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# Morphology of the Urban Phenomenon and Its Relation with Urban Livability

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## ABSTRACT

The livability of a city is a crucial aspect that greatly influences the well-being of its residents, and its relationship with the city's morphology is significant. This study aims to examine the correlation between block livability and block form. In the first step, the goal is to propose a quantitative model, the "Livable Block Index (LBI)," to measure the level of livability. The LBI considers the multi-functionality of urban zones as a key factor in measuring block livability, analyzing both the variety of uses within each lot and the distribution of uses across the block. Additionally, the study investigates the form of urban blocks, considering their area, shape, and proportions. The proposed model is applied to specific districts in Tehran, using Grasshopper for data modeling, visualization, and analysis. Initial findings reveal a meaningful relationship between block form and livability levels; however, it is apparent that a comprehensive understanding requires the consideration of additional parameters. Further research is necessary to develop a more comprehensive view of the correlations between urban block form and livability.

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# 1. Introduction

Reviewing the officially documented history of cities reveals that the morphology of urban phenomena influences human behavior and the way cities operate (Samy, 2023). In other words, the city is a dynamic environment for social interactions and public life. The public life and social well-being of cities can be translated to livability, which is naturally a qualitative aspect of cities that can be quantified [1]. A livable city is achievable through improving the quality of the city's structure, which will help cities become more sustainable, safe, mixed-use, walkable, attractive, and alive [2].

In this study, the primary objective is to examine the influence of urban morphology on livability. To achieve this goal, a clear definition of urban morphology and livability will be established. Subsequently, each parameter will be measured to quantitatively assess the qualities of urban phenomena and their relationship with livability. The study of urban morphology is a part of the study of the physical characteristics of cities and, in its own right, is related to the aggregations and configurations of building types that are the results of an evolutionary process of urban activities [3]. Livability, on the other hand, pertains to the qualitative aspects of cities that contribute to the overall quality of life and well-being of their inhabitants. It encompasses elements like sustainability, safety, mixed land use, walkability, attractiveness, and vibrancy.

In recent years, there has been notable academic interest in quantifying urban livability, although the development of a comprehensive theoretical framework for its quantitative evaluation remains challenging [4].

For instance, Jane Jacob's qualitative perspective suggests that characteristics such as mixed land use, small blocks, diverse historical buildings, and appropriate building densities contribute to improving livability in cities [5]. Similarly, Alexander argues that modern planning, with its emphasis on functional zoning, has led to the creation of single-use urban zones that negatively impact the livability of cities [6].

In addition to the qualitative definition and parameters of livability mentioned earlier, there are suggestions for measuring livability that focus on specific factors. For instance, a study conducted by Frost [7] reveals that reducing travel time between residential areas in urban settings contributes to increased livability. The study evaluated commuting time by considering annual vehicle miles traveled between urban and suburban areas. However, it is important to recognize that such analyses may vary depending on factors such as time of year and season while emphasizing multi-functionalism.

The modernist approach to urban planning has promoted functional segregation, resulting in fragmented and discontinuous city dynamics [8]. Opponents of mono-functional urbanism argue that one of the advantages of creating mixed-use urban settings instead of mono-functional urban zones is reducing travel times for city residents and transforming vehicle-oriented urban lifestyles into more walk-oriented alternatives. In short, cities that benefit from mixed-use neighborhoods are more walkable. On the other hand, cities as hubs of social life benefit from multi-functionality, as mixed-use neighborhoods would effectively support more face-to-face interactions among the residents [9].

Consequently, in this article, multi-functionalism is regarded as a valid criterion for evaluating the livability of cities. As such, applied methods and contributing factors for evaluating urban multi-functionalism are important to discuss. Recently, numerous methods for measuring urban multi-functionality have emerged. The most widely used method, coined entropy, is a method that measures the degree to which various functions occur equally within a given area [10]. As a method of quantitative evaluation, entropy is criticized due to the fact that it merely evaluates the balance of occurrence of various functions within a given area rather than addressing the effective mixture and coexistence of these differing functions. It means that by adding a new function to an already existing mixture of functions within a given urban area, the degree of entropy of the resulting mix will be reduced because of the lack of equivalence [11].

More recently, the Mixed-Use Index (MXI) has been developed to assess the degree of mixed functions in a quantitative way. The MXI model measures the ratio of residential, working, and amenity functions per square meter in a given urban zone. In this model, the ratio of residential and non-residential uses should be equal for the purpose of achieving the desired level of livability [12].

Recently, there have been numerous spatial models for analyzing the properties of each urban block. One of the recent frameworks in this regard is Spacematrix, which was developed to measure urban density as it relates to urban form or morphology. In this model, density is related to the built mass, which uses the floor space index, ground space index, and network density as analytical criteria [13].

Some researchers claim that urban density and urban form are independent of each other [14]. That is, density is more a result of the typology of the buildings in a block. Meaning that the size, shape, and proportion (known as morphology) of a block are not considered in this model.

This is in line with research initiatives that perform at multiple scales and show how the morphology of the built environment (block form) can be effectively related to the land uses and patterns within which they mix and their impact on the livability of the cities in question [15]. We stand by the proposition that creating an appropriate size of the urban block and improving the level of multi-functionalism would reduce the need for travel, increase walkability, and increase the intensity of public life that causes livability in the cities [16]. Hence, we believe that studying the urban block form in terms of its physical characteristics to improve the level of livability is valuable.

To validate the proposed model, the city of Tehran as a vibrant metropolitan city is surveyed. Today, Tehran is experiencing rapid expansion, which causes uncontrolled, unplanned, and uncoordinated development [17]. This rapid growth will continue with greater intensity in the following decades [18]. The different stages of development in Tehran have prompted various zones in terms of urban morphology. Each and every zone hosts different socioeconomic activities that may have a straightforward relationship with the diversity of block forms. In its current condition, livability in the city has become crucial due to a lack of pedestrian zones, the inefficient allocation of spaces for social interaction, and the need for cross-city travel to handle the daily needs of the city's inhabitants [19].

The study then explores the correlation between livability and urban block form quantitatively. As already discussed, the multi-functionality of an urban setting is utilized to measure the level of livability. To arrive at presentable results, firstly, the index of multi-functionalism is measured in each block as a percentage. Secondly, the degree of mix distribution in a given block is considered, and then the physical characteristics of an urban block in terms of its size, shape, and proportion are estimated. Ultimately, the relationship between the percentage of mixed uses and the pattern of their distribution in each urban block is evaluated against the physical properties of the block to draw meaningful correlations. In summary, our contribution can be summarized in three ways:

- Quantifying the livability of an urban area
- Identifying and measuring three parameters of urban block form: block area, block proportion, and block shape
- Investigating the correlation between livability and urban block form

# 2. Research Method: Quantification of Urban Livability and the Urban Block Form

In this quantitative evaluation, four parameters are considered for each urban patch: proportion, total area, shape, and livability of blocks. The first three parameters are for calculating the form of the urban block in different ways, and they will be compared with the level of livability. To ensure comparability between all urban patches, the same data modeling, analysis, and visualization system is set up in Grasshopper. In the following sections, the method for evaluating these parameters and the method used to generate maps, diagrams, and sorted arrangements of blocks will be discussed.

## 2.1. Livable Block Measurement

The very definition of livability suggests that a multifunctional block could be considered a livable block [20]. Therefore, multifunctionalism is used as a criterion to evaluate the percentage of livability. A multifunctional block hosts two or more functions simultaneously, such as residential, commercial, cultural, or industrial [2, 21]. However, livability is not solely related to the existence of a variety of functions within a block but also to the noticeable and effective intensity of human presence [22, 23].

Accordingly, the Livable Block Index (LBI) is developed with the purpose of measuring livability in a given block. The LBI model deals with the degree of livability in a quantitative way in terms of two parameters: firstly, the percentage of mixed-use lots in each block that corresponds to the variety of uses in a block; and secondly, the distribution of mixed-use lots in the block, which is generally related to human permeability.

### 2.2. Livable Block Index (LBI)

The LBI model defines livability as the existence of mixed-use urban blocks with an appropriate range of mixed-use patch distribution. The first step in obtaining the desired results was to record land uses within an urban block through a field survey. Land uses were categorized into five groups: mixed-use (co-existence of two or more functions within a single lot), residential, commercial, official, and services. Survey groups colored each lot in the center based on its associated land-use hue. The image was then utilized to assign a quantitative value to each lot in Grasshopper. Based on block division topology, for each lot, the neighboring lots with edges in common were determined. As seen in Fig. (**1**), if the land use value of the lot is different from any of the neighbors, the lot is assigned as livable.

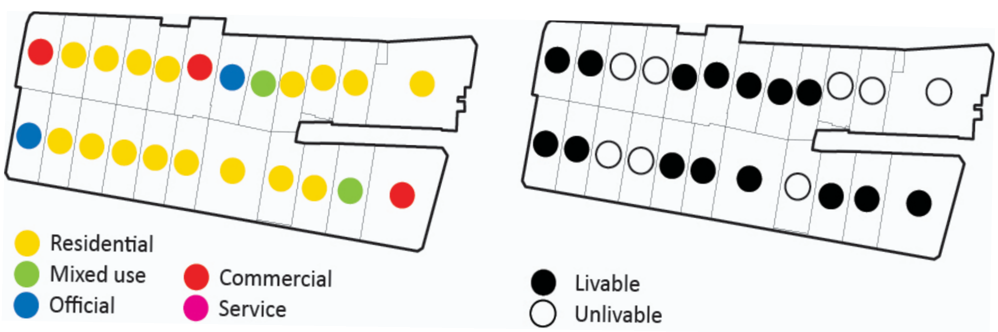


**Figure 1:** Illustrating the land use of each lot based on the field survey (left) to find livable and unlivable lots based on their land use dissimilarity to neighboring ones (right).

At this point, the evaluation of the number and total area of livable lots within a given urban block is complete. However, it is also important to consider the pattern of distribution of livable lots and the physical range of their effectiveness in each block. To accomplish this, we consider a 1-meter offset for each livable lot, which represents its range of effectiveness, as shown in Fig. (**2**).

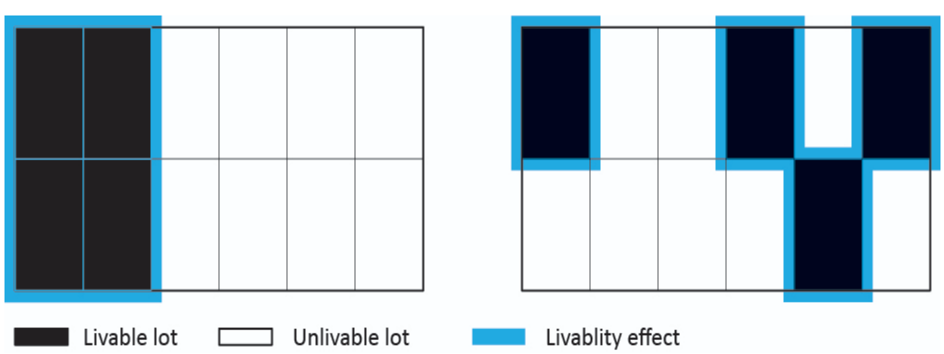


**Figure 2:** Study the distribution of livable lots within the block and their respective areas of effectiveness.

It is important to mention that the calculation of the total area for livability only considers the portion of the offset that falls within the block. To calculate the livable block index, we combine the total area of livable blocks and their inner offset, dividing them by the total area of the block. This calculation provides us with the livable block index metric, as depicted in Fig. (**3**).

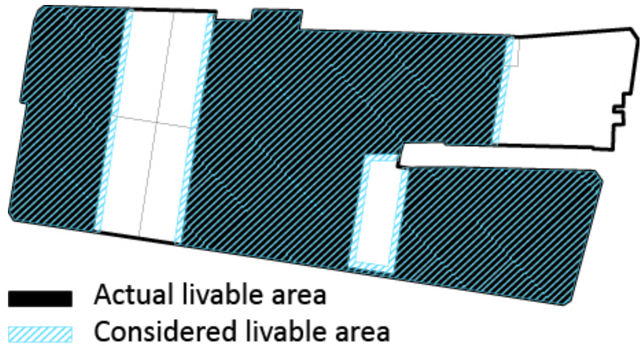


**Figure 3:** The area considered for the livability index calculation is the 1-meter offset of livable lots as long as they are still within the actual boundary of the block.

## 2.3. Evaluating the Total Area, Proportion, and Shape of the Urban Blocks

The block area is calculated using the precise block boundary, but due to the irregular shapes of most blocks, proportion values are estimated. One approach to determining the proportion involves finding the fittest bounding box for the block, although this method becomes inefficient for larger urban areas due to lengthy processing times. Instead, an alternative method is employed. It begins by generating the shortest line from the block center to its convex hull. By extending this line to reach the other side of the convex hull, the shortest edge of the bounding box is obtained. The second edge is obtained by rotating the line 90 degrees around the center and repeating the process. The block proportion is then derived by dividing the width of the bounding box by its length, resulting in a value between 0 and 1. Please refer to Fig. (**4**) for a visual representation.

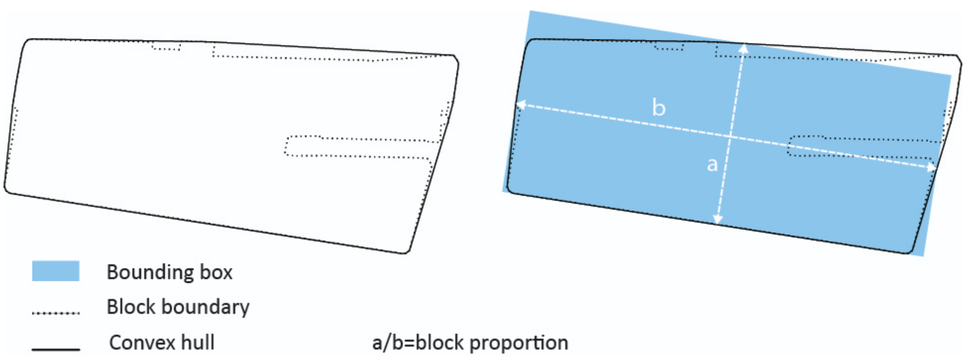


**Figure 4:** Method of generating a bounding box based on a convex hull and calculating block proportion.

After defining the block area and block proportion, we move forward to calculating the block shape. The block shape is defined based on the number of intersections formed by the streets surrounding the block. The values of interest for this parameter include 3, 4, 5, 6, and more corners. We manually color each block's center with a different hue for each edge number value, as illustrated in Fig. (**5**). The resulting image is used to extract values from Grasshopper and assign them to each block for further comparison.

## 2.4. Data Visualization

### *2.4.1. Generating Maps*

Once the relevant parameters, including the livable block index, block area, block proportion, and block shape, have been calculated, the subsequent stage involves visualizing them on maps. A unique colored map is generated for each parameter, effectively showcasing the spatial distribution, patterns, and areas of urban blocks with similar parameter values. To enable easier comparison between various urban patches, the range for each parameter is determined by selecting the maximum and minimum values from the comprehensive dataset, which encompasses values from all three study areas.

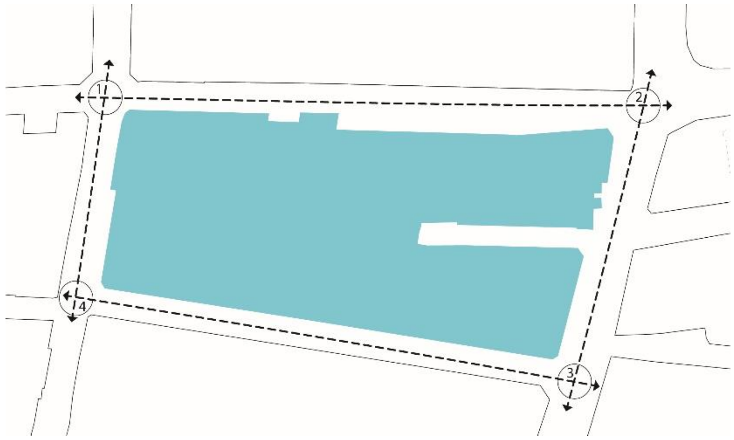

**Figure 5:** Defining block shape based on the intersection of adjacent streets.

### *2.4.2. Sorting Blocks*

To deepen our comprehension of the impact of block area, proportion, and shape on the livability index, we utilized a sorting method inspired by the artwork "Ville Ranges" by Armelle Caron (shown in Fig. **6**). Drawing from her artistic approach, we adapted it as a data visualization tool to unveil novel insights and data patterns within our constructed dataset.

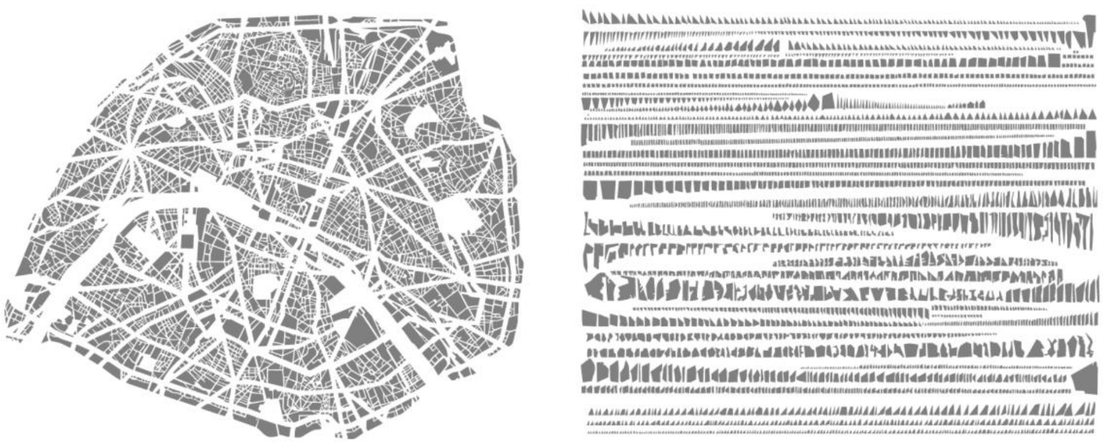

**Figure 6:** Partitioning of the city blocks created by Armelle Caron.

Initially, we classified the blocks into three groups according to their total area, proportion, and shape. Within each group, we further sorted the blocks based on their size. The livability index was used to assign a specific color to each block, providing a visual representation of its livability level. Analyzing the number of blocks in each group allowed us to gain insights into the prevailing characteristics and the distribution of values within each dataset. By observing the livability color gradient, it was possible to visually assess the relationship between the evaluated parameter and the livability index.

### 2.5. Relationship Analysis

To explore the relationship between the livability index and the block area, shape, and proportion, a statistical method known as linear regression was utilized. Linear regression is used to study the relationship between two quantitative variables. In this case, the livability index was considered the independent variable and plotted on the x-axis, while the block area, block shape, and block proportion were the dependent variables. The linear regression is formulated as in Equation (1), which is also illustrated in Fig. (**7**) for further explanation.

$$Y = Mx + C \tag{1}$$

Where X is the independent variable, Y is the dependent variable, M is the slope of the line, and C is the Y-intercept. The slope and Y-intercept are calculated as in Equations (2) and (3), respectively.

$$M = \frac{\sum_{i=1}^{n} \quad (x_i - \underline{x})(y_i - \underline{y})}{\sum_{i=1}^{n} \quad (x_i - \underline{x})^2} \tag{2}$$

$$C = \underline{y} - M \times \underline{x} \tag{3}$$

Where $\underline{x}$ *and* $\underline{y}$ are the average values of x and y variables, respectively.

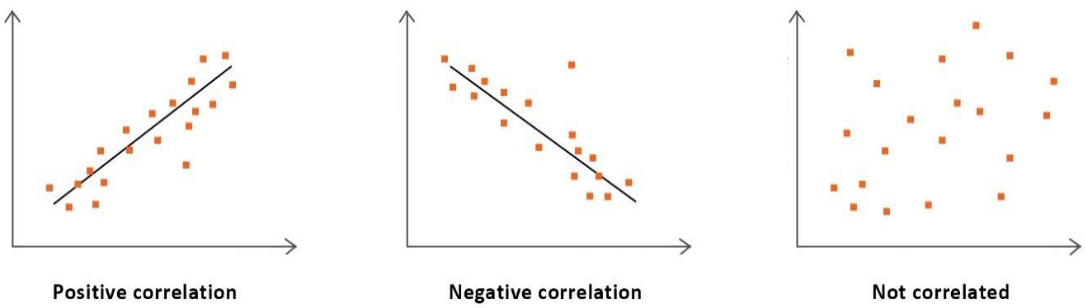


**Figure 7:** Linear correlation.

By analyzing the results of the linear regression analysis, we can determine the extent to which the block area, shape, and proportion influence the livability index. This quantitative analysis provides valuable insights into the relationship between urban livability and the physical characteristics of the urban block form.

# 3. Tehran as a Testbed to Experiment with the Proposed Method

Tehran, a city that is constantly evolving, has experienced significant changes in various aspects, including social, structural, economic-political, and cultural areas, in recent years. Along with these transformations, vehicle movement has become predominant since the late 1960s [24]. Therefore, promoting human interaction in the urban environment has become increasingly important for enhancing public life through shared spaces [25].

What makes Tehran a critical case is the rapid and ongoing nature of its transition. To further evaluate the effectiveness of our proposed method, we have selected three different zones in Tehran as a testbed, as shown in Fig. (**8**). Each zone represents a distinct urban morphology and hosts a different socio-cultural situation, reflecting various stages of urban development in the city.

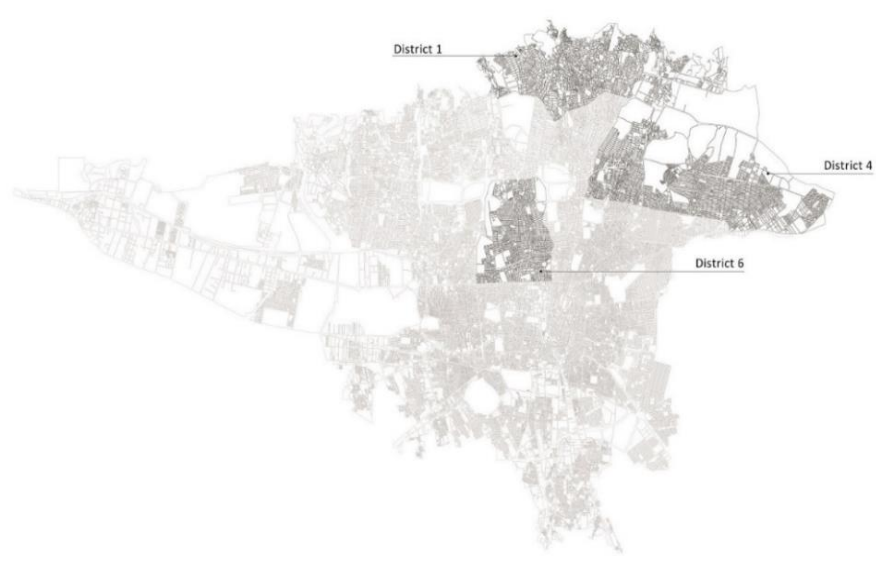


**Figure 8:** Three selected zones of Tehran.

The three selected zones in Tehran provide diverse urban environments for testing the proposed method. The first zone in District 1 is situated in the northern highlands of the city, characterized by an organic urban fabric and abundant natural features like rivers and valleys. This district has become a popular area for real estate development [26].

The second zone in District 4, located in the northeast, was once agricultural land and transformed into a residential area with a high percentage of green spaces. It was developed based on an official plan, with a regular grid as the blueprint for urban development [26]. The third zone in District 6, situated in the center of the city, is one of the oldest parts of Tehran and is known as its cultural hub. It features a variety of urban block forms and functions, including universities, parks, hospitals, and residential areas. District 6 is considered more livable compared to the other districts due to its abundance of amenities and facilities [27]. The selection of these diverse districts ensures the validation of the proposed method and its results.


**Figure 9:** Selected areas of the three chosen districts of Tehran.

# 4. Discussion of the Results

### 4.1. Measurement of Livability for Three Selected Zones of Tehran by Using the LBI Model

The process of measuring livability involved the use of the Livable Block Index (LBI), which was applied to three selected zones across different districts of Tehran. The analysis began with on-the-ground observation and mapping of land use activities in the studied districts, as shown in Fig. (**10**). The objective was to assess the livability of each zone by considering the characteristics of the lots and blocks, focusing on land use similarity and the distribution of mixed-use areas.

Fig. (**10**) visually represents the different activities within the zones, with black points indicating mixed-use areas where two or more activities coexist. Thus, according to our literature review, multifunctionalism could define livability. Therefore, the goal was to determine the number of activities within each block and identify these mixed-use areas for identifying the livable lots.


**Figure 10:** Land use mapping of three studied districts of Tehran.

The synthesis of Fig. (**10**) led to the identification of livable blocks and their areas of effectiveness, as depicted in Fig. (**11**). This figure illustrates the distribution of livable lots based on their land use similarity, where livable lots are represented in black, unlivable lots in white, and affected lots by the livable lots in gray. The figure allows for an easy visualization of the level of livability in each zone.

In Zone 4, there are a considerable number of livable lots distributed throughout the area. It is evident that most livable zones are located close to the streets, while livability decreases as one moves away from the streets and towards the center of the blocks, resulting in a trend towards monofunctionally. A similar pattern can be observed in Zone 6, where there is a higher concentration of livable lots around the perimeter of the zone.

In contrast to the other zones, Zone 1 exhibits a distinct configuration of livable lots attributed to its irregular morphology. While the model consistently indicates a certain level of livability along the main street, there are discernible variations within Zone 1, specifically on the left side, in terms of livability levels. This suggests that the distribution and effectiveness of livable lots in Zone 1 differ from the patterns observed in the other zones. The irregular morphology of Zone 1 likely contributes to these variations, emphasizing the influence of block shape and layout on the livability of the area.

These findings provide valuable insights into the distribution and patterns of livability within the studied zones. The analysis highlights the importance of proximity to streets and the influence of block morphology on the distribution of livable lots and their effectiveness.


**Figure 11:** Finding livable lots based on their land use dissimilarity to neighboring ones.

In the next phase of the study, the livability index was mapped at the block level, considering the aggregation of mixed-use lots and their areas of effectiveness. Fig. (**12**) displays the urban blocks with a blue hue that increases based on the percentage of livable areas within each block. The findings align with the previous observations, indicating that Zone 4 has a higher number of livable blocks compared to the other zones, while the livability in Zone 1 is comparatively lower. In Zone 6, livable blocks are primarily concentrated along the main street, and there is a noticeable decline in livability as one moves away from the main street.

This finding further supports the hypothesis that the livability of individual blocks is strongly influenced by the overall livability of the surrounding streets. The distribution of activities in the zones may not be optimally organized, particularly when there are secondary streets in the neighborhood with limited supportive activities. Most activities in these areas are predominantly residential without sufficient nearby supportive services. It is essential to recognize and incorporate a taxonomy that defines the relationship between different functions and how they can mutually support each other, providing adequate livability for each distinct area. This kind of interpretation comes from the results of the LBI model that facilitates the legibility of a city to understand the problematic issues and find solutions for them.

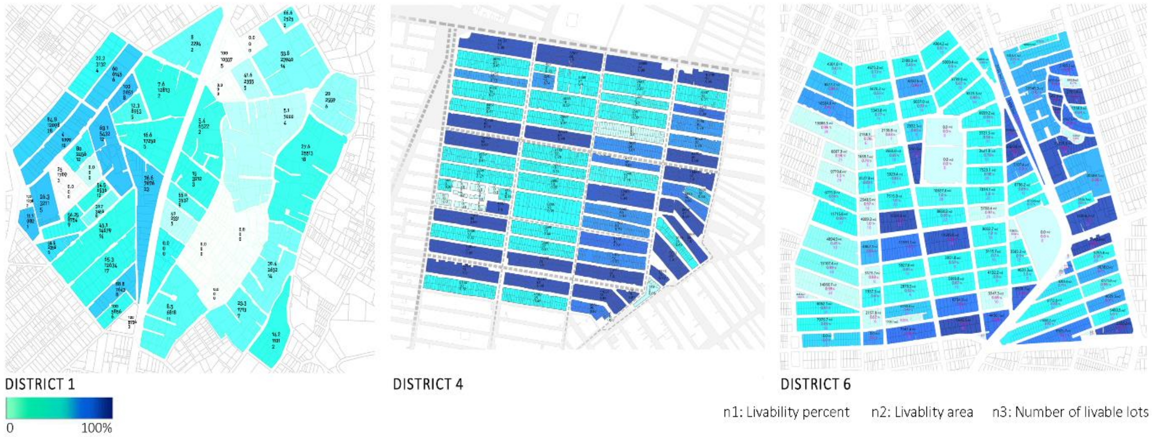


**Figure 12:** Livability percent of the urban block in zones 1 (left), 4 (middle), and 6 (right).

To obtain more comprehensive results in the future, it would be beneficial to consider the parameter of mixed-use in combination with other relevant parameters from additional studies. This would provide a more holistic understanding of livability and support informed decision-making for improving the urban environment.

## 4.2. Urban Block form Measurement

Consequentially, following the assessment of the livability in these three zones, the urban block forms are examined further based on three physical characteristics: size, shape, and proportion. Size represents the total area of a block; shape refers to the number of corners it possesses; and proportion relates to the ratio of its width to length. Fig. (**13**) on the left displays a color-coded representation of the block areas in each zone. We tried to firstly separate each block area with different colors which range from 54 $m^2$ to 71026 $m^2$ for each zone. Then, in Fig. (**13**) on the right, we sorted them based on their area. The smallest area is on the bottom and the largest one moves to the top. Additionally, for each range, for example, for the bottom row, we again sorted them based on size. So, the smallest is closer to the point 0,0. After their arrangement, the livability rate that was calculated in the previous section is applied to each block with a blue gradient to be able to see their livability in accordance with their area. This process continues for each parameter of the urban block form. This visualization aids in comprehending the level of the livability of each block in comparison with its area. Upon a quick glance at the graph in Fig. (**13**), it becomes apparent that the majority of blocks in Zone 1 are larger compared to the other zones, yet their livability is lower. Additionally, it is evident that in Zone 6, the individual blocks have smaller areas compared to other zones, and the livability index varies across different block sizes.

Building on the findings from Fig. (**14**), the relationship between block shapes and livability becomes more apparent. Block shape refers to the configuration of streets within a block, specifically the number of corners where streets intersect. It can vary from three corners, forming a triangle, to blocks with five, six, or even more corners. The shapes of the blocks, as shown in Fig. (**14**) on the left, illustrate the variations across the three districts. Additionally, Fig. (**14**) on the right examines the correlation between block shape and the livability index, revealing intriguing patterns.

Zone 1 is primarily composed of blocks that lack a distinct shape, while District 4 is characterized by a higher prevalence of rectangular blocks. In contrast, District 6 exhibits a noticeable variety of block shapes. These variations in block shapes have implications beyond aesthetics; they impact the overall livability of each zone.

The shape of blocks is closely tied to the number of connecting streets. When the distribution of functions within a zone is appropriate, it tends to attract more people, thereby enhancing livability. Interestingly, the most livable blocks in District 1 tend to have fewer corners, suggesting a relationship between block shape and livability. Irregular block shapes offer advantages by allowing for a greater number of streets, facilitating a diverse range of functions within the same area. This contributes to the potential enhancement of livability.

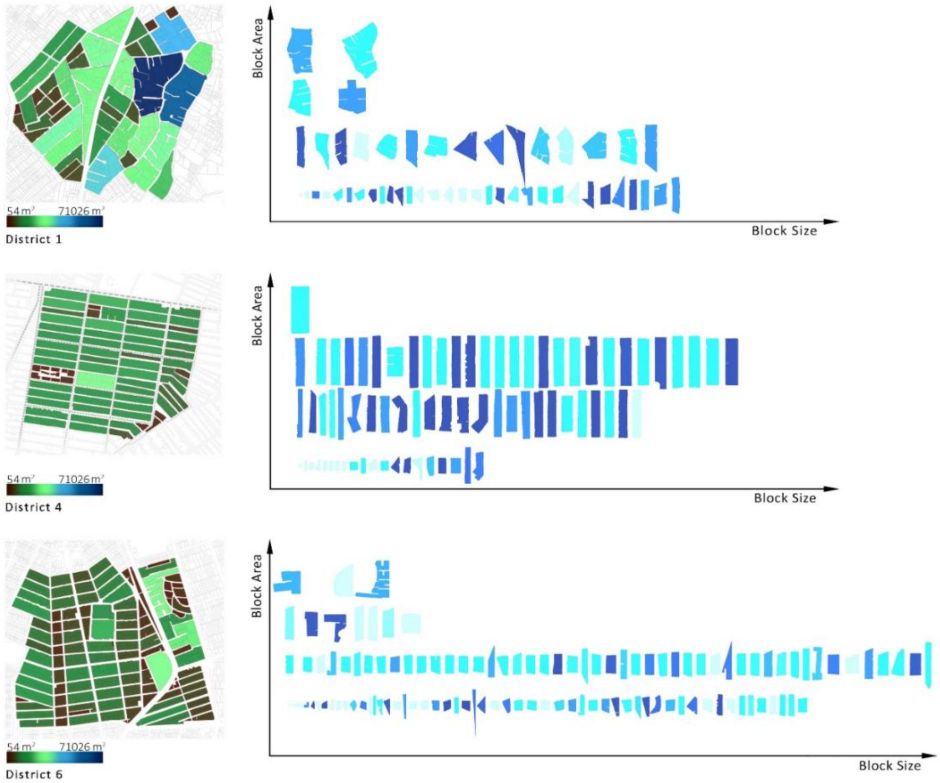


**Figure 13:** left: Block area in districts 1, 4, and 6; right: Block arrangement based on their area.

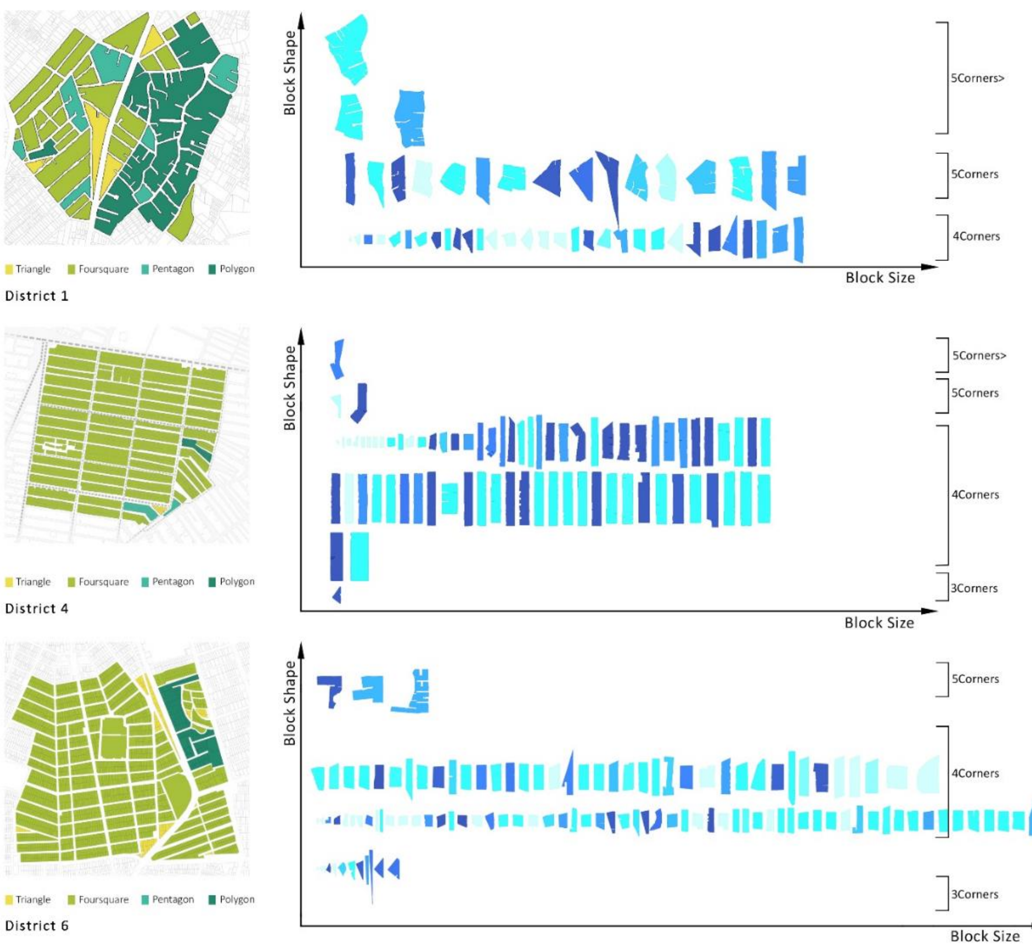


**Figure 14:** left: Block shape in districts 1, 4, and 6; right: Block shape arrangement based on their area.

In summary, the findings from Fig. (**14**) highlight the significance of block shape in influencing the livability index. The relationship between block shapes, street distribution, and the presence of diverse functions emphasizes the potential for improved livability in areas with irregular block shapes and well-planned distributions of functions.

Fig. (**15**) illustrates the block proportion, which is represented by a value ranging from 0 to 1. The left side of the figure shows the actual distribution of block proportions, while the right side visualizes the arrangement of each block based on its proportion, using a blue hue to indicate livability.

In District 1, despite the irregular shapes of the blocks, those with bounding box shapes closer to a proportion value of 1 are found to be more livable. Conversely, in District 4, blocks with elongated rectangular shapes exhibit a higher livability index.

District 6 displays a variety of proportion values among the blocks, and livable blocks can be observed across different block proportions. However, once again, blocks with proportions closer to 1 tend to be more livable. This analysis reveals a consistent pattern across different districts: as the block proportion approaches 1, livability increases.

It is important to note that other parameters influence the level of livability even within blocks of the same proportion. However, as a general observation, narrower blocks tend to offer a higher level of livability. This may be due to the closer proximity of different activities within these blocks, facilitating increased interaction among users and enhancing the overall livability of the area.

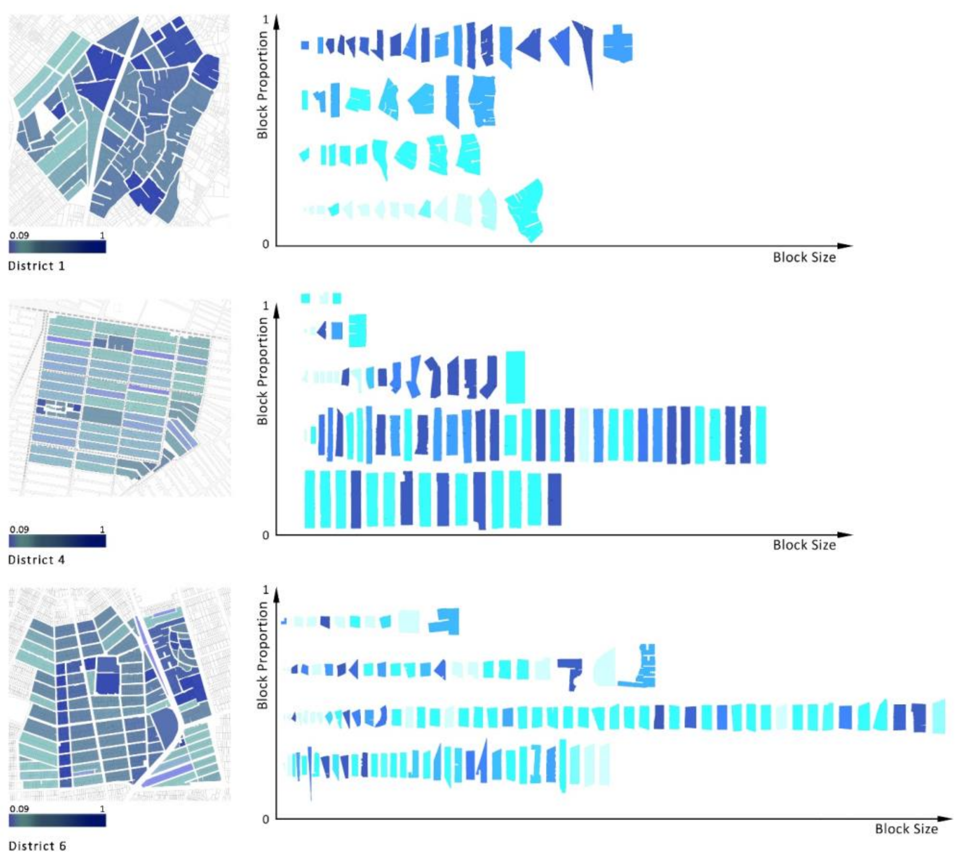


**Figure 15:** left: block proportion in districts 1, 4, and 6; right: block proportion arrangement based on their area.

## 5. Data Analysis Discussion

In this step, the focus is on examining the relationship between block form and livability in each zone. The objective is to determine if there is a meaningful correlation, whether it is ascending or descending, between various parameters of block form and livability. To facilitate this analysis, a computer-based approach utilizing linear regression was employed. A dataset was generated based on the collected data on livability and the analysis of block-form. The following discussion explores the analysis of each block form parameter in relation to livability.

As illustrated, Fig. (**16**) provides an illustration of the relationship between the livability index and block area for the three studied zones in the city of Tehran. Each zone is depicted with a specific color code. Linear regression was utilized to analyze the impact of the livability index on the block area and vice versa. Taking into account the uncertainty in the collected data, linear regression proved to be a suitable method for examining this dataset. From the plotted data, it can be inferred that there is a meaningful relationship between the block area and the livability index, as the trend is ascending. Meaning that, as the block area increases, there is an observed increase in livability. However, it is important to note that the correlation coefficient of this relationship varies across different zones, likely influenced by other parameters at play.

Indeed, it is crucial to recognize that certain zones within a city may have limitations when it comes to having large block areas, highlighting the importance of considering multiple parameters in assessing livability. However, it is worth noting that larger blocks can also provide opportunities for creating more pedestrian-friendly zones, which can contribute to increased livability. Consequently, a holistic analysis that takes into account various relevant factors is necessary to obtain accurate and reliable conclusions. Relying solely on computer-based analyses focusing on a single parameter may not provide a comprehensive understanding of livability and its determinants.

In summary, a comprehensive approach that considers multiple parameters is essential to ensuring the validity and reliability of conclusions regarding livability assessments. By considering factors such as block size, accessibility, distribution of activities, and pedestrian-friendly design, a more accurate understanding of livability can be achieved.

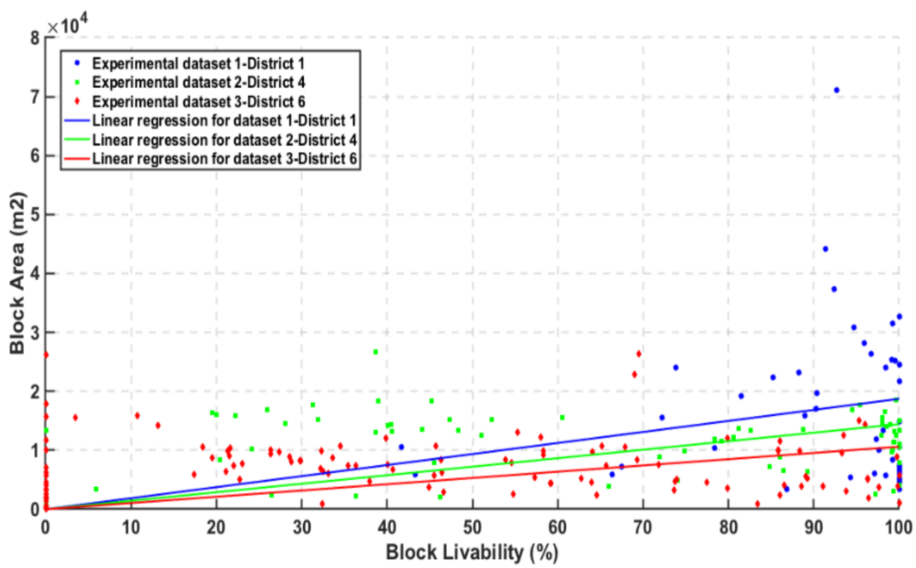


**Figure 16:** Linear regression relation between livability and block area in three studied districts.

Turning to Fig. (**17**), the correlation between block proportion and the livability index is indeed more pronounced. The trend clearly highlights the strong relationship between block proportions and livability. As previously discussed, blocks with proportions closer to 1, indicating narrower shapes, are likely to be more livable. This finding further supports the notion that block proportion plays a significant role in determining the livability of urban areas.

Conversely, moving on to Fig. (**18**), it presents the relationship between block shape and the livability index for the three studied zones in Tehran. Due to the variations in livability values associated with different block shapes, as determined by the number of corners, linear regression was found to be unsuitable for analyzing the dataset.

To enhance readability and interpretation, we processed the livability index values before presenting them in Fig. (**18**). This involved eliminating fluctuations caused by noise or collection errors and calculating average values for each block shape within each zone.

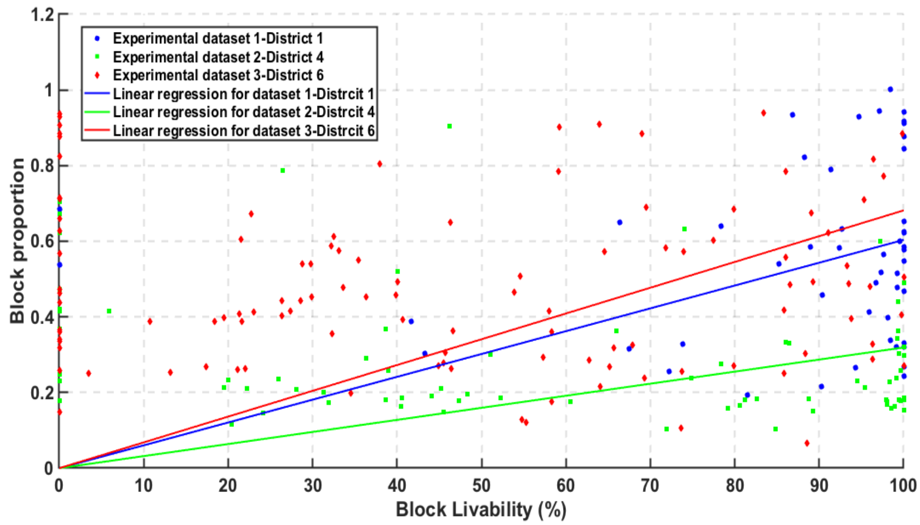


**Figure 17:** Linear regression relation between livability and block proportion in three studied districts.

Based on the figure, although there is no apparent clear ascending or descending trend, certain observations can be made. Blocks with 3 corners display the highest livability index for each zone, whereas blocks with 4 corners exhibit the lowest livability index, especially when compared to blocks with 3 corners. The livability index for blocks with five and six corners shows no significant differences across the three zones. Notably, in zone 1, which consists of blocks with irregular shapes, there is a particularly strong correlation with the livability index compared to the other zones. This finding emphasizes the substantial impact of irregular block shapes on livability in urban areas.

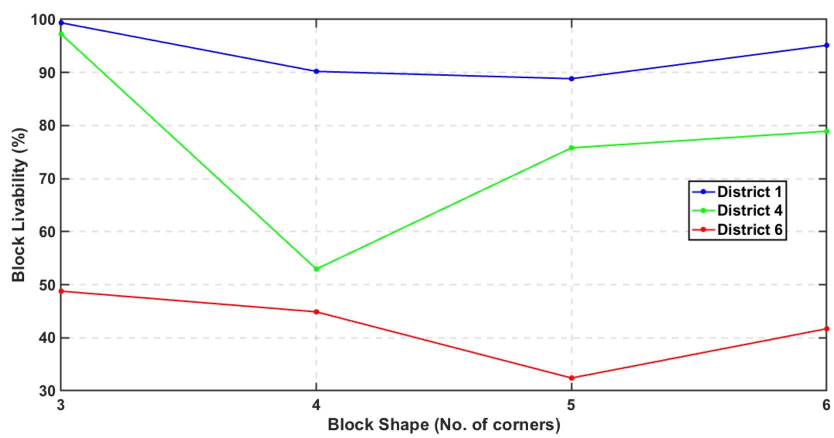


**Figure 18:** Relationship between livability and block shape in three studied districts.

The findings of this study reveal that the livability index demonstrates a stronger correlation with block proportion compared to block area. Additionally, block shape, especially in irregularly shaped areas, significantly impacts the livability index. When evaluating livability, it is crucial to acknowledge the substantial influence of multi-functionalism. In the interpretation of the findings, it becomes evident that higher levels of livability are closely tied to the presence of diverse activities and their effective distribution within urban blocks. Each parameter of the urban block form plays a role in shaping livability by enabling the coexistence and interaction of various activities. Therefore, it is important to understand that an enhancement in livability is not solely attributed to a single activity, but rather arises from the harmonious combination and arrangement of different activities within a block.

For example, in a larger block, higher livability is not solely attributed to a single function, such as residential or commercial. Instead, it is observed when a mix of different functions is aggregated within the block, fostering increased interaction among users. In such cases, creating pedestrian zones near each principal activity within the block can further enhance livability and sustainability, contributing to the overall livability of the city. Similarly, the number of corners in a block also influences livability. Blocks with fewer corners tend to exhibit a higher level of livability because the configuration of activities promotes greater interaction among them. In comparison, a block with more corners may require careful attention to the distribution of activities to ensure they can effectively serve each corner at an equal level. Additionally, narrower blocks offer a higher probability of facilitating interactions among various activities, thereby enhancing livability. Then again, for other types of blocks that are wider, the consideration of their distribution comes up. Therefore, urban block form could play a significant role in shaping livability, and considering this parameter in designing and planning a city is important enough. However, it is important to recognize that urban livability is a complex and multifaceted phenomenon influenced by a multitude of parameters beyond the three characteristics explored in this study.

Moreover, the application of linear regression not only quantifies the relationship between the livability index and block physical characteristics but also enables predictions for blocks beyond the studied dataset's range of area and proportion. This method holds value in future city design by considering and evaluating each parameter that influences livability.

When examining existing studies that analyze livability, it becomes evident that a comprehensive examination of effective parameters for livability is lacking. For instance, the entropy model, which emphasizes the balance between different activities [10], fails to consider the possibility that adding an activity to a specific area could enhance its livability while simultaneously reducing overall entropy. Similarly, Frost's study [7] that measures travel time to assess livability overlooks the fact that different activities can have varying impacts depending on the time of day and the user type. In contrast, our model concentrates on the physical characteristics of the city, establishing a foundation for activating facilities and services through the configuration and availability of diverse activities. Thus, our objective is to propose a comprehensive model that not only identifies challenges within cities but also aids urban designers in creating more livable and sustainable urban environments.

To further enhance the validity and applicability of this study, it is crucial to validate the findings across different cities and incorporate additional elements. This will contribute to the development of a more comprehensive model that can effectively address the complexity of urban environments. By considering all relevant parameters, we can ensure that cities operate in a more efficient and sustainable manner. Therefore, it is necessary to conduct further research to expand and refine this study, ultimately creating a more comprehensive model that effectively addresses the multifaceted nature of urban environments. This will provide valuable insights and guidance for urban planners and designers in their efforts to create livable and sustainable cities.

# 6. Conclusion

In conclusion, this article employs the LBI model to quantify livability by calculating the level of multi-functionality as a crucial factor. By examining the correlation between the livability index and three physical characteristics of urban blocks, this study sheds light on the intricate relationship between morphology and urban livability at the neighborhood level. From this study, we understand that there is a meaningful relationship between urban morphology and livability. However, it is important to note that the study was evaluated for specific districts of Tehran, and therefore, it shows that it can be further extended to other parts of Tehran and also other cities around the world.

When comparing our findings with other proposed models, it becomes evident that variations in activities can have a significant impact on the level of livability, especially when considering the well-organized distribution of these activities. Therefore, it is not only the presence of multi-functionality and the diversity of activities that determine livability but also the careful configuration of each activity in relation to its neighboring areas and streets. This emphasizes the importance of considering the correlations between urban morphology and livability in the design of sustainable and livable cities. By understanding these relationships and incorporating them into urban planning and design processes, we can strive to create cities that are not only functional but also promote the well-being and quality of life for their residents.

The field study highlights the correlation between urban livability and the physical characteristics of the urban fabric, which is well reflected in the proposed analytical model to quantify the concept of livability. This approach can serve as a valuable framework for future investigations that seek to quantify other naturally quantifiable phenomena. Moreover, the development of such a model enables to save time by analyzing different parts of other cities around the world more efficiently.

In summary, while the study provides valuable insights into the relationship between urban livability and the physical characteristics of urban blocks, further research is necessary to validate the findings across different contexts and explore the influence of other relevant parameters. By utilizing this knowledge and building upon future research, we can strive to create urban environments that prioritize the well-being and quality of life of their residents. This collaborative effort involving researchers, policymakers, and communities can contribute to the development of cities that are truly livable, sustainable, and inclusive.

## Conflict of Interest

The authors declare no conflict of interest.

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