

# Citizens' perception of urban form indicators from sustainable development point of view; Case Study: 1<sup>st</sup> district of Tabriz

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## Original Research

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## Abstract:

**Aims:** Urban form plays a crucial role in sustainable development by influencing environmental quality, social equity, and economic efficiency. Understanding citizens' perceptions of urban form indicators provides valuable insights for urban planners to develop strategies that align with local needs. This study examines the significance of urban form indicators for sustainable development in District 1 of Tabriz, Iran, aiming to assess how residents perceive and importance of prioritize these indicators.

**Methodology:** A mixed-method quantitative approach was employed, using a structured survey to collect data from 384 residents of District 1, selected through random sampling. A questionnaire was designed based on urban form indicators identified from prior research. Statistical analyses, including the Wilcoxon and Kruskal-Wallis nonparametric tests, were conducted to evaluate differences in the perceived importance of indicators.

**Findings:** The results revealed that access to public transportation, building age, and sky visibility factor (SVF) were the most significant indicators for sustainable urban development. Public transportation accessibility ranked highest, with a mean score of 3706.75, followed by building age (2971.75) and SVF (2650.52). The Wilcoxon test confirmed significant differences among the indicators ( $p < 0.05$ ), highlighting the need for prioritization in urban planning. The Kruskal-Wallis test further demonstrated disparities in residents' perceptions across various urban form elements, emphasizing the necessity for participatory approaches in urban development policies.

**Conclusion:** The study underscores the importance of integrating citizen perceptions into sustainable urban planning. The findings suggest that transport accessibility, materials, and building characteristics are critical factors in achieving sustainable development. Policymakers should incorporate these insights to formulate data-driven urban strategies that enhance livability, environmental resilience, and social inclusivity. Future research should explore the intersection of urban form, social equity, and climate adaptation to create more sustainable and adaptive urban environments.

**Keywords:** Sustainable urban form; Citizen perception; Urban planning policy; Urban form indicators

## Introduction

Urban development patterns have disrupted environmental order, posing serious threats to the survival of humankind and the sustainability of life on Earth [1]. From an urban planning perspective, one of the strategies to achieve sustainable development and improve the quality of the urban environment is to balance the spatial distribution of land uses through a sustainable urban form. Undoubtedly, dis-

cussing sustainability and sustainable urban development is meaningless without considering cities and urbanization [2]. Although cities cover only a small percentage of the Earth's surface, they are densely populated and generate a substantial amount of economic activity. The unsustainability of urban development is one of the most significant challenges of the third millennium. In a sense, the city is like a living, dynamic organism, constantly experiencing

degradation or decay over time due to natural, human, and social factors. When cities experience rapid growth due to changes in their economic, political, or social roles, they often undergo significant structural changes and may suffer damage or alterations to their overall climate. This phenomenon has been particularly noticeable in recent decades in Iranian cities, as urban populations have grown rapidly and migration to cities has increased. On the other hand, a sustainable neighborhood that seeks vibrancy and quality depends critically on its users. To encourage greater user participation and involvement, attention should be given to their needs and opinions. It's worth noting that these opinions can be combined with specialized sustainability criteria.

From the perspective of urban planners, one of the strategies to achieve sustainable development and improve the quality of the urban environment is to balance the spatial distribution of land uses through a sustainable urban form [3]. In recent decades, one of the fundamental pillars of sustainable development has been achieving sustainable urban development. However, since cities have complex systems, their conditions are not always straightforward or easily altered; thus, they must be evaluated carefully from a sustainability perspective, identifying the factors that influence sustainability. Urban form, defined as the spatial distribution pattern of human activities in the city, significantly impacts the sustainability of the built environment, as travel demand, urban heat islands, and energy consumption are influenced by the city's form and shape. Sustainability indicators serve as essential technical tools for monitoring and managing sustainable urban development. In this context, urban form indicators aligned with sustainable development should be identified.

Therefore, the city of Tabriz, having similar challenges, has been selected as a case study for a region of Tabriz city by identifying and studying the indicators of the urban form that is considered in sustainable development. On the other hand, a significant challenge in urban sustainability indicators is the lack of a participatory approach that could be integrated with citizens' perspectives. This study identifies and examines local citizens' views, using their collective perceptions to develop a policy for adjusting these indicators. In addition, the need to examine and define urban form indicators from a sustainable development perspective becomes essential.

The development of Tabriz, like other major Iranian cities, has been influenced by non-native models and imported spatial configurations. The most prominent Western pattern in urban construction can be observed in the form of high-rise buildings and relatively high densities. Additionally, rapid urban growth and rural-to-urban migration have led to the emergence of an informal economy and informal settlements, both of which are clearly observable in Tabriz's District One. Following the Brundtland Commission, sustainable development plans were proposed for cities worldwide. Some of these plans, when applied superficially, have challenged the urban fabric of Iranian cities. Alternatively, over the past decades, strategies for Iranian urban development have been implemented, which, while temporarily success-

ful, have shown limited long-term impact, especially for Tabriz. In other words, it seems necessary to approach sustainable development strategies from a local perspective through neighborhood residents. Tabriz is divided into ten municipal districts, making it Iran's third-largest city by area and fourth-largest by population. District One, located in eastern Tabriz, is bordered by the Pasdaran Northern Beltway to the north, Basij and 29 Bahman Boulevards to the south, and the Ideh-Lu suburb to the east. According to the 2016 census, this district houses approximately 215,000 residents across 1,550 hectares of urban land. District One encompasses a variety of morphological structures, including high-density, low-density, informal settlements, planned and unplanned areas, and neighborhoods with both high and low socioeconomic statuses. Thus, it provides an ideal case for exploring residents' perceptions of sustainable development indicators from an urban form perspective.

District One of Tabriz has been selected as the study sample. In a study by Hamidi et al. [4] conducted in this district, urban form indicators were examined from the perspective of sustainability by experts. However, this study investigates whether residents, as stakeholders, have an understanding of urban form and sustainable development. Accordingly, the research objectives are as follows:

- Examine residents' opinions regarding the importance of urban form indicators in sustainable development;
- Rank the research indicators by their level of importance;
- Investigate the extent of the differences in the importance of urban form indicators from the perspective of residents in terms of sustainability.

### Research background

In the Table 1, the National and international research in the field of sustainable development indicators from the perspective of sustainable development are given.

The review of the background of the research shows that the researches carried out both inside and outside the country have separately studied the effect of urban form indicators with different dimensions that are effective in sustainable development. So that some indicators in the field of energy consumption, climate change, livability etc. has been studied. The studied indicators have studied the environmental dimension in the first place and the social dimension of sustainable development in the second place. Among the factors of urban form (physical environment, land use and public transportation facilities), the strongest relationship with the disease rate in neighborhoods is related to land use [5]. The indicators of urban form related to the system of parts and buildings have generally been used in researches related to the environmental aspect of sustainable development. Also, the indicators related to the street system have been used in researches related to the social dimension of sustainable development.

In the Table 2, researches which focus on sustainable development and citizens are presented.

The need to pay attention to the human requires and behavioral patterns of citizens and different social groups that

**Table 1.** Background of the research.

Row	Subject	Variables	Indicators
1	Inclusive urban space production model for sustainable development in South Africa	Factors affecting the production of urban space with a special focus on the role of the government, private sector and society.	Urban texture urban emphasis
2	Paradigm shift in sustainable urban planning for Thailand's provincial cities from the perspective of urban development stages during the 2010s	Land use management, population growth	Mixed-use
3	Evaluating the effect of sky view coefficient and building shade ratio on air temperature in different scenarios of residential and commercial buildings: a case study of Beijing, China	The sky view factor (SVF) is a critical structural index of buildings and combines height and density characteristics measured for different hours of the day.	SVF (sky view factor)
4	Benchmarking the sustainability of concrete and steel modular construction for buildings in urban development	Measuring the stability of concrete and steel modular construction	Age of building, quality of building
5	Assessing progress towards sustainable development goals for Chinese urban land use: A new cloud model approach	Spatial and temporal patterns of urban land use sustainability	Mixed-use, urban texture index
6	Urban development sustainability, industrial structure adjustment, and land use efficiency in China	Efficiency of urban land use in industrial and commercial structure	Mixed-use, access to business
7	Empirical evidence of urban climate adaptation alignment with sustainable development: Application of LDA	Using multidimensional scaling and cluster analysis to further describe the findings, the Intergovernmental Panel on Climate Change (IPCC) confirms that urban adaptation enables sustainable development and resilience.	NDVI (Normalized Difference Vegetation Index)
8	Using streetscape imagery and a geo-detector to understand how the street-level built environment is related to urban poverty: a case study in Guangzhou.	5 factors in the street view: sense of vegetation, sense of color complexity, sense of road openness, sense of sky openness, and sense of building area	NDVI, SVF
9	Greening plans as (re)presentation of the city: Toward an inclusive and gender-sensitive approach to urban greenspaces	First, urban design for different uses and perceptions of green space, Second, the awareness and expertise of municipal employees regarding social justice. Third, integrating inclusiveness and care to recognize the multiple needs of city dwellers.	NDVI
10	Renaturing cities: from utopias to contested realities and futures	How human knowledge and values of nature can be activated through changing urban nature.	NDVI
11	A novel approach to assess the urban land-use efficiency of 767 resource-based cities in China	In the study of land use, three indicators have been proposed: the intensity of construction in the urban area, the intensity of urban night light, and the tendencies towards the desired urban area and density.	Mixed-use, land use

Continued of Table. 1.

Row	Subject	Variables	Indicators
12	Impact of urban form on building energy consumption and solar energy potential: A case study of residential blocks in Jianhu, China	This study is an optimization framework for urban form design based on building density, open space ratio, shape factor and average area ratio (PAR) have a significant correlation with the total energy consumption intensity of the block building.	Urban form elements, quality of construction
13	Assessing sustainable urban development based on functional spatial differentiation of urban agriculture in Wuhan, China	Characteristics of land use structure and spatial differentiation for urban agricultural performance in Wuhan and the influence mechanisms between them	Land use, NDVI
14	Effects of uncertainty in heat transfer of building envelope on heating/cooling demand in urban texture	Modeling heat consumption of building in urban focus on heat transmission	Quality of construction
15	Relationships between building characteristics, urban form and building energy use in different local climate zone contexts: An empirical study in Seoul	This study investigates the relationship between building characteristics (shape), urban form, and energy consumption of a residential building in a local eschel in Seoul, South Korea.	Urbanform elements
16	The impact of urban form on building energy and cost efficiency in temperate-humid zones	Evaluation of building energy consumption with heat transfer of the building envelope according to the designer's specifications	Urban form elements
17	Relationships between building characteristics, urban form and building energy use in different local climate zone contexts: An empirical study in Seoul	It examines the relationship between building characteristics, urban form and residential building energy consumption at the local level for Seoul, South Korea.	Urban form elements
18	Fractalopolis: a fractal concept for the sustainable development of metropolitan areas	Fractal geometry	Fractal index
19	Urban morphology indicator analyzes for urban energy modeling	Standardized difference vegetation index (NDVI), building height, plot area, open space (O), artificial green areas (G), natural green areas (V)	NDVI, Fractal index
20	Investigating effective factors in urban growth using the F-ANP model "case study: Bojnord city"	Distance from the city center, net population density, commercial density, number of amenities, road density and population density	Access to public transportation & commercial center
21	Evaluation of the relationship between communication and urban sustainability (case study: Tehran)	Presence in urban space, communication rationality, critical attitude, and social capital	Access to educational & bussines centers
22	Explanation of indicators, qualities of urban form and their spatial distribution at the level of neighborhoods of Tehran metropolis	Accessibility to public transportation, stops density, neighborhood design type	Accessibility, urban texture index
23	Explanation of physical and functional components affecting spatial justice in marginal settlements, a case study (Mashhad metropolis)	Access to urban facilities: service distribution pattern, accessibility to Public transportation services, physical diversity: percentage of public open spaces, number of households per residential unit	Access of to public transportation, Fractal index, texture

Continued of Table. 1.

Row	Subject	Variables	Indicators
24	Fractal urban models and their potential for sustainable mobility	Spatial structure of streets and road networks	Access to residential, business, education
25	Access to urban transportation system for individuals with disabilities	Transport accessibility will be assessed on the perceived level of service, accessibility, safety and travel behaviour	Accessibility
26	Exploring transportation networks relationship to healthcare access and as affected by urban sprawl	Measurement of urban form components-density, mixed use, street network and proximity-and spatial criteria of access to health care providers.	Accessibility
27	Investigating the effect of city form on functional energy consumption in the residential sector, case study: Shiraz city	Building structure, building life, structure type and area with energy consumption	Age of building, quality of building
28	Urban Form, Density and Solar Potential	Examining the building shape and density with 3 design variables: the freeness of the ground surface, the daylight factor in the facade of the building, and the solar energy on the building	SVF
29	Evaluating the impact of form on the sustainability of studied urban neighborhoods: Amol	Population density, overall residential density, building density, density of nodes, intensity of use, mixing of uses	Mixed-use

occur in urban spaces, as well as the flexibility of these urban forms for the presence, participation and activity of all social classes and groups, gender, age, on the social dimension of sustainable development. The city emphasizes that paying attention to the needs and preferences of citizens, such as vegetation, the quality of materials, can provide the basis for participation and establishing environmental sustainability in the city. Based on this, the current research has collected the indicators of the urban form (which were studied separately and scattered) and extracted the indicators from the background using the existing background. In general, no research has been done in line with the objectives and assumptions of the current research inside or outside.

### Theoretical foundations

The concept and idea of sustainable development was first introduced through ecological programs such as the world conservation strategy by the "International Union for Conservation of Nature(IUCN)". This strategy identified poverty, population pressure, social inequality, and trade conditions as key factors driving habitat destruction. The modern understanding of sustainable development is deeply rooted in environmental movements from the last century, with Barbara Ward first formalizing the term in the mid-1970s.

The most official definition, however, was introduced in the Brundtland Report (1987), defining sustainable

development as development that meets the needs of the present without compromising future generations' ability to meet their own needs [6].

Urbanization is one of the key challenges for sustainable development. The rapid growth of cities, driven by industrialization, economic shifts, and demographic trends, has reshaped urban environments in profound ways. Uncontrolled urban expansion has exacerbated issues such as energy inefficiency, increased carbon footprints, and diminished livability [7]. Consequently, scholars have increasingly focused on the relationship between urban form and sustainability, emphasizing the need for compact cities, efficient land-use planning, and integrated transportation networks [8]. Urban morphology directly impacts travel behavior, air quality, energy consumption, and climate resilience [9]. For example, Portland's Urban Form Technical Task Force (2008) asserts that compact and well-planned urban forms can reduce travel distances, lower carbon emissions, and promote sustainable mobility. Larco (2016) noted that the links between urbanization and sustainability focus on how urban form affects transportation, water quality, habitat, equity concerns, and pollution in cities.

In Iran, the rapid pace of urbanization has led to significant transformations in urban structures, requiring adaptive policies to enhance sustainability and improve quality of life [10]. Given these dynamics, urban sustainability assessments must incorporate both expert analyses and

**Table 2.** Background of the research.

Row	Subject	Objective
1	Unraveling public perceptions of the Sustainable Development Goals for better policy implementation	The purpose of this article is to analyze public understanding of sustainable development indicators through public information and how to better involve people in their implementation.
2	Citizen engagement with sustainable energy solutions-understanding the influence of perceived value on engagement behaviors	We seek to empirically investigate the challenge of how utilitarian, social, and environmental values influence the engagement behaviors of various citizens with sustainable energy solutions.
3	A decision-making approach for determining strategic priority of sustainable smart city services from citizens' perspective: A case study of Hong Kong	This study enriches the theoretical framework of people-centered smart city research through the innovative integration of two models to determine the development priority for SC services, which can effectively serve as a practical decision-making tool for policy makers.
4	Revisiting modal split as an urban sustainability indicator using citizen science	A narrative-based livability survey to capture street-level liveability experiences and assessments
5	Explaining the environmental qualities that affect citizens' participation in urban public arenas as a social aspect of sustainable development	Identifying the characteristics and environmental characteristics of public areas worthy of participation from the eyes of citizens
6	Investigating the level of satisfaction of citizens with the performance of the municipality (Sari city)	Measuring the level of citizens' participation and satisfaction with the urban development performance of Sari municipality
7	Analysis and evaluation of the role of social capital in sustainable neighborhood development (case study: Ilam city)	Determining the alignment of social variables in sustainable social development of Ilam city

public perceptions to ensure that development strategies align with local needs. Citizen participation has been recognized as a fundamental principle of sustainable urban planning, fostering community engagement and ensuring inclusive decision-making. This study integrates these perspectives to develop a holistic framework for evaluating urban sustainability in Tabriz's Region 1.

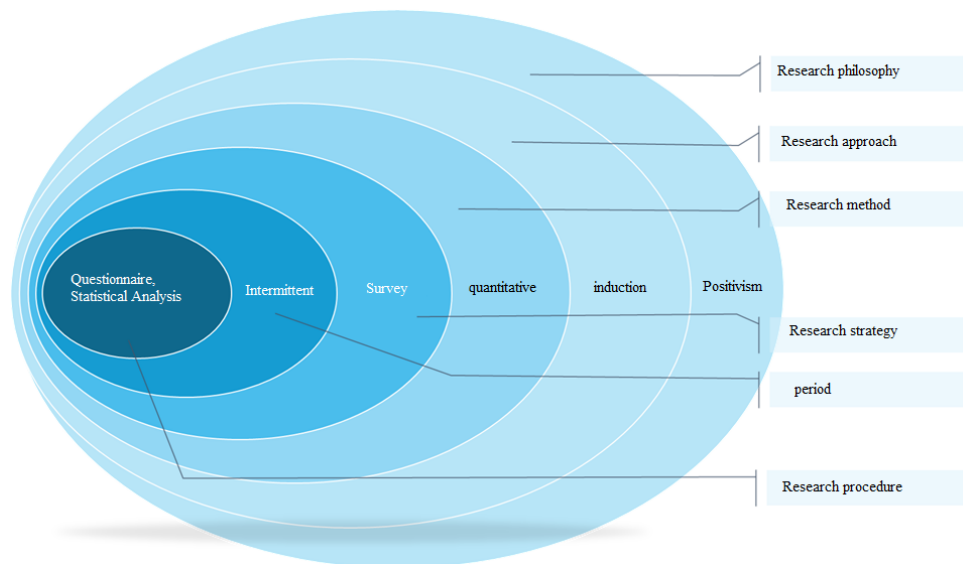
A partnership that is based on the presence and face-to-face meetings of citizens in the urban public arena and their activities and social interactions in such arenas will, in fact, guarantee the goals and social strategies of sustainable development in urban planning and design [11]. Urban services can be one of the most important duties of the municipality, and what the people of the community think about the activities and urban services provided by the municipality and how they look at the society and the surrounding environment is of particular importance [12].

### Research methodology

According to Saunder's onion model of research, figure 1, in terms of research philosophy, this research is a type of research with positivist philosophy. In positivist research, it is believed that reality exists objectively and concretely, and measurable characteristics that are independent of the researcher can be used. In terms of the research approach, the research is from part to whole and therefore,

it is inductive. In terms of research methodology, it is quantitative and in terms of strategy, it is known. In terms of time horizon, this research is a single-section research because in single-section research, information is collected only at one point in time. Since the current research is of a survey type, we will focus on the survey strategy. This strategy seeks to discover the existing facts and describe a research community in the field of distribution of a certain phenomenon. Due to the field nature of the research, in this research, a researcher-made questionnaire was used to collect information, and the items were designed in the form of a five-level Likert scale.

The statistical population of the research is 218,647, which is the population of residents of Tabriz city. Using Cochran's formula, 384 people were determined as the statistical sample of the research with an error of 5%, and this number of questionnaires was completed. The sampling method was random from those who lived in first distraction of municipality. SPSS software was used to pre-process and analyze the questionnaires. Table 3 shows the research variables. The variables are divided into four categories: building system, parcels, street network system and urban texture. This division is based on the elements of the urban form introduced by Oliveira [13].



**Figure 1.** Research methodology according to the Saunders onion research model.

**Conceptual definition of variables**

- Age of building:

The useful life of the building in Iran is stated to be 30 years at most, which is very different compared to European countries. Mistakes in design, implementation, operation and maintenance, lack of stability in urban planning rules are among the factors that cause premature aging of buildings and their wear and tear and turning into a worn texture [14]. The life of the building in relation to the materials used in its construction is indicative of the amount of depreciation and wear and tear of the residential unit. Therefore, there is a relationship between building life and sustainability. So, if the housing and neighborhood is newly built, it is resistant to natural disasters and produces less pollution and consumes less energy [14–16].

- Building materials:

Building materials account for a large share of energy consumption. Therefore, the amount of energy consumed by the materials used in the building during their life cycle is an important parameter in determining the energy efficiency of the building. In addition, the materials used in a building are one of the most influential factors in the degree of vulnerability of that building to natural disasters, especially earthquakes. Energy efficient building materials require effective daylight harvesting and thermal insulation to reduce

electricity consumption and ventilation costs. Half of all energy produced in developed countries is used for heating, cooling, ventilation and humidity control in buildings to meet the increasing thermal comfort needs of occupants. In this regard, the use of local materials or new technologies can be helpful [17–19].

- Quality of construction:

Urban constructions should be quality-oriented, this high quality promotes positive social activities and behaviors. There is usually a close relationship between the materials used in a building and its quality. In comparison of similar buildings, the building that has the lowest construction quality has a higher probability of destruction compared to other buildings. If the materials are not suitable for weather conditions and chemical quality of water and soil, they will wear out quickly and will not have more energy efficiency. Thus, there is a moderate correlation between building quality and per capita electrical energy consumption and per capita functional energy consumption [15, 20, 21].

- Fractal index:

Fractal dimension has been used to identify the shape of the earth’s parts, or in other words, the degree of regularity of the parts. The fractal dimension offers new ways of looking at geographical phenomena and is a new tool for analyzing the geographical space [22, 23]. In this index, where the

**Table 3.** Research variables.

Building type	Parsels & lots system	Transport infrastructure	Urban texture
Age of building	SVF	Access to primary road	
building material	Mixed-use	Access to public transportation	Urban texture index
Quality of construction	NDVI	Access to commercial center	
Fractal index		Access to educational center	

Source: Authors, 1401

dimension of fractality is between 1 and 2, the more the obtained number is one or closer to one, the more regular the desired shape is, and the closer it is to two, the less regular it is. No matter how irregular the shape of the piece is, it faces problems in terms of design, form, light, proper ventilation and other factors, which causes the formation of low-quality houses in terms of livability [24].

- Urban texture index:

Each type of urban fabric leads to different microclimates. Fine-grained texture continuously increases thermal comfort, air trapping, increasing air pollution, increasing the need for energy for cooling and ventilation. Instead, this context reduces the accessibility and travel demand. Coarse-grained, discontinuous texture causes optimal air ventilation, suitable thermal comfort and energy reduction for cooling and ventilation. Instead, it increases trip production and reduces accessibility. In addition, this tissue is more vulnerable and less efficient after accidents and natural disasters [21, 25].

- Sky view factor:

SVF is a parameter in urban climatology that indicates the amount of sky observed from a point on Earth. A geometric ratio that expresses the fraction of the sky visible from the observer's point of view. A quantitative and dimensionless factor is between 0 and 1 [26]. The results of several studies have shown that the sky visibility coefficient directly affects the average radiant temperature, spherical temperature, air movement speed, thermal comfort and urban heat islands [27–29].

- Accessibility:

Access to the main street, access to public transportation, access to commercial centers, access to school are known to be effective urban form variables in travel demand. Travel demand and reducing unnecessary trips is one of the studied concepts in sustainable transportation. Sustainable transportation is transportation that provides access to the basic needs of people and communities in a way that this access happens safely and with human and ecosystem health and with equality between and within generations [30]. Travel demand is related to air pollution; Therefore, the less travel is produced, the less pollution is produced [31].

- NDVI (Normalized difference vegetation index):

NDVI is widely recognized as one of the most widely used techniques for vegetation assessment [32].

The results of numerous researches have shown that urban vegetation and green spaces have a significant effect on the quality of life, citizens' health, reducing the effects of heat islands, air cooling, day and night thermal comfort [32–35]. Cooling caused by plants' evaporation has a significant impact on energy demand reduction in warm and cold seasons and air conditioning. In the present study, the effect of plant use on roofs and walls, in different views of the building, has been investigated for estimating energy consumption reduction [36].

- Mixed-use:

Mixed use as an important approach in the urban renaissance of Europe and the idea of compact city in America and under the title of new urbanism, and it is considered as an important tool for creating and maintaining an attractive, livable and sustainable urban environment [37]. One of the significant advantages of bringing centers of activity closer to each other, that is, mixing land uses, is reducing the volume of travel demand, which is within the framework of sustainable urban development goals [38]. One of the newest methods of travel demand management is the management of citizens' traffic behavior on a micro scale. According to the content of Agenda 21, sustainable urban travel is a trip in which the use of a personal vehicle for intra-neighborhood and short trips is minimized and such trips are replaced by walking or bicycle trips [39].

### Study area

District 1 of Tabriz is the seventh district among the 10 urban districts of Tabriz in terms of its area with 1563 hectares as indicated in green in figure 2. It is adjacent to districts 10, 8, 5 and 2. In terms of location, it is located approximately in the north of Tabriz.

This area, with a population of 218,647 in 2015, covers about 6.5% of the area of Tabriz city. Most of its area is covered by semi-flat lands (5 – 15% slope) with 40.13% of its total area. 35% of the total area of this area has smooth and unrestricted lands [40]. Map No. 1 shows the location of Zone 1 in the urban area of Tabriz.

In this area, the area of built-up land is equal to 793.5 hectares and green and open urban land is equal to 769.3 hectares. These uses per capita are 37.6 and 36.4 square meters, respectively. The mentioned lands cover 50.8 and 49.2 percent of the area of the region, respectively.

Figure 3 shows the parcel map, and Table 4 presents the corresponding sttics, respectively.

The survey of the major uses of this area shows that residential use is 38.1%, service use is 17.3%, road network is 23.9% and other uses are 20.7% of the area. Also, the largest area of the region is dedicated to residential use. The area and per capita land use data of district 1 of the Tabriz metropolis are presented in Table 5 as part of the research data.

### Research and interpretation

To examine the significance of urban form indicators for sustainability, this study not only employed statistical tests but also considered the implications of the findings for urban policy formulation. A key insight derived from the analysis is that indicators such as access to public transport, building age, and sky view factor are not just statistically significant but also highly relevant for practical urban development policies. This suggests that urban planners should prioritize these factors in designing sustainable cities that cater to both environmental and social needs.

At first, Normal Distribution Test of Data To assess the normality of the research variables, the Kolmogorov-Smirnov test was employed. The output shows that the significance level is less than 0.05; therefore, the assumption of normal

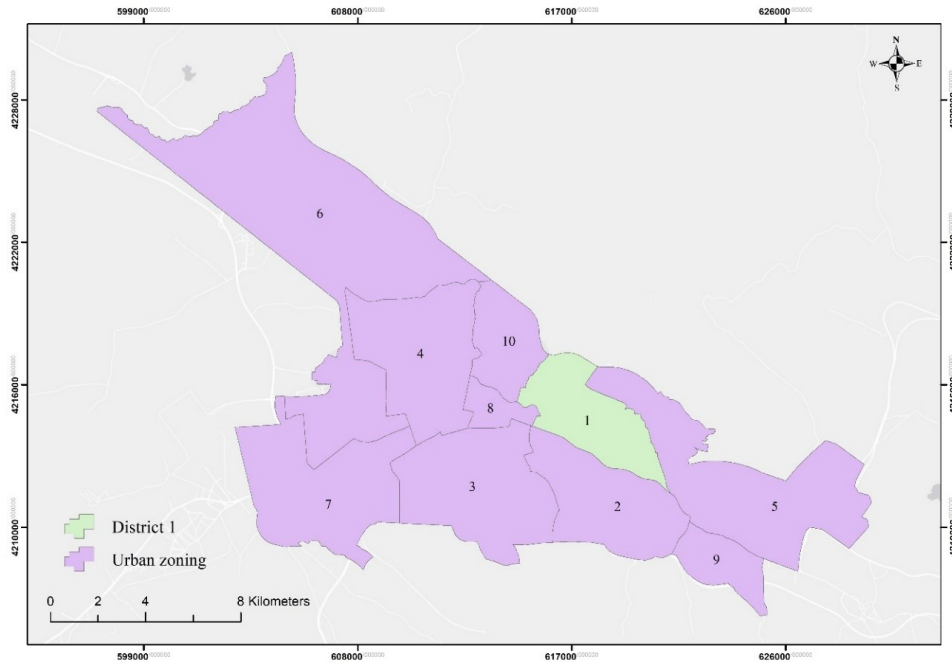


Figure 2. District one of Tabriz location.

distribution is rejected.

**Wilcoxon test**

Due to the non-normal distribution of inter-group data, the Wilcoxon single-variable test was applied to examine the differences in desirability among various indicators. The results indicate a significance level below 0.05 for the research indicators, thereby rejecting the null hypothesis of

no difference and confirming the research hypothesis of a difference between the indicators. This suggests that, according to citizens, indicators vary in importance, with some indicators considered more significant than others.

To test the research hypothesis for all indicators, a median value of 3 was used in this test. Participants viewed the indicators as aligning with the importance assigned in the study and influencing sustainable development. Furthermore, no significant differences were observed between indicators

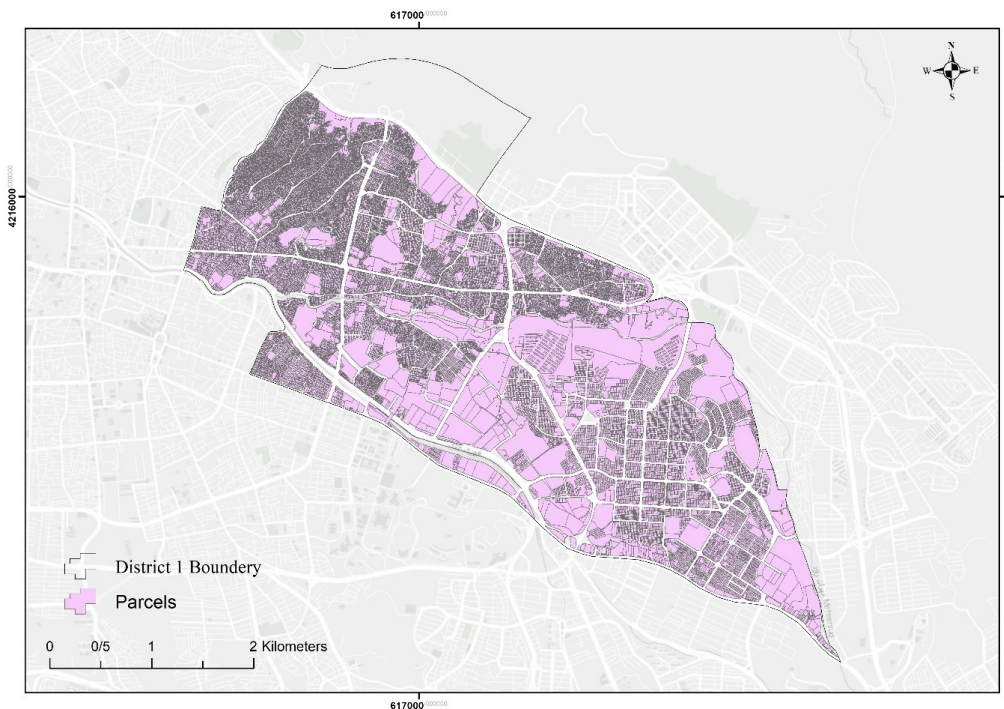


Figure 3. District one of Tabriz land use parcels.

**Table 4.** Area and per capita of built-up lands, green and open urban lands of.

Land type	Area (hectares)	Per capita (square meter)		Percentage	
		Region	City average	Region	City average
Built up land	793.5	37.6	66.8	50.8	41.8
Green and spare urban lands	769.3	36.4	92.9	49.2	58.2
Total	1563	74	159.7	100	100

Refrence [40]

**Table 5.** Area and per capita of large land uses in Tabriz 1<sup>st</sup> municipality zone.

Land use	Area (hectares)	Per capita (square meter)		Percentage	
		Region	City average	Region	City average
Residential	596	28.2	29.5	38.1	18.4
Business	270	12.8	26.1	17.3	16.4
Road network	4.373	17.7	24	23.9	15
Total	5.323	15.3	80.1	20.7	50.2

Source: [40]

such as building fabric condition, access to commercial centers, fractal index, and major building materials. This implies that citizens, as stakeholders residing in the area, do not differentiate between these indicators, viewing them as equally important and relatively stable in terms of importance.

In contrast, the stability of access to main streets, educational use, NDVI, and land-use diversity indicators appeared similar to each other but notably differed from access to public transport and building age indicators (ranked fifth in terms of stability). It's also essential to consider the data's standard deviation for a precise determination of dif-

ferences between means. Descriptive statistical data of the Wilcoxon method, as shown in Table 6, were obtained for interpretation. To this end, both statistical tests and graphical comparisons were employed. Based on the figures, building age, access to public transport, and sky view factor were ranked as more important than the other indicators.

#### Kruskal-Wallis test

To examine the stability differences among various indicators due to the non-normal distribution of inter-group data, the Kruskal-Wallis test was conducted. This test assesses differences in the dependent variable's scores across three

**Table 6.** Wilcoxon univariate test results.

Variable	Test statistic mean	Standard error	Sig.	Mean of questanire	Mean of test
Urban texture index	62481	764.1662	0.00	3	3.33
NDVI	33698	736.1284	0.00	3	2.78
acc. To public transportation	87210	736.1366	0.00	3	2.33
acc. To commercial center	61211	764.1662	0.00	3	3.33
Building material	32322	976.1857	0.00	3	4.33
Mixed-use	-62354	758.1515	0.00	3	2.33
Quality of construction	15576	43.784	0.00	3	3
The building life	44751	976.1857	0.00	3	4.33
acc. To first grade road	42622	963.12	0.00	3	4
acc. To educational center	12685	304.592	0.00	3	2.67
SVF	66215	976.1857	0.00	3	4.33
Fractal index	61981	123.1765	0.00	3	3.5

Source: Research output

or more groups of an independent variable. Based on the adjusted significance level (Adj sig < 0.005), a significant relationship was found between the success of the research indicators in sustainable development.

To pinpoint the source of these differences, pairwise comparisons of the indicators were performed which is presented in the following Table 7. The results showed no significant differences among the following pairs: access to main streets and NDVI, access to educational use and NDVI, primary building materials and building fabric condition, primary building materials and fractal index, primary building materials and sky view factor, building fabric condition and sky view factor, fractal index and sky view factor, and access to public transport and building age.

Pair indicators: Code 1 refers to the texture condition index, code 2 refers to the sky visibility coefficient, code 3 refers to access to public transportation, code 4 refers to access to main streets, code 5 refers to access to commercial centers,

code 6 refers to access to educational use, code 7 refers to NDVI, code 8 represents mixed-use, code 9 represents fractal index, code 10 represents quality of construction, code 11 represents materials of building, and code 12 represents age of building.

3D Graph Based on SPSS Pairwise Comparisons, Using the results from SPSS's Pairwise Comparisons table and the Adj Sig column, a 3D graph was generated based on the mean rank of each variable. This ranking reflects residents' perspectives on the success of achieving sustainable development in Tabriz's District 1. According to mean ranks, access to public transport holds the highest importance with a mean rank of 3706.75, followed by building age and sky view factor with mean ranks of 2971.75 and 2650.52, respectively.

**Table 7.** Kruskal-Wallis test results.

Pair indicator	Mean difference of test	Standard error	Static standard deviation	Sig.	Adj. significance
10*8	221.375	91.594	2.417	0.016	1
10*4	705.5	91.594	7.703	000/0	000/0
10*7	972	91.594	10.612	000/0	000/0
10*6	1279.125	91.594	13.965	000/0	000/0
10*11	-2160.875	91.594	-23.592	000/0	000/0
10*1	2294.5	91.594	25.051	000/0	000/0
10*9	2339.8775	91.594	25.576	000/0	000/0
10*2	238.5	91.594	26.044	000/0	000/0
10*5	2734.749	91.594	29.857	000/0	000/0
10*3	3441.799	91.594	37.576	000/0	000/0
10*12	-3706.751	91.594	-40.47	000/0	000/0
8*4	484.125	91.594	5.286	000/0	000/0
8*7	750.625	91.594	8.195	000/0	000/0
8*6	1057.749	91.594	8.195	000/0	000/0
8*11	-1939.5	91.594	-21.175	000/0	000/0
8*1	2073.125	91.594	22.634	000/0	000/0
8*9	-2118.5	91.594	-23.129	000/0	000/0
8*2	2164.125	91.594	23.627	000/0	000/0
8*5	2513.374	91.594	27.441	000/0	000/0
8*3	3220.374	91.594	35.159	000/0	000/0
8*12	-3485.375	91.5947	-38.053	000/0	000/0
4*7	-266.5	91.594	-2.91	004/0	239/0
4*6	-573.625	91.594	-6.263	000/0	000/0
4*11	-1445.375	91.594	-15.889	000/0	000/0
4*1	1589	91.594	17.348	000/0	000/0
4*9	-1634.375	91.594	-17.844	000/0	000/0

Continued of Table. 7.

Pair indicator	Mean difference of test	Standard error	Static standard deviation	Sig.	Adj. significance
4*2	1680	91.594	18.342	000/0	000/0
4*5	-2029.249	91.594	-22.155	000/0	000/0
4*3	2736.249	91.594	28.847	000/0	000/0
4*12	-3001.251	91.594	-32.767	000/0	000/0
7*6	307.125	91.594	3.353	0/001	0/53
7*11	307.875	91.594	-12.98	000/0	000/0
7*1	1332.5	91.594	14.439	000/0	000/0
7*9	-1367.875	91.594	-14.934	000/0	000/0
7*2	1413.5	91.594	15.432	000/0	000/0
7*5	1762.749	91.594	19.245	000/0	000/0
7*3	2467.749	91.594	26.964	000/0	000/0
7*12	-2734.751	91.594	-29.857	000/0	000/0
6*11	-881.751	91.594	-9.627	000/0	000/0
6*1	1015.375	91.594	11.086	000/0	000/0
6*9	-1060.751	91.594	-11.185	000/0	000/0
6*2	1106.375	91.594	12.079	000/0	000/0
6*5	1455.625	91.594	15.892	000/0	000/0
6*3	2162.625	91.594	23.611	000/0	000/0
6*12	-2427.625	91.594	-26.504	000/0	000/0
11*1	133.625	91.594	1.459	0/145	1/000
11*9	179	91.594	1.954	0/051	1/000
11*2	224.625	91.594	2.452	0/014	0/937
11*5	573.874	91.594	6.265	000/0	000/0
11*3	1280.874	91.594	13.984	000/0	000/0
11*12	-1545.878	91.594	-16.878	000/0	1/000
1*9	-45.375	91.594	-0.495	0/620	000/1
1*2	-91	91.594	-0.994	0/320	1/000
1*5	-440.249	91.594	-4.807	000/0	000/0
1*3	-1147.249	91.594	-4.807	000/0	000/0
1*12	-1412.251	91.594	-15.419	000/0	000/0
9*2	45.625	91.594	0.498	0/618	1/000
9*5	394.894	91.594	4.311	000/0	0/001
9*3	1101.874	91.594	12.03	000/0	000/0
9*12	-1366.875	91.594	-14.923	000/0	000/0
2*5	-349.249	91.594	-3.813	000/0	0/009
2*3	-1056.249	91.594	-11.532	000/0	000/0
2*12	-1321.251	91.594	-14.425	000/0	000/0
5*3	707	91.594	-7.719	000/0	000/0
5*12	-972.001	91.594	-10.612	000/0	000/0
3*12	-256.001	91.594	-2.893	0/004	0/252

## Conclusion

Urban form, defined as the spatial distribution of human activities within a city, plays a pivotal role in determining the sustainability of the built environment. Citizens' perceptions of urban form indicators-such as green spaces, public transport accessibility, walkability, and building density-serve as critical feedback mechanisms for urban planners to align development strategies with public expectations. The study highlights that non-native urban patterns and imported spatial configurations have significantly influenced Tabriz's urban structure, particularly through high-rise developments and increasing population density. Additionally, rapid urban growth and rural-to-urban migration have contributed to the rise of informal settlements and economic disparities.

Given the diversity of urban textures in Tabriz-ranging from dense and informal settlements to planned and unplanned neighborhoods-the study area provides an ideal case for examining the sustainability of urban form. The findings suggest that integrating citizens' perspectives into urban planning enhances the effectiveness of sustainability policies, ensuring that urban development is both contextually relevant and socially inclusive.

Methodologically, this study employed a quantitative approach using a researcher-designed questionnaire administered to residents of District One. Statistical analysis using Wilcoxon and Kruskal-Wallis tests confirmed significant differences in the importance of various urban form indicators. Specifically, access to public transportation ranked highest in importance (3706.75), followed by building age (2971.75) and sky visibility factor (2650.52). The study further revealed a notable divergence between expert and citizen perspectives on urban sustainability indicators, emphasizing the need for more inclusive urban planning approaches.

The practical implications of these findings emphasize the necessity for urban policymakers to incorporate citizen-driven data into their sustainability strategies, ensuring that urban development aligns with real-world community needs rather than purely theoretical models. Future research should further explore the intersection between urban form, social equity, and environmental resilience, ensuring that urban development frameworks prioritize both sustainability goals and local community needs.

### Authors contributions

Authors have contributed equally in preparing and writing the manuscript.

### Availability of data and materials

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### Conflict of interests

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.

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