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Assessment of the visual aesthetic quality of the urban landscape in the Tabriz metropolis

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ABSTRACT

To improve human well-being, there is a growing awareness of enhancing aesthetic benefits through landscape design, planning and management. Monitoring long-term changes can play a significant role in the direction of urban management. This study aims to visually evaluate the aesthetic quality of the Tabriz metropolis landscape and monitor changes in Landscape aesthetic quality (LAQ). LAQ is assessed based on visual scale, naturalness, stewardship, historicity, complexity, disturbance, ephemera, and imageability. Using multiple temporal satellite images and landscape metrics, we analyze land use changes between 1984 and 2020. The results reveal that urbanization has led to landscape fragmentation and loss of coherence over the past three decades. Additionally, we calculate the weights of the criteria using the CRITIC[1] method, highlighting the changing importance of different factors. In addition, we calculate the weights of the criteria using the CRITIC method and highlight the variable importance of different factors. Then, by overlaying the layers and multiplying by the obtained weights, we draw the LAQ map for different years. The results are historicity with a coefficient of 0.22, naturalness 0.15, Disturbance 0.14, and coherence. 0.14, ephemera 0.13, complexity 0.11, and visual scale 0.11 in 1984. For the year 2020, the coefficient for historicity is 0.13, naturalness is 0.18, disturbance is 0.11, coherence is 0.10, ephemera is 0.10, complexity is 0.12, and visual scale is 0.26 Historicity and naturalness hold the greatest weights in 1984, while visual scale and naturalness receive the highest weights in 2020. Significant changes are observed in districts 9 and 1, while districts 7 and 6 show minor adjustments. The findings provide valuable insights for improving ecological networks in future urban planning in Tabriz. Urban management should consider these calculations to enhance the LAQ index.

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1. Introduction

The term aesthetics is derived from the Greek word “aisthētikos” meaning “perception by the sense” which represents the starting point of the aesthetic sensation acquired through physical pleasure. After German philosopher Alexander Baumgarten published a definition in 1750, this period became known as the “enlightenment” period, which contributed to the modern understanding and measurement of aesthetics (Lothian, 1999).

Landscape aesthetics incorporates a variety of complex and dynamic concepts, including aesthetics, scenic beauty, aesthetic pleasure, and aesthetic acceptability, and is formed based on the interaction between physical characteristics and the perception of the observer (Daniel, 2001). Interactions between humans and landscapes could contribute to the development of landscape aesthetics (Ribe, 2006).
Moreover, it is essential to consider that the quantity and quality of the objects encountered

in the environment affect the cognitive perceptions of those who are attracted to them (Fumagalli et al., 2020). Several studies have argued that it is possible to quantify and determine whether scenery is sufficiently attractive for humans to be attracted to it based on aesthetic considerations by mapping and quantifying landscape composition (Carlson, 1977; Mundher et al., 2022; Van Berkel and Verburg, 2014; Wang et al., 2019). To date, a great deal of research has focused on examining people's perceptions of rural landscapes and aesthetics (Cabrini et al., 2023). The general public, particularly in Western nations, can be described as nature enthusiasts. In other words, the majority of people recognize the inherent value of nature and, consequently, its right to exist regardless of its utility to humanity (De Groot and van den Born, 2003). According to a report by the United Nations, more than fifthy-five percent of the world's population resides in cities and urban areas. It is anticipated that by 2050, it will exceed 68%. It is anticipated that this rapid development will exert significant pressure on the natural environment and cause a number of problems that will directly impact environmental issues, such as the regional ecological pattern and urban sustainability (Girma et al. 2019; Wanghe et al., 2020). This pressure on urban environments has led to the destruction of green spaces and landscapes (Dampage et al., 2022; Jorgenson and Burns, 2007; Laurance, 2007; Suciptoroso, 2022). Moreover, urban landscapes are primarily formed and shaped by human activity, which is a concept of aesthetics that is easily understood. Therefore, the landscape is an extremely important aspect of urban residential satisfaction, which is defined as the sphere in which humans interact with environmental phenomena and comprehend their surroundings (Sahraoui et al., 2016). Due to their direct influence on the lives of urban residents through the delivery of various values and functions, urban green spaces are a crucial component of the urban landscape (James et al., 2009). Historically, the primary advantages of urban green space have been health, aesthetics, and recreation. However, the benefits and applications of green spaces range from psychological and aesthetic benefits to helping to reduce and adapt to climate change and green marketing of cities through its greenery (Carrizo Moreira et al., 2023; Chan and Marafa, 2014; Gulsrud et al., 2013; Tian et al., 2014). Aesthetics have played an important role in the modern landscape preservation and protection of urban green space, particularly in the preservation of urban forested areas deemed particularly beautiful. A contentious issue among experts has been how to quantify urban landscapes and green spaces or urban green infrastructures (Chen et al., 2009). Urban green infrastructure consists of a network of near-natural and designed spaces and elements in cities, planned and maintained in such a way that the infrastructure as a whole provides a high level of utility, biodiversity, and aesthetic appeal, as well as a wide range of ecosystem services. Regardless of ownership or origin, the green infrastructure can include all forms of sites and elements characterized green infrastructure (Kaltenborn and Bjerke, 2002). Infrastructure integration can lead to multifunctional solutions that provide multiple advantages simultaneously, such as improving aesthetics, reducing pollution, mitigating climate change impacts, and improving stormwater management (Lovell and Taylor, 2013). Nonetheless, the development of geographical information systems (GIS) and the use of spatial data generated in urban environments have enabled experts to apply a vast array of geoinformatics techniques to quantify perceptual factors, such as the aesthetics of urban environments. Numerous studies with varying scopes and methodologies have been conducted in this field, making it difficult to develop a unified process for mapping and evaluating urban landscapes. Research has shown that socio-demographic factors such as gender, social status, education, and cultural heritage impact the aesthetic perception of landscapes (Hafner et al., 2018; Howley, 2011; Kaltenborn and Bjerke, 2002). While examples from urban landscapes are few, several studies have attempted to develop scalable LAQ methods that apply to regional-level cases in a range of European countries and beyond (Kalivoda et al., 2014; Langemeyer et al., 2018; Lindemann-Matthies et al., 2010; Schirpke et al., 2013; Swetnam et al., 2017; Van Zanten et al., 2014). This research in itself is one of the first researches that evaluated the quality of aesthetics in the metropolis of Tabriz and is considered as a kind of innovation. The purpose of this article was to examine the visual aspects of landscape aesthetics utilizing visual scale, historicity, naturalness, complexity, coherence, ephemera, and disturbance as scale indicators.

The primary goal of the current research is to determine the LAQ in the Tabriz metropolitan area and develop a novel LAQ method using the CRITIC approach that is applicable to an urban environment. Additionally, this study aims to assess the changes in LAQ within the Tabriz metropolitan area, providing valuable insights for urban management, ecological planning, and the improvement of the LAQ index. Furthermore, this research contributes to the broader understanding of landscape aesthetics in urban contexts, offering potential implications for urban sustainability and enhancing the quality of life.

2. Material and Methods

2.1. Study area

Tabriz is the provincial capital of the province of East Azerbaijan, which is situated in the northwest of Iran (Figure 1). Within the study area, which is bounded by 38°1'N to 38°9'N and 46°11'E to 46°23'E. The population of Tabriz has increased steadily from 289,996 in 1956 to 1,773,033 in 2020 (Statistical Center, 2020). As the fourth largest city in Iran (Feizizadeh et al., 2021), the foundation of this historic city dated back to 1500 B.C. but due to the severe earthquakes, few historic buildings remained from ancient eras. In 2012, Tabriz was selected as the most beautiful city of Iran, and it is nominated as the tourism capital of Islamic countries in 2018. Tabriz used to be the capital of Iran during different dynasties like Ilkhanid, Kara Koyunlu, Ak Koyunlu, and Safavid; it was the residence of the royal family and crown prince during the Qajar Dynasty period. Tabriz is famous as “the city of the firsts”; and the Historic Bazaar Complex of Tabriz is the biggest roofed bazaar in the world, inscribed as a World Heritage Site in 2010. Tabriz experiences the phenomenon of rapid urban growth causing the formation of slum settlements in the border zones of the city (Asbagh, 2019). it has undergone significant environmental and physical changes as a result of its growing population. Approximately 28 percent of Tabriz consists of 6880 hectares of barren territory (Naghsh Moheet engineering consultant co, 2014). Many of these lands have the potential to expand the city’s green space and ecological networks. It has the passage of two rivers within the city, which originate from the surrounding highlands and play a vital role in improving the environmental condition of the city and regulating the urban climate, is an additional environmental feature of Tabriz that can be utilised to expand the ecological network of Tabriz.

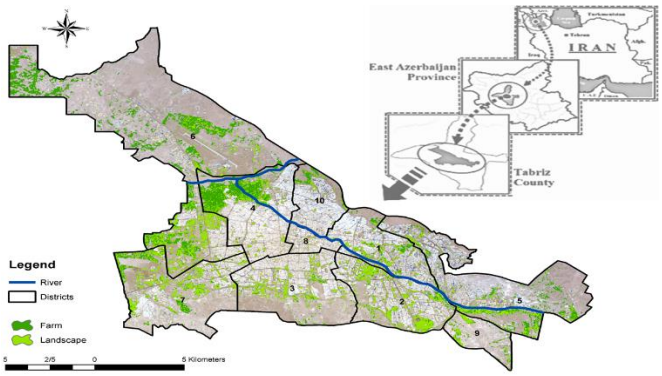

Fig. 1. The location of the study area in East Azarbaijan province (Tabriz county), NW Iran.

2.2. Data and methodology

Assessment of LAQ requires the calculation of sub-indicators based on primary and secondary data sets. In this investigation. As indicated in the Table 1, we used Landsat satellite images of 1984 and 2020 and digital elevation model (DEM), land use, and statistical information obtained from Tabriz Municipality and Iran Statistics Organization.

Table 1. Characteristics of Remote sensing data.

	Source	Resolution(m)	Date
Landsat 5 (TM)	US Geological Survey	30	1984/06/24
Landsat 8 (OLI)	US Geological Survey	30,15(PAN)	2020/06/27

This paper's LAQ calculation framework is founded on the methodology proposed by Tveit and Sang, 2014. We have used eight of the key concepts, identified by Tveit et al. 2006 Ode, 2008 and used them in other researches (Chen et al., 2009; Daniel, 2001; Havinga et al., 2021; Hermes, Van Berkel et al., 2018; Junge et al., 2015; Kalinauskas et al., 2021; Kerebel et al., 2019; Tveit et al., 2018; Wang et al., 2021; Wang et al., 2016). LAQ is an overlay of visual scale, naturalness, stewardship, historicity, complexity, disturbance, ephemera, and imageability indicators. Based on the secondary and primary data sources, these indicators are derived from smaller sub-indicators. According to the figure 2 below: Complexity, Ephemera, Coherence derived from satellite image data and Naturalness and Disturbance from field observations and Historicity and Visual scale and Complexity (Diversity)from land use map Figure 2 illustrates the framework for this investigation.

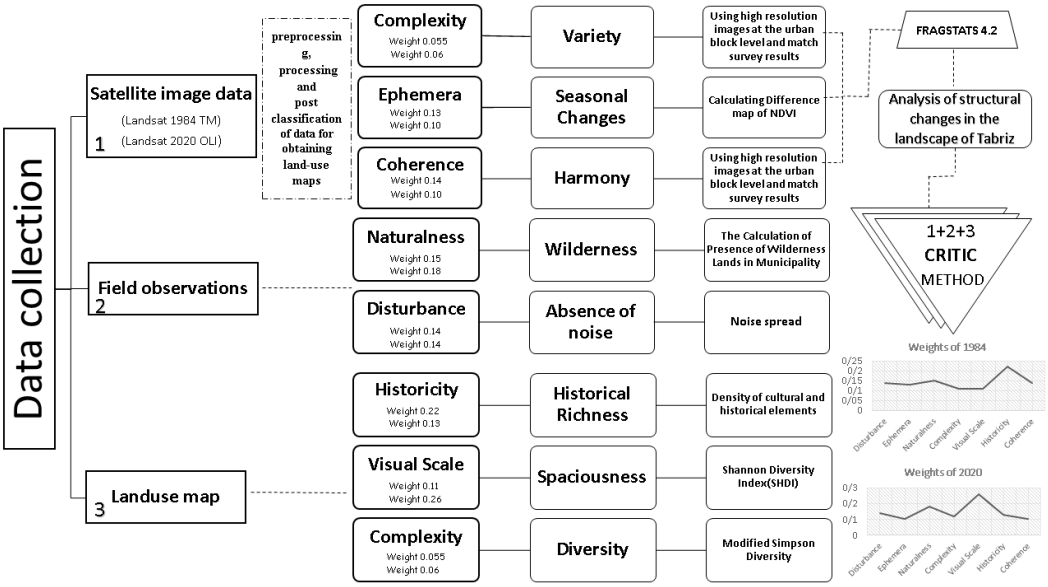

Fig. 2. Framework for landscape aesthetics quality mapping and assessment in Tabriz metropolitan. Created by authors.

Landscape room, visibility, openness, enclosure, and spaciousness comprise the visual scale from a landuse map. Naturalness is defined as wilderness and natural vegetation, while historicity refers to historical continuity and historical richness. Diversity and variety are essential components of complexity. Disturbance is marked by sound and negative human influence. Seasonal and weather-related variations are regarded as ephemera.

Table 2. Summary of key concepts and their definitions, dimensions, and indicators (author-modified).

Concept	Definition From (Tveit et al., 2006)	Dimensions in an urban context	Potential indicator	References
Naturalness (3g)	Closeness to a preconceived natural state	Wilderness Wild/Ecological Lush and abundant Undisturbed nature	Vegetation diversity Wildlife presence Ddead wood presence Aamount of native vegetation	Anderson, 1991 Clay and Smidt, 2004 Ellis et al. 2006 Kim and Kaplan, 2004 Palmer, 1997 Sullivan III, 1994 Sullivan and Lovell, 2006 Van Herzele and Wiedemann, 2003 Arriaza et al. 2004
Visual Scale (3d)	The perceptual units that reflect the experience of landscape rooms, visibility and openness	Openness Spaciousness	Vegetation density and structure Canopy closure Size of open space Amount of visual obstacles such as walls, shrub, hedges, fences and gates	Kaplan and Kaplan, 1989 Qureshi et al. 2010 Heyman, 2012 Voelker and Kistemann, 2013 Vogt and Marans, 2004 Zhang and Lin, 2011

Historicity (3c)	Reflects the visual presence of time layers and the amount, condition and diversity of cultural elements.	Historical richness; Traditional; Cultural history; Heritage architecture	Presence of historical buildings Presence of old and archaic trees	
Complexity (3a)	The diversity and richness of landscape elements and features, their interspersion as well as the grain size of the landscape	Diversity; Variety	Variety of urban green areas Variation in topography Variation in forest species and structure; Diversity of elements Perceived species richness (wildlife and plant) Perceived habitat richness Diversity in pattern, colour, style and textures	Bell, 1999 Dramstad et al. 2001 Ode and Fry, 2002 Özgüner and Kendle, 2006 Ode et al. 2010 Ode and Miller, 2011 Peckham et al. 2013
Coherence (3b)	reflection of the unity of a scene, where coherence may be enhanced through repeating patterns of colour and texture but also correspondence with natural conditions and surrounding.	Harmony Peace Coherence vegetation and natural landscape Harmony with surrounding built up areas		Litton, 1974 Palang et al. 2000 Swanwick, 2002 Caspersen and Olafsson, 2010 Zhang and Lin, 2011 Voelker and Kistemann, 2013 Zhang et al. 2013
Disturbance (3e)	lack of contextual fit and coherence, where elements (related to constructions and interventions) deviate from the context.	Negative human impact Noise	Presence/amount of features such as: golf course, construction work, wheel-tracks, forestry, litter, graffiti, electric poles, wires and transformers Noise level	Hernandez et al, 2004; Zhang and Lin, 2011; Heyman, 2012; Voelker and Kistemann, 2013
Ephemera (3g)	The presence of elements changing with season and weather.	Seasonal change	Amount of flowering plants/bushes	Taylor et al. 2002; Pachaki, 2003; Todorova et al. 2004; Eroğlu et al. 2012; Voelker and Kistemann, 2013

2.3. Importance of criteria through intercriterion correlation (CRITIC)

To effectively reduce subjective factors, the CRITIC weight method was used to assign values to multiple indicators. CRITIC is a correlation-based technique that extracts fundamental information from decision criteria using analytical testing. It determines the weights based on the contrast's intensity and the criteria's contrasting nature. The CRITIC method introduces conflict to the MCDM framework. Typically, it is used to generate objective weights for MCDM techniques that rank businesses based on financial indicators and economic factors. The CRITIC algorithm employs m indexes and n alternatives (block chain) (Zafar et al., 2021). Each indicato's value is normalized to the interval [0.1] and the standard deviation for each indicator is calculated (Diakoulaki et al., 1995). The contrast intensity of an indicator is measured by its standard deviation, j. The information provided by an indicator is calculated using equation 2.

$$cj=\sigma j \sum_{k=1}^{m} 1-r_{jk} \quad (1)$$

where cj is the information provided by the jth indicator and rij is the linear correlation between indicators j and k.

$$cw_j=\frac{c_j}{\sum_{j=1}^{m} c_j} \quad (2)$$

where cw_j is the indicator weight using the CRITIC Method. In this technique, the weight of the criteria is not determined by the opinion of the experts. Despite the fact that experts use their knowledge and experience to determine the weights of the criteria, as the number of criteria increases, the likelihood of human error and uncertainty about the results also rise. The weight of each criterion in the CRITIC method

is determined by calculating the standard deviation and internal correlation of the criteria. In this article, to effectively reduce subjective factors, the CRITIC weight method was used to assign values to several indicators.

Table 3. Correlation matrix of 1984.

	Disturbance	Ephemera	Naturalness	Complexity	Visual Scale	Historicity	Coherence
Disturbance	1	-0/409	-0/674	0/806	0/847	0/527	-0/545
Ephemera	-0/409	1	0/950	0/211	0/138	-0/991	0/988
Naturalness	-0/674	0/950	1	-0/106	-0/179	-0/983	0/987
Complexity	0/806	0/211	-0/106	1	0/997	-0/078	0/058
Visual Scale	0/847	0/138	-0/179	0/997	1	-0/004	-0/016
Historicity	0/527	-0/991	-0/983	-0/078	-0/004	1	-1
Coherence	-0/545	0/988	0/987	0/058	-0/016	-1	1

Table 4. Contrast matrix of 1984.

	Disturbance	Ephemera	Naturalness	Complexity	Visual Scale	Historicity	Coherence
Disturbance	0/000	1/409	1/674	0/194	0/153	0/473	1/545
Ephemera	1/409	0/000	0/050	0/789	0/862	1/991	0/012
Naturalness	1/674	0/050	0/000	1/106	1/179	1/983	0/013
Complexity	0/194	0/789	1/106	0/000	0/003	1/078	0/942
Visual Scale	0/153	0/862	1/179	0/003	0/000	1/004	1/016
Historicity	0/473	1/991	1/983	1/078	1/004	0/000	2/000
Coherence	1/545	0/012	0/013	0/942	1/016	2/000	0/000
	5/447	5/112	6/006	4/112	4/217	8/529	5/528

Table 5. Correlation matrix of 2020.

	Disturbance	Ephemera	Naturalness	Complexity	Visual Scale	Historicity	Coherence
Disturbance	1	0/768	0/620	0/154	-0/941	0/022	-0/640
Ephemera	0/768	1	-0/027	0/751	-0/984	0/658	0/984
Naturalness	0/620	-0/027	1	-0/680	0/204	-0/771	-0/206
Complexity	0/154	0/751	-0/680	1	-0/857	0/991	0/858
Visual Scale	-0/641	-0/984	0/204	-0/857	1	-0/781	-0/641
Historicity	0/022	0/658	-0/771	0/991	-0/781	1	0/782
Coherence	0/640	0/984	-0/206	0/858	-1	0/782	1

Table 6. Contrast matrix of 2020.

	Disturbance	Ephemera	Naturalness	Complexity	Visual Scale	Historicity	Coherence
Disturbance	0/00	0/23	0/38	0/85	1/64	0/98	0/36
Ephemera	0/34	0/00	1/03	0/25	1/98	0/34	0/02
Naturalness	0/38	1/03	0/00	1/68	0/80	1/77	1/21
Complexity	0/85	0/25	1/68	0/00	1/86	0/01	0/14
Visual Scale	1/64	1/98	0/80	1/86	0/00	1/78	2/00
Historicity	0/98	0/34	1/77	0/01	1/78	0/00	0/22
Coherence	0/36	1/00	1/21	0/14	2/00	0/22	0/00
	4/55	4/83	6/87	4/79	10/6	5/1	3/95

Table 7. Descriptive Statistics of 1984 & 2020

	Contrast matrix 1984	Contrast matrix 2020	Standard deviation 1984	Standard deviation 2020	Contrast * Standard deviation 1984	Contrast * Standard deviation 2020	Weights 1984	Weights 2020
Disturbance	5/44	4/44	1/83	1/48	8/06	8/12	0/14	0/11
Ephemera	5/11	3/85	1/83	1/48	7/56	7/05	0/13	0/10
Naturalness	6/00	6/86	1/83	1/48	8/88	12/55	0/15	0/18
Complexity	4/11	4/78	1/83	1/48	6/08	8/75	0/11	0/12
Visual Scale	4/21	10/06	1/83	1/48	6/24	18/41	0/11	0/26
Historicity	8/52	5/10	1/83	1/48	12/62	9/33	0/22	0/13
Coherence	5/52	3/94	1/83	1/48	8/18	7/21	0/14	0/10

3. Results and discussion

Equations 3 and 4 were used to calculate the LAQ maps for 1984 and 2020 using data derived from the critical model.

LAQ 1984 = [(Complexity×0/11) + (Coherence×0/14) +(Historicity×0/22) + (Visual scale×0/11) + (Disturbance×0/14) +(Naturalness×0/15) +(Ephemera×0/13) (3)

LAQ 2020 = [(Complexity×0/12) + (Coherence×0/10) +(Historicity×0/13) + (Visual scale×0/26) + (Disturbance×0/11) +(Naturalness×0/18) +(Ephemera×0/10) (4)

Tabriz was a municipal garden in the past, as evidenced by photographs from 1984. This is

because the city had an adequate quantity of green space per person. Fewer individuals reside in the city. There is less traffic and noise pollution. The majority of the city's ecological texture has been preserved, making it more visually appealing. Based on the outcomes of the CRITIC method, History and historical context received the highest coefficient of 0.22 in 1984. In addition to History and historical context, the coefficients for Coherence, Disturbance, and Ephemera were 0.14, 0.13, and 0.11, respectively.

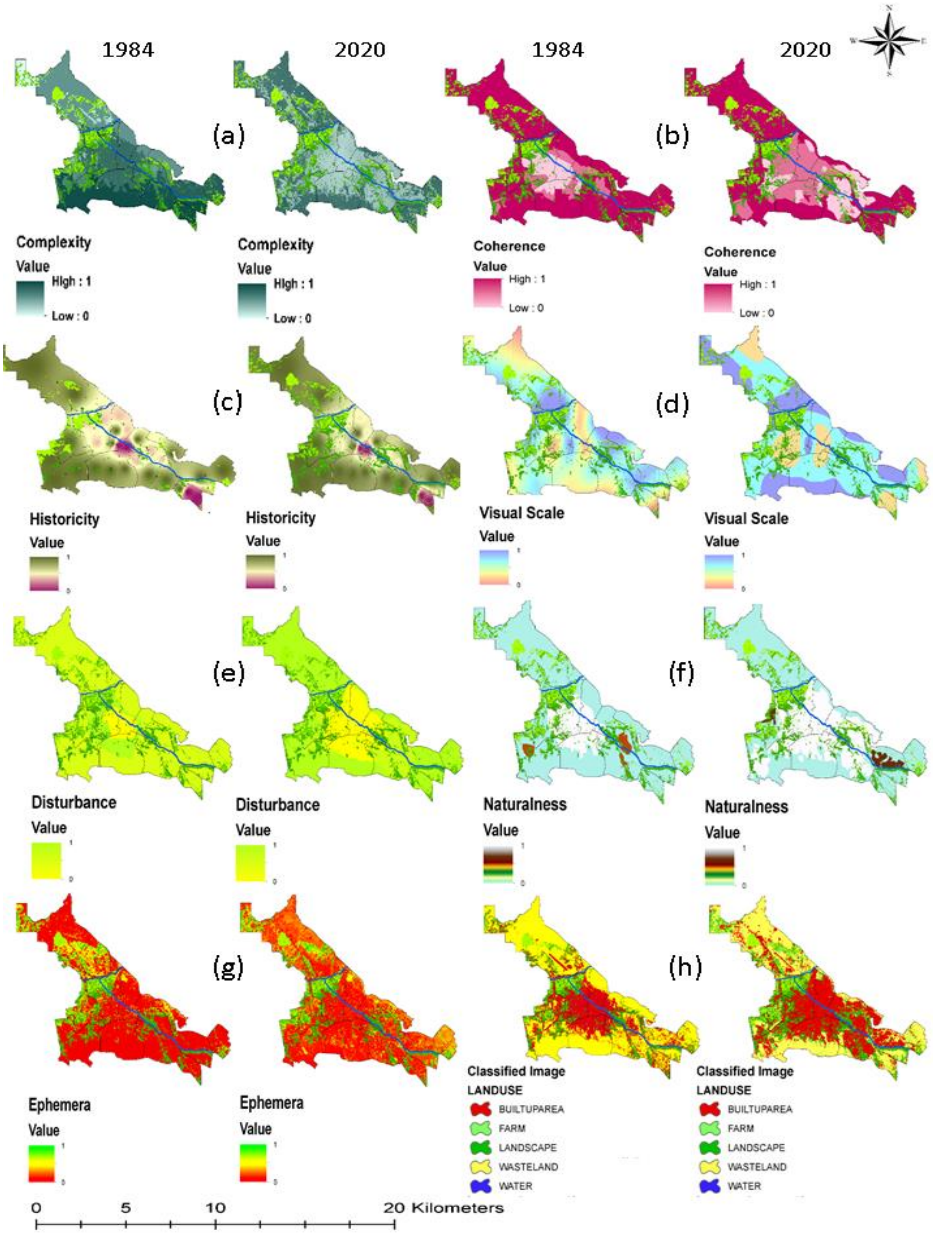

Fig. 3. 1984 and 2020 Results (a) Complexity, (b) Coherence, (c) Historicity, (d) Visual Scale, (e) Disturbance, (f) Naturalness, (g) Ephemera, (h) Classified Image.

Figure 3 shows the maps of 1984 and 2020 and their changes. According to data derived from image changes, urban development in Tabriz has eliminated a number of green spaces. The city's lungs have been replaced by new structures. The images of the year 2020 reveal that the city of Tabriz, which was formerly a city garden, has an adequate amount of green space per person. Population growth and the migration of most villagers to Tabriz have led to the destruction of the city's ecological fabric, as well as the fragmentation of urban green space and destruction of green belts. Due to urbanization, the city's aesthetic appeal has diminished significantly. Visual scale with a coefficient of 0.26, Naturalness with a

coefficient of 0.18, Historicity with a coefficient of 0.13, Complexity with a coefficient of 0.12, and Disturbance with a coefficient of 0.11 have the highest coefficients in 2020, as indicated by the CRITIC method. We conclude with the Ephemera index, which has a coefficient of 0.10. This index has the lowest rank.

Complexity (a)

The analysis reveals that the complexity of the landscape is generally lower in the central areas of Tabriz compared to the outskirts. Notably, the southern areas exhibit a more prominent level of complexity. This indicates that the southern regions of the city possess a greater diversity of elements and visual intricacies, contributing to a more visually complex landscape.

Coherence (b)

The findings suggest that in 1984, the highest degree of coherence was observed in the city center. However, as the city has grown and the population has increased, the concentration of coherence in 2020 has reached a point where there is no longer a distinct pattern. This implies that the spatial organization and coherence have become more dispersed and less concentrated as the city expanded.

Historicity (c)

The analysis of the 1984 maps indicates that areas with a greater amount of green space and older features exhibit a higher degree of historicity. In contrast, the areas of 10-3-7 in the municipality had the lowest amount of historicity in 1984. However, in the 2020 maps, districts 9 and 8 demonstrate the lowest levels of historicity. This suggests that over time, the distribution of historic elements and the preservation of historical features have changed within the city.

Visual scale (d)

The analysis reveals that the visual scale is wider in the suburbs compared to the city center. This suggests that the outskirts of Tabriz offer more expansive and panoramic views, contributing to the aesthetic experience of the landscape.

Disturbance (e)

The study findings indicate that the city center experiences the least amount of disturbance, while the level of disturbance increases with greater distance from the center. This can be attributed to the concentration of urban activities and infrastructure in the central areas, resulting in a relatively lower level of disturbance in comparison to the surrounding regions.

Naturalness (f)

The study indicates that in both 1984 and 2020, the city center has the least amount of naturalness, while areas further away from the center exhibit a higher degree of naturalness. This finding highlights the impact of urbanization on the loss of natural elements within the city and emphasizes the importance of preserving and enhancing green spaces.

Ephemera (g)

The ephemera factor indicates the potential for experiencing seasonal changes through variations in vegetation. The study highlights that areas with a greater amount of greenery offer a higher chance of observing and experiencing these seasonal changes throughout the year. This emphasizes the importance of preserving and promoting green spaces to enhance the ephemeral qualities of the landscape.

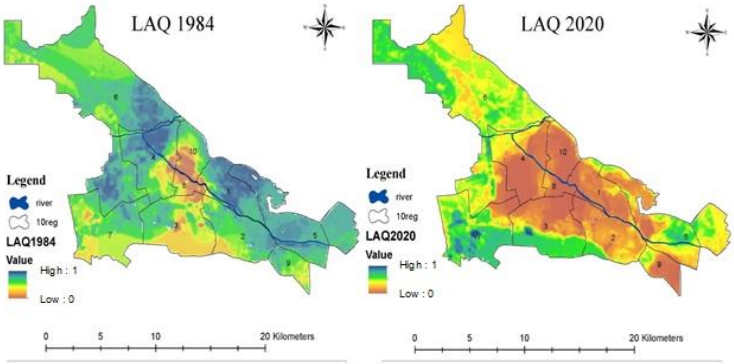

Fig. 4. Results of LAQ in 1984 year and in 2020 year.

According to Figure 4, the aesthetic quality has clearly decreased over the past 36 years. In the table 8, LAQ changes are shown based on regions in Tabriz municipality.

Table 8. LAQ values for each of the municipal areas of Tabriz metropolis.

District	*LAQ 1984*	*LAQ 2020*
1	Max:0/97 Min:0/48	Max:0/72 Min:0/55
2	Max:0/88 Min:0/54	Max:0/62 Min:0/64
3	Max:0/85 Min:0/46	Max:0/63 Min:0/54
4	Max:1/00 Min:0/50	Max:0/70 Min:0/65
5	Max:0/94 Min:0/65	Max:0/91 Min:0/59
6	Max:0/95 Min:0/61	Max:0/86 Min:0/57
7	Max:0/88 Min:0/54	Max:0/93 Min:0/58
8	Max:0/71 Min:0/46	Max:0/63 Min:0/42
9	Max:0/86 Min:0/58	Max:0/73 Min:0/52
10	Max:0/84 Min:0/45	Max:0/70 Min:0/42

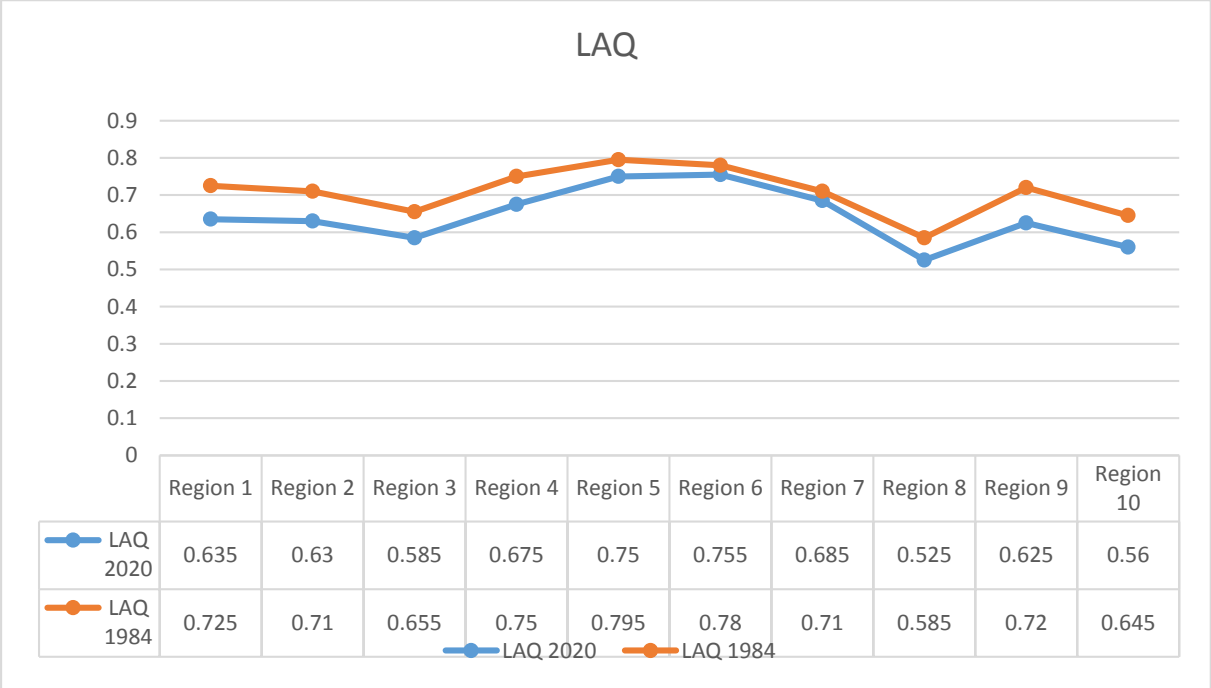

Fig. 5. Results of LAQ in 1984& 2020 by municipal areas.

The figure 5 shows the results of LAQ in 1984& 2020 by municipal areas. As we move towards the east from the central parts, due to the fact that in these areas the growth and construction speed is higher than in the west, the destruction of green space and as a consequence the reduction of LAQ also happens more. Districts 9, 1, and 10 experienced the greatest amount of change, while districts 7, 6, and 5 experienced the least amount of change.

4. Conclusion

The changes of the last three decades have been examined, and based on this we have developed a framework based on stratified multi-temporal satellite images, landscape metrics, and then each index. Furthermore, the aesthetic quality of the study area was evaluated in current conditions according to the following index. Several methods and models that have been utilized in similar research are included in the framework. This research in itself is one of the first to evaluate the quality of aesthetics in the metropolis of Tabriz. We analyzed land use changes between 1984 and 2020 using land use maps derived from multiple temporal satellite images and landscape metrics in the first part of this study. As a result of urbanization, there is an increase in built-up land and a reduction in ecological uses (farms, gardens, and green spaces) and other uses, such as uninhabited

areas. The landscape of Tabriz has fragmented and lost its coherence over the past three decades. The importance of urban green space within the urban landscape has been stressed within multiple studies (REF), our study show that with the passage of time, land development in Tabriz has gradually become connected and dominated, but the green and ecological lands have become smaller and disconnected day by day. These points are particularly important in the central areas of the city, which have high population and residential density and the impossibility of establishing large habitats in these areas. It is practically impossible to create green networks and environmental development in the metropolis of Tabriz without paying attention to these parts. Therefore, it is necessary to pay attention to this factor in development planning in order to prevent the increase in fragmentation and decrease in the cohesion of the green space. These land cover/land use changes are similar to the findings of other studies from different parts of the world (Hermes et al., 2018; Kalinauskas et al., 2021; Mahmoudzadeh, 2007; Rahimi, 2016; Taheri et al., 2014; Wang et al., 2016; Wu et al., 2021). However, none of these examined landscape measures and ecological connectivity to detect landscape change. In contrast, within this study we explored the effects of land cover/ land use change on LAQ through the developed CRITIC method, to evaluate the aesthetic quality of the landscape, which is a more efficient means of quantifying landscape changes over time. Most studies previously have only carried out LAQ for one year, this study looks at changes over these years. Towards the end of the research, we calculated the weight of the criteria based on the degree of importance of combining and stacking layers based on the CRITIC method, our methods principle is to use the contrast intensity of indicators and confliction between indicators to reflect the amounts of both information and independence of the indicator, thereby determining the weight. For this reason, it has significant advantages over other weighting methods which only consider the indicator information or independence. The results are historicity with a coefficient of 0.22, naturalness 0.15, Disturbance 0.14, and coherence. 0.14, ephemera 0.13, complexity 0.11, and visual scale 0.11 in 1984. For year 2020, the coefficient for historicity is 0.13, naturalness is 0.18, disturbance 0.11, coherence is 0.10, ephemera is 0.10, complexity is 0.12, and visual scale is 0.26. For example, the Ephemera index had a greater impact on aesthetics in 1984, due to the destruction of vegetation in recent years, this index has a lower impact on LAQ with a drop of 0.3 in 2020.

4.1. Summary and practical conclusions

The first step in improving the aesthetics of the environment is to pay attention to the naturalness of the space and maintain the ecological conditions of the environment by preserving natural resources and old green spots. Audiences are captivated by the sound of the pristineness of the space. The order and arrangement of the space creates a good feeling and eliminates visual pollution. We should pay attention to harmony and coordination when designing our spaces. Using different plant species and incorporating visual elements that create variety and complexity in the landscape can ensure that our landscape remains attractive throughout the year. A final point is that spaciousness plays an influential role in perspective and the more the better for LAQ. As part of the strategy, ecological spaces (farms, landscapes, and water) and empty lands of Tabriz were considered as potential opportunities to play an essential role in the future ecological development of the city. Therefore, it is imperative that these lands be protected. The focus of our study was on the past and present state of the city. Thus, the results may be limited and uncertain, and further research is required. It is the result of years of inefficient land use planning, which, if continued, will make the situation even more complicated. As a result of this research, ecological networks can be maintained and improved as a part of future development planning for Tabriz. Considering the importance and role of each layer in LAQ, urban management should pay special attention to the results of these calculations and strengthen these indices in order to improve the LAQ index.

Conflict of interest

The authors declare no conflict of interest.

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