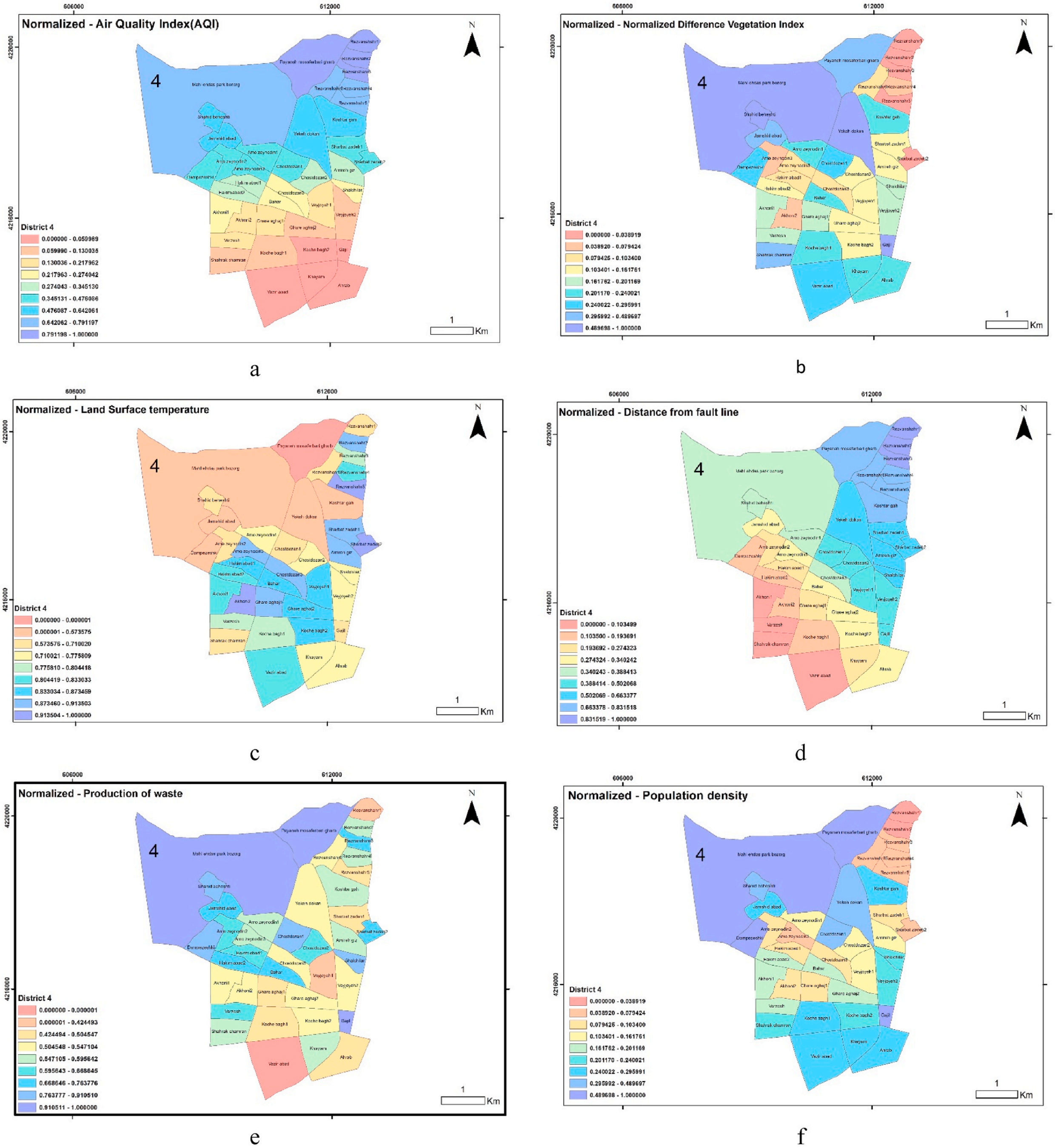

Fig. 6a. Maps of the normalized variables for the districts of 4, (**a**). Air Quality Index (AQI).

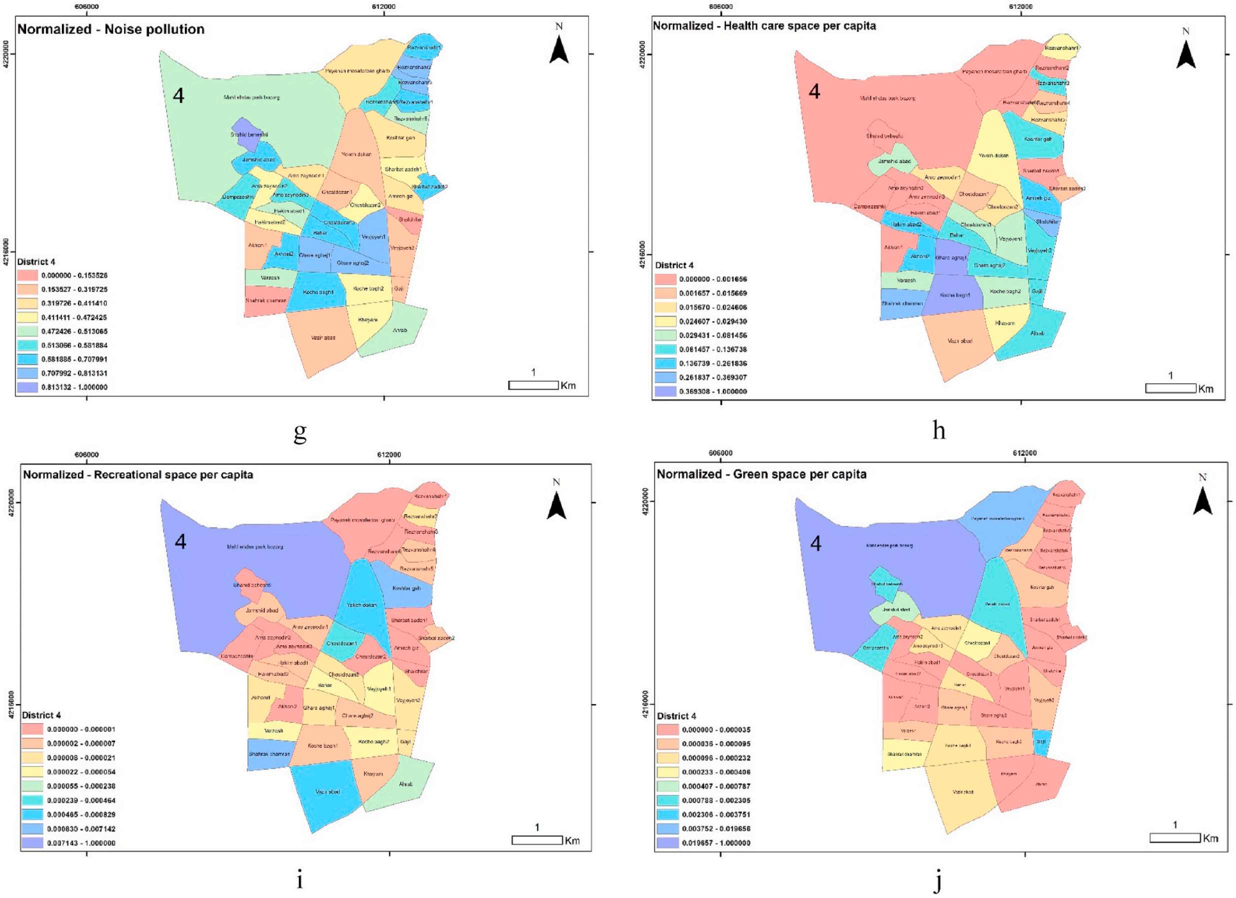

Fig. 6b. (**b**). Normalized Difference Vegetation Index (NDVI), (**c**). Land Surface temperature (c○), (**d**). Distance from fault line(m), (**e**). Production of waste (ton), (**f**). Population density, (**g**). Noise pollution (dB), (**h**). Health care space per capita (m^2), (**i**). Recreational space per capita (m^2), (**j**) Green space per capita (m^2). (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

Table 2
The final statistical results of layers in the district 4.

Variable	Mean	Standard deviation	Mean × Standard deviation	Weight
Air Quality Index (AQI)	8.391	.278	2.331050	0.129
Normalized Difference Vegetation Index (NDVI)	7.739	.234	1.814732	0.101
Land Surface temperature	11.671	.184	2.152613	0.119
Distance from Fault line	9.003	.257	2.313669	0.128
Production of waste	7.667	.183	1.403799	0.078
Population density	8.793	.228	2.005782	0.111
Noise pollution	8.723	.205	1.788578	0.099
Health care space per capita	9.709	.205	1.994613	0.110
Recreational space per capita	7.124	.158	1.126075	0.062
Green space per capita	7.105	.158	1.122752	0.062

4. Discussion

In the urban environment quality map for district 2, it was determined that the combination of variables in terms of high environmental quality corresponded to Abrasan, Golbad and Tabriz University in the north, Golshahr in the south, Eel Goli in the east, and Defa moghdas museum Park in the east. In district 4, Bozorg Park in the northwest, Qara Aghaj in the center, and Gajil in the east have shown significantly better environmental conditions as a result of the abundance of green areas and vacant land. As a result of the proximity to industrial and petrochemical land uses in District 4, high population densities, and destruction of green space, the western neighborhoods of District 4 have poor environmental quality, and the disruption of natural landscapes directly impacts air quality,

Table 3
The final statistical results of variables in district 2.

Variable	Mean	Standard deviation	Mean × Standard deviation	Weight
Air Quality Index (AQI)	9.031	.265	2.397	0.132
Normalized Difference Vegetation Index (NDVI)	6.163	.182	1.120	0.061
Land Surface temperature	10.252	.229	2.348	0.129
Distance from Fault line	9.040	.263	2.376	0.130
Production of waste	7.855	.269	2.115	0.116
Population density	8.022	.268	2.152	0.118
Noise pollution	8.267	.223	1.846	0.101
Health care space per capita	7.320	.208	1.521	0.084
Recreational space per capita	6.776	.171	1.161	0.064
Green space per capita	6.878	.171	1.178	0.065

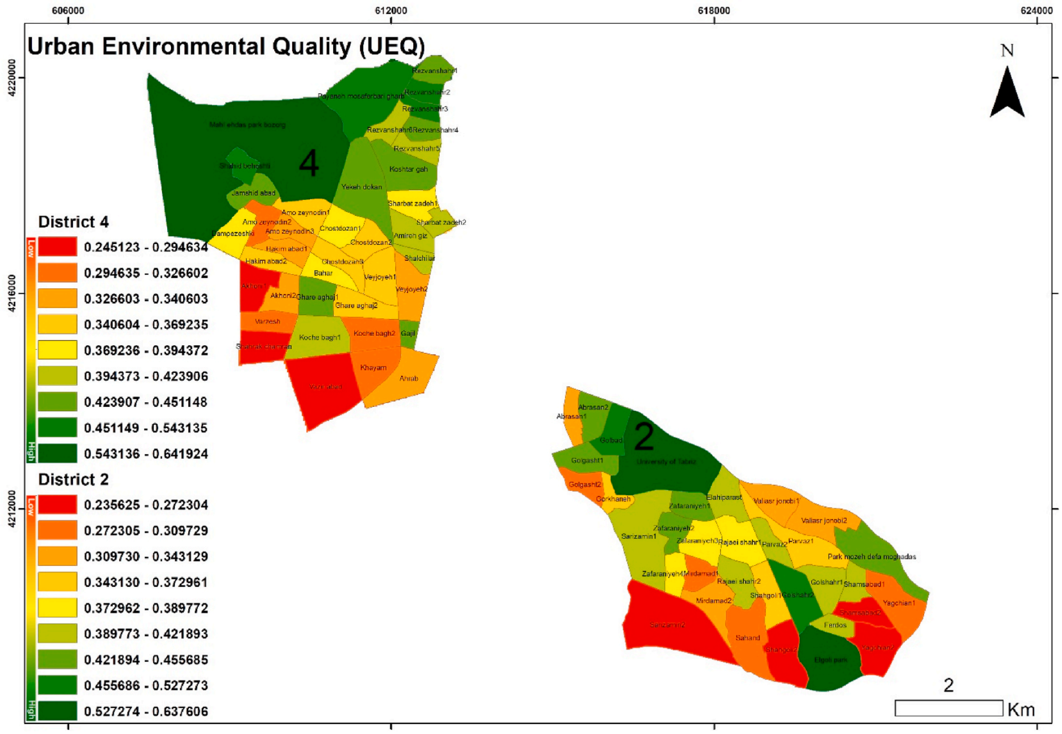

Fig. 7. UEQ maps districts 4 and 2 using a weighted linear combination of variables based on the CRITIC model.

green space availability, land surface temperature, and noise pollution. Other than those neighborhoods impacted by the ecology of Eel Goli Park in district 2, we have observed a general decline in the quality of urban environmental conditions in the southern districts due to a lack of green spaces and high-density construction. Even though the average difference between district 4 and district 2 is not significant, the air quality index for district 4 is lower than for district 2, primarily due to the high population density, the high use of cars, and proximity to industrial centers. In order to improve the quality of the environment, public transportation can be improved and diesel usage at Tabriz Power Plant can be limited during colder months. There are ways to reduce the land surface temperature in both districts, including increasing parks and green space levels, as well as prioritizing sensitive age groups (children and the elderly) in deficient neighborhoods. NDVI measures the greenness of an environment. By adding green spaces and green roofs to vertical surfaces, the UEQ of the environment can be increased. Both districts should consider expanding green corridors in order to enhance the quality of their UEQ, since green space is distributed in a centralized manner in both areas. A direct relationship exists between population density and waste production, and these indicators are higher in district four as compared to district two. For these indicators to improve in districts, it appears necessary to implement solutions such as separating the source from the trash, eliminating plastic bags, and promoting municipal tax deductions. One of the most expensive and time-consuming variables in this study was sound pollution, which has an inverse relationship with green space and population density, and it peaks during the early morning and evening hours. The most important findings of the research can be summarized as follows. There is a Northwest-Southeast decrease in Urban Environment Quality in Tabriz as a result of a spatial modeling study. The urban environment quality conditions are better in district 2 than in district 4. Six of ten indicators are significantly different between the two districts, according to the T-test analysis of the models' inputs. In terms of Urban Environment Quality, the green areas rank highest while commercial and high-density

Table 4
Independent Samples Test results to determine significant differences between averages.

Independent Samples Test										
		Levene's Test for Equality of Variances		*t*-test for Equality of Means						
		F	Sig.	**t**	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95 % Confidence Interval of the Difference	
									Lower	Upper
AQI (Air Quality Index)	Equal variances **not** assumed	18.56	0.00	−0.76	57.01	0.45	−2.56	3.35	−9.26	4.15
Normalized Difference Vegetation Index (NDVI)	Equal variances assumed	0.24	0.62	−0.91	72.00	0.37	−0.02	0.02	−0.05	0.02
Land Surface Temperature (LST)	Equal variances assumed	0.43	0.51	−3.12	72.00	0.00	−1.97	0.63	−3.23	−0.71
Distance from fault	Equal variances **not** assumed	26.16	0.00	11.31	49.76	0.00	2843.65	251.40	2338.64	3348.66
Waste production	Equal variances assumed	1.74	0.19	3.87	72.00	0.00	2.08	0.54	1.01	3.14
Population density	Equal variances assumed	3.92	0.051	4.26	72	0.00	83.54	19.57	44.52	122.57
Sound Intensity Index	Equal variances assumed	2.43	0.12	−27.16	72.00	0.00	−15.31	0.56	−16.44	−14.19
Health center space pc	Equal variances **not** assumed	10.22	0.002	−1.40	33.57	0.17	−1.19	0.85	−2.92	0.53
Recreational space pc	Equal variances assumed	0.31	0.58	0.25	72.00	0.81	6.14	24.98	−43.65	55.93
Green space pc	Equal variances assumed	1.50	0.22	0.61	72.00	0.54	400.32	656.53	−908.44	1709.08

residential land uses are at the bottom. It is considered an efficient way to improve the quality of the environment in both districts to implement fixed sound intensity recording systems. This is along with expanding public transportation to reduce the use of personal vehicles. The diversity of variables in this study is consistent with similar studies that use both natural and human indicators [31,41,111]. Most researchers use multivariate analysis methods as the basis for quantitatively evaluating environmental quality [34,39,112,113]. This research has benefited from the efficiency of this method along with statistical analysis.

5. Conclusion

According to the United Nations Sustainable Development Agenda for the third millennium, sustainable development for cities and communities is an important objective. A comparative approach and MCDM tools were used to examine the UEQ in two urban areas of Tabriz metropolis. In order to analyze the urban environmental quality, 10 main variables include Health center space pc, Recreational space pc, Population density, AQI, Sound Intensity Index, Distance from fault, LST, NDVI was identified. In order to map research variables quantitatively, satellite images were used for NDVI index, sound intensity was measured with the Light Weight Noise Meter GM1357 Digital Handy Sound Level Meter for Sound Quality Control, air pollution data was collected from Tabriz air quality measurement stations, and population statistical block data of two districts was used to prepare per capita and distance variables. The CRITIC model uses correlation and standard deviation to avoid the use of subjective judgment in order to produce a more realistic map of urban environmental quality. In future studies, the authors propose applying multi-temporal satellite images and landscape metrics to examine land use changes and ecological connectivity condition on UEQ. There is no doubt that the rapid urbanization trend in Tabriz metropolis especially in 2 and 4 districts will be responsible for the development of building lands and shrinking of green and ecological lands, resulting in the downward trend in the UEQ index. Ecological space (farms, green spaces, and water bodies) and unoccupied lands in the two districts were considered as potential elements for raising UEQ conditions in the two districts. The diversity of variables in this study is consistent with similar studies that use both natural and human indicators. Most researchers use multivariate analysis methods as the basis for quantitatively evaluating environmental quality. This research has benefited from the efficiency of this method along with statistical analysis. Following are some practical recommendations for improving the Urban Environment Quality in two regions based on the obtained scores. Enhancing and reviving damaged natural areas to increase their balanced distribution within the ecological network while protecting the remaining green areas. Increasing artificial green areas will facilitate the establishment of a balanced distribution. Enhance the size of green areas by establishing large green areas in order to reduce the effects of urban heat islands. To reduce earthquake vulnerability, upcoming urban development should be directed towards the south. It is important to mix land use and adopt the policy of creating multi-core urban centers in order to reduce personal travel. Utilizing smart growth and infill development strategies to promote urban renewal through the activation of deteriorated textures. Encourage the culture of waste segregation at the source in order to reduce the volume of municipal solid waste. Instead of increasing sales density and altering land use in an arbitrary manner, sustainable sources of income should be considered.

Data availability statement

The data will be available upon reasonable request thourgh corresponding authors.

CRediT authorship contribution statement

Hassan Mahmoudzadeh: Writing – original draft, Validation, Supervision, Software, Project administration, Methodology, Formal analysis, Data curation, Conceptualization. **Asghar Abedini:** Writing – original draft, Visualization, Resources, Project administration, Investigation, Formal analysis. **Farshid Aram:** Writing – review & editing, Visualization, Validation, Software, Resources, Formal analysis. **A. Mosavi:** Writing – review & editing, Validation, Resources, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e24921.

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