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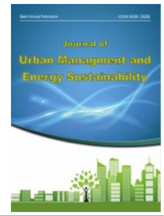

ORIGINAL RESEARCH PAPER

Evaluation of urban energy resilience by measuring physical-spatial components (Case study: Tehran District 2)

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ABSTRACT

During the recent decades, irreparable damage and casualties caused by the significant increase in the occurrence of natural disasters all over the world, the approach of Resilience in the face of accidents and unexpected events in order to prevent the wastage of urban energy is a global issue facing city managers and a large part of Studies and research should be devoted to this And since more than 80% of the world's energy is consumed in urban areas and due to the increase in population, this share is expected to increase in the future; Therefore, achieving urban energy resilience is considered one of the essential aspects of urban Resilience, and the topic of energy and urban energy resilience is a necessity for future urban development. Unfortunately, despite the existence of many laws and regulations in the field of energy, in the construction industry, energy wastage is very high in our country. In this regard, this research aims to evaluate and analyze the Resilience of urban energy, in terms of descriptive-analytical methods and nature. In terms of practical and developmental purpose, considering the research community including 30 urban experts with a non-probability targeted sampling method with A researcher-made questionnaire tool was taken, and by reviewing the literature related to Resilience and presenting an abstract concept, it explained the relationship between urban energy resilience and the measurement of physical generators. After collecting the required data, the physical data was analyzed using a spatial model. Finally, the spatial analysis results have been done by producing the resilience map of the region in the ARC GIS environment by overlaying the layers. The results of the spatial study indicate that reducing the effect of physical components leads to a decrease in urban energy resilience, and paying attention to making cities more resilient in order to achieve optimal management and energy conservation of cities is achieved by increasing physical Resilience.

Running Title: Urban energy resilience by measuring physical-spatial components

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1. Introduction

The topic of energy and Resilience of urban energy is one of the most important topics of the day, which is expected to increase due to the increase in population because most of the world's power is consumed in urban areas. (Leon and Mars, 2014). Also, crises have long affected human societies in a comprehensive way due to the complex communication in cities, and rebuilding and restoring the conditions before the problem, as well as improving it and trying to compensate for the aforementioned damages, has become the primary goal of city managers. In this regard, the framework of the Hugo Plan was approved by the United Nations International Strategy for Crisis Reduction (UNISDR) on January 22, 2005, which was a positive move. Since the approval of this legal bill, the main goal of planning for risk and risk reduction of crisis, in addition to reducing vulnerability, has tended to focus on creating Resilience in communities (Mayunga, 2007). This means that the city should be designed in such a way, and its structure and elements should be planned so that the characteristics of a resilient and resistant system are included. For the city to be placed in a resilient system, the city's vital infrastructures, such as; Water, electricity, etc., should be efficient before and after the crisis, and by explaining these things, a city can increase or improve its capacity in terms of Resilience against threats and energy disruption. Thus, society's ability should be such that it not only responds to crises but also achieves more functionality and capability in this way. To have a resilient city, the cooperation of all departments and organizations and even the city's residents are needed to show the best response to the incidents that occur in the shortest possible time (Katabchi and Ressaei pour, 2017).

In recent years, the vulnerability of Iranian cities, especially urban centers, to unexpected incidents and accidents has increased. Meanwhile, the metropolis of Tehran is also associated with many problems, and according to the research conducted, it is very vulnerable to natural disasters and energy wastage.

In addition, the second district of Tehran has worn-out urban structures and informal settlements, high population density, the inefficiency of the communication network and lack of resistance of buildings in most of the neighborhoods, which has caused the region to face a severe crisis. In this regard, the current research aims to evaluate and analyze urban energy resilience in Region 2 and answer these main questions: "Is there a relationship between urban energy resilience and physical-spatial indicators? To what extent is Tehran's 2nd region physically resilient in urban energy subject?" So, in the beginning, present research has been introduced with different variations with analysis and investigation of urban resilience indicators according to the views. However, urban energy resilience has not been investigated by measuring physical-spatial components, trying to explain the relationship between physical Resilience and urban energy resilience and provide a conceptual model through documents and library studies. Then with the help of spatial and related analyzes the use of analytical maps assesses the physical-spatial condition of area 2.

2. Theoretical Foundations

2.1. urban energy resilience

The root of the word Resilience is taken from the word Resilio, which means having a resilient state or returning to past states (Ghiathvand and Abdul Shah, 2015), which is a concept related to cities and planning and urban development plans since the 1990s and in response to environmental threats. The regulation of social and institutional frameworks appeared to show that cities should be able to act stably and withstand problems in complex and unpredictable conditions. Resilience is a new analytical dimension of the vocabulary of disaster for which there is still no universally accepted definition (Briguglio et al., 2008). From the point of view of urban planning, the problem of Resilience and settlements can be examined from two perspectives, structural-institutional and physical tools. The idea that has existed so far in the management of incidents and urban management has often been a retrospective view of the incidents after the crisis, which according to the developments created in the cities and the existence of logical models and methods in order to deal with urban risks before the incident, This attitude needs to be improved. It is necessary to open a suitable place in the national policies of each country so that favorable conditions can be created for effective and efficient risk reduction at different levels.

Resilience is a multifaceted approach, and when examining its various dimensions, its dimensions and criteria can be considered differently according to the meaning and different sciences. For example, in an article, Marana et al. (2019) presents new guidelines for developing resilience management in Europe designed by the H2020 Smart Resilience Project. The project includes five support tools for city resilience, covering local resilience planning and supporting research into the Resilience of buildings and city-wide operations. McLean et al. (2014) measured Resilience from six dimensions; They examined knowledge, social network, people's communication, economy, governance, and infrastructure. In the study of Rose and Berks (2014), attention has been paid to dimensions such as social, economic, institutional, infrastructure, and environment. According to Katter, four key sets (social vulnerability, infrastructure and built environment, natural and endangered systems, risk reduction and planning) of criteria are necessary to create a resilience framework in society. Each of these four components can be presented in GIS as different layers of information. In fact, their framework for understanding community resilience is a function of three dimensions of vulnerability. According to the stated contents, the approach of Resilience includes various social, economic, institutional, physical, and environmental dimensions, but since the main reason is the spread of the dimensions of the crisis, physical damage, such as the destruction of buildings and public uses. , the failure of the communication network and the blocking of passages, etc., at the time of the accident; Therefore, the physical structure, as one of the most important mechanisms for making the urban system resilient, plays an essential role in improving the efficiency of rescue operations and evacuation of the city. A resilient physical structure means the system can maintain the expected service level and return to that level in a certain time frame. It implies spatial Resilience to the environment and human relationships with that environment (Allen et al., 2016).

Along with the growth of cities and the diversity of urban needs, human issues will also threaten cities in addition to natural damage and threats. Since cities are the primary energy consumers, the continuity of energy services is necessary for their effective functioning, and considering that one of the essential risks in economic activities is energy risk; therefore, providing energy resources is one of the most critical issues of countries (Matsumoto et al., 2018).

Access to energy is one of the most important aspects of prosperity and sustainable development of modern societies; In such a way that the level and type of energy used by cities affects not only the economy, environment, and well-being of citizens but also the residents of other cities. Today, cities are highly dependent on fossil fuels in such a way that energy is directly related to the economic, environmental, and social development of a country (Chalvatzis and Ioannidis, 2017). According to the United Nations report, the city form directly impacts energy consumption (and achieving sustainable development) (Mitchell, 2005); Therefore, energy saving is one of the most important challenges of today's cities. Energy resilience is a field of Resilience that has not been well studied in urban studies literature. Among those studies that deal with urban energy, only a few have discussed energy and Resilience together. Meanwhile, 60 to 80 percent of the world's energy is consumed in cities, and due to the ever-increasing rate of global urbanization, urban areas are expected to remain so. As the principal place of global energy consumption in the future, by changing the concentration of carbon dioxide in the atmosphere and thus intensifying the greenhouse effect, the increase in energy consumption in urban areas will contribute to further warming of the climate, and therefore, it can be considered as a main driving force of climate change. be taken in turn, climate change and global warming can negatively impact the energy sector by increasing energy demand and intensifying extreme events that threaten the security of generation, transmission, and distribution infrastructure. Furthermore, even under the most stringent climate policy scenarios, proven reserves of conventional oil and gas, which account for the largest share of global energy consumption, will be depleted before 2050, with adverse consequences for availability, accessibility, and affordability. Energy resources are depleted (Sharifi, Yamagata, 2016). So far, brief research has been done in the field of urban energy resilience; In a case study, Jess et al. (2019) investigated the Resilience of energy and its application in energy systems, the development of theories and definitions, and the criticisms of the theory of Resilience, as well as the similarities and differences of these studies. Sharifi and Yamagata (2016) in a study by reviewing various studies in the field of urban energy resilience, tried to create a conceptual framework, identify planning criteria and also relate these criteria to the basic components of the conceptual framework in order to evaluate urban energy resilience. In the energy discourse, Matzenberger et al. (2015) define system energy resilience as the ability to maintain system performance and deal with disturbances and the possibility of using positive opportunities to increase system capacity. Rezaei and Gurbanpour (2018) investigated the assessment and analysis of the dimensions and components of urban energy resilience with the approach of structural equation modeling of Bushehr city. They stated that energy is one of the vital infrastructures for sustainable urban development, which a strategic view It can increase the Resilience of societies in times of uncertainty such as global climate change and unpredictable natural disasters. Razovian et al. (2017) in research presented a conceptual framework for evaluating the Resilience of urban energy in order to achieve a sustainable city. The results showed that urban resilience evaluation tools should include criteria and indicators that consider the aspects of reducing the effects and adapting to climate change in the direction of sustainable development. The review of studies in the field of urban Resilience indicates the fact that a resilient urban system in terms of energy must have the characteristics of availability, ability to collect or access, acceptability or acceptance and financial ability in different conditions of uncertainty (Sharifi and Yamagata, 2016). Availability indicates the existence of sufficient reserves of resources and energy reserves and suitable infrastructure to transform them into energy services (Sovacool, 2011; Sovacool and Mukherjee, 2011). Accessibility refers to the importance of spatial proximity of energy supply and demand (Kruyt et al., 2009). Also, it leads to fair distribution of energy services (in terms of quantity and quality) to all members of society (Sovacool, 2011). According to the presented materials, it is significant to emphasize the contribution of the building sector in the energy consumption of countries; Because the building sector accounts for 40% of the total energy consumption of countries. Therefore, it can be easily concluded that the building sector has a major contribution to environmental pollution and consumption of fossil fuel resources. For this reason, in most of the industrialized countries, basic measures have been taken in the field of consumption pattern modification, using different tools, including the compilation of urban design rules and regulations. In fact, the goal of energy-based urban design is to create urban configurations that reduce energy demand, especially in relation to the dependencies between energy systems and urban form for higher energy performance and the location of the energy layers system along with maintaining It is a high level of human comfort (Fonseca, 2016). On the other hand, the conscious design of buildings and human settlements, especially housing, considering the energy issue, can significantly reduce their dependence on energy consumption for heating and cooling construction. Many variables that depend on the shape and form of the city, such as population density, building density, mix of uses, accessibility, non-compliance with correct standards, the system and pattern of segmentation and segregation of urban land, the compatibility of uses have a direct relationship with the conservation of energy in cities.

2.2. Presenting the conceptual model of the research

A decrease in Resilience in cities increases the vulnerability of the city system and ultimately causes a waste of urban energy, and as stated, physical Resilience is one of the most influential dimensions in the Resilience of societies, through which the state of societies can be assessed in terms of their characteristics. It evaluated the physical and geographical influence during the accident and systematically evaluated how the city's elements and physical structure are connected. In the presented model (Figure 1), urban Resilience has been discussed and investigated from various dimensions. With emphasis on the physical dimension, the main components of energy resilience have been presented, which is the intersection and turning point of urban energy resilience by measuring the physical features in the building part occurs. Let's consider the city as a complex set of buildings and people. Most of a city's Resilience is directly related to the city's energy conservation and, to some extent, its facilities, and the Resilience of a building is directly related to its vulnerability and prevention of energy wastage.

The presented conceptual model (Figure 1) states that the physical component significantly impacts energy wastage. The building was introduced as one of the essential components of physical Resilience. One of the main reasons for energy wastage in the building sector emphasizes the architecture and how the building is designed to reduce energy consumption or wastage. The tricks of harmonizing architecture with nature and the environment and using renewable and clean resources, the appropriate use of the climatic conditions of each region, paying attention to the design context, etc., can be effective in energy wastage. On the other hand, although some topics of the national building regulations (including topic 19) can be considered very important to save energy consumption, unfortunately, they face obstacles in implementation that can be regarded as one of the reasons for energy wastage. These obstacles or factors can be divided into internal and external components. Internal factors include those factors that cause building vulnerability itself, such as area, floors, skeleton, age, building materials, the quality, connection of the buildings and compactness of the structure, the type of building design, the building plan, the weight the number of units, etc. External factors of the building that indirectly affect the destruction of the building. including the population density in the area, the vulnerable population in the area, the width of the roads, the slope of the area, the structure of the city, the type of neighboring uses, the desirability of the use in relation to the location, distance from hazardous uses, etc. both internal and external) have important effects on urban energy resilience. For example, the separation of land in small dimensions, which is an external and regulatory factor, causes the fragmentation of open spaces and in practice reduces the usefulness of open space for absorbing renewable energies, and this is if the separated parts are divided according to the type

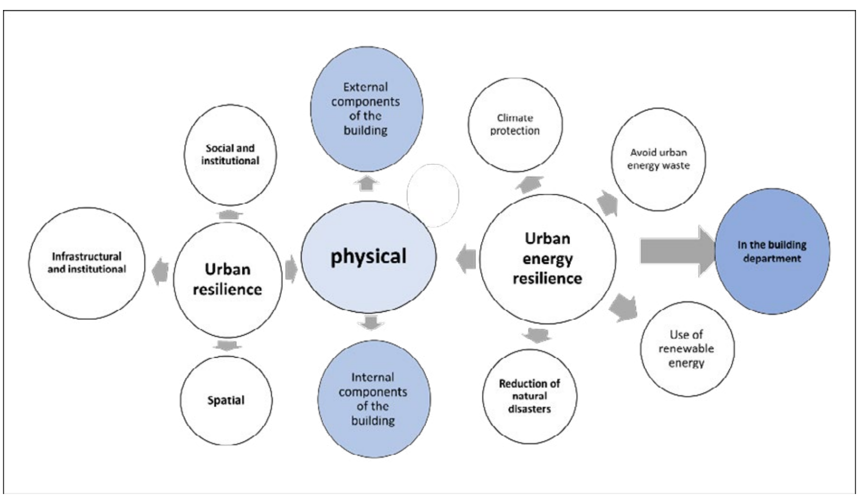

Fig. 1: The relationship between the components of urban resilience and energy (authors)

of use. If it is smaller, physical vulnerability will also be strengthened.

On the other hand, the granularity of urban tissues will also have an effect on the efficiency of the communication network, so that the larger the granularity, the percentage of traffic nodes and the number of dead ends will be lower, and the permeability of the tissue will decrease, and the use of intelligent transportation system in order to maintain urban energy resilience, becomes more efficient. Also, the characteristics of the building structures, the quality of the building and the life of the building, the number of separate building units in each part, the type of building materials, occupancy levels and other issues have a direct impact on the energy consumption in the building. According to the mentioned variables and components and by applying the principles and criteria of the energy topic and explaining the concepts in this knowledge, cities can be made resilient in terms of energy and in the design of new cities, by observing these principles and considering flexible urban plans, avoid accidents and minimize energy waste; Therefore, in order to ensure the full realization of physical Resilience to achieve urban energy resilience, four dimensions related to sustainability and Resilience and indicators and components of the urban form derived from the most important components mentioned in two internal and external dimensions in Figure 2 are proposed.

3. Research Method

This research, with a practical and developmental goal, assessed urban energy resilience with physical components of Tehran's 2nd district its main goal, and analysis different aspects of physical Resilience with a descriptive-analytical method and nature. To apply the proposed models and theoretical approaches,

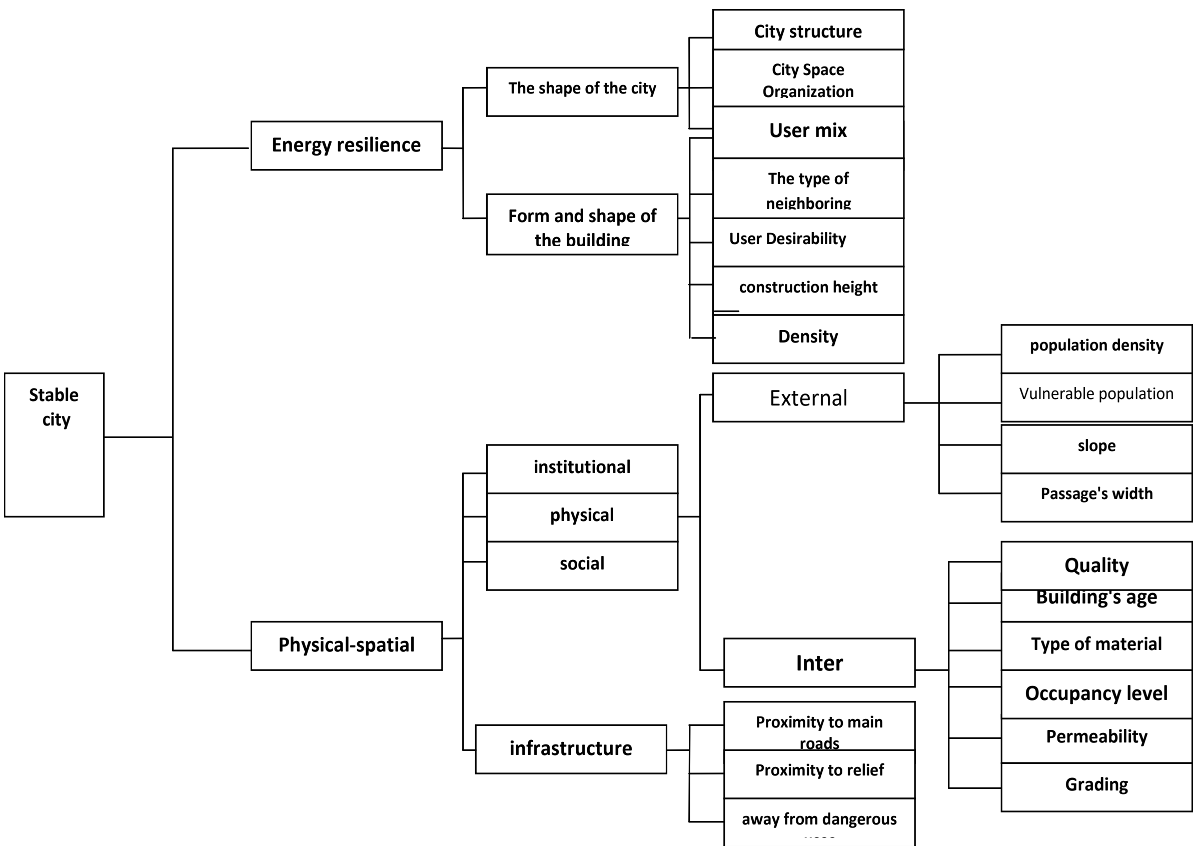

Fig. 2: Urban energy resilience model with physical components (authors)

firstly in the form of library and documents (articles, statistics, and documents) and to analyze the state of Resilience, he has used spatial perception and a researcher-made questionnaire with a 5-point Likert scale. To check the qualitative validity of the questionnaires, experts' opinions were used (content validity method), and the reliability of the questionnaires was checked using Cronbach's alpha in SPSS21 software. The mentioned coefficient for questionnaires was equal to 0.937, indicating the questionnaires' reliability and the internal correlation between the questions (Table 1).

The following, first, to examine the existence of the relationship between urban energy resilience and physical indicators with the help of the T-test of single payment samples and after confirming the hypothesis, the data required for the research in two categories: spatial (spatial) and non-spatial (descriptive) data are categorized and with them, from the analyzes of the use of spatial resilience maps in the ARC GIS environment using the Spatial Analysis tool and through the figuring function with the weights obtained from the model, each of the layers is assigned, and finally, the layers are combined Resilience maps of the region are produced. Actually, The model that is presented here includes the factors and indicators that are effective in Resilience. Firstly, the way of having each of the dimensions of urban energy resilience components was determined with physical measures at the level of the neighborhoods, and then the degree of having different regions in 2 The total level of Resilience is measured.

4. Findings

District 2 of Tehran is one of the densest areas of Tehran metropolis and in the danger zone of natural disasters, the presence of faults, history of earthquakes has caused this area to be exposed to damage and crisis and become one of the high-risk areas. This is while physical problems prevailing in the region and human issues situation such as area being enclosed between highways and arterial roads, the dense tissue of the body, the cultural and social position of the citizens of the region in the face of crises, unusable roads, the density of the population and the lack of quality of the structures. (Worn texture) the presence of numerous knots and arches in the road network is a sign of the unfavorable situation in this area. From the set of stated natural and human problems governing the 2nd region of Tehran, the lack of readiness of the region and the lack of energy resilience and preventing energy wastage in this region despite the presence of new and newly built tissues, the importance and necessity of developing requires to maintain physical resilience. It is important to renew the construction rules in this area.

Table 1: Reliability calculation of research questionnaires with Cronbach's alpha coefficient

Cronbach's alpha coefficient	Variable
Resilience(physical)	82%
Urban energy resilience	80%
The whole questionnaire	0.937

Table 2: T-TEST test and component desirability analysis

Component	The amount of T	Degrees of freedom	error rate 1sig
infrastructure	3.09	29	0.007
institutional (management)	3.43	29	0.005
Spatial	4.16	29	0.001
physical	5.03	29	0.000
the environment	1.79	29	0.938
Climate protection	2.139	29	0.41
Energy waste in the building sector	3.38	29	0.000

Therefore, this research includes a statistical population of 30 urban experts and specialists. Related experts with experience in the field of resilience, university faculty members, senior municipal managers, 20 men and 10 women; Of these, 56% have master's degree and 44% have doctorate degrees, 32% are between 30 and 40 years old and 68% are over 40 years old. In the inferential statistics section, due to the parametric nature of the research data, the one-sample T-test has been used to find a significant relationship between urban energy resilience and physical indicators. The results of the sample t-test for the analysis of the desirability of the status of the components were obtained in Table 2. According to the results obtained from the T-test, it is clear

Table 3: Resilience indices of urban engineering with physical-spatial dimension

Urban energy		Resilience
external	internal	
Natural hazards	quality of building	
The pattern of segmentation and separation of land and urban grain fields	Building Materials	physical-spatial
Building Density:	Age and life of the building:	
Access to the leading road network	Building quality:	
	Number of floors	

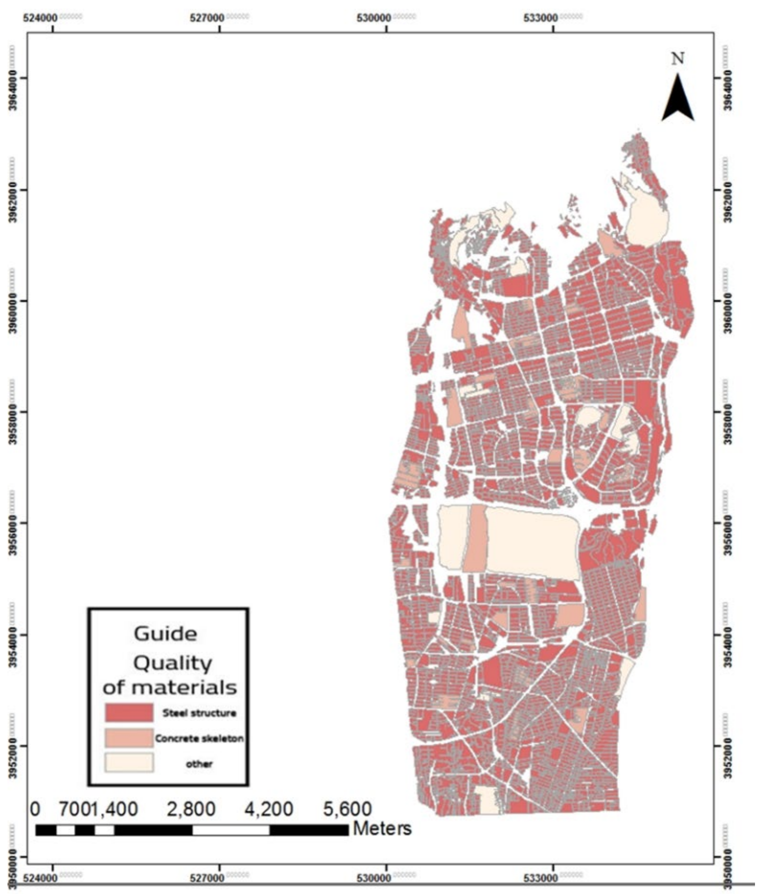

Fig. 3: Construction materials quality map

that the status of all the resilience components is moderately desirable at the 99% confidence level. The amount of T obtained according to the test value of each component (which is close to the average) shows that the amount of attention paid to the four components is moderately significant.

As shown in Table 2, according to experts, the physical criterion (5.03) was ranked first, and the spatial criterion (4.16) was ranked second. Therefore, it is appropriate to consider a physical-spatial dimension for Resilience. In the following, according to the specific goals of research and field investigation, the criteria related to energy resilience are divided into two general categories, internal and external (Table 3). It should be noted that each of the mentioned indicators has its importance. And their significance and influence on the level of Resilience are not the same. Therefore, an expert questionnaire was completed to determine and estimate the weight of each indicator. Finally, the average of opinions was considered as the weight of each of the indicators. The cases that could prepare maps and spatial analysis have been discussed in the next section.

1) Material layer; The materials used in the facade of the building are particularly effective in the amount of energy consumption. In this context, materials should be selected that help to prevent the increase of energy consumption based on the location environment. Also, the type of building materials is one of the determinants of housing quality. The type of materials in this research was divided into two general categories

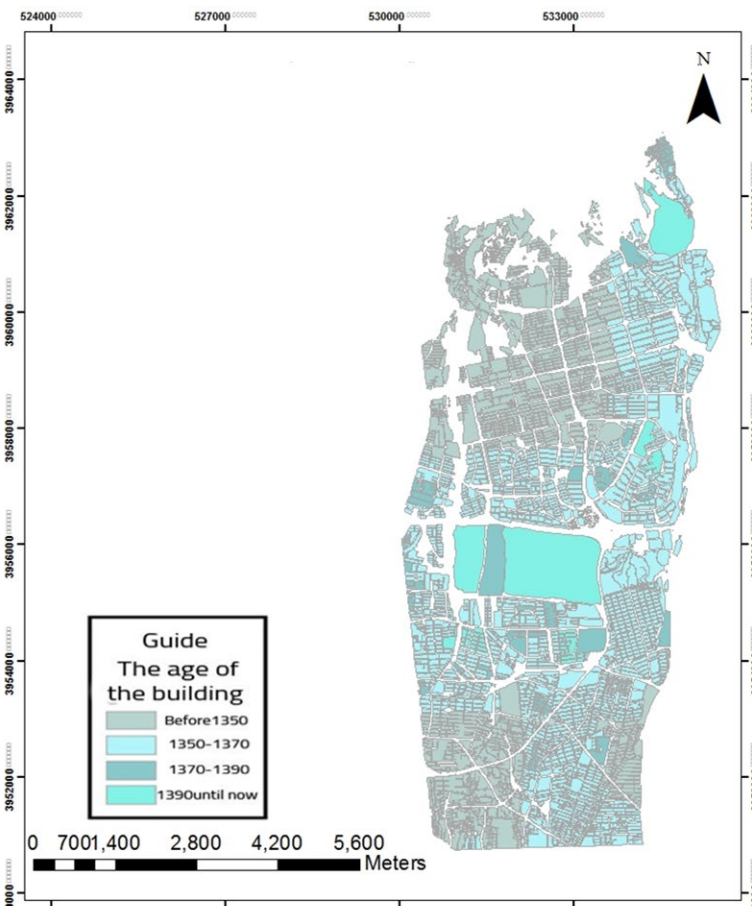

Fig. 4: Map of the age and life of the building

of metal and concrete frame (Figure 3), and types of materials such as; Iron and brick, block and brick, block and wood, and clay and mud were considered in the other category due to the small number. According to the results, more than half of the houses in the region are made of durable materials (metal frame and concrete), which account for 92%. Buildings built with blocks, bricks, clay, and mud, which mostly occurred in the northern border of the region and due to informal settlements in Farahzad neighborhood and surrounding areas, have created low-quality housing and are also located in the worn-out fabric of the region, approximately 8%. are assigned to themselves. In this context, the use of some smart building materials is suggested to change the color of the facade of the building according to the weather conditions and create the best efficiency in terms of solar energy absorption.

2) Building age and life layer: Among the existing criteria for determining urban energy resilience, building age is one of the most comprehensive criteria that can provide a correct estimate of the total energy consumption of the building. This means that the older the building is, the lower the level of compliance with the principles of energy conservation according to the rituals of the day. Therefore, it is necessary to pay attention to the life of buildings (from the construction, operation, and demolition phase) and the design of new buildings in accordance with the provisions of the 19th National Building

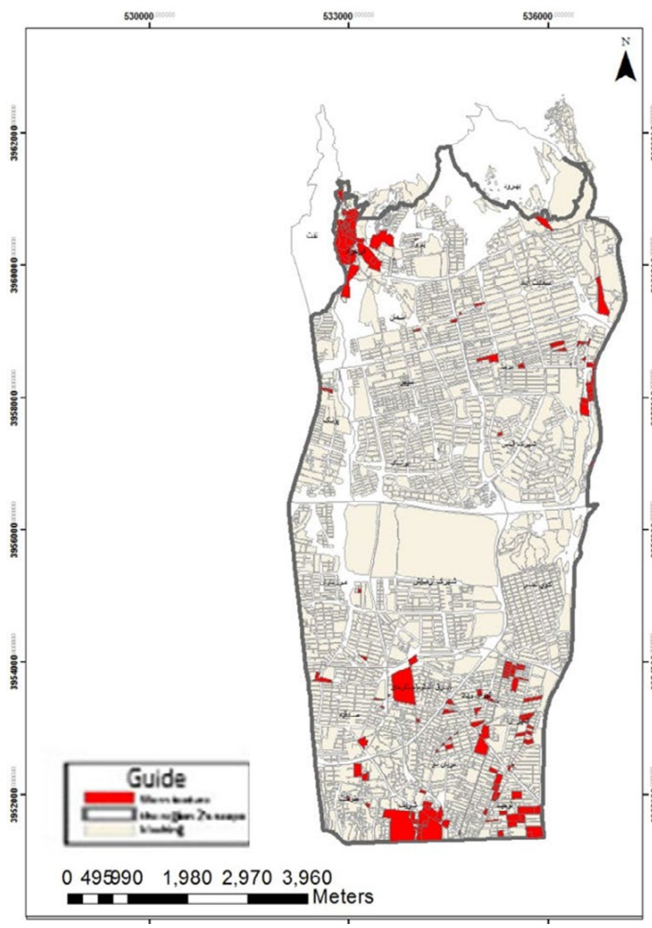

Fig. 5: Map of the pattern of segmentation and separation of land and urban grain fields

Regulations. In the current research, the age of the buildings in the region is divided into four groups (Figure 4). Accordingly, 49% of the buildings are less than ten years old, 32% are 10-30 years old, and 19% are more than 30 years old. A significant percentage of buildings in this area is in good age conditions, which could provide energy resilience in this sector with proper design.

3) The pattern layer of segmentation and separation of the land and the urban seed area:

4) The occupation pattern of the land affects not only the size and external surface of the building, but since the different directions and fronts of the building are different from each other in terms of energy acquisition, it plays an essential role in light and building energy acquisition. Various factors are involved in forming the pattern of land occupation in urban contexts. Still, the usual ways of land occupation are examined only in terms of energy balance and energy consumption in the building for heating and cooling in the year's seasons. According to the surveys (Figure 6), 34% of the plots in the area are 200-500 square meters, 43% are more than 500 meters, and 17% are 100-150 meters. Only 6% of the plots are less than 100 square meters in the southern parts. The southwest of the region and the neighborhoods of Marzdaren, Tehran Villa, Tawheed, Tarasht, and Sharif is seen more, while the suitable size of residential plots and numerous gardens and parks in the east of the region create a more open and flexible urban space.

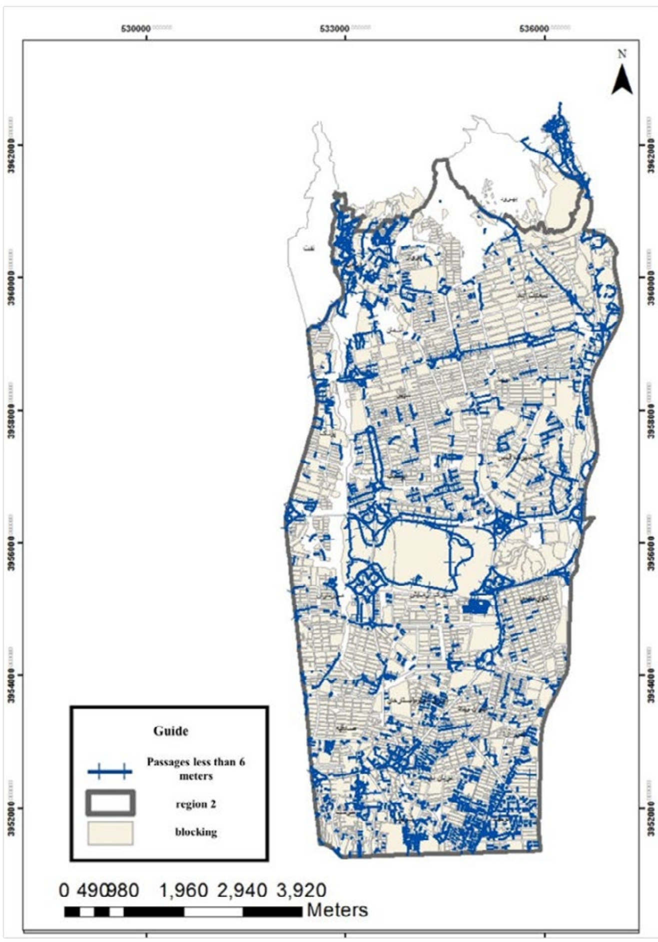

Fig. 6: Map of access to the main road network

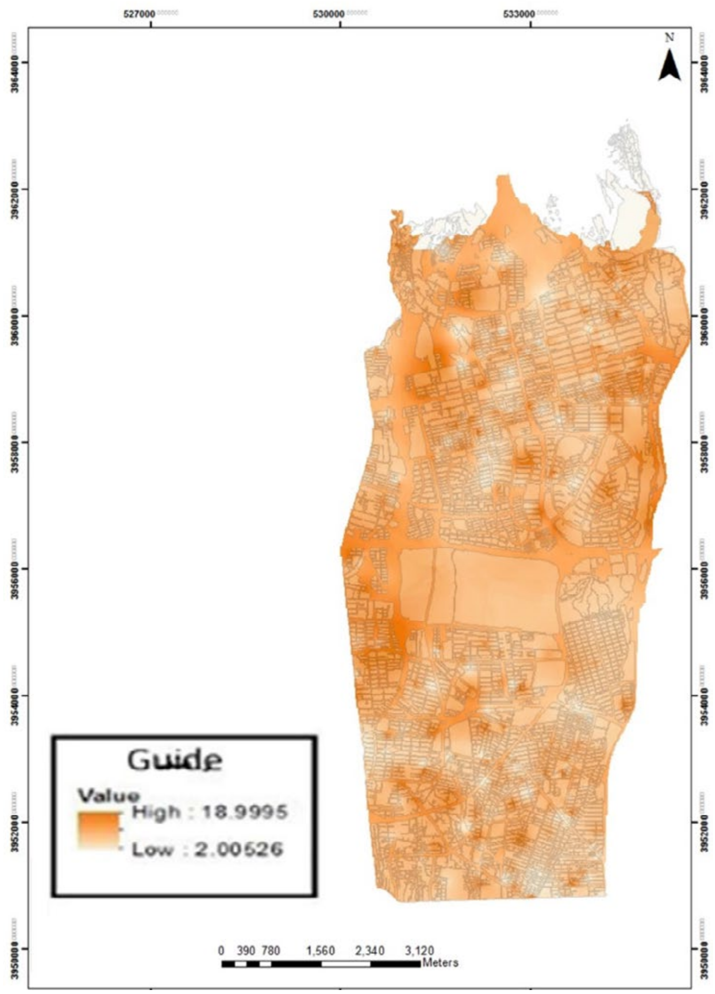

Fig. 7: Energy resilience map of region 2

5) The layer of access to the leading road network: based on the spatial analysis map, the access to the main road network in region 2 is in a favorable condition due to new constructions and often following urban standards and norms, and the urban hierarchy is respected and only in In the north-west of the region and the south-east side, the accesses and road network are somewhat problematic, and often roads with a width of fewer than 8 meters are seen in these limits, which causes slow movement and lack of response to daily needs.

5. Conclusion

One of the most critical aspects of prosperity and sustainable development of modern societies is access to energy; In such a way, the level and type of energy used by cities affects the economy, environment and well-being of citizens and the residents of other cities. On the other hand, based on research, the energy consumed in buildings is about 5 to 6 times higher than international standards. According to global statistics, Iran is one of the most energy-consuming countries in the world. Meanwhile, the construction industry is one of the most influential factors in energy consumption, and many experts and officials consider buildings the most significant energy loss sources. The findings indicate that rapid and unplanned urbanization, environmental degradation, and population concentration in disaster-prone areas have weakened the community's capacities for resistance and rehabilitation. These uncertainties have been resolved by introducing the new concept of Resilience, such as durability, flexibility, and return to balance. It is essential to make cities resilient to achieve optimal management and maintain the energy resilience of cities by increasing physical-spatial Resilience. Therefore, optimizing energy consumption in the building is very important.

In this article, after the investigations and the confirmation of the hypothesis that there is a relationship between urban energy resilience and physical-spatial criteria, spatial analysis maps were produced for the 2nd district of Tehran. The results indicate the optimal level of Resilience in newly built and coordinated neighborhoods. This is while 372 construction permits have been issued in Region 2 this year, which would have taken a big step to prevent energy wastage if the 19th topic of the National Building Regulations of Iran on saving energy was maintained Based on principles and rules of urban energy, and the old neighborhoods of the region, including Farahzad, Parvaz and south of the Tehran region, Vila, Darian No, Tawheed, and Sharif neighborhoods have an unfavorable level of Resilience and a decrease in physical-spatial components, a reduction in quality construction and followed by a decline in urban energy resilience. Also, to produce the final map of the energy resilience of the region by measuring the physical-spatial components, after specifying the criteria to evaluate the Resilience of urban blocks, the information related to each index is put together in the GIS environment. The final map is obtained, and it is necessary to It should be noted that this map includes low, medium, significant, and high vulnerability ratings, which are defined by applying these intervals to areas with low and high energy resilience.

Urban energy resilience assessment results can enable planners and decision-makers to identify priorities, track the achievement of goals, and make more informed decisions that facilitate the transition to low-carbon and more resilient societies. According to the above explanation, to increase the energy resilience at the level of region 2 to achieve sustainability, the following are suggested:

- Compilation and application of necessary rules and regulations related to energy resilience and urban sustainability
- Paying more attention to the degree of enclosure (the height of the building to the width of the passage)
- Applying the appropriate distance between high-rise buildings and road bodies through the creation of green spaces to reduce energy consumption
- Improving the quality of housing in worn-out structures of the region, especially in the northern parts of the region
- Applying laws to control building density

References

Allen, C. R., Birge, H. E., Bartelt-Hunt, S., Bevans, R. A., Burnett, J. L., Cosens, B. A., Uden, D. R. (2016). Avoiding decline: Fostering Resilience and sustainability in midsize cities. Sustainability (Switzerland), 8(9). https://doi.org/10.3390/su8090844

Briguglio, L., et al. (2008). "Conceptualising and measuring economic vulnerability and resilience." UNU-WIDER, RP2008-55.

Chalvatzis, K. J.; Ioannidis, A. (2017). Energy supply security in the EU: Benchmarking diversity and dependence of primary energy. Applied energy. https://doi.org/10.1016/j.apenergy.2017.07.010

Fonseca, J. A. (2016). "Energy efficiency strategies in urban communities: modeling, analysis, and assessment." ETH-Zürich, Zürich: Doctoral Thesis.

Ghiasvand, A.; abdolshah, F. (2015). The concept and measurement of economic Resilience. Economics Research, 15(59), 161-187.

Jesse, B. J., Heinrichs, H. U.; Kuckshinrichs, W. (2019). Adapting the theory of Resilience to energy systems: a review and outlook. Energy, Sustainability and Society, 9(1), 27. https://doi.org/10.1186/s13705-019-0210-7

Kabachi, E. Ressaiepour, M. (2017) Urban Resilience: Presenting a Conceptual Model of Urban Planning and Management, Specialized Scientific Journal of Architecture Volume Cover of the first year - number one, number 1.

Kruyt, B., van Vuuren, D. P., de Vries, H. J.; Groenenberg, H. (2009). Indicators forenergy security. Energy policy, 37(6),2166-2181. https://doi.org/10.1016/j.enpol.2009.02.006

Leon, J., March, A. (2014). Urban morphology as a tool for supporting tsunami rapid resilience: A case study of Talcahuano. Chile, Habitat International, 43:250-262. https://doi.org/10.1016/j.habitatint.2014.04.006

Maclean, K., Cuthill, M.; Ross, H. (2014). Six attributes of social Resilience. Journal of Environmental Planning and Management, 57(1), 144-156. https://doi.org/10.1080/09640568.2013.763774

Marana P, Eden C, Eriksson H, Grimes C, Hernantes J, Hawick S, Pyrko I., (2019). Towards a resilience management guideline-Cities as a starting point for societal Resilience. Sustainable Cities and Society, 101531. https://doi.org/10.1016/j.scs.2019.101531

Matsumoto, K. I., Doumpos, M.; Andriosopoulos, K. (2018). Historical energy security performance in EU countries. Renewable and Sustainable Energy Reviews, 82, 1737-1748. https://doi.org/10.1016/j.rser.2017.06.058

Matzenberger, J., Hargreaves, N., Raha, D; Dias, P. (2015). A novel approach to assess the Resilience of energy systems.International Journal of DisasterResilience in the Built Environment,6(2), 168-181. https://doi.org/10.1108/IJDRBE-11-2013-0044

Mayunga J.S. (2007). Understanding and Applying the Concept of Community disaster resilience: A capital-based approach, a draft working paper prepared for the Summer Academy for social vulnerability and resilience building, 22 - 28 July 2007, Munich, Germany.

Mitchell, G. (2005). "Urban development, form, and energy use in buildings: A review for the Solutions project." Solutions and EPSRC Consortium.

Razovian, M. T; Mozen, S; Qorchi, M. (2017). Providing a conceptual framework for assessing urban energy resilience to achieve sustainable cities, the first conference on competitiveness and the future of urban developments.

Rezaei, M, Gurbanpour, A. (2018). Evaluation and analysis of dimensions and components of urban energy resilience with structural equation modeling approach (case study: Bushehr city). Scientific-Research Quarterly Journal of Economics and Urban Management; 7 (28): 21-40

Ross, H.; Berkes, F. (2014). Research approaches for understanding, enhancing, and monitoring community resilience. Society & Natural Resources, 27(8),787-804. https://doi.org/10.1080/08941920.2014.905668

Sharifi, A.; Yamagata, Y. (2016). Principles and criteria for assessing urban energy resilience: A literature review. Renewable and Sustainable Energy Reviews, 60, 1654-1677. https://doi.org/10.1016/j.rser.2016.03.028

Sovacool, B. K. (2011). Evaluating energy security in the Asia pacific: Towards a more comprehensive approach. Energy Policy, 39(11), 7472-7479. https://doi.org/10.1016/j.enpol.2010.10.008

Sovacool, B. K.; Mukherjee, I. (2011). Conceptualizing and measuring energy security: A synthesized approach. Energy,36(8), 5343-5355. https://doi.org/10.1016/j.energy.2011.06.043

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