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An analysis of spatial inequality in Tehran Metropolis: applying selected residential quality indicators to its 22 urban districts

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Abstract. The purpose of this paper is to investigate the distribution of residential quality indicators in the 22 districts of Tehran with emphasis on the urban inequality approach. The research method is descriptive-analytical and prescriptive with its scope being the 22 districts of Tehran in 2016. The TOPSIS model, Coefficient of Variation (CV), Moran's spatial autocorrelation, and Gi statistic (hot-spot analysis) have been used to analyze the data. Data were collected using library and documentary methods. The findings indicate that the 22 districts of Tehran have heterogeneity and divergence in terms of the selected residential quality indicators. This paper found a significant relationship between the quality of residence and social classes in Tehran. Throughout its development, the social classes of Tehran have become more distinct and its rich and poor districts – in the north, center and south of the metropolis – have separated more vividly. To solve the detrimental spatial inequality of Tehran and achieve sustainable development, the paper suggests the importance of applying the true nature of urban planning , especially in terms of residential planning primarily in the parts of the metropolis that inequality is predominantly observed.

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1. Introduction

Spatial inequality at the urban scale has attracted the attention of scholars as one of the key inequality dimensions (David et al., 2018) and has turned it into a topic of research in various urban-studies-related disciplines. Spatial inequality is a significant phenomenon in the non-realization of the concept of the right to the city (Meshkini et al., 2021) since it prevents citizens' civic participation in urban policy-making and planning processes. Measuring urban spatial inequalities has become essential to accomplish sustainable development goals (Cole et al., 2018). Spatial inequalities are rooted in rapid urbanization. Thus, the accelerating urban growth in developing countries has caused an abundance of economic, physical and social problems (such as poverty, environmental pollution, traffic, crime). With the emergence of these major problems in cities, concepts such as environmental quality and quality improvement were proposed in various economic, physical, ecological and social dimensions to inform the tackling of such problems. The importance of studying spatial inequalities in terms of residential quality indicators rests in the awareness of the form, function, specific features and transformation of urban spatial structure. Awareness of the factors contributing to the inequality of residential areas supports urban planners and policy-makers in appropriate decision-making to deal with the negative aspects of spatial inequality. In addition, taking the qualitative aspects into account in policies and plans has led to new dialogues and topics in urban planning and policy-making. It can be said that the purpose of urban planning is no longer to merely respond to the physical-functional needs and wants of people, but that it has the additional purpose of responding to their environmental, social, mental and economic needs and improving the quality of life of people residing and working in cities.

Similar to many other metropolises in less-developed countries, Tehran metropolis has gone through massive urbanization over the last five decades. As the capital of Iran, Tehran is the 23rd most populated city in the world (World Bank, 2016) with a day population of 12 million and a night population of around 8.4 million (Yousefi & Farahani, 2019). The increased population has led to a higher demand for services and facilities, and the economic fluctuations have presented families and individuals with many inequalities in Tehran's urban/metropolitan districts. Urban/metropolitan authorities plan and make policies based on their perception of various inequalities. The extreme vastness of urban/metropolitan districts in the Tehran metropolis has made it difficult to develop a comprehensive framework to fight spatial inequalities. This has resulted in the prevalence of an incomprehensive planning approach. Not only has this incomprehensive approach failed to resolve inequalities, but it has also contributed to it. Therefore, spatial inequality has become one of the most important concerns of Tehran citizens, as can be traced in their social movements (such as street protests). This issue is a complicated challenge for urban planners and policy-makers. Outside political and social circles, spatial inequalities in Tehran metropolis have gained the attention of academic circles, as they constitute a popular academic research subject. Previous studies indicate that Tehran's residential inequalities have received less attention in terms of spatial analyses, as few studies have conducted a spatial analysis of the residential quality in Tehran.

Few researchers have discussed residential spatial inequalities. They often only pay attention to spatial inequalities in a whole city. This study specifically focuses on the residential aspect of spatial inequalities. The theoretical gap that the present study seeks to fill is to display spatial inequalities in terms of residential quality indicators in the 22 urban/metropolitan districts of Tehran. The study will proceed to analyze spatial inequality in residential areas by focusing on economic, physical, socio-cultural and ecological dimensions. Accordingly, the aim of this study is to conduct a spatial analysis of residential quality by applying selected indicators in Tehran's 22 urban/metropolitan districts. To achieve this purpose, the questions to be answered by this paper are:

1. How are the indicators of residential quality spatially distributed in the 22 urban/metropolitan districts of Tehran?
2. What pattern does this distribution follow? and
3. What is the spatial pattern of the selected and applied indicators?

1.1. Spatial inequality: an overview

Spatial inequality emerges from unequal income distribution and access to facilities and resources (Yousefi & Farahani, 2019) and varies from one country to another based on national economic development (Bohman et al., 2019). In past decades (1950–2010), spatial inequalities in settlements have mostly been explained by geographical location, urban–rural polarization and the size

of settlements (Checa & Nel·lo, 2021) but spatial inequality indicators have recently changed to reflect a framework of civil rights such as the right to the city, quality of life, livability, a just city, urban prosperity, urban justice, etc. (Zarghamfard & Meshkini, 2021). The change in these variables is due to the fact that urbanization has expanded the geographical area of urban areas, which has resulted in a complex urban network. This urban network has, for various reasons, led to an incoherence in the spatial hierarchy that has highlighted the inequalities.

Research on spatial inequality accounts for a large portion of the academic literature across the world in the fields of sociology, geography, and urban and regional planning, which can be divided into three groups. Studies such as those conducted by Burgers & Musterd (2002), Pacione (2002), Shanahan et al. (2014), Landi et al. (2018), Szabo et al. (2018), Akita and Miyata (2018) and Perera (2018) have investigated inequality in cities on a general level. This group of studies mainly relies on quantitative criteria, the most prevalent of which include gross and net GDP *per capita*, human development, and gender inequality indices. Studies such as those conducted by Night (2003), Noble et al. (2006), Maloutas (2007), Musterd and Ostendorf (2013), Milne (2017), Taylor et al. (2018), Peiró-Palomino (2019) and Biloria et al. (2020) have investigated inequality from the perspective of urban welfare. They use urban welfare indicators as the criteria for their work, are more focused on citizens' perception of spatial inequality and use perceptual indicators as the basis for their analyses. The third group of studies, which includes those conducted by Cheshire and Magrini (2009), Cassiers and Kesteloot (2012), Sidhwani (2015), Martínez et al. (2016), Van Lanen (2017), Lelo et al. (2019), Faka (2020) and Sargazi et al. (2021), rely on spatial analyses and use them to demonstrate inequalities in a city. They consider space and location at local, regional and national levels and present analyses based on qualitative and quantitative indicators, the output of which is in the form of maps. Spatial analyses provide a deeper insight into the social, cultural, ecological, physical and economic inequalities and make these inequalities easier to understand for urban authorities.

1.2. Spatial inequality in Tehran: the problem under study

The Tehran metropolis is always facing the challenge of spatial inequality as the capital of Iran and has taken up a major portion of inequality studies in Iran. Systematic study of the literature indicates that Iranian scholars have adopted different approaches in the study and measurement of Tehran metropolis's spatial inequalities.

The first approach examines the weighted changes in GDP *per capita* in various districts and is supported by politicians and economists such as Lotfian (2010), Azouji (2011), Mirzaei et al. (2015), Samadi et al. (2015) and Hosseinishokouh et al. (2021).

The second approach is concerned with social changes in various districts and is supported by social scientists such as Azamazadeh (2003), Sedaghatifard and Sakhamehr (2013), Latifi and Babagoli (2015), Riazi (2016), Sadeghi and Zanjari (2017), Ahrabiansadr (2017), Rahmatabadi et al. (2019) and Kalantari and Shokouhi (2019). They are of the view that inequalities in the metropolis of Tehran have led to the formation of unequal residential spaces. They consider spatial inequality to be the result of difference is the access that residents of Tehran's neighborhoods have to valuable social resources such as wealth, power and capital. They consider spatial inequality to be the result of the difference in Tehran neighborhood dwellers' access to financial wealth, power and cultural capital and argue that the spatial inequalities in Tehran metropolis have resulted in less-advantaged and undesirable urban spaces and have also impacted citizens' behaviors. These scholars use the principles of the Chicago School of Social Ecology to analyze residential inequalities.

The third approach is related to spatial analysis at the urban level. Their analysis unit is the neighborhood, district, region and metropolis, and is supported by urban planners and geographers such as Meshkini and Rahimi (2012), Yaghfoori et al. (2017), Ghaderihajat and Mokhtarihashi (2019), Fallahi and Mohammadi (2018), Abdi Daneshpour and Shafiee (2018), Briaji et al. (2019), Maroofi et al. (2020) and Pourahmad et al. (2021). They study the weights of residential indicators in Tehran urban districts and neighborhoods and often use them for radical solutions through a spatial visualization of the inequalities. David Harvey's social justice (Harvey, 1973), Henri Lefebvre's right to the city (Lefebvre, 1968), and Edward Soja's spatial justice (Soja, 2013) are the basis of their analyses, and they provide analyses of livability and quality of life in the framework of Tehran's social geography. These scholars eventually propose strategic spatial planning to reduce the spatial inequalities in the Tehran metropolis.

Some researchers have studied the roots of spatial inequality in the residential quality of Tehran and have introduced factors such as unplanned urbanization and village-to-city migration (Molaei Qelichi et al., 2017), urban development plans and national modernization (Mashayekhi, 2019), the unsustainable change in land use (Taravat et al., 2017), excessive government intervention in land affairs (Meshkini et al., 2019), inefficient urban policies (Meshkin et al., 2021), inefficient residential policies (Zarghamfard et al., 2019), unbalanced distribution of physical residential indices (Marsosi et al., 2021), industrialization in Tehran (Pazhuhan, 2021), the flow of oil revenues (Hein & Sedighi, 2016), inadequate regulations and limited privatization (Yousefi & Farahani, 2019), the unbalanced distribution of urban cooling ecosystem services (Ghorbani et al., 2022) and income inequalities (Noroozi et al., 2020) as the most important factors contributing to spatial inequality in Tehran metropolis. Studies such as those of Yousefi and Farahani (2019) and Zarghamfard and Meshkini (2021) reveal that the spatial inequality in Tehran residential quality stems from the Iranian capitalist features and imported neoliberal policies. This means that housing in Iran has become a capital good and its ownership is very important for households. Hence, households spend the most on it. On the other hand, global policies (such as sanctions and oil price fluctuations) severely challenge Iran's housing sector and cause inequalities to deepen. It must be noted that the multiple functions of this city at local, regional, national and international levels have made it a major center of capital production, consumption and accumulation. Thus, the residential spatial inequalities have spread over the city and manifested themselves in physical, ecological, political, economic and socio-cultural aspects.

2. Methodology

This paper is descriptive-analytical, meaning that, in addition to studying and investigating the status of inequality in the quality of residence in the districts, it explains and justifies its reasons. In terms of purpose, it is practical, which means that it seeks to eliminate inequalities in the quality of residence and achieve sustainable development. The geographical scope of research is 22 urban/metropolitan districts of Tehran. The temporal scope of this paper is cross-sectional and focuses upon 2016. The method of collecting data for the specified indicators is content analysis. 79 objective indicators were selected from the related theoretical and empirical texts to investigate spatial inequalities in residential quality, examples of which in the scope of the study are more frequent and of more importance. Then, these indicators were categorized to the four physical, socio-cultural, economic and environmental dimensions. The selected indicators were taken from statistical yearbooks, the Iran Statistics Center, and official statistics of Tehran Municipality (2016). The TOPSIS multi-criterion technique, Coefficient of Variation (CV), Moran's spatial autocorrelation, and the Gi statistic method (hotspot analysis) have been used to analyze the data.

In this paper, using Shannon's entropy weighting statistical model and the TOPSIS technique, the districts of Tehran were ranked. The TOPSIS model is one of the best multi-criterion decision-making methods (MCDM), which is considered an efficient method in prioritization. One of the most important reasons for choosing this technique is its clear mathematical logic and lack of implementation problems compared to other ranking methods. The districts were ranked by this method, and the importance coefficient of each studied indicator was determined. Shannon's Entropy Method was also used to weight the studied indicators, due to its simplicity and documentation. In the following steps, to check how many residential quality indicators are unevenly distributed among the districts, the variation coefficient method was used. Finally, to investigate the spatial analysis and display inequality among urban districts on the map, the Gi statistic (hotspot analysis) and Moran's spatial autocorrelation method were used to determine the distribution pattern or distribution of inequality in the districts of Tehran. It is necessary to perform the Gi statistic to check the existence of spatial autocorrelation.

2.1. Study area

Tehran Metropolis, with an area of 1,336 square kilometers, is located between the Alborz mountain range and the northern edge of the Dasht-e-Kavir desert. This geographical location has created a slope in the city, in a way that the northern parts are higher than the southern parts. According to the last census in 2016, the population of Tehran was 8,737,510. Tehran is now the capital of Iran and the most populous city in Iran, and almost all organizations, administrative institutions and executive organizations are located there. Based

on political divisions, the metropolis consists of 22 districts and 353 neighborhoods. The most populated districts of Tehran are district 4, followed by districts 5 and then 15, and the least populated is district 22 (Fig. 1).

2.2. Introducing the indicators

According to the issues raised in the scope of the study, indicators were selected from the related theoretical and empirical texts to investigate the spatial inequalities of the urban environment quality, the examples of which in the scope of the study are more frequent and of more importance. The research indicators are in the form of four physical, socio-cultural, economic, and environmental dimensions, including the following cases:

1. The physical dimension, which includes 35 indicators: residential area *per capita*, percentage of residential units under 50 m^2 to all residential units in the district, percentage of residential units under 75 m^2 to all residential units in the district, number of households per residential unit, average building age, ownership of building site and standing property/standing property, mortgage and rent, number of total regular residential units, apartment residential units, non-apartment residential units (tents, huts, sheds, slums, etc.), area of below 50 m^2, area of 51–75 m^2, area of 76–80 m^2, area of 81–100 m^2, area of 101–150 m^2, area of 171–200 m^2, area of 201–300 m^2, area of 301–500 m^2, area of over 500 m^2, built area, metal structure, armed concrete structure, brick and iron materials, brick and wood materials, cement block materials, all-brick or stone and brick materials, all-wood materials, sun-dried brick and clay materials, access to medical centers, access to police stations, access to firefighting stations, access to Crisis Management Shelters, Access to Public Transport Stations.
2. The socio-cultural dimension, which includes 12 indicators: total migrants, literacy rate, number of disputes and conflicts, number of car accident injuries on roads monitored by cameras (2013–2017), number of car accident mortalities according to forensics (2016–2017), number of cultural centers, cinemas and active cultural event venues, public libraries, active NGOs and CBOs, educational area *per capita*, medical area *per capita*, ratio of recreational-sports area to total area.
3. The economic dimension, which includes 20 indicators: dependency burden, male employed population, female employed population, male unemployed population, female unemployed population, homemakers, students, income without a job, men's employment rate, number of employed people per hectare of employment land use in the district, employment growth rate, average rent for a square meter of residential land use, average price of a square meter of residential land use, women's employment rate, housing ownership, commercial land use *per capita*, average price of a square meter of residential land use in the spring, average price of a square meter of residential land use in the summer, average price of a square meter of residential land use in the autumn, average price of a square meter of residential land use in the winter.

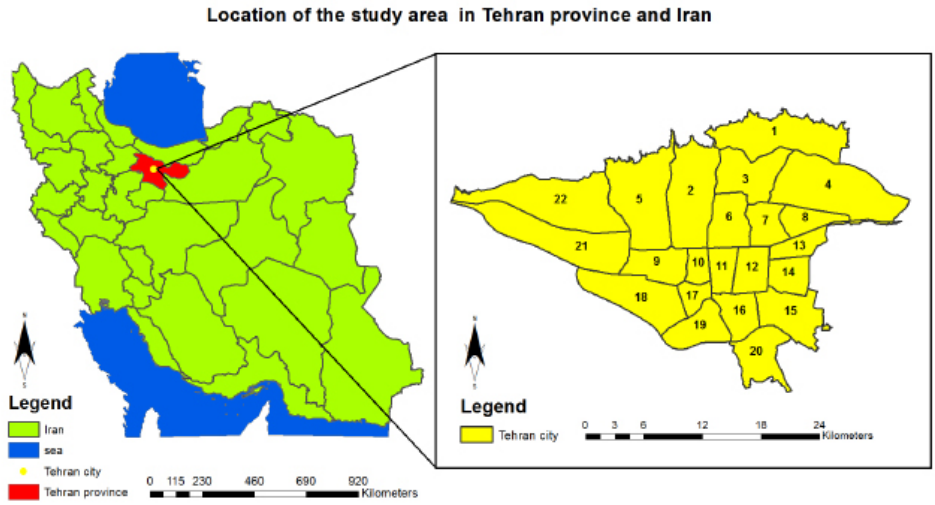

Fig. 1. Geographical location of Tehran
Source: Own work

4. The ecological dimension, which includes 12 indicators: park and green space *per capita*, public garden area *per capita*, passages *per capita* (tree planting, refuges, spandrels, afforestation within the area), the number of public parks, mean noise pollution along the highways during the day, and urban waste (seven indices: average air pollutants, O_3, CO, NO_2, PM2.5, PM10, SO_2).

2.3. Analysis of the residential quality indicators: TOPSIS analysis

The TOPSIS method was first proposed by Hwang and Yoom in 1981 (Ziari et al., 2010: 23). This method is used to examine inequalities between districts. TOPSIS is one of the best multi-indicator decision-making models, in which *m* options are evaluated by n indicators. TOPSIS has features and privileges such as the order of priorities in the model output and the use of weight coefficients. The foundation of this method is the concept that the best option will be the option that has the shortest distance with the ideal positive value and the largest distance with the negative value. In this model, the optimal options with the most similarity to the objective get a higher rank. For this purpose, to rank and evaluate the districts of Tehran in terms of residential quality indicators using the TOPSIS multi-criterion decision-making model, the spatial structure of 22 districts of the Tehran metropolis has been analyzed. The steps of implementing the TOPSIS technique are as follow:

1. Using 79 indicators measuring physical, socio-cultural, economic and environmental dimensions, a matrix was formed for 22 districts.
2. Standardization of data and building a standard matrix.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$

3. Normalization of the decision matrix. The weights of the criteria are multiplied in the standard matrix. Shannon's entropy method was used to calculate the weights of the investigated indicators. In this method, the greater the dispersion in the values of an index, the more important that index is. In this section, calculations have been avoided for the sake of brevity.
4. Choosing the best and worst ideal values.
5. Calculating the distance of each option from the worst and the best ideal value.

$$S_i^+ = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^+\right)^2}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}$$

6. Determining the relative proximity (similarity index), which is equal to the distance of the minimum option (S_i^-) divided by the sum of the distance of the minimum and ideal alternative (S_i^+), which is represented by (C_i^+) and is calculated by the following formula.

$$CL_i^* = \frac{CL_i^-}{CL_i^- + CL_i^+}$$

7. Ranking the options based on the amount (CL*). The above amount fluctuates between zero and one. A value of one indicates the highest rank, and a value of zero indicates the lowest. Finally, the results of the TOPSIS technique were summarized in (Table 1).

Findings obtained from the TOPSIS technique show that, in the physical dimension, districts 1 and 3 have the first and second ranks with scores of 0.83 and 0.70, and district 15 stands last with a score of 0.18. In terms of socio-cultural indicators, districts 16 and 5, with scores of 0.76 and 0.22, stand in the first and second position, and district 17, with a score of 0.06, stands last. In regard to economic indicators, district 19 has the highest rank, with a score of 0.5346, while district 3 stands in last place with a 0.30 score. In the case of environmental indicators, district 4, with a score of 0.71, has the highest rank, and district 18, with a score of 0.19, holds the lowest position. Finally, the average score of the TOPSIS calculation in the 22 districts of Tehran for the integrated indicators was 0.58. Since the optimal limit in this model is number one, the Metropolis of Tehran is slightly above the average in terms of quality of residence indicators. Based on this, the northern districts of Tehran, including districts 1, 3, and 4, have been assigned the first to third ranks, respectively. By contrast, district 15 ranked last.

Based on the coefficient of variation calculated for the four dimensions of the quality of residence, the socio-cultural dimension has more dispersion than other dimensions, and the economic dimension has less variation. The Coefficient of Variation (CV) for these indicators was calculated as 0.16%, which indicates the inhomogeneity and divergence between the 22 districts of Tehran from the perspective of residential quality indicators.

2.4. Classification of districts based on a combination of indicators

The four dimensions (79 indicators) were eventually integrated to calculate the residential quality score. To analyze and interpret the information better, it is necessary to classify the data according to a logical order. Categorizing the data requires calculating the amplitude of changes, the number of classes and the distance of classes using specific formulas. Therefore, all the data were imported into a table called the "frequency distribution table".

Each class was defined into the following four groups according to its specific spectrum coefficient.

- Advantaged districts: Districts that do not have the problems of less advantaged districts and whose residents are often affluent and have good opportunities and sufficient welfare. Indicators such as residential area *per capita*, building age, land and housing value, education *per capita,* treatment *per capita* and recreational-sports area in these districts have favorable conditions. Districts with a score greater than 0.7048 are included in this group.
- Relatively advantaged districts: Districts in a relatively favorable situation in terms of the level of development and quality of life are included in this category. The residents of this district are upper middle class (those who hold professional management jobs and have experienced higher education). Districts with scores greater than 0.6048 and less than 0.7048 are included in this group.
- Semi-advantaged districts: These are districts that face fewer problems than Less-advantaged districts. The residents of this district are lower middle class (including people such as office workers, teachers and nurses). Districts with a score of more than 0.5048 and less than 0.6048 are included in this category.
- Less-advantaged districts: Districts that, due to the lack of efficient management and proper planning, are facing issues such as the lack or unfair distribution of urban facilities and services (such as health centers, public transport stations, cultural centers, cinemas, public libraries and green space), lack of basic infrastructure, lack of security, social problems and urban crime, all kinds of pollution and physical wear and tear. Most of the residents of these districts have less access to facilities and services in society. Districts with a score of less than 0.3048 are considered in this group.

The districts and their percentage that fall into each of the mentioned groups are as follows:

- Advantaged districts: among the 22 Tehran urban districts, district 1, with a TOPSIS score of 0.79, ranks highest, and greatly above the other districts. The concentration of urban facilities and services such as medical, welfare, cultural, recreational and educational services, the abundant public parks, low pollution, low crime rates and high-quality of constructions in this district have resulted in the high residential quality of district 1 and placed it in the "advantaged" group.
- Relatively advantaged districts: Three districts, (2, 3 and 4) are included in this group.
- Semi-advantaged districts: 17 urban districts (5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 16, 17, 18, 19, 20, 21, 22) had coefficients of 0.5048–0.6048. This group of districts had a relatively unfavorable condition in terms of residential quality indicators and are the second priority for planning.
- Less-advantaged districts: district 15, with a mean coefficient of -0.3048, was classified in this group. Factors such as low durability of materials and structures and aged buildings, unfavorable visual quality, residents' deprivation of equal opportunities, lack of equal and fair access to suitable urban facilities and services, low literacy rate, educational, medical, and cultural needs not being met and unemployment have resulted in district 15 being considered a less-advantaged district. Thus, this district must be the first priority in urban planning and policymaking (Fig. 2).

Table 1. Ranking of Tehran Metropolis in terms of residential quality indicators

Indicators	Physical		Socio-cultural		Economic		Ecological		Total	
District	TOPSIS score	Rank	TOPSIS score	Rank	TOPSIS score	Rank	TOPSIS score	Rank	TOPSIS score	Rank
1	0.8275	1	0.1467	6	0.3045	21	0.5235	2	0.7856	1
2	0.6471	3	0.1177	10	0.3171	20	0.2611	16	0.6208	4
3	0.7008	2	0.1433	7	0.3032	22	0.4453	3	0.6718	2
4	0.6315	4	0.0821	18	0.3344	19	0.7095	1	0.6295	3
5	0.6186	5	0.2220	2	0.3886	14	0.3409	11	0.6022	5
6	0.6176	6	0.2075	3	0.3348	18	0.1935	22	0.5957	6
7	0.6059	8	0.1852	5	0.3630	17	0.2192	20	0.5851	8
8	0.6034	9	0.0825	17	0.5114	3	0.2324	18	0.5827	9
9	0.5959	15	0.0668	20	0.3792	16	0.2724	15	0.5742	19
10	0.5941	17	0.0728	19	0.4979	4	0.3517	10	0.5766	17
11	0.5914	19	0.1287	8	0.4087	11	0.2399	17	0.5717	20
12	0.5903	20	0.2070	4	0.4659	5	0.4176	5	0.5788	15
13	0.6004	11	0.0865	15	0.4045	13	0.3360	12	0.5801	12
14	0.5968	14	0.1056	12	0.5323	2	0.2900	14	0.5802	11
15	0.1848	22	0.0638	21	0.4183	8	0.4023	8	0.2048	22
16	0.5897	21	0.1270	9	0.4125	10	0.4332	4	0.5778	16
17	0.5923	18	0.0630	22	0.4277	6	0.4131	6	0.5765	18
18	0.5983	12	0.0872	14	0.4077	12	0.2136	21	0.5793	14
19	0.5952	16	0.7568	1	0.5346	1	0.3795	9	0.5708	21
20	0.5975	13	0.1011	13	0.4126	9	0.2283	19	0.5800	13
21	0.6010	10	0.0827	16	0.3854	15	0.3261	13	0.5825	10
22	0.6062	7	0.1062	11	0.4203	7	0.4032	7	0.5935	b
Mean	0.5993		0.1474		0.4075		0.3469		0.5818	
Standard deviation	0.1040		0.1412		0.0670		0.1186		0.0945	
CV	0.1735		0.9584		0.1644		0.3419		0.1625	

Source: Authors' own elaboration

Generally, around 4.5% of the urban districts were advantaged, while 13.6% were relatively advantaged, 77.3% were semi-advantaged and 4.5% were less-advantaged. Geographically, it could be said that the distribution of the residential quality indicators indicates a declining trend from northern to southern and from eastern to western districts. These results indicate a deep spatial disparity in the distribution of the studied indicators between the districts of Tehran, and the dominant space is in semi-advantaged and less-advantaged districts (Table 2).

2.5. The spatial distribution pattern of residential quality indicators in Tehran's 22 urban districts

Moran's spatial autocorrelation and the Gi statistic were used to identify the patterns of residential quality indicators' spatial distribution and to investigate the inequality status of residence quality indicators in Tehran in the ArcGIS software environment.

Hotspot analysis calculates the Getis-Ord-Gi statistic for all complications in the data. The calculated Z-score shows where the data are clustered in high or low values. This tool looks at each complication in the framework of its neighborhood. If its value is high, it is impressive and meaningful. But a hotspot is not only statistically significant; for a complication to be considered a hotspot and statistically meaningful, in addition to its value, its neighborhood must also have high values. The local sum of a complication and its neighbors is relatively compared with the total sum of all the complications. When the local sum is unexpectedly higher than the expected local sum, and the difference is so high that it cannot be considered a random variation, a Z-score will consequently be obtained (Roustayi

Table 2. Classification of Tehran's 22 urban districts by residential quality indices

Group	Zone	Districts	Classes	Number	%
1	Advantaged	1	+0.7048	1	4.5
2	Relatively advantaged	2,3,4	0.6048–0.7048	3	13.6
3	Semi-advantaged	5,6,7,8,9,10,11,12,13, 14,16,17,18,19,20,21,22	0.5048–0.6048	17	77.3
4	Less-advantaged	15	-0.3048	1	4.5

Source: research findings, 2021

et al., 2016: 129). The Getis-Ord-Gi statistics is calculated using the following equation.

$$G_i^* = \frac{\sum_{j=1}^{n} w_{i,j}\, x_j - \bar{x} \sum_{j=1}^{n} w_{i.j}}{s \sqrt{\frac{\left[n \sum_{j=1}^{n} w_{i.j}^2 - \left(\sum_{j=1}^{n} w_{i.j}\right)^2\right]}{n-1}}}$$

To investigate further and show the spatial inequality in residential quality in the metropolis of Tehran, hotspot analysis was done by Arc GIS software and its features for all the indicators used in the paper. This analysis calculates the Getis-Ord-Gi statistic for all complications in the data. Besides, the Z-score indicates in which districts data with high or low values are clustered. Statistically, the larger the Z-score is, the higher values that make up the hotspot are clustered. In terms of significant and negative Z-scores, it can be said that smaller Z-scores indicate the clustering of low values making up cold spots. Hotspot analysis has been performed at this stage for each of the research indicators (Fig. 3).

The red spots in each of the maps above indicate high Z-score values, which are called "hotspots". These spots indicated that the high value of the studied indicators has clustered in the demonstrated districts. Districts with hotspots have a better condition in terms of the studied indicators. Blue or cold spots indicate districts' deprivation in terms of the said indicators. At the next stage, the mentioned indicators were integrated to make up the hotspot map of residential quality indicators (Fig. 4). The advantaged clusters in these maps are located in the northern and north-eastern districts of Tehran, while the disadvantaged clusters are located in the southern and south-eastern parts of the map. Thus, one could say that the distribution of various physical, socio-cultural, economic and ecological indicators across Tehran urban districts has led to inequalities and differences in terms of citizens' access to urban facilities and services. The emergence of urban poverty and squatter settlements is one of the consequences of this inequality. Southern and south-eastern districts lack the standard and required facilities which has led to their poor residential quality. Reduced efficiency, crime, increased mental and emotional problems, unsafety, increased public distrust, various pollutions, the lack of suitable educational facilities, inaccessibility to fair urban facilities and services and deprivation from a healthy diet due to economic poverty are other consequences of the inequality in Tehran. Moreover, the unbalanced distribution of parks and green spaces, the huge price gap between northern and southern lands and properties, the concentration of resources and facilities such as welfare, service, medical, sports facilities, etc. in northern and north-eastern districts have contributed to the spatial inequality and unfair distribution of urban facilities and services. This inequality and difference threaten social cohesion and will lead to the polarization of some urban districts. Thus, planning and policymaking must be implemented to reduce the spatial inequalities and the social gap. Moreover, fair distribution of urban facilities across the city can reduce these inequalities to some extent. It must be mentioned that, as long as an unfair approach to the districts of Tehran and

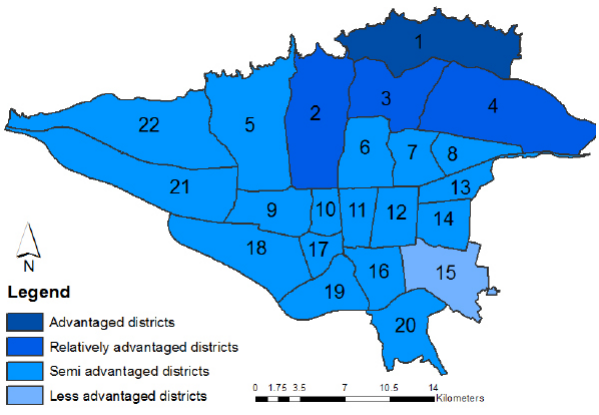

Fig. 2. Classification of Tehran's 22 urban districts by integrated residential quality indicators
Source: Own work

their residents persists, the issues of social gap and spatial inequalities will remain unsolved in the city.

Figure 2, which has been zoned based on the integrated residential quality index, indicates that four districts (1, 2, 3 and 4) have been classified as advantaged and relatively advantaged, while 18 districts have been classified as semi-advantaged and less-advantaged. However, Fig. 4, which has extracted these indicators using hotspot analysis, indicates that the ten northern districts (1, 2, 3, 4, 5, 6, 7, 8, 21 and 22) are relatively advantaged, while the seven southern districts are disadvantaged and extremely disadvantaged.

In Moran's spatial autocorrelation method, the spatial autocorrelation is checked based on the location of two values and the characteristic of geographic features. This analysis evaluates the distribution pattern of complications in space by simultaneously considering the location and the feature. The results of this method indicate that complications are random, scattered or clustered in space. Moran's spatial autocorrelation tool calculates Moran's index and evaluates the calculated index using the standard *Z*-score and the P-Value (which measures significance). Moran's index for spatial autocorrelation is obtained through the following relationship.

$$I = \frac{n}{So} \frac{\sum_{i=1}^{n} \sum_{i=1}^{n} w_{i,j} z_i z_j}{\sum_{i=1}^{n} z_i^2}$$

As the statistics and maps indicate, the 22 urban districts of Tehran suffer from inequality in terms of residential quality indicators. The spatial autocorrelation index has been used to demonstrate the pattern of this inequality distribution. Moran's spatial autocorrelation is among the most important and practical analytical tests on spatial data. The value of this index varies between -1 and 1, so values larger than zero indicate a cluster pattern, while values below zero indicate a scattered pattern and the value of zero indicates a random pattern on the output of the model. Table 3 demonstrates the numerical demonstration of the spatial autocorrelation in the spatial distribution in Tehran, 2016.

The Moran's coefficient calculated for the year 2016 in this paper is 0.2 with a P-value (the probability of the randomness of observations) of 0.077 and a Z-score of over 1.77, and the Moran's index indicates a value above zero, which indicates that the indicators of residential quality have a cluster pattern in the studied area. Figure 5 provides a graphic demonstration of this analysis.

3. Discussion

Based on the TOPSIS method, in the physical dimension, districts 1 and 3 have the first and

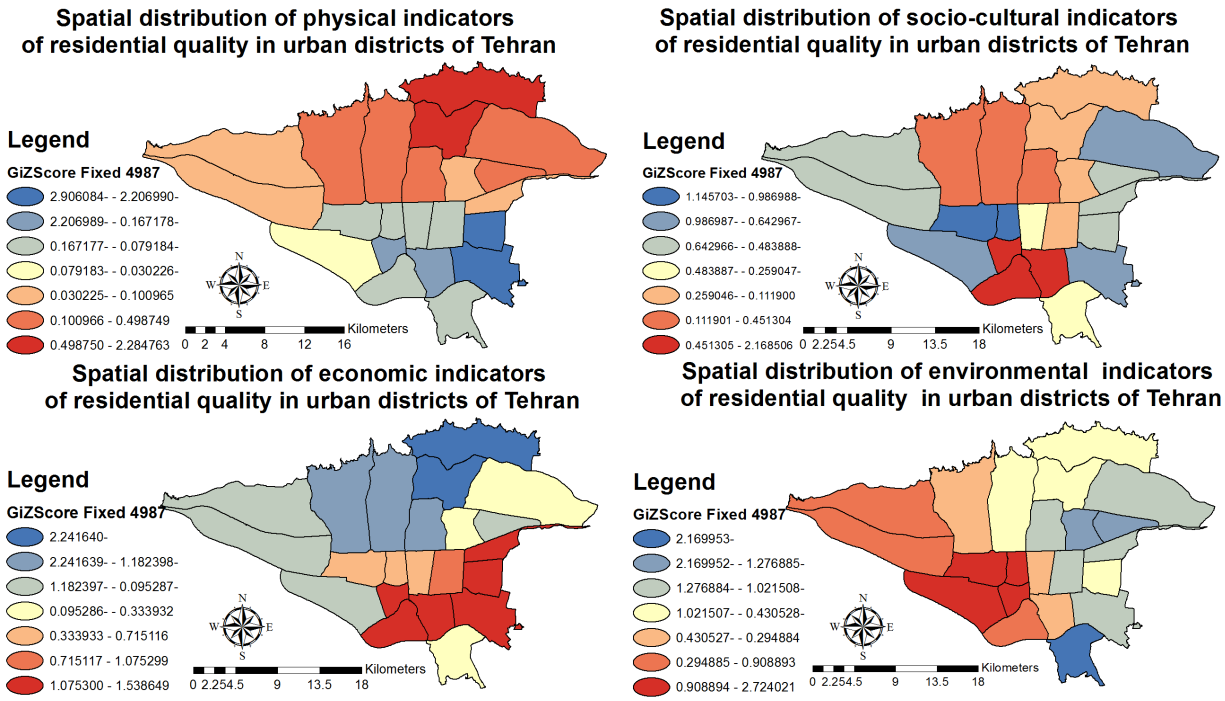

Fig. 3. Hotspot analysis on residential quality indicators
Source: Own work

second ranks and district 15 has the lowest. In the socio-cultural aspects, districts 16 and 5 stood in first and second positions, while district 17 had the lowest rank. In terms of economic indicators, district 19 held the highest position, and district 3 had the lowest. From the environmental point of view, district 4 stood in the highest place, while district 18 placed last. Results of the integrated residential quality index indicated that the northern urban districts, i.e., districts 1, 3 and 4, ranked first through third, and district 15 ranked the lowest.

These findings indicate the heterogeneity in the social, economic, physical and environmental conditions and the gap between the north and south of Tehran, which has pushed the spatial structure of Tehran towards polarization. Around 4.5% of the urban districts were advantaged, while 13.6% were relatively advantaged, 77.3% were semi-advantaged, and 4.5% were less advantaged. The distribution of residential quality indicators shows a downward trend (which means a decrease in the quality of living) from north to south and east to west. These findings introduce the parts of the city that should be prioritized in planning attention to promote the fair distribution of residential quality indicators. The placement of districts in four different groupings confirms the spatial inequality between districts regarding the selected residential quality indicators. Based on the coefficient of variation calculated for the four dimensions of the quality of residence, the socio-cultural dimension has more dispersion than other dimensions, and the economic dimension has less variation. Therefore, it can be said that socio-cultural status has contributed the most to the observed inequalities. The calculation results of the coefficient of variation for all indicators was 0.16%, which indicates the heterogeny and divergence between the 22 districts of Tehran from the perspective of the selected residential quality indicators.

To illustrate the unequal situation of residential quality indicators better, the Gi statistic (hotspot analysis) was used. According to the analysis results, the ten northern districts, i.e., districts 1, 2, 3, 4, 5, 6, 7, 8, 22 and 21, are of the advantaged and relatively advantaged clusters, and the seven southern districts are of the disadvantaged and extremely disadvantaged ones. The concentration of the disadvantaged and extremely disadvantaged districts in the southern districts is mainly due to the increasing number of immigrants settled in these districts, plus the integration of rural settlements into the main city. Owing to the prevailing physical, economic and social conditions, these urban districts are more vulnerable and unstable, and the quality of their housing is low. This difference and inequality threaten social cohesion and would eventually increase the social gap and polarization of districts and the occurrence of various kinds of social damage.

Scrutinizing the theoretical literature, no research has been found in the field of spatial inequality analysis, in terms of having quality indicators of housing in 22 districts of Tehran. This paper presents new research that has not been discussed in any other study. There exists similar research carried out on spatial inequality in Tehran from different perspectives, such as social capital

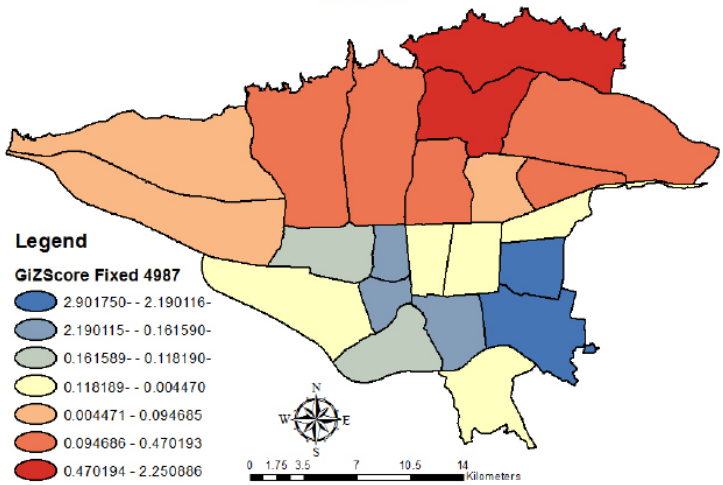

Fig. 4. Spatial distribution pattern of residential quality indicators in Tehran's urban districts
Source: Own work

Table 3. Numerical demonstration of spatial autocorrelation of distribution of integrated residential quality indicators in Tehran

Moran's Index:	**0.200398**
Expected Index:	**-0.047619**
Variance:	**0.019680**
z-score:	**1.767927**
p-value:	**0.077073**

Source: research findings

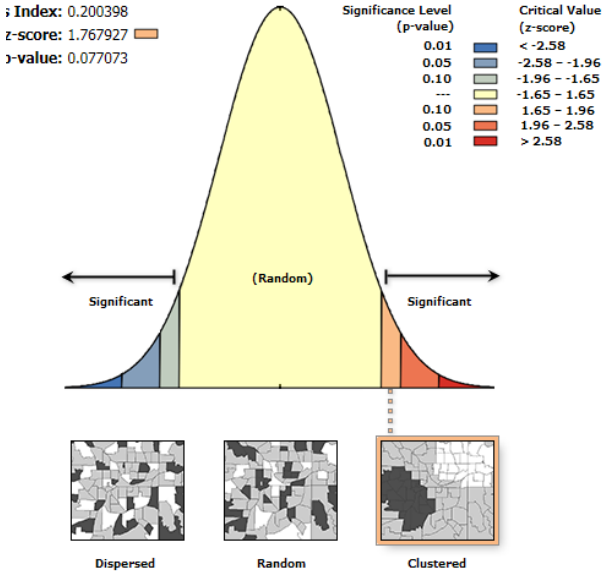

Fig. 5. Graphic demonstration of spatial autocorrelation (Moran's statistic) for the spatial distribution of residential quality indicators in Tehran

(Shadi et al., 2017), housing, healthcare, education and transportation (Yousefi & Farahani, 2019) and urban parks (Bahriny & Bell, 2020). In fact, the present paper is based on research by Marsosi et al. (2021). The urban districts of Tehran are unbalanced in terms of residential quality, which means there are spatial inequalities in Tehran that have resulted in some districts ranking higher in terms of residential conditions and some ranking lower. After the spatial analysis of the inequalities, the reasons for these inequalities were investigated as:

Accelerating urbanization and the needs of the population: the urbanization movement in Iran stems from the political-economic relations with the West and exogenous development (Rahnamaei et al., 2019). Major national development plans were put on the agenda in the form of the modernization theory after World War II, and Tehran was a place where these plans were implemented. Thus, the city attracted a major part of the national capital and became a center for capital accumulation. Besides this, the migrations from villages to Tehran increased after land reforms. The increase in the population and the concentration of the resources increased the demand for urban services and facilities, which resulted in social classes, such that rich persons resided in the privileged districts of Tehran while poor people settled in the south of the city. Over time, this social gap between the north and south of Tehran intensified and shaped the current spatial inequalities.

Capitalist and neoliberal policymaking: the gap between rich and poor has intensified greatly with the progress in economic globalization and neoliberalism (He and Huang, 2021). Reconstruction of the social and economic structures divides urban districts and results in spatial polarization in cities (Sassan, 1991). As a result of the spatial processes, the elites are concentrated in one part of the city while minorities, immigrants and the lower social class reside in other districts (Maloutas, 2007). Tehran metropolis has been severely impacted by globalization processes over recent decades, and capitalism and neoliberal policies from various parts of the world have penetrated this city. In line with the increase in the impact of global policies, social gaps and polarization also increase. Neoliberal policies have influenced the spatial urban pattern of Tehran over the past decades in various ways. For instance, the price of housing underwent a 100% increase while rents, too, increased significantly. Under such circumstances, the gap between the districts intensified and the spatial inequalities became more tangible than ever.

The concentration of power and wealth in Tehran: the most important cultural, political, economic, administrative, military and service institutions are established in Tehran and have led to the accumulation of capital that has created many job opportunities. However, this capital has not been distributed fairly across the city. Thus, some of the districts of Tehran have developed in clusters due to the presence of privileged social classes and institutions of power, while some have remained deprived of development. It could be said that the growth of Tehran has exceeded its balanced development, which has disrupted its sustainability. In general, phenomena such as ecological separation, slums, poverty and social exclusion have occurred

due to the concentration of capital in Tehran, all of which are justifiable given the spatial inequality.

Spatial transformation, urban creep and irregular distribution of services and facilities in Tehran: the problems of Tehran intensified after the 1960s due to reasons such as an oil-oriented economy, the decline of the rural economy, fast population growth and government investment in large cities (Pilehvar, 2021). Thus, in addition to the social, economic, cultural and political transformations (Mashayekhi, 2019), extreme changes in the physical and spatial growth of Tehran changed it from a dispersed urban district to a single-core city (Pazhuhan, 2021). The city thus expanded, and its population grew day by day. Under such circumstances, the demand for urban services and facilities increased significantly. However, the needs of the citizens in all districts of Tehran were not fully met, which resulted in the creation of unfair spaces. As Harvey (1992) states, the strategy of facility and service spatial distribution is an essential factor in the realization of social justice. However, it was revealed in this paper that spatial inequality was quite evident in Tehran. It must be noted that the spatial distribution of urban facilities is not random and is, rather, subject to management approaches.

Urban management inefficiency: the spatial imbalance in cities is generally due to the inefficiency of urban management and the governing ideology (Ghaedrahmati et al., 2018). Although the institutionalization of modern planning in line with global standards has been sought in the urban management system (Jafari and Hein, 2021), malpractice in urban management is still observed in Tehran. The management of Tehran is complicated and multifaceted, since various public organs are concentrated in the city and each of them follows its own advantages, and this prevents the formation of cohesive spatial management. Furthermore, non-experts usually enter the city council after each city council election, and a non-expert mayor is thus elected for the city. Various examples of lack of specialization can be observed in the management of the Tehran urban complex, which has long been subject to criticism. The lack of specialization and political management of Tehran has prevented the balanced realization of urban planning standards for all districts, which leads to spatial inequality in various economic, social, cultural and ecological aspects and results in social polarization. As Ghaderihajat and Mokhtarihashi (2019) argue, plans must be developed in short, medium and long-term horizons with the approach of land management strategy using the concept of spatial justice while considering the available resources to provide the grounds for optimal management of Tehran so that the problems of the city can be solved and its optimal management can be achieved.

4. Conclusion

This paper was conducted with the purpose of measuring and analyzing the spatial inequality of residential quality according to the specified indicators in Tehran. The results indicate the existence of differences and spatial inequality in the distribution of the selected and applied indicators against the 22 districts in such a way that, in terms of residential quality indicators, the Tehran metropolis is divided into three parts, i.e., north, center and south. In the northern districts, the indicators of the quality of residence are in the desired condition, while the central districts (including districts 11, 12 and 13) and southern districts are disadvantaged. The spatial inequality in Tehran can be related to such factors as the reflection and outcome of the environmental and physical situation, planning and management inadequacies and the non-existence of a control mechanism for the housing planning system, the difference in citizens' lifestyles, and the economic status and value of the land in the Tehran metropolis. The social structure of people and the socio-cultural facilities have contributed the most to these inequalities. It can be stated that there is a significant relationship between the quality of residence and social classes in Tehran. This means that people with similar social and economic status are more likely to live closer to each other. In addition to the characteristics of people, neighborhoods and districts are divided based on facilities and services related to housing, which limit or expand people's opportunities depending on their classes. With the development of the Tehran metropolis, social classes are becoming more distinct, and as a result, the separation between the rich and poor districts is becoming more and more vivid. The continuation of this process will bring many economic, social and political costs.

To solve the detrimental spatial inequality of Tehran, the paper suggests the importance of applying the main principles of urban planning, especially in terms of residential planning primarily in the parts of the metropolis where inequality is predominantly observed. In detail, it suggests that, in urban planning (especially housing planning) for the metropolis of Tehran, southern and south-eastern parts should be prioritized. Also, creating integrated urban management can be helpful in this field. In urban plans and policies, the officials and managers of the city should take the needs of the people and

their participation into consideration by providing short-term, medium-term and long-term solutions to adjust the spatial inequality of the metropolis districts of Tehran. In developing countries, especially Iran, to achieve sustainable development, the attitude of academics and practitioners must change in such a way that sustainable development is not just a theoretical matter, but there is an urgent need to prepare the requirements to ensure that it is realized and practiced.

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