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AN EMPIRICAL ANALYSIS OF THE RELATIONSHIP BETWEEN URBAN VITALITY AND SOCIOSPATIAL CHARACTERISTICS: CASE STUDY OF ANKARA METROPOLITAN AREA

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ETHICAL STATEMENT

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(M. Sc. Thesis)

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ABSTRACT

Urban vitality is an important indicator of the success of urban areas, as it can lead to a higher quality of urban areas and satisfaction for residents. However, many socio-spatial issues, such as poor accessibility, urban sprawl, land speculation, lack of urban services, and safety issues, threaten human well-being and the vitality of urban areas. This thesis seeks to empirically identify the factors associated with urban vitality and provide recommendations for improving it in Ankara Metropolitan Area. The method of the study is based on correlation analyses and regression models that analyze the association between socio-spatial variables, such as sociodemographic characteristics, street configuration, density, and urban services with the density of food and catering businesses, which was used as an urban vitality indicator. The study found that variables such as population density, building intensity, chain markets, and sports and cultural facilities are positively associated with urban vitality, while large distances from metro stations and city centers are negatively associated. Furthermore, sociodemographic characteristics such as income levels, land prices, education levels, and population ages are significantly associated with urban vitality. The results also show that the overall level of vitality is higher in older urban areas and lower in sprawling suburban areas. The thesis' findings are useful for urban planners and policymakers as they build a bridge between vitality and socio-spatial characteristics in urban areas empirically and provide insights into important urban vitality factors, which can be used to develop policies to enhance the success and quality of urban areas.

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KENTSEL CANLILIK VE SOSYOMEKÂNSAL ÖZELLİKLER ARASINDAKİ İLİŞKİNİN AMPİRİK BİR ANALİZİ: ANKARA BÜYÜKŞEHİR BÖLGESİ ÖRNEĞİ

(Yüksek Lisans Tezi)

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ÖZET

Kentsel canlılık, kentsel alanların başarısının önemli bir göstergesidir; çünkü kentsel alanların daha kaliteli olmasını ve yaşayanların memnuniyetinin artmasını sağlayabilir. Bununla birlikte, zayıf erişilebilirlik, kentsel yayılma, arazi spekülasyonu, kentsel hizmetlerin eksikliği ve güvenlik sorunları gibi birçok sosyo-mekansal sorun, insan refahını ve kentsel alanların canlılığını tehdit etmektedir. Bu tez, ampirik olarak kentsel canlılıkla ilişkili faktörleri belirlemeyi ve Ankara Büyükşehir Bölgesi'nde kentsel canlılığı iyileştirmek için öneriler sunmayı amaçlamaktadır. Çalışmanın yöntemi, sosyodemografik özellikler, sokak konfigürasyonu, yoğunluk ve kentsel hizmetler gibi sosyo-mekansal değişkenler ile kentsel canlılık göstergesi olarak kullanılan olan yiyecek ve içecek işletmelerinin yoğunluğu arasındaki ilişkiyi analiz eden korelasyon analizlerine ve regresyon modellerine dayanmaktadır. Çalışma, nüfus ve bina yoğunluğu, zincir marketler ve spor ve kültürel tesisler gibi değişkenlerin kentsel canlılık ile pozitif olarak ilişkili olduğunu, metro istasyonlarına ve şehir merkezlerine olan uzaklık mesafelerin ise negatif olarak ilişkili olduğunu bulmaktadır. Ayrıca, gelir seviyeleri, arazi fiyatları, eğitim seviyeleri ve nüfus yaşları gibi sosyodemografik özellikler, kentsel canlılık ile önemli ölçüde ilişkilendirilmiştir. Sonuçlar aynı zamanda genel kentsel canlılık seviyesinin gelişimi eski olan bölgelerde daha yüksek ve kentsel yayılma olan bölgelerde daha düşük olduğunu göstermiştir. Tezin bulguları, ampirik olarak kentsel alanlarda canlılık ve sosyo-mekansal özellikler arasında bir ilişki kurdukları için şehir planlamacılar ve politika yapıcılar için yararlı ve kentsel alanların başarısını ve kalitesini artırmaya yönelik politikalar geliştirmek için kullanılabilecek önemli kentsel canlılık faktörlerine ilişkin bulgular sağlamaktadır.

Bilim Kodu : 80208
Anahtar Kelimeler : Kentsel canlılık, mekânsal regresyon, sosyodemografik, arazi kullanım karması, erişilebilirlik, sokak merkeziliği, Ankara
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1. INTRODUCTION

According to United Nations statistics, the percentage of the world's population living in urban areas will increase from around 55% in 2018 to around 68% in 2050 (United Nations [UN], 2018). Moreover, cities are important nodes in global economic and political networks and generate 80-95% of global GDP at a steady rate (Fang, Shi & Gao, 2021).

Successful cities often offer a balance between organized and definable urban forms and places of varied activities, social connections, and transactions. What seems like a mess to some is often just the daily practices of city life. In the absence of such urban activities, cities could easily lose their vitality and consequently become lifeless (Montgomery, 1998). In this regard, urban vitality has been a concern, especially over the past decade. Urban activities emerge from the interaction between people and their urban environment. This means that high-quality vital urban environments that provide people with adequate services and social spaces lead to a higher quality of life and satisfaction in these urban areas.

Urban vitality and sustainability are closely linked and have a mutual relationship; Vibrant urban areas tend to have a strong economy, which can help to support sustainable development by providing new jobs and economic opportunities. Urban vitality also promotes the use of sustainable transportation such as public transportation, walking, and cycling, which can reduce dependence on private cars and decrease greenhouse gas emissions. Therefore, the vitality of urban areas can be considered an important indicator of its success especially from social and economic perspectives.

Many researchers have worked to measure urban vitality and explore the factors that influence it. The physical and built urban environment has been proven to be one of the most important factors influencing the vitality of urban areas. For example, the decline of Detroit, Glasgow, Liverpool, and Leipzig shows a change in their physical environment due to many factors such as population loss, vacancy, and high crime rates; This made their physical environment unable to maintain the urban vitality required for residents (Kim, 2018, cited in Chen, Lang & Li, 2022). Spatial arrangements of urban areas and built environment are considered to be one of the main factors that prevent or stimulate urban problems and, therefore, the quality of urban areas.

Problem definition

Recently, a growing number of socio-spatial issues have emerged and threaten human well-being in urban areas. Some of these problems include poor accessibility, urban sprawl, land speculation, lack of urban services, and safety issues due to low population density and poor surveillance. These urban issues can have negative impacts on the people and vitality of the city; For example, poor accessibility limits economic opportunities and hinders mobility, making it difficult for people to access jobs, education, and healthcare. Urban sprawl leads to increased commuting times and traffic congestion, decreasing productivity and increasing stress levels. Land speculation drives up property prices and results in unequal distribution of wealth, leading to social and economic disparities. Lack of urban services leads to a lower quality of life for residents and hinders the development of local businesses. Safety issues make residents feel insecure and may lead to decreased investment and social activities.

Solving the problems of the urban environment requires holistic approaches because cities are composed of complex structures (Montgomery, 1998). A broader vision of the causes of the urban problems that face cities is necessary to find effective solutions. Solving such problems is not limited to the provision of street furniture and pedestrian crossings. This requires a holistic approach that analyze not only the immediate causes of the problems but also the socio-spatial conditions that contribute greatly to the real root of the problems.

The spatial relationships between urban elements (buildings, roads, etc.) constantly influence the vitality of urban areas and make them or less livable. This has led many researchers to pay more attention to the concepts of livability and vitality, which are shaped and/or influenced by the socio-spatial characteristics of the city. Furthermore, livability and urban vitality are the main indicators of the quality of urban areas; Measurable spatial patterns form the basis for the development of livable and vibrant cities (Martino, Girling & Lu, 2021). Therefore, the study of the urban form and the built environment is a way to objectively assess the relationships between different urban elements and human activities to understand their dynamics and improve urban vitality. Yet few researchers have examined how these patterns and relationships relate to the socio-spatial conditions across the urban setting. For this reason, this thesis aims to build a bridge between vitality and socio-spatial characteristics in urban areas empirically using spatial analysis in order to understand their relationship, identify the factors that are associated with urban vitality, and provide recommendations for improving urban vitality in Ankara.

Aim of the study

This thesis aims at exploring the relationship between urban vitality and the socio-spatial characteristics of Ankara empirically. Urban vitality is the main focus of the study because it was found to be among the main indicators of urban areas' quality. Specifically, finding answers to the following questions is the main objective of this study:

- What is the relationship between sociodemographic characteristics and urban vitality in Ankara Metropolitan Area?
- How does land use mix and spatial characteristics of neighborhoods influence urban vitality in Ankara Metropolitan Area?
- What is the impact of accessibility factors on urban vitality in Ankara Metropolitan Area?
- What policies and implications can be recommended to improve the vitality of Ankara Metropolitan Area?

Previous studies analyzed urban vitality at different levels of analysis. Some studies analyzed the correlation between the characteristics of specific neighborhoods, streets, or buildings and urban vitality at the micro level (Maas, 1984; Gülden Demet & Giritlioğlu, 2008; Zarin, Niroomand & Heidari, 2015; Sung & Lee, 2015; Sung, Go & Choi, 2013; Kim, 2018). Other studies focused on the characteristics of the entire city and how they affect urban vitality at the city level (Ye, Li & Liu, 2018; Zeng, Song, He & Shen, 2018; Zhang et al., 2021; Li, Li, Jia, Zhou & Hijazi, 2022; Liu, Zhang & Long, 2019; Sulis, Manley, Zhong & Batty, 2018).

Many studies showed that urban vitality is affected greatly by local contexts (Zeng et al., 2018; Yue et al., 2021; Awwaad, 2017; Jalaladdini & Oktay, 2012). As a result, it was necessary to empirically analyze the relationship between urban vitality and socio-spatial characteristics in Ankara Metropolitan Area because it would provide insights into the unique socio-spatial factors that contribute to urban vitality in this particular region. By analyzing the specific context of Ankara Metropolitan Area, we can gain a deeper understanding of the factors that influence urban vitality in this area, and how they may differ from other cities around the world. This knowledge can be used to inform urban planning and policy decisions aimed at promoting sustainable and livable urban environments in Ankara, as well as other cities facing similar challenges.

Ankara is chosen as a case study for many reasons; As the capital, it has the second largest population in Türkiye. It also ranks second among other cities in the country, especially in terms of the degree of urbanization, the share of employment, literacy, university degree, and gross domestic product (Ozuduru, Varol & Ercoskun, 2014; Turkish Statistical Institute [TURKSTAT], 2021). The urbanization process of Ankara failed to produce solutions to sociodemographic and urban problems such as social segregation, urban sprawl, land speculation, and lack of vitality in the new-development areas of the city (Saafan & Ozuduru, 2022) despite all planning efforts. This was mainly because of the vague growth direction of the city (Cengiz et al., 2022) and urban planning policies that have been inconsistently changing since the creation of the first urban plan of the city in 1929 (Batuman, 2013). These problems affect the quality and vitality of urban areas in the city negatively.

The study area in this thesis includes 378 neighborhoods which are typical representatives of the central and more urbanized urban neighborhoods of Ankara, with more than 1000 inhabitants per neighborhood. They are distributed in 9 central districts of the city (Çankaya, Yenimahalle, Gölbaşı, Etimesgut, Keçiören, Sincan, Mamak, Altındağ and Pursaklar) with a total study area of approximately 1 112,9 km^2 (111 289,7 ha) and a total population of 5 139 207 in 2021. These 378 neighborhoods were selected to provide a comprehensive understanding of the relationships between the socio-spatial characteristics and urban vitality in Ankara Metropolitan Area.

Method

This thesis followed specific steps to answer the research questions. The first step was to review the literature on urban quality, built environment and vitality. The relationship between these concepts is complex and multidimensional. The built environment, which includes the physical structures and spaces in a city, can have a significant impact on the quality of urban areas; A high-quality built environment can contribute to a sense of vitality by promoting social interaction, physical activity, and access to essential services and amenities. Conversely, a poor-quality built environment can negatively impact the quality of urban areas by limiting access to basic necessities and opportunities for social engagement. Urban design, planning, and policies can play a key role in shaping the built environment and promoting urban vitality. For this reason, reviewing the literature on these concepts provided empirical insights into their mutual relationship.

Urban vitality literature showed that certain measures can be used as urban vitality indicators. The density of small food and catering businesses was used as an indicator to quantitatively explore urban vitality in the city of Ankara, although they may not reflect all aspects of the vital urban areas (Ye et al., 2018). Several exploratory quantitative and spatial analyses were carried out to create a comprehensive understanding of the city's overall vitality. Additionally, 26 attributes of socio-spatial characteristics were defined and grouped into three categories to better understand urban environment of the city. These categories are the socio-demographic characteristics, land use mix characteristics, and accessibility factors. Multiple exploratory and spatial analyses were also used to understand the urban form of the city and the spatial pattern of each study variable. To investigate the relationship between urban vitality and the socio-spatial characteristics of the city, correlation analyses and a series of regression models were employed.

The study identified several socio-spatial characteristics significantly associated with urban vitality in Ankara, including urban density, street configuration, and urban services. Accessibility factors, such as proximity to public transportation and distance from the city center, were also found to be correlated with urban vitality. The study indicates that older areas with compact development and higher land use mix have higher levels of urban vitality. Moreover, higher income, land prices, and education levels were found to be associated with higher levels of urban vitality. The results have important implications for urban planning and development, emphasizing the need for compact, mixed-use development and accessible public transportation to promote urban vitality.

Structure of the thesis

Apart from the introduction and references' chapters, the core of this thesis consists of four chapters that contribute to fulfilling the aim of the study:

The first chapter is a comprehensive review of the literature regarding the relationship between quality of urban areas, built environment, and vitality. This chapter is composed of three main sections: First, different criteria that define the quality of urban areas in reviewed. Then the concept of urban vitality and its relation to other important concepts such as livability and viability is introduced. In this section, the indicators and criteria of urban vitality, including Jacobs' (1961), are described as well. Jacobs' urban vitality criteria (1961) were revisited recently by many researchers because they provide a useful framework, which is still valid nowadays, for assessing the vitality of cities (Sung & Lee, 2015; Delclòs-Alió & Miralles-Guasch, 2018; Fuentes et al., 2020; Banchiero, Blečić, Saiu, & Trunfio, 2020; Gómez-Varo, Delclòs-Alió, & Miralles-Guasch, 2022).

Measuring urban vitality has been an interest of many researchers recently (Sulis et al., 2018; Kim, 2018; Chen, Wu, & Biljecki, 2021; Garau, & Annunziata, 2022; Wu, Ye, Gao, & Ye, 2023); In this section, a further exploration of the indicators and analysis methods of urban vitality was conducted in order to identify effective and suitable indicators and analysis methods for the case study of Ankara.

The following chapter explains the study method in detail. It defines the study area, its urban form, and development processes along with introducing the materials and data sources, and the analysis methods. The results' chapter presents the results of the spatial analyses of urban vitality, socio-demographic characteristics, land use mix, and accessibility. Additionally, the findings of the correlation analysis and regression models are also discussed.

The last chapter provides a summary of the thesis, discusses the implications of the findings, and suggests policies to improve urban vitality in Ankara Metropolitan Area.

2. THE RELATIONSHIP BETWEEN QUALITY OF URBAN AREAS, BUILT ENVIRONMENT AND VITALITY

The quality of urban areas is an important issue in urban planning. It can help overcome urban problems and improve human satisfaction. Thus, increasing urban areas' quality in cities is a very important topic for urban planning. The quality of urban areas is a concern for many people nowadays because of the increasing population and fast urbanization processes. At the same time, city's forms are changing to make space for new residents. Therefore, we should evaluate the relationship between the built environment and urban areas' quality in cities. By doing so we can play a vital role in guiding urban development to a more sustainable one. For this reason, studies about how the built environment shapes the quality of urban areas have gained increasing focus in the literature (Mouratidis, 2021).

Sustainable development considers meeting the needs of the people living nowadays without ignoring the needs of the coming generations (Nikoofam & Mobaraki, 2020). The satisfaction of individual needs is a prerequisite for urban sustainability and also creates human "well-being". Thus, it is of great importance for achieving a high quality of urban life. Therefore, environmental, social, and economic aspects should be taken into account to achieve sustainable development while meeting unforeseeable future demands. This means that the concepts of quality of urban areas and sustainability are connected.

Traditionally, the quality of urban life has been associated with four themes of related psychological studies and public policies, namely: the level of individual satisfaction, health, objective indicators of life quality, and sustainable development (Nikoofam et al., 2020). Urban sustainability should take into account both the objective and subjective indicators of quality of urban areas. Examples of objective indicators include access to basic services such as housing, employment, public transportation, education, and healthcare. Examples of subjective indicators include safety and how satisfied the individuals are with their overall urban environment. Urban sustainability should strive to improve both objective and subjective indicators of quality of urban areas in order to ensure a high quality of life for all residents (Nikoofam et al., 2020).

The features of urban areas play an important role in the quality of urban areas for its inhabitants. Factors such as livability, vitality, and identity are crucial for understanding the relationship between people and their living environment. These concepts are often discussed in urban planning and environmental psychology to highlight the importance of place perception in shaping social dynamics and decision-making (Li, Jia, Lusk & Larkham, 2020). To improve the quality of urban areas, planning principles such as mixed-use, vitality, diversity, pedestrian-friendly, accessibility, and decent transportation have been integrated into urban design. These principles are believed to positively contribute to the livability, vitality, and identity of a place, which ultimately leads to a more sustainable and better quality of urban areas for the inhabitants.

High place satisfaction is associated with people's high preference for that place; People prefer to stay in such places longer and do different urban activities (Li et al., 2020). In other words, the vitality of a place is considered to be a key indicator of high place satisfaction and place quality, which is a key sign of the quality of its urban built environment. In this context, this section focuses on a more detailed examination of the relationship between the quality of urban areas, built environment, and vitality.

2.1. The Quality of Urban Areas

The concept of quality of urban areas has become increasingly important with the increase in urban population worldwide. It is important because of its intersection with other key concepts. Some of these concepts are sustainability, viability, and vitality. The bodies that are involved in managing and operating the urban areas should pay attention to the complexity of cities and define solutions for the challenges they are facing. In this sense, measuring and analyzing the quality of urban areas can be used as a tool by urban planners to solve those challenges (Velibeyoğlu, 2014). Quality-of-urban-area studies are used for different purposes such as policy evaluation, monitoring of the effect of planning policies in the field, and evaluation of urban design. Additionally, they support restructuring of urban planning and management strategies (Velibeyoğlu, 2014). They also help planners fulfill the needs of different socio-economic groups living in different areas and help them understand how they are satisfied with their urban environment (Velibeyoğlu, 2014).

Moreover, quality of the built environment is one of the main factors influencing the quality of urban areas. The perceived urban qualities of the built environment are major concerns in placemaking, including convenience, safety, accessibility, comfort, desirability, and maintenance. For example, previous studies have shown that environmental satisfaction and quality of place are significantly associated with walking activities in urban areas (Li et al., 2020). Squares, streets, buildings and other physical elements in the built environments are the components of a city for basic social and economic activities, such as housing, work and communication, that physically and cognitively influence the experience in a place (Li et al., 2020). In this context, this section introduces the concepts of quality of the built environment and the quality of urban areas and examines their relationship.

Quality of urban life can have different meanings for different people and includes terms ranging from “welfare” which focuses on individual preferences and to “good place” which focuses on location qualities (Velibeyoğlu, 2014). It can also be assessed relative to various terms like "life satisfaction", "indicators of a healthy city" or "indicators of sustainability". The quality-of-urban-life literature indicates that there is no widely accepted definition of the concept. According to Ayna (2019), the quality of urban areas examines urban space in relation to its ecological and physical characteristics. In particular, environmental assessments are based on the natural features of the neighborhood, while physical assessments are related to the analysis of buildings and services. Quality of urban areas indicates life satisfaction and happiness and influences the behavior of people in urban areas. It includes the extent to which the basic needs and wants of residents are met and provided by urban infrastructure components (Ayna, 2019). Quality of urban areas means safe streets, healthy environments, diverse urban activities and vital social and economic conditions in cities. The quality of the built environment plays an important role in improving or reducing the quality of urban areas. For this reason, in this thesis, the quality of urban areas is defined based on their built environment qualities and the sociodemographic conditions of their residents.

Good urban place offers people the opportunity to find and express their personality (Ronael, 2019). Experience of place is characterized by the emergence of identity, sense of belonging and physical quality which emphasizes the importance of the built environment in the creation of a place. The interrelationship between the built environment and social interaction can be seen as a driver of place production. Therefore, environmental qualities of a place play an important role in shaping the meaning of the place (Ronael, 2019).

Many researchers discussed the concept of place quality and identified various criteria that convey “sense of place” to explain the relationship between design and urban life (Lynch, 1981; De Arruda Campos, 2012; Montgomery, 1998). The importance of the sense of place in contemporary urban life has increased since the 1970s; Therefore, the problem of the quality of a place has been the main research topic of architects, urban planners, and designers for 50 years (Ronael, 2019). According to Ronael (2019), between 1960 and 1970 diversity, vitality and social sensibility were key indicators of place quality. On the other hand, between 1970 and 1980, design flexibility and adaptability came to the fore to face external factors such as the economic and social constraints, and researchers tried to find the ideal physical form to support social interactions and activity opportunities.

After 1980, the concept of quality was analyzed in detail in relation to the negative effects of industrialization and modernization; In addition, many researchers have identified physical and social indicators of urban quality. Between 1990 and 2000, ecology and sustainability issues were adopted as the main affiliations to place quality. It was noted that what is suitable for future generations and suitable for existing nature creates a successful urban space (Ronael, 2019). After 2000, sustainability was the main concern and many issues such as scale and human behavior, attachment to space and identity, social sustainability and perceptibility emerged as main determinants of space quality. Today, the development of place quality criteria continues and changes according to the latest developments (Ronael, 2019).

A study by Montgomery (1998) presented one of the criteria for the quality of urban places from different perspectives. He stated that the principles of making a place are: activity (a product of vitality and diversity), image, and form (Figure 2.1.). This reflects the determinants that contribute to urban vitality in an urban environment. These factors contribute to a strong sense of place that makes residents satisfied with their city (Awwaad, 2017).

Activity is the intersection of two related concepts: vitality and diversity. According to Montgomery (1998), vitality is the main feature that distinguishes successful urban areas from others. It indicates the number of people (pedestrian traffic) on and around the street all over day and night, the active street life, and in general how busy or alive a place seems to be. According to Lynch (1981), a vital city is one that successfully meets the needs of its residents in a safe environment. An image of a place, however, is a set of feelings and impressions about it that are based on individuals' values, beliefs, and ideas as well as wider cultural values.

Lynch's five dimensions (1981) of city performance are used to help define what makes a good city. These include vitality, sense, fit, access, and control. A good city form stimulates activity, has a positive image, and creates a strong sense of place. To achieve this, there should be complexity, diversity of primary uses, a fine-grained economy, an active street life, good contact and visibility, a well-designed public realm, easy movement, a good network of green and water spaces, and diverse architectural styles (Montgomery, 1998).

According to Montgomery (1998), a good place is characterized by a permanent and growing vitality. This can only be achieved in the long term by a complex variety of primary land uses and (mostly economic) activities. The key to maintaining a variety of activities lies in the presence of relatively large (high-density) heterogeneous and diverse people with different tastes within easy reach. Thus, the most active and interesting urban areas are often complex areas with large numbers of small businesses trading with consumers and other businesses (Montgomery, 1998).

The key to successful urban areas is the complex and diverse transaction base. This should include economic and monetary transactions in addition to social and cultural transactions. However, Montgomery (1998) believed that the transactional basis of economic activity was the main condition for a good urban area. Since the city is what provides space for transactions, the concept of urban vitality is largely concerned with providing opportunities for transactions to occur over longer timescales to form a pattern of increasing diversity, interaction, and complexity (Montgomery, 1998). Montgomery (1998) summarized the characteristics of a successful urban place as follows:

- Complexity.
- Variety of movement (especially pedestrians).
- Variety of primary uses.

- Fine-grained economy.
- Vibrant street life.
- Different working and opening hours.
- Presence of people’s attractors.
- Legibility (The extent to which the components of the urban area are arranged in a consistent and recognizable arrangement (Montgomery, 1998)).
- Imageability (The impact the urban environment has on someone's life (Montgomery, 1998)).
- Knowledgeability (Information on activities, local events and traditions (Montgomery, 1998)).

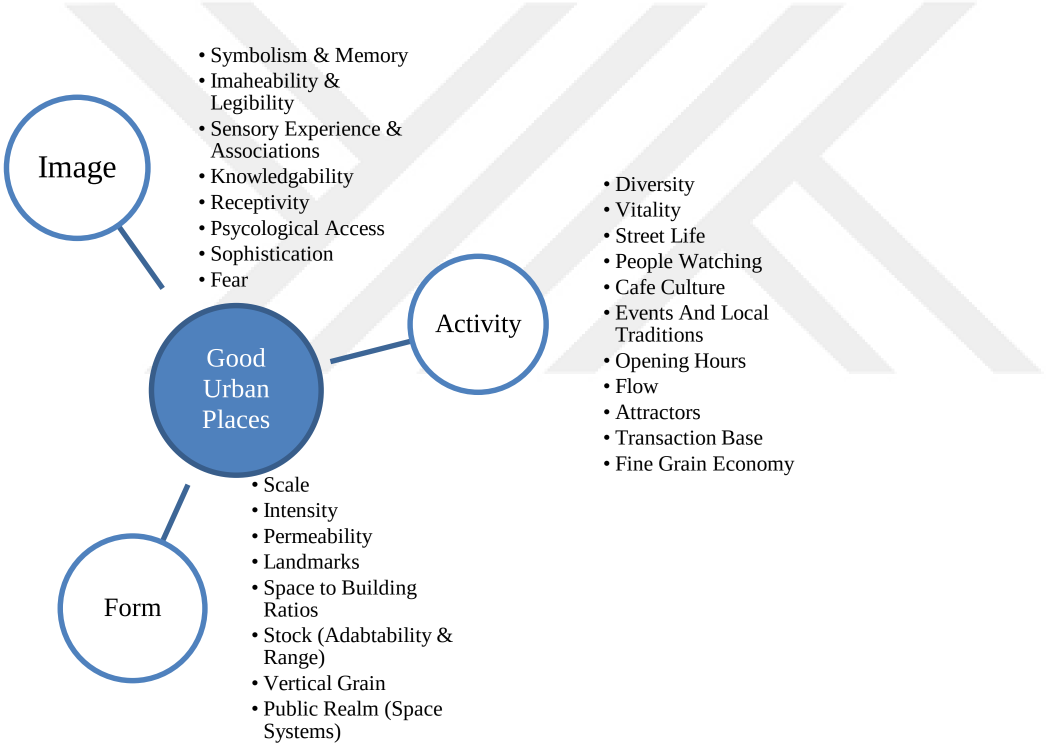


Figure 2.1. Summary of the elements of good urban places, Montgomery (1998).

A more recent study by Fang et al. (2021) proposed a system of quantitative indicators of the quality of the built environment. Their evaluation focused on measuring three main categories: the economics of urbanization, infrastructure development, and urban attractiveness. In particular, the percentage of urban population, GDP per capita, value-added services, income per capita, built-up area per capita, living area per capita, green space per capita, road area per capita, number of tourists, government spending on culture, foreign direct investment and the volume of export trade as quantitative indicators of the quality of urban built development.

Ronael (2019) proposed a comprehensive model for assessing the quality of urban places. His criteria covered several perspectives, such as natural, transport, land use, performance, economic, social, and cultural. Natural included sustainable infrastructure, environmental pollution, and the presence of natural objects. Transport consisted of accessibility by public transport, accessibility by personal transport, availability of parking lots, proximity to public institutions, proximity to residential areas, alternative transport options, proximity to recreation areas, and proximity to universities. Land use included the presence of cafes, restaurants and bars, variety of day and night use, architectural aesthetics, architectural diversity, age and quality of buildings, presence of concerts, and exhibitions. Performance included venues, diversity of land use, presence of historical assets, presence and quality of urban furniture. Economic included rental opportunities and productivity, suitable land/property value, proximity to employment opportunities, proximity to skilled labor, and proximity to other firms. Social encompassed feeling of belonging, opportunities for social engagement, cohesion value, different social groups, and the presence of a neighborhood spirit. Finally, cultural perspectives included identity and image, cultural ties and tolerance, history and traditions, cultural activity, and symbolic meanings (Ronael, 2019).

The quality of the urban environment concept does not only cover the physical characteristics of urban areas such as streets, building blocks, and land use; it encompasses all aspects of urban life in urban environments. People with similar characteristics live in similar neighborhoods and local districts. Therefore, the characteristics and socio-demographic conditions of the environment in which people live, have a significant impact on its quality (Nikoofam et al., 2020). As various human activities intertwine in urban space, a highly integrated interaction emerges between urban functions and place values, influencing people's perceptions of the quality of that place (Li et al., 2020). This means that the physical characteristics and spatial conditions of the urban area always play an important role in shaping its quality.

The spatial conditions of urban areas allow residents to establish informal contacts with their neighbors, thereby establishing close ties. Crime theories are based on weakened relationships, especially in urban environments (Ayna, 2019). The physical characteristics of urban areas also have a direct impact on individual life and community consciousness: for example, pedestrian-centric urban development promotes eye contact, social interaction, and community activities, and provides opportunities for denser community networks that can enhance people's well-being, trust, and secure community (Jalaladdin & Oktay, 2012). Pedestrian-friendly urban development also provides more attention, which makes streets safer and creates a safer urban environment, as noted by Jane Jacobs (1961, cited in Maas, 1984; Montgomery, 1998).

Density also has an important place among the physical characteristics of a city; There are many studies examining the positive and negative effects of population density and housing density on the quality of urban areas and satisfaction of neighborhood residents. The main finding of these studies is that the effect of density on satisfaction cannot be determined directly and should be considered together with other factors. For example, physical components of the environment such as neighborhood location, green spaces, and sports fields and playgrounds have a significant impact on neighborhood satisfaction. These neighborhoods are valuable as key points of urban interaction and social communication. Open spaces and public spaces in neighborhoods are important not only for the quality of urban areas but also for social interaction. These effective grounds for community trust and participation are also potential spaces for community activities. Proximity to shopping streets, main roads and frequently used services are local physical features associated with satisfaction and high quality of urban areas (Ayna, 2019).

According to Velibeyoğlu (2014), in Türkiye, participation in the cultural activities offered by the city is related to the economic conditions and accessibility of the city. It is also interesting that safety as a criterion of environmental quality has the highest priority. Income level, physical comfort, quality of construction, home layout, apartment size, accessibility to urban facilities, public safety, relationships with neighbors, green space status, and accessibility are indicators of the high quality of urban areas. Proximity to the city center, offices, shops, and municipal services is another important reason for the high quality of urban areas (Velibeyoğlu, 2014).

In summary, the quality of urban areas is related to the degree of urban vitality. In other words, greater communication and interaction on the streets and in public places are associated with healthier communities, higher levels of happiness, and quality of urban areas (Azmi & Karim, 2012). Therefore, the vitality of urban areas is an important indicator of to what extent they are successful and of high-quality.

2.2. Urban Vitality

As mentioned earlier, people and their activities increase safety in public spaces. This results in active, full-of-movement streets that are more pleasant to use (Jalaladdini and Oktay, 2012). Thus, responding to the needs of people for places that contain and adapt to their activities in the city is the main goal of a quality public space (Lynch, 1961; Montgomery, 1998). Similarly, the public space in a city is largely determined by the level of social activity and the interactions that take place there (Awwaad, 2017). In addition, previous research has shown that urban vitality is an important indicator of the relationship between the physical urban environment and social life (Maas, 1984; Jalaladdini & Oktay, 2012).

Urban attributes required for a well-functioning urban area include social interactions, diversity, business operations, accessible places, signs, parks, walkways, etc. Urban vitality promotes the perception of urban space through individual experience. This connection becomes clear in the work of Mass (1984). He derived the concept of "sense of place" from the process of determining the vitality of urban spaces. According to him, the overall effect of vitality is to create an exclusive atmosphere or sense of place. This sense of place characterizes the entire vital urban environment. Essentially, an urban sense of place promotes urban vitality. This connection is expressed in the constant presence of people engaging in various activities in public spaces. Thus, human activity transforms meaningless spaces into spaces with unique characteristics (Maas, 1984).

In the literature, the concept of urban vitality has been expressed and developed with different terms that refer to similar meanings over time. The environment created by the modern era in the 1960s made urbanists think about the human side and their needs in cities. After the 1960s, scientists began to discuss vital urban areas (Atak, 2020). Then, in the late 1980s, the emphasis shifted to the vitality of the city center (Maas, 1984). In the 1990s, the focus was on the revitalization of urban areas and the restoration of their cultural significance (Montgomery, 1998). Today, discussions about urban vitality focus on creating well-functioning public spaces through enhancing social, cultural, experiential, spatial, and economic transactions (Awwaad, 2017).

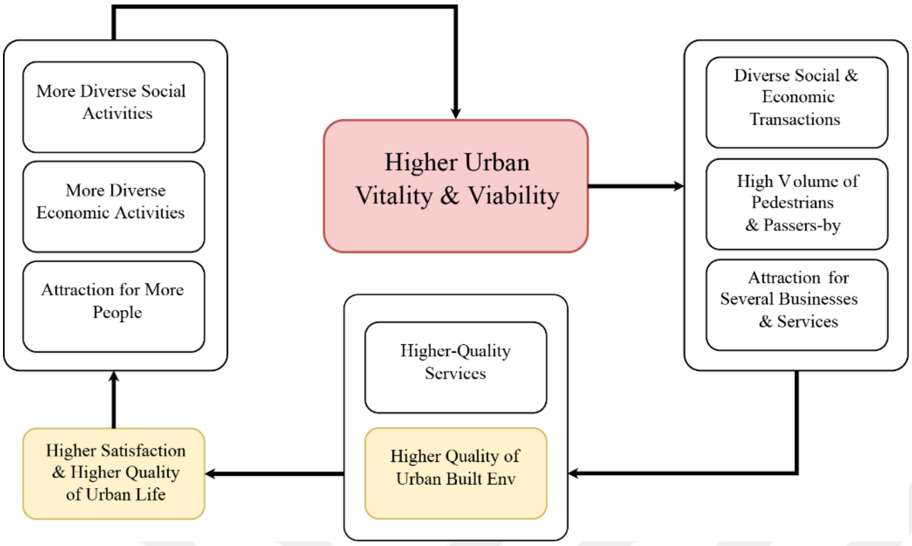


Figure 2.2. The conceptual framework of the study

Ravenscroft (2000) in his study discussed the concept of urban vitality from a socioeconomic perspective. From this perspective, he discussed the vitality of urban areas in the context of sustainability. The concepts of sustainability and vitality are an important part of a healthy urban area (Ravenscroft, 2000). Referring to Jacobs' (1961) argument that healthy and successful cities are those that can support a wide diversity of uses that attract significant numbers of people, Ravenscroft referred to vitality as the way a city center is occupied at different times and places. However, he defined viability as the center's continued ability to attract investment. Thus, these two metrics are interrelated, the relative level of ‘business’ (vitality) is considered an important factor in making new investment decisions (viability), and at the same time, the constant development of new facilities (viability) creates an increasing attractiveness for people (vitality). This relationship is based on the increase in the different types of transactions that can take place in urban centers (Montgomery, 1998; Ravenscroft, 2000).

Ravenscroft explored the concepts of viability and vitality in relation to the health of urban areas. Essentially, vital and viable urban areas are considered healthy. Figure 2.2. provides a summary of the urban vitality cycle that explains the relationship between urban vitality and viability, urban quality of life, and the built environment.

The concept of urban vitality first emerged in the 1960s. One of the first key figures to define this concept was the American journalist Jane Jacobs, who wrote her famous book *The Death and Rise of Great American Cities* in 1961. She defined urban vitality as the way an urban center is busy at different times and in different places. Lynch (1981, pp. 118-19) defines vitality as a measure of the effectiveness of urban design. He defines it as the degree to which the design of places supports human functions, biological needs, and abilities. Maas (1984) gave a comprehensive definition of urban vitality. The definition states that urban vitality is a synergy that somehow derives from the diversity of unique business and leisure opportunities and a dense and diverse pedestrian population. The elements of this definition can be roughly divided into three categories: people, their activities and capabilities, and the environment in which these activities are carried out. Maas also described the general characteristics of urban vitality: The first and most distinctive feature of all vital urban areas is the size and density of the pedestrian population on the streets. Therefore, the "perception" of vitality is highly dependent on the apparent number of people in the environment (Maas, 1984).

Table 2.1. Summary of the definitions of urban vitality

References	Urban Vitality Definitions
Jacobs, 1961	The way an urban center is busy at different times and in different places.
Lynch, 1981	The extent to which the form of places supports human functions, biological needs, and abilities.
Gehl, 1987	The activity of the people in the streets and between buildings.
Maas, 1984	The synergy resulting from a "diversity" of somehow "unique" business and entertainment opportunities and a dense, diverse pedestrian population.
Montgomery, 1998	The number of people present on and around the streets (pedestrian flows) at different times, the use of facilities, the number of cultural and celebratory events throughout the year, the presence of active street life and generally the extent to which a place feels alive and lively.
Ravenscroft, 2000	An increased attraction for people.
Jalaladdini & Oktay, 2012	Vital urban public space is a safer, more desirable, and more attractive space that offers more choices for social activities while being a place for cultural exchange.
Awwaad, 2017	The continuous presence of people in public spaces engaging in various activities.
Xia et al., 2020	The intensity of socio-economic activities.

Vitality, as defined by Montgomery (1998), is the number of people on and around the streets at different times (pedestrian traffic), the use of facilities, the number of cultural and festive events throughout the year, the presence of active street life, and the extent to which a place appears lively and bustling in general. In other words, urban vitality lies in the constant presence of people engaged in various activities in public places (Awwaad, 2017). Jalaladdini and Oktay (2012) define a vital urban public space as a safer, desirable and attractive space that offers more opportunities for social activities and is a place of cultural exchange. Vitality is a measure of how socially successful an urban space is (Jalaladdin et al., 2012). Xia, Yeh & Zhang (2020) broadly define urban vitality as the intensity of socioeconomic activity (Figure 2.2.). Table 2.1. summarizes the definitions of urban vitality.

In general, the main theme of urban vitality is the constant presence of people at different times of the day with different activities on the streets and in public places. This also applies to safer, more pleasant, and inviting streets and public spaces that offer more opportunities for social activities as places of cultural and economic exchange. Therefore, urban vitality is considered important to enliven places through the constant presence of people and their activities in a well-designed public space to maintain a high quality of life in urban areas. This makes urban vitality a composite of various integrations and relationships among the complex elements of the city on which the growth of the city depends on its health. Therefore, urban vitality criteria have been developed to assess the quality of urban life. They include the economic, cultural, social, physical, and many other aspects of the urban environment.

Urban vitality criteria show that the city is alive and that there is a healthy interaction between the various elements of the city. Spatially applicable parameters and stimuli are needed to realize vitality (Paköz & Işık, 2022). According to Sung et al. (2013), Jacobs (1961) proposed 4 basic and 2 additional conditions for the physical environment of urban areas as the main drivers of urban vitality. (1) mixed land use, which is a planning strategy with more than one, preferably more than two primary functions in an area; (2) small blocks that provide opportunities for communication and meetings; (3) buildings of different ages from different eras, reused for different purposes and attracting different people; (4) high urban density; Dense concentration of people and buildings leads to more frequent and varied interactions between people living in and visiting a particular area (Jacobs, 1961 as cited in Chen et al., 2022); (5) transport and accessibility to public facilities, including parks, bus stops and train stations, as they act as a trigger and hub for walking; (6) Urban barriers should be properly controlled so that they do not interfere with pedestrian activities such as single-use large facilities (such as university campuses, large parking lots and large parks) and arteries (such as embankments, railways, highways) (Sung et al., 2013).

In addition to Jacobs' criteria of urban vitality, Montgomery (1998) stated that retail is a fundamental element of urban life and contributes greatly to the revitalization and vitality of cities. He argues that the transactional basis of economic activity is considered the main driver of a good and vibrant urban place. According to Jalaladdin et al. (2012), not all vital places have the same causes or functions in the same way. Therefore, people in different places in cities experience different emotions. However, it is clear that vital places are healthier and safer, where people can interact more and stay longer. However, the presence of people is not possible with only commercial functions, because they must be supported by pleasant walking opportunities that allow pedestrians to have a pleasant time without having to eat or drink (Jalaladdini et al., 2012). Awwaad (2017), on the other hand, found that the issues affecting the urban vitality of Doha's neighborhoods mainly centered around adaptation to the local climate, context, and culture.

Since urban vitality is considered a sign of to what extent an urban area is socially successful (Jalaladdini et al., 2012), many recent studies have attempted to measure the vitality of a place based on specific indicators. Below the different indicators of urban vitality that were proposed in the literature are discussed and explained.

2.2.1. Indicators of urban vitality

The vitality of a city is, with no doubt, critical to the livability and sustainability of the urban environment. It can be considered as one of the main indicators of the activity of people in the city because it reflects the intensity and frequency of interactions between people. Urban vitality is an important element in attracting businesses and creating jobs. If urban vitality declines, the city faces a series of negative effects known as urban shrinkages, such as depopulation loss, infrastructure depletion, and economic deterioration. Therefore, urban vitality should be measured frequently (Chen et al., 2022).

Recent studies on urban quality of life and urban vitality often involve setting performance indicators. Some of these studies have focused on measuring objective indicators such as urban form conditions (i.e., combination of uses, proximity to green spaces, markets, hospitals, and distance to public transport), and environmental characteristics (i.e., natural resources, such as forests, lakes, rivers and seas), etc. (Velibeyoğlu, 2014). These two concepts not only depend on how people perceive their environment and to what extent this environment meets their needs and expectations but also on the objectively measurable conditions of the physical urban environment. However, the choice of research approach often depends on its geographic scope. In other words, the evaluation of urban life quality and urban vitality based on people's perceptions is more meaningful at the street and neighborhood scale. However, when the scope of the study covers, for example, the entire city, the objectively measured conditions of the physical urban environment are often the best choice. This is evident in the literature review of urban vitality indicators in this section.

In addition to the urban vitality factors that Jacobs listed in her book, current research has extended the vitality approach by adding different indicators and components to explore the concept in different contexts (Paköz et al., 2022a). Recently, many scholars and researchers have attempted to quantify and measure urban vitality. To do this, the researchers needed to find other measurable attributes or activities in the city that could be used as indicators of urban vitality. Such urban vitality indicators can be listed as single and composite indicators as follows.

Single urban vitality indicators

The number of pedestrians was one of the first indicators of the vitality of a city. Due to its simplicity, it is suitable for survey-based research. For example, Maas (1984) used the number of pedestrians as an indicator to test his model of urban vitality. Similarly, Jalaladdini et al. (2012) found that the presence of pedestrians at different times of the day preserved the liveliness of Salamis and Ziya Rizki streets. However, the determinants of vitality in the two streets were different. Going to restaurants, cafes and bars was the dominant activity on Salamis Street, while shopping or window shopping was the dominant activity on Ziya Rizki Street (as shown in Table 2.2.) (Jalaladdin et al., 2012). Sung et al. (2013) investigated the relationship between various physical environment attributes to walking (Sung et al., 2013; Sung et al., 2015) and the number of pedestrians on the streets of Seoul, South Korea (Sung et al., 2013). A study by Sung et al. (2015) showed that walking is associated with six conditions of Jacobs' urban vitality in the built living environment of the city of Seoul.

Table 2.2. Analysis results of the study by Jalaladdini et al. (2012).

The items of comparison	Salamis St.	Ziya Rızkı St.
Dominant user type	Students	Tourists
Dominant social group	Friend groups	Family groups
Dominant activities	*The use of restaurants, cafes & bars*	*Shopping or window shopping*
Street activities’ time	From early morning till late night	From late morning till evening
The most vital time of the street	From early evening till late times at night	Late mornings and evenings

Ye et al. (2018) identified typical morphological building density categories and typology and examined the relationship between these morphological categories and urban vitality. They measured urban vitality by the number of small eateries in individual neighborhoods (Ye et al., 2018). Similarly, Yue and Zhu (2019) explored the relationship between urban vitality and street centrality in Wuhan. The vitality of the city was measured using social media ranking data. In particular, the total number of social media reviews of restaurants in a given location was used as an indicator of urban vitality, with higher reviews pointing to higher urban vitality (Yue et al., 2019).

In a study by Xia et al. (2020), day and night urban vitality were measured using small food services and night lighting data, respectively. Since urban areas with small food businesses are considered vital, small food businesses have been used as an indicator of the attractiveness of urban areas. Moreover, without adequate foot traffic and intense urban activity, small catering businesses struggle to survive. Therefore, places where small catering businesses are developed, as a rule, are densely populated. On the other hand, areas suitable for the establishment of small catering businesses also encourage walking, relaxation and other leisure activities. Compared to large restaurants and department stores, small catering establishments are more flexible and better reflect current urban life. Therefore, data on small catering establishments can be considered as an accurate reflection of the vitality of cities during the day (Ye et al., 2018; Xia et al., 2020).

In addition, Yang, Cao & Zhou (2021) investigated the non-linear relationship between the built environment and urban vitality, using Shenzhen as an example and the Baidu Heat Index as an indicator of vitality. The average intensity of the collected Baidu Heat Indices (BHI) was used to calculate daytime and nighttime BHI (Yang et al., 2021). Similarly, Tang & Ta (2022) measured the dynamic vitality of cities in terms of density, variability, and night ratio based on Baidu heat map data in the central city of Shanghai.

Composite urban vitality indicators

Table 2.3. Sub-category of indexes for creating the questions in the survey in the study of Zarin et al. (2015)

No	Indexes	Sub-factors
1	The variety of attractions	The existence of shopping centers, organizations, and institutions, groceries, salespersons, particular masons, plants, and waterfronts.
2	Hostel activity	Enough light at night, different uses.
3	Welfare	Social and structural security, attention to people's emotions and learning, identity, and belonging.
4	Availability and contact	Availability of roads, adequate corridors, public transportation, parking space for cars, security of passengers, parking space for motors and bicycles
5	People cooperation	Adequate space for social interaction, holding street ceremonies, and types of individual and group activities.
6	Readability	A clear vision of the urban environment and citizen signs
7	Aesthetics	Modification of street space, street signs, and building views, different colors in streets, and changes in lighting.
8	Hygiene	Reduction of environmental pollution, voice pollution, weather, and expulsion of upper-level waters.

In contrast to individual indicators, composite urban vitality indicators are often more complex and comprehensive. For example, Gülden Demet and Giritlioğlu (2008) used the number of residences, population, commercial area and prices per square meter (m^2) of land as performance indicators for urban vitality in Istanbul. However, Zarin et al. (2015) prepared 8 indices related to urban vitality with 35 sub-factors for their study in Tehran. The results of the analysis ranked the impact of the 8 indicators on urban vitality as follows: (1) contact and accessibility, (2) diversity of attractions, (3) well-being, (4) aesthetics, (5) hygiene, (6) human contact (7) hostel activity, and (8) readability. Table 2.3. shows all subcategories of the indexes used to create questions in the questionnaire (Zarin et al., 2015). Similarly, Awwaad (2017) measured neighborhood vitality in the city of Doha based on indices determined by three dimensions of neighborhood vitality (sociocultural, experiential, and spatial dimensions). Nine key indicators of urban vitality were analyzed and measured (Table 2.4.) (Awwaad, 2017).

In addition, point-of-interest (POI) density, mixed-use levels, location check-in density, housing prices, and population change have also been used as indicators to measure the urban vitality of new development sites emerging in Chinese cities from 2005 to 2015 (He et al., 2018). Li et al. (2022) used urban vitality data based on the detection of street elements and features such as pedestrians, bicycles, motorcycles, buses, private cars, and trucks in street images from Baidu. A composite measure of urban vitality was then obtained by calculating the mean of check-ins and street view data (Li et al., 2022). In contrast, Chen et al. (2022) used Shannon's entropy model based on four dimensions of GIS data of point-of-interest density, taxi traffic density, building density, and road density to measure and analyze urban vitality in Xiamen Island, China.

Table 2.4. Nine key urban vitality indicators (Awwaad, 2017).

Key Indicators of Neighborhood Vitality	
• Heterogenous society • Society’s behavior • Occupancy in the public realm • Pedestrianization • Variety of activities	• Unique activities • Time of activities • Place features • Neighborhood’s morphology of the physical environment

Due to the fact that urban vitality has numerous indicators of different natures, there have been many urban vitality analysis methods that have been used by different researchers recently.

2.2.2. Assessment methods of urban vitality

The difference in terms of the research tools used in city-wide studies versus street and neighborhood scales is remarkable. While earlier studies focused on the observation of pedestrian flow, street activities, and walkability surveys (Maas, 1984; Gülden Demet et al., 2008; Zarin et al., 2015; Sung et al., 2015; Sung et al. 2013; Kim, 2018), the recent studies conducted in China used city-wide big data (Yang et al., 2021; Tang & Ta, 2022;

Ye et al., 2018; Zeng et al., 2018; Zhang et al., 2021; Li et al., 2022; Liu et al., 2019; Sulis et al., 2018). Big data can be obtained from mobile phone data, social media verification data, sensor data, GPS (global positioning system) data and points of interest (POI). Since these data are comprehensive, accessible, and available in real-time, using these data is a very effective method to measure the location-based movements of people in city-scale urban vitality studies (Atak, 2020).

For example, Gülden Demet & Giritlioğlu (2008) conducted a two-stage study to determine the extent of urban vitality in the Eminonu district of Istanbul. By creating a defined benchmark index, data collected between 1985 and 1988, and 2002 and 2004 were evaluated to examine the change in urban vitality over time. In order to better explain the change in urban vitality in the selected areas, a public opinion poll was also conducted, which was assessed using factor analysis (Gülden et al., 2008). Similarly, a survey study was conducted to explore the factors that influence the vitality of the city by examining two streets of Tehran (Zarin et al., 2015). 384 questionnaires were distributed among different people included in the study using the Kukran formula with a confidence level of 95% and a random sample. The data were then analyzed using a multivariate inverse regression method, and then the level of vitality in the study and the impact of each indicator on vitality were determined. For the study, eight indices of urban vitality with 35 subfactors were prepared. After that, survey respondents were asked two questions: (1) how strong is the influence of each factor on your vitality and (2) how much importance is attached to each factor in your area (Zarin et al., 2015).

Another study was conducted by Sung and Li (2015) to empirically test Jacobs' theory of urban vitality. They examined the relationship between the built environment and walking using a multilevel regression analysis in which walking was the dependent variable. They used 1823 samples of valid telephone survey data from all over Seoul. In addition, objective measures of built environment variables were measured in buffer zones 500 m from participants' home addresses (Sung et al., 2015).

Awwaad (2017) conducted a comparative, quantitative and qualitative analysis in three districts of Doha to assess vitality issues and recommend measures to improve it. The measurement method is adapted from the Global Sustainability Assessment System weighting methodology. Data were collected using three main tools: surveys, systematic area observations, and interviews with local planners. Quantitative data was obtained in the course of a survey aimed at residents of the neighborhoods. Qualitative data was collected from neighborhood environmental observations and interviews with local planners (Awwaad, 2017).

In a different way, Jalalaaddini et al. (2012) investigated street vitality and its determinants in two main streets in Famagusta and Kyrenia in Northern Cyprus on the topic of street vitality as the main indicator of their success. A systematic comparison was made based on elements such as user types, social groups, activities and interactions, and the duration of activities during the day (Jalaladdin et al., 2012). Sung et al. (2013), however, performed several linear regression analyses to explore the relationship of different physical environments with the number of pedestrians and their activity on the streets of the Seoul metropolitan area in South Korea. In addition, He et al. (2018) used association rule analysis in their work to analyze the impact of different types of urban expansion (infill, edge expansion, and outlaying expansion) on urban vitality (He et al., 2018).

However, Ye et al. (2018) created a regression model to explore the relationship between morphological categories and urban vitality. The general interpretation of the regression models was consistent with the theoretical predictions made by Jacobs (1961) and Montgomery (1998). Meng and Xing (2019) proposed a framework to examine the relationship between landscape features and urban vitality. First, multilevel features were quantified using 17 spatial measures. Second, they used surveys based on social media data and proposed effective measures to measure urban dynamics. Finally, four linear regression models were proposed to investigate the relationship between landscape features and urban vitality (Meng et al., 2019).

In addition, Yue and Zhu (2019) investigated the relationship between urban vitality and street centrality in Wuhan, China. Geospatial imaging was used followed by a chi-square test and correlation analysis. Spatial regression models were then created to analyze the importance of the downtown street and its impact on urban vitality. The geodetector method was used to further assess the extent of these effects (Yue et al., 2019). In another study, the spatial relationships between urban land use density and urban vitality were examined using the Local Spatial Association (LISA) indicator (Local Moran's I), and five metropolitan areas in China were examined to assess whether there were differences between different cities (Xia et al., 2020).

In addition, Yang et al. (2021) used gradient-enhancing decision trees to explore the uniform non-linear relationships between the built environment and urban vitality, using Shenzhen as a case study and the Baidu Heat Index (BHI) as a measure of vitality. To illustrate the various relationships between the built environment and BHI, they developed two models, one for the day and one for the night. The average intensity of the collected Baidu Heat Indices was used to calculate the daytime BHI and the nighttime BHI. The independent variables included four categories: land use, points of interest (POI), transportation accessibility, and distance from the city center (Yang et al., 2021).

In addition, Paköz, Yaratgan & Şahin (2022) examined the city of Kayseri using Jane Jacobs' criteria for what makes a city livable and alive. Using Kernel Density analysis, they studied 87 districts of the city, assessed each district's vitality and compared the results with their own observations to understand the validity of Jacobs' views in various contexts (Paköz et al., 2022b). In a different way, data from multiple sources from 1025 communities were pooled to assess the relationship between urban vitality and the built environment in Wuhan, China (Li et al., 2022). Also, a deep learning method is adopted to analyze images from the street view. Based on these analyses, a composite indicator of urban vitality was developed along with social media data. After that, six parameters of built environment factors, city form and function, neighborhood characteristics, landscape, street configuration and location were analyzed using a spatial regression model (Li et al., 2022).

Chen et al. (2022), on the other hand, used Shannon's entropy model based on four dimensions of GIS data on POI density, taxi traffic density, building density, and road density to measure and analyze urban vitality. They then applied a regression model to explore the relationship between land-use diversity and urban vitality. Their results showed that four dimensions are associated with urban vitality. In particular, a stronger relationship between land-use diversity and urban vitality has been reported (Chen et al., 2022). Tang and Ta (2022) also applied a set of ordinary least squares (OLS) regression models to explore the relationship between the built environment and urban vitality measures.

The remaining of this section provides analyses of some of the results of the prementioned studies concerning exploring the effect of the urban environment conditions on urban vitality. In specific, the effects of population and neighborhood attributes, urban form, land-use function, street configuration, location attributes, and climate and culture on urban vitality are discussed.

2.3. The Effect of Built Environment on Urban Vitality

The extent and nature of urban activity largely depend on the built urban environment (De Arruda Campos, 2012). For example, in an area with high-rise buildings, underground car parks, heavy vehicular traffic and long distances between buildings, pedestrian traffic is more or less impossible because the conditions of the urban public space around nearby buildings are very poor. Under these conditions, most residents prefer to avoid such public spaces. Urban social activity depends especially on the quality of urban spaces and constitutes an important part of urban activities. These are particularly attractive activities that disappear when urban conditions are bad and thrive when they are good. The importance of improving the quality of daily and social activities in cities can be seen when pedestrian or traffic-free zones are created in existing urban areas. Numerous studies have shown that improved physical conditions lead to impressive increases in walks, longer average time spent in one place, and a much wider range of urban activities (De Arruda Campos, 2012).

The physical characteristics of a city typically include the size, density, shape, scale, and configuration of the road network and population centers within the urban area. The urban form is a combination of geographical and cultural environments. It covers the physical elements and human relationships with those elements. Therefore, human activity in this area is closely related to the urban form. Therefore, the urban form can be defined as a spatial representation of human flows in an urban area that includes social, geographic, physical, and cultural relationships (Atak, 2020). The urban form creates an environment for human activity. Thus, the urban form is defined as the spatial organization of human activity at a given time (Atak, 2020). Since the urban built environment is also the result and driving force of urban life, urban vitality as an aspect of urban life also depends on the built environment. The vitality of a city is basically a characteristic of the interaction between the physical environment and human activities.

The connections between density, vitality and urban form have been extensively explored. Most researchers refer to density as a synonym for population density, but it can also mean morphological density (density of the built environment in a given area). Higher population density has been associated with economic viability due to increased human movement, improved health, and reduced greenhouse gas emissions through better walking (Martino, Girling & Lu, 2021). It can be said that the urban environment can help us understand and appreciate urban life. Therefore, the analysis of the relationship between the urban environment and urban vitality is important for assessing the quality of life in this urban environment. Considering this information, the main purpose of this thesis is to show the relationship between urban vitality and the urban environment.

Next, the results of some of the previous studies about the effect of the urban environment conditions on urban vitality are introduced under six urban environment dimensions: population and neighborhood attributes, urban form, land-use function, street configuration, location attributes, and climate and culture.

2.3.1. Population and neighborhood attributes

Adequate population density and development in the city of Istanbul have played an important role in enhancing urban vitality in functionally diverse areas. New investment was found to have a positive impact on urban vitality indirectly by increasing demand for urban areas (Gülden et al., 2008). In their study, Sung et al. (2013) found that pavement width, number of street lanes, presence of street furniture and topography were positively related to the number of pedestrians. The results also showed that, overall, older buildings were positively associated with greater walking and activity. In addition, the overall net density of buildings was positively correlated with pedestrian mobility on the streets. In contrast, the density of buildings for office use and the density of other properties were not significant (Sung et al., 2013).

A study by Sung et al. (2015) showed that walking habits vary by demographic; Their results showed that women, the elderly, and families with fewer workers walked less in residential buildings. It has also been determined that apartment residents walk less than residents of single-family buildings (Sung et al., 2015). These results suggest that demographic and socioeconomic characteristics can also affect the urban vitality of an area. Zarin et al. (2015) in their study in Tehran listed the impact of 8 district characteristics indices on urban vitality as follows: (1) contact and accessibility, (2) various attractions, (3) well-being, (4) aesthetics, (5) Hygiene, (6) contact with people, (7) hostel activity and (8) readability. However, Awwaad (2017) found that Doha's neighborhoods were partly vital due to society and its activities, but not to the physical environment. The main reason for this was the lack of access, security and equity in Doha's physical environment (Awwaad, 2017).

On the other hand, Ye et al. (2018) found that building typology tends to play a more important role than building density in stimulating urban vitality. In particular, the "block" and "strip" typologies have been associated with significant positive effects on urban vitality, even after taking into account the effect of building density (Ye et al., 2018). In a different context, Meng and Xing (2019) found that high building density improves urban vitality, while the high building landscape index, or percentage of undeveloped areas, reduces urban vitality. Also, more facilities in fewer buildings and other areas helped attract more people regardless of specific urban functions. On the contrary, separating more roads between buildings tends to reduce the vitality of city life (Meng et al. 2019).

Additionally, Xia et al. (2020) showed a significant positive spatial autocorrelation between urban land use density and urban vitality according to global statistics. Therefore, socio-economic activities most likely spread to densely populated urban areas. It was also found that high-density mixed-use street blocks that are likely to have relatively high urban vitality are mostly located in old urban areas. Additionally, local spatial inequalities were found in all five metropolitan areas, indicating overcrowding or underutilization of urban areas in all cities (Xia et al., 2020). Yang et al. (2021) also confirmed that building density is essential for urban vitality; Of all the built environmental variables tested in that study, the total floor area was the most important determinant, accounting for approximately 45% of the predictive power of both daytime and nighttime BHI (Yang et al., 2021).

On the other hand, Paköz et al. (2022b) found that, according to the Jacobs criteria, not only historical and commercial centers within the city, but also many redeveloped and newly developed areas have high values of urban character (urban vitality). However, the measured vitality figures differed from the perceived urban vitality observed with the naked eye in some areas of the city. For example, Yenidogan and Mevlana in the Talas region witnessed a vital urban environment around the clock, thanks to Erciyes University's capacity to meet the needs of its young population. However, due to the lack of short and old buildings and low street density, the urban character of these two areas is low. Other examples are the Selçuklu, Osman and Danishmentgazi districts where urban vitality values are classified as high due to short and old buildings, many streets and population density. These areas also had the highest number of Syrians in the city. Although the share of mixed-use buildings is close to zero, these neighborhoods are full of very lively street life. This situation has been interpreted due to the diversity of the population and the relationship between buildings and streets in these areas (Paköz et al., 2022b).

Li et al. (2022) confirmed the importance of sufficient population density to maintain the vitality of a place, which is consistent with the findings of many previous studies. However, they stated that the population itself does not support urban vitality without a supportive environment, which is supported by the results of their study that found a negative relationship between the share of residential area and urban vitality. The results also showed that population density, community age, open space, pavement rate, street lights, density of shops and recreational areas, integration and proximity to transportation are positive factors that contribute to the vitality of the city. In contrast, the effects of road density, green space, and proximity to parks had opposite results (Li et al., 2022).

2.3.2. Urban form

In addition to the characteristics of the population and the neighborhood, the good features of the urban form are used to create vibrant neighborhoods that attract human activity and connect residents and passers-by with the community's supportive services and amenities. Urban form refers to spatial models of buildings, districts, and streets that are interconnected with patterns of urban activity (Lang, Hui, Chen, & Li, 2020).

The results of the study by Gülden Demet and Giritlioğlu (2008) showed that the traditional urban pattern alone is not sufficient to sustain urban vitality. On the other hand, studies by Sung et al., (2013) and Sung et al., (2015) showed that smaller parcel size was positively associated with pedestrian count and walking activity. Although significant correlations were reported between pedestrian activity, highways, and surface railways, the analysis results for major roads, rivers, and streams were not significant (Sung et al., 2013). Pedestrian-friendly neighborhoods (measured by the ratio of four-way intersections to all intersection types) were positively associated with walking. Additionally, shorter distances between buildings and streets were positively associated with walking. This showed the importance of Jacobs' view of the street for urban vitality. In addition, lower pedestrian activity was associated with more residential buildings within the 500 m buffer zone; this suggests that large-scale one-use large developments can be negatively correlated with pedestrian activity (Sung et al., 2015).

In addition, He et al. (2018) measured the urban vitality of new development sites that appeared in Chinese cities from 2005 to 2015. Infills were found to be characterized by location check-in density with high POI densities and low mixed-used lands and mixed values of population change. On the other hand, edge expansion is associated with higher population change and urban functional mix. Finally, outlaying expansion (urban sprawl) is associated with several negative urban vitality values, especially variables related to the interaction between people and their environment (He et al., 2018).

Lang et al. (2020) conducted a comprehensive analysis of the impact of local urban forms around metro stations on people's accessibility and social engagement. The first important finding of the study is that urban form is closely related to walkability, spatial features, and human activities in transit-oriented development (TOD) areas. High-value access, gravity, and proximity zones contained additional amenities and services, while valuable intermediate zones attracted additional individual social activities. In addition, in general, traditional areas were found to exhibit high levels of reach, gravity, betweenness, and straightness, while integrated development areas exhibited high levels of closeness. The second important result showed that the social activity of people was closely associated with amenities and services, which were largely influenced by the distinctive form of the city, the style of development of the area, temporal changes and functions. In addition, traditional neighborhoods have patterns of social amenities, services, and activities evenly distributed throughout the space, while integrated development areas have large commercial building complexes concentrated at specific points. In addition, people's activities have changed over time; people have greater access to high-betweenness areas during leisure time and greater access to high-gravity areas with large groups of functional buildings during working hours. Streets and functional buildings have also been found to influence the nature of people's social interactions in dense urban settings (Lang et al., 2020).

2.3.3. Land-use mix

Urban form and land use diversity have been found by many researchers to influence urban vitality simultaneously. In the city of Istanbul, functional diversity in neighborhoods with sufficient population and building density has played an important role in increasing urban vitality (Gülden et al., 2008). Despite their vital role in preserving the vitality of the city, commercial functions alone could not increase the vitality of the Eminönü district. This is because of the absence of other important factors such as functional diversity, physical space quality, security, etc. In addition, despite the existence of the traditional urban fabric, negative changes occurred in the neighborhoods where manufacturing and wholesale areas increased (Gülden et al., 2008). In a similar context, Meng and Xing (2019) found that commercial and public lands have a positive effect, while residential and industrial lands have a negative effect on urban vitality.

Another study by Sung et al. (2013) found that a combination of two or more major land uses had a positive effect on pedestrians on the main streets of Seoul, South Korea. In particular, residential neighborhoods with neighborhood amenities, such as grocery stores and small clinics, were very positively associated with walkers. In addition, foot traffic had a more positive association with commercial, semi-residential, and semi-industrial areas than with residential areas alone. In contrast, residential/office mixed use was negatively associated with street footfall due to the fact that office workers commute to work on weekends (Sung et al., 2013). These results are consistent with the work of Sung et al. (2015) that showed that walking is more common in areas where non-residential and residential spaces are highly mixed.

Yang et al. (2021) used BHI (Baidu Heat Index) as an indicator of urban vitality. They revealed that transportation infrastructure was also important during both daytime and nighttime BHI. Moreover, while the share of office space was more important for BHI during the day than at night, restaurants and entertainment venues were more important for BHI at night than during the day (Yang et al., 2021). In conclusion, mixed land use functions were proven to be one of the main urban environment factors that contribute positively to urban vitality.

2.3.4. Street configuration

In addition to land use diversity, as discussed earlier, the accessibility of urban areas also plays an important role in shaping their vitality. In this context, Sung et al. (2013) showed that in the large city of Seoul in South Korea, lower street intersection density is associated with more pedestrians on weekdays, while higher street intersection density is associated with more pedestrians on weekends. In a different context, Wang, Xu and Guo (2018) took the city of Shenzhen, China as an example and used reclassified points of interest (POI) data to represent commercial, public service, and residential areas and explored various relationships between street centrality and different types of urban land use densities. They calculated three global and local centrality indices (Closeness, betweenness, and straightness). The results showed that global closeness and straightness are high in the city center and the roads with high global betweenness form the backbone of the road network. Commercial areas and public services were concentrated in the densely populated city center, while in residential land they were relatively dispersed. This analysis shows that commercial and public services are more dependent on central location than residential (Wang et al., 2018). In other words, vital urban locations are based on central rather than residential areas.

Yue et al. (2019), however, analyzed the relationship between urban vitality and street centrality in Wuhan, China. The results showed that street centrality plays an important role in shaping the spatial distribution of urban vitality. In particular, urban vitality was most affected by betweenness centrality, followed by closeness and straightness in walking mode. But in driving mode, straightness had the biggest impact on urban vitality, followed by closeness and betweenness. As a result, vital areas are usually located at the most centric streets (Yue et al., 2019). In addition, Lang et al. (2020) found that dense and closely connected street networks are strongly associated with areas rich in tourist destinations and human activities.

In a different context, Al-Saaidy and Alobaydi (2021) analyzed the spatial characteristics of the street network in the Iraqi city of Baghdad in relation to population density, providing insight into the quality of urban form. The study, which used Multi-centrality Assessment as an analytical approach, surveyed 12 streets in two different urban structures formed in the Rusafa area. The correlation between the central location of the streets and the density of people was carried out and compared for the two study areas. The results show that urban life is more active on organic streets where vitality, mobility, and density exist with high betweenness centrality values; this is in contrast to modern, newly developed, streets offering that showed low values (Al-Saaidy et al., 2021). A similar conclusion was reached by Zhang, Chen, Zhu, Wang, and Zhang (2022), who recorded that betweenness was the best measure for capturing vitality in downtown Beijing and Shanghai.

2.3.5. Location attributes

Sung et al. (2013) found that proximity to commercial buildings was positively associated with the number of pedestrians during the week. Accessibility to public transport facilities such as train stations and bus stops (Sung et al., 2013; Li et al., 2022) also had a significant correlation with the number of pedestrians on the street. Also, the analysis showed that walking activity increased due to proximity to the Central Business District (CBD). Meanwhile, the distance measure for parks was negatively correlated with pedestrian traffic (Sung et al., 2013; Li et al., 2022). This indicated that park facilities play a negative role in promoting pedestrian activity on Seoul streets. Perhaps this result illustrates a critical aspect of park vitality in South Korea (Sung et al., 2013). On the other hand, in a study by Sung et al. (2015) distance from the city center was found to have a strong positive association with walking. The walking activity was also found to be negatively correlated with distance to bus stops. However, distance from train stations did not show a strong correlation with walking. This meant that the relationship between public transport and walking could be different depending on the mode of transport and their interaction (Sung et al., 2015).

In a different context, a study by Awwaad (2017) found that, in general, coastal areas had the highest vitality, followed by city center areas. The lowest degree of neighborhood vitality was associated with the suburban neighborhoods of Doha, the most recently developed (Awwaad, 2017). Similarly, Xu et al. (2018) selected nine different streets of different ages in the old, central and new urban areas of Nanjing, China, and proposed a framework for assessing street vitality in different time dimensions. They found that high efficiency and appropriate accessibility are important prerequisites for creating street vitality; The older and main city areas were closer to several metro stations and had convenient transport links. Later, the metro began to be used in the new urban area, before that buses were the most used means of transport. In general, the streets of the old and main urban areas had more established public transport and a higher frequency of vehicular traffic than the new urban area. Also, because they were close to residential areas or large commercial establishments, they tended to have more street vitality due to their convenience. In summary, street vitality in new urban areas was lower than in old and core urban areas (Xu et al., 2018).

2.3.6. Climate and culture

Pedestrian activity is directly related to the vitality, economic well-being, and safety of the city. Thus, pedestrian accessibility and activity have become key areas of concern for urban planners who are facing new challenges in their efforts to improve conditions for pedestrians, ensure safety and improve the quality of life of the population. Individual walking behavior varies depending on weather conditions, the built environment, and local social events.

For example, in downtown Toyota, Aichi, Japan, Eom and Nishihori (2022) developed pedestrian distribution indices to examine the number of pedestrians and inequality in space and time. In particular, they examined how weather conditions and special events affected pedestrian activities. They found that weather conditions affect not only the number of pedestrians, but also their spatial and temporal distribution. They also argued that festivals and events provide opportunities for positive economic impact and enhanced social interactions and relationships. In particular, the results showed that extremely high temperatures above about 31°C reduce both the pedestrian distribution area and the overall volume. In addition, it has been determined that all the events examined lead to an increase in the number of pedestrians, which has a side effect such as the expansion of pedestrian-dominated areas around the city center. However, the results differed not only by the type of event, but also by its time. For example, city festivals attract large numbers of pedestrians and have a large impact on the city center, while the impact of sporting events was more limited spatially along the way to the stadium (Eom and Nishihori, 2022).

Awwaad (2017), on the other hand, listed a number of issues affecting the design of the physical environments of Doha's neighborhoods. All focused on adapting to the local climate, context and culture (Table 2.5.) (Awwaad, 2017). Poor circulation routes, lack of vegetation and other green elements, and lack of land use mix can lead to a lack of connectivity between neighborhoods, lack of natural climate-cooling elements, and lack of attractive focal points which is essential for creating vibrant urban areas. A lack of housing diversity led to a lack of social diversity, which is important for creating a sense of vibrancy and inclusivity in cities. And a lack of basic family-oriented facilities created a lack of family-oriented environment, which is essential for creating economic vitality in conservative communities (Awwaad, 2017).

Table 2.5. Problems of the physical environment of the neighborhoods in Doha (Awwaad, 2017).

Problems of The Physical Environment of The Neighborhoods in Doha
• Lack of safe and well-integrated circulation routes for pedestrians, cyclists, and vehicles. • Lack of vegetation (shade trees, landscaped buffers, green visual barriers, etc.). • Lack of land use mix, where the residential land use should be supported by retail, commercial, religious, educational, and recreational uses. • Lack of housing diversity where at least two housing typologies should be present in a neighborhood. • Lack of the neighborhood’s basic family-oriented facilities such as; a green park, hypermarket, cafes and restaurants, and mosques.

3. STUDY METHOD

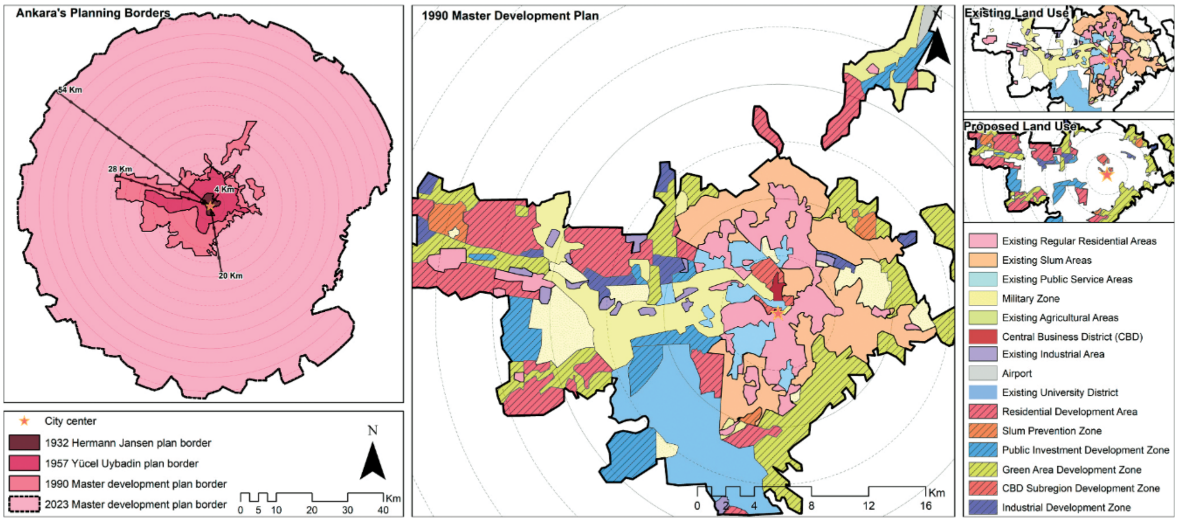
The Study Method chapter provides a detailed explanation of the research design and methods used to explore the spatial relationship between urban vitality and the socio-spatial characteristics in Ankara. The chapter is divided into three main sections: Study Area, Materials and Data Sources, and Method of Analyses.

The Study Area section describes the geographic scope and boundaries of the research, as well as the characteristics and urban development history of the study area. The Materials and Data Sources section provides information about the data sources used in the study, including the types of data and the data collection methods used. This section also explains how the data was processed and cleaned for analysis.

The Method of Analyses section provides a detailed explanation of the statistical techniques used to analyze the data and create models. The section is further divided into two sub-sections: Spatial Analyses and Correlation and Regression Analyses. The Spatial Analyses sub-section describes the methods used to understand the spatial pattern of each variable in the study, while the Correlation and Regression Analyses sub-section describes the methods used to explore the relationship between the study variables and how the socio-spatial characteristics are related to urban vitality.

3.1. Study Area

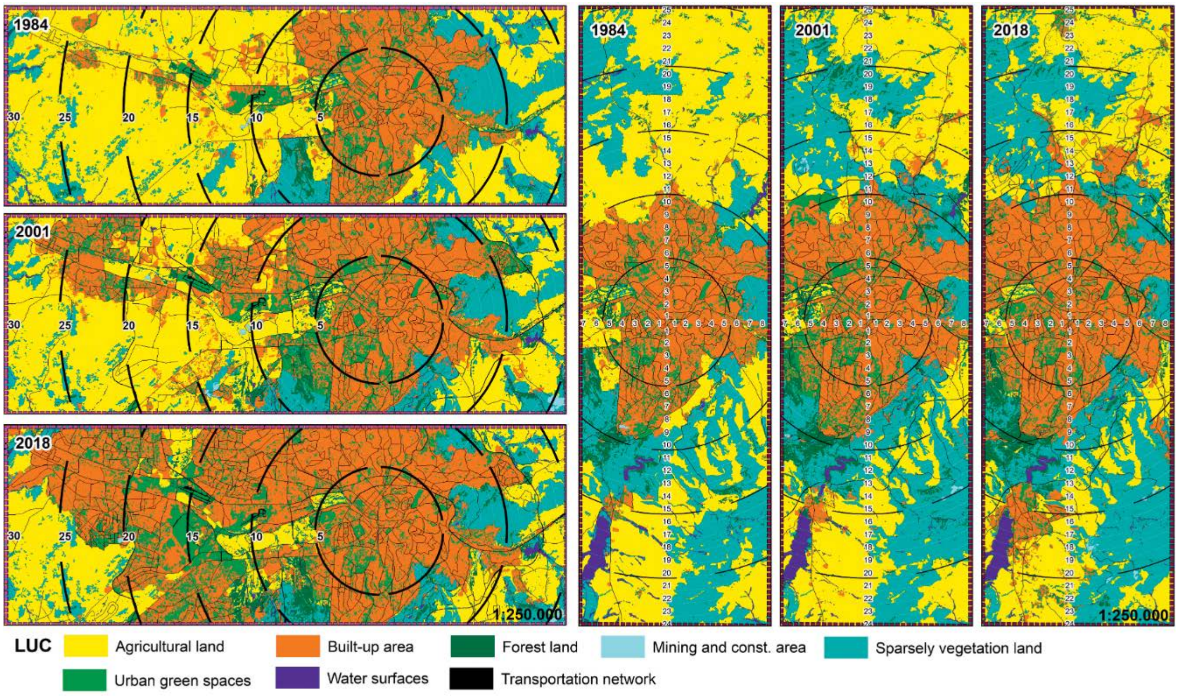
Ankara was a small Ottoman city of fewer than 30 000 people. The city was the center of the national struggle between 1920 and 1923 and was later declared as the capital of the nation-state. By 1923, the city attracted immigrants, particularly state officials from Istanbul. Ankara changed dramatically in the 1950s: in 1952, Kızılay, the center of Yenişehir, was officially recognized as a central business district (CBD). The landlords were allowed to build apartments along the boulevard with shopping areas on the ground floor and in the basement. Türkiye's first skyscraper was also built in Kızılay. This was the transfer of the city center from the old center of the Ulus to Kızılay (Batuman, 2013). The decentralization policies in the 1970s and corridor development in the 1990s expanded the city outwards especially to the west and southwest, although it was originally planned as a compact city (Ozuduru et al., 2014).



Map 3.1. Ankara urban plans. Source: (Cengiz et al., 2022)

Ankara's 1990 master plan changed the direction of urban development from the north-south axis to the west axis, placing mass housing development areas (Batikent, Eryaman, and Sincan) and industrial areas (Ostim and Sincan) to the west of the city, giving direction to newly established urban areas beyond the topographical thresholds to areas with better air quality. However, after the plan approval, the changes made in the plan and the fragmented plan changes for the regions outside the continuous built-up area made the plan increasingly inefficient. In 1984, a new administrative structure was accepted and The Metropolitan Administration was established (Cengiz et al., 2022).

The inability to direct the development of municipalities outside the boundaries of the metropolitan municipality within the framework of the plan created new urban problems in this period. Although the development plan for 2015, which was prepared in 1986, could not be implemented, it led to significant land speculation in the southwest corridor development axis. In addition to the western development corridor proposed in the 1990 master plan, the 2015 master plan also proposed to develop north, northeast, and south corridors (Cengiz et al., 2022). With this proposal, the urban growth around the new subcenters accelerated in the north, northeast, and south directions of the city. The implementation of the zoning plan prepared by the district municipalities for new residential areas in the slums around the city and the partial plans on the western and southern axis of the city disturbed the balance of residential and working areas. In addition, the decentralization proposed in the 2015 structural plan could not be achieved. Speculative development took place in areas where axes were defined in the plan, and the city began to expand in these areas (Cengiz et al., 2022). Map 3.1. summarizes the development history of Ankara's urban plans.



Map 3.2. Land use/land cover map (1984–2001–2018). Source: (Cengiz et al., 2022)

Land use decisions in Ankara are driving urban growth in some regions, and this incentive is increasing population density. According to Cengiz et al. (2022), the city of Ankara became compact within 10 km around the city center in each direction between 1984 and 2018, and after 10 km there was an expansion trend in all directions, but the expansion trend was especially high in the western direction. Therefore, in these years there was an agglomeration of the population in the western direction. Between 2009 and 2018, population growth in the region between 13 and 32 km to the west corresponded to 48,5% of Ankara's total population growth. The shape of residential areas, formed by the increasing trend of urbanization from the city center to its surroundings, was irregular and complex. This was due to the commercial and small business districts in the suburbs, the impact of spatial planning decisions, and the reliance on the Central Business District (CBD) in the city center. The increasing trend in border expansion, which was 40% between 1984 and 1992, increased to 56% between 2009 and 2018. This shows that the impact of urban areas on the empty patches around Ankara has decreased over the years (Map 3.2.); In other words, the urban patches in Ankara have been merged over the years and their shapes have become smoother (Cengiz et al., 2022).

Today, due to the location of the city's metro system and urban planning policies, Ankara's western and southwestern corridors have become the two main axes of the city's development. The urban forms along Ankara's two development corridors show distinct differences. The west axis exhibits a higher degree of land use diversity and high building density. The southwest corridor is almost entirely residential and has a significantly lower population density (Babalik-Sutcliffe, 2013). Despite that, Ankara's main employers, the main government institutions, have been moving to the southwest (Ozuduru et al., 2014).

Map 3.3. Study area

The process of urbanization, which began when Ankara was announced as the capital of Türkiye, did not bring solutions to the city’s problems. Planning efforts were not able to solve these problems and contributed to making them chronic (Cengiz et al., 2022). They failed to bring the necessary vitality to the newly established subcenters in the new development areas. This led to the unbalanced distribution of population and employment densities. This resulted in overpopulation, the inadequacy of housing and public services, and problems with transportation, accessibility, and employment. Therefore, this study will play an important role in addressing these issues by identifying the different levels of urban vitality in the city and the various socio-spatial factors associated with them. In this way, certain policies and implications can be made to target the urban areas suffering from a lack of vitality and poor quality of urban environment.

This study selected 378 central neighborhoods in Ankara (Map 3.3.) to examine the relationship between the socio-spatial characteristics and urban vitality. These neighborhoods are considered to be representative of the more urban and central areas of the capital city and have a population of at least 1000 people per neighborhood. The study area is approximately 1 112,9 km^2 (111 289,7 ha) and had a total population of 5 139 207 in 2021 (Table 3.1.). These neighborhoods were selected to gain a comprehensive understanding of the connections between the socio-spatial attributes of the city and its overall vitality.

Table 3.1. Statistics of the central districts of the study area in Ankara

District	2021 Population of District	Number of Neigbourhoods (per District)	Area of District (km2)
Gölbaşı	28 561 (0,6%)	14 (3,7%)	174,5 (15,7%)
Pursaklar	77 602 (1,5%)	11 (2,9%)	34,0 (3,1%)
Altındağ	151 862 (3,0%)	21 (5,6%)	73,4 (6,6%)
Etimesgut	338 596 (6,6%)	30 (7,9%)	144,0 (12,9%)
Sincan	410 233 (8,0%)	30 (7,9%)	95,0 (8,5%)
Yenimahalle	846 770 (16,5%)	55 (14,6%)	185,5 (16,7%)
Mamak	879 338 (17,1%)	55 (14,6%)	89,4 (8,0%)
Keçiören	973 876 (18,9%)	47 (12,4%)	97,9 (8,8%)
Çankaya	1 432 369 (27,9%)	115 (30,4%)	219,1 (19,7%)
Total	5 139 207 (100,0%)	378 (100,0%)	1 112,9 (100,0%)

3.2. Materials and Data Sources

The socio-demographic, land use, and street network data of Ankara's neighborhoods database were obtained within the scope of the ongoing project, numbered TÜBİTAK SOBAG 218K368, and used in this thesis (Table 3.2.). Data were cleaned and organized using ArcMap software to be suitable for this study. 26 attributes are identified for measuring socio-spatial characteristics. Besides, 12 580 food and drinking places form the points of interest (POI) data. The study area has an 11 456,9 km street network.

The socio-demographic characteristics, land use mix, and accessibility data are essential to understand the relationship between urban vitality and socio-spatial characteristics of the city. Sociodemographic data provide insight into the population characteristics, such as the age group composition, and the education and socioeconomic conditions of neighborhoods' residents. Land use mix provides information on land use characteristics, density, and vitality. Accessibility data provide a picture of the street configuration and location of the existing focal centers and transportation nodes in the area. These data are important to understand urban vitality and how it is affiliated with the socio-spatial characteristics in Ankara. Food and catering businesses were selected as indicators of urban vitality in the city (Ye et al., 2018) because they reflect, to some extent, the intensity of socioeconomic activities in urban areas.

Table 3.2. Data description and sources.

Data	Year	Type	Source
Population numbers	2021	Count	TURKSTAT **
Above-60-age Population	2020	Ratio	TURKSTAT **
Below-14-age Population	2020	Ratio	TURKSTAT **
Population Graduated from Higher Education	2020	Ratio	TURKSTAT **
Population with Primary Education	2020	Ratio	TURKSTAT **
Average monthly income	2019	Average (Turkish Lira per Month)	Başarsoft Information Technology **
Average market values of the land by neighborhood	2020	Average (Turkish Lira per m2)	District Municipality Website **
Floor area ratio	2019	Ratio	Private Company **
Building height	2019	Floors Count	Private Company **
Residential units' numbers	2019	Count	TURKSTAT **
Chain markets numbers	2019	Points (Shapefile)	Başarsoft Information Technology **
Number of Food & Catering Businesses	2019	Points (Shapefile)	Başarsoft Information Technology **
Sport & culture facilities	2019	Points (Shapefile)	Private Company **
Education facilities	2019	Points (Shapefile)	Private Company **
Tourism facilities	2019	Points (Shapefile)	Private Company **
Universities	2019	Points (Shapefile)	Private Company **
Street links	2019	Lines (Shapefile)	Private Company **
Street intersections	2022	Points (Shapefile)	Generated Using Street Links Data **
Ulus	2022	Point (Shapefile)	Generated Using Google Maps *
Kızılay	2022	Point (Shapefile)	Generated Using Google Maps *
Metro stops	2022	Points (Shapefile)	Generated Using Google Maps *
Train stops	2022	Points (Shapefile)	Generated Using Google Maps *
Large industrial neighborhoods	2019	Polygons (Shapefile)	Başarsoft Information Technology **
Neighborhood boundaries	2019	Polygons (Shapefile)	Başarsoft Information Technology **

** Obtained within the scope of the TÜBİTAK project.
*   Obtained within the scope of this thesis.

The neighborhood unit was the unit of analysis in this thesis and the 26 attributes were grouped under three categories: <u>Sociodemographic characteristics, land use mix, and</u>

accessibility. The selection of the variables of the analysis was made depending on their relevance to urban vitality in the previous literature. Tables 3.2., 3.3., and 3.4. present data sources, variables' descriptions, and descriptive statistics of the analysis variables respectively. Points of interest data (POI) were used under land use mix category. They were grouped under two groups: urban services and urban vitality indicators. They were further classified into several variables (Table 3.3.) and separated to different fields (Table's column). Then, they were spatially joined with the corresponding neighborhoods' polygons using ArcGIS software for mapping and analysis.

Sociodemographic characteristics include: the percentage of primary education graduates (PrimaryEdu_P), the percentage of higher education graduates (HigherEdu_P), percentage of the population group below 14 years old (Age_B14P), percentage of the population group above 60 years old (Age_60AP), the average monthly income in Turkish lira (MonthIN_M), the average market values of the land in 2020 by neighborhood (in Turkish Lira) (Y2020_Price), and population density per km2 for the year 2021 (PopD_2021).

Land use mix includes three groups of variables: *land use characteristics*, *urban services*, and *urban vitality*. *Land use characteristics* include: building coverage ratio (FAR) (Building footprint density – The sum of total buildings' footprints divided by the area of the corresponding district), the average number of buildings' floors in the neighborhood (BHeight_M), the density of residential units per (km^2) (ResU_km2), and the density of POI of the chain markets per (km^2) (ChainM_km2).

Urban services cover the density of POI of the sport & cultural facilities per (km^2) (S_Culture_km2), the density of POI of the educational (universities excluded) facilities per (km^2) (Edu_km2), the density of POI of the tourism-related facilities per (km^2) (Turs_km2), and the density of POI of the universities per (km^2) (Univ_km2). *Urban vitality indicators* consisted from: the number of small catering businesses' POI per (km^2) (FD_km2), the number of small catering businesses' POI per total street length (km) (FD_stkm), in addition to the logarithms of the aforementioned variables (Log_FD_km2 and Log_FD_stkm respectively) to transform their spatial distribution from skewed to normal. This helped improve the results from the regression models.,The number of small catering businesses in 15 neighborhoods were modified from 0,00 to 0,001 to be able to calculate Log_FD_stkm and Log_FD_km2 because the logarithm of 0,00 is undefined.

This made the lowest value of FD_stkm and FD_km2 is 0,000014 and 0,000043 respectively. As a result, the lowest value of Log_FD_stkm and Log_FD_km2 is -11,19 and -10,05 respectively (Table 3.4.).

Table 3.3. Description of the analyses' variables.

Categories		Variable	Description
Sociodemographic Characteristics		PopD_2021	2021 population density per (km^2)
		Age_60AP	Percentage of the population group above 60 years old
		Age_B14P	Percentage of the population group below 14 years old
		HigherEdu_P	The percentage of higher education graduates
		PrimaryEdu_P	The percentage of primary education graduates
		MonthIN_M	Average monthly income in Turkish lira
		Y2020_Price	The average market values of the land in 2020 by neighborhood (in Turkish Lira)
Land Use Mix	Land Use Charact.	FAR	The sum of total buildings' footprints divided by the area of the corresponding district.
		BHeight_M	The average number of buildings' stories in the neighborhood
		ResU_km2	The density of residential units per (km^2)
		ChainM_km2	The density of POI of the chain markets per (km^2)
	Urban Vitality	Log_FD_km2	The logarithm of FD_km2
		Log_FD_stkm	The logarithm of FD_stkm
		FD_km2	Number of small catering businesses' POI per area of the neighborhood (km^2)
		FD_stkm	Number of small catering businesses' POI per total street links' length (km)
	Urban Services	S_Culture_km2	The density of POI of the sport & cultural facilities per (km^2)
		Edu_km2	The density of POI of the educational facilities per (km^2) (universities excluded)
		Turs_km2	The density of POI of the tourism-related facilities per (km^2)
		Univ_km2	The density of POI of the universities facilities per (km^2)
Accessibility	Street Configuration	SLegnthD_kmkm2	The total road length (km) in the neighborhood divided by its total area (km^2)
		SIntersectD_km2	The number of street intersections in the neighborhood divided by its total area (km^2)
		TPBtA5000	Betweenness street centrality index with search radius 5 km
		MAD5000	Closeness street centrality index with search radius 5 km
		TPBtA1200	Betweenness street centrality index with search radius 1,2 km
		MAD1200	Closeness street centrality index with search radius 1,2 km
	Location	NEAR_ULUS	Distance (m) to the old city center (Ulus)
		NEAR_KIZILAY	Distance (m) to the city center (Kızılay)
		NEAR_METRO	Distance (m) to the nearest metro station
		NEAR_TRAIN	Distance (m) to the nearest train station
		NEAR_INDUS	Distance (m) to the nearest industrial neighborhood

<u>Accessibility</u> encompasses two groups of variables: *location* and *street configuration variables*. *Location* included: distance to the old city center (Ulus) (NEAR_ULUS), distance to the city center (Kızılay) (NEAR_KIZILAY), distance to the nearest metro

station (NEAR_METRO), distance to the nearest train station (NEAR_TRAIN), and proximity to the large industrial neighborhoods (NEAR_INDUS). All distances were calculated from the centroid of the corresponding neighborhood to the point feature of the concerned locations in meters. To measure ‘NEAR_KIZILAY’ and ‘NEAR_ULUS’, Kızılay square and Ataturk statue in Ulus square were selected as the new and old city centers’ centroids respectively.

Street configuration group contains: street density (SLegnthD_kmkm2) (the total street length (km) in the neighborhood divided by its total area (km^2)), street intersection density (SIntersectD_km2) (the number of street intersections in the neighborhood divided by its total area (km^2)), and street centrality indices (TPBtA5000, MAD5000, TPBtA1200, and MAD1200); Street configuration was based on Multiple Centrality Assessment (MCA) as it provides a more comprehensive interpretation of the street configuration (Yue et al., 2019); MCA is a method developed by Porta et al. (2006, cited in Yue et al., 2019) to evaluate location advantages in a city. The MCA is composed of three network-based centrality indices: Closeness, straightness, and betweenness. Each index assesses the centrality of streets from different angles. Closeness measures how close a location is to other locations along the shortest routes in the road network. Straightness indicates how accessible a place is by straight paths to other places. Betweenness evaluates the frequency that a place is crossed by using the shortest paths connecting other places (Yue et al., 2019).

In this thesis, closeness and betweenness centrality measures were considered. Two different modes of street centrality assessment were defined. These are walking and driving modes. The five-minute walk is a standard that describes the average distance a pedestrian is willing to walk before deciding to drive. The unit of measurement is represented by a radius of ¼ mile, or 400 meters in five minutes since the average human walking speed is about 2 miles per hour (Azmi et al., 2012). However, according to Ozuduru, Webster, Chiaradia & Yucesoy (2021), the analysis of pedestrian behavior in Ankara (UAP, 2014, as cited in Ozuduru et al, 2021) showed that the average walking time in the city is 18 minutes. In general, a person can walk about 75 m/minute, which is equivalent to walking about 1 350 m in 18 minutes. Furthermore, according to the Ankara Transport Master Plan (UAP, 2014, as cited in Ozuduru et al., 2021), the average round trip time by car to work is 34,35 minutes, which was found to cover around 7 km to 14 km

(Ozuduru et al., 2021). For this reason, this thesis selected a network distance threshold of 5 km for driving distance and 1,2 km for walking distance for the calculation of street centrality in driving and walking modes respectively.

Table 3.4. Descriptive statistics of the analyses' variables.

Categories		Variable	Minimum	Maximum	Mean	Standard Deviation
Sociodemographic Characteristics		PopD_2021	0	58784,96	13595,79	11135,24
		Age_60AP	0	0,25	0,1	0,05
		Age_B14P	0	0,31	0,19	0,06
		HigherEdu_P	0	0,73	0,25	0,14
		PrimaryEdu_P	0	0,48	0,2	0,08
		MonthIN_M	818,69	16747,14	7356,45	4826,69
		Y2020_Price	0	4368,33	572,03	511,29
Land Use Mix	Land Use Charact.	FAR	0	0,44	0,19	0,12
		BHeight_M	0,05	24	10	4,26
		ResU_km2	8,03	25697,8	6446,08	4867,03
		ChainM_km2	0	46,82	7,69	7,98
	Urban Vitality	Log_FD_km2	-10,05	6,87	2,41	2,63
		Log_FD_stkm	-11,19	3,65	-0,42	2,25
		FD_km2	0,000043	964,22	44,82	90,15
		FD_stkm	0,000014	38,57	1,93	3,34
	Urban Services	S_Culture_km2	0	38,47	1,05	3,7
		Edu_km2	0	117,06	5,96	9,1
		Turs_km2	0	7,69	0,08	0,6
		Univ_km2	0	34,96	0,6	2,81
Accessibility	Street Configuration	SLegnthD_kmkm2	2,32	40,84	19,22	7,95
		SIntersectD_km2	6,19	408,13	130,76	71,03
		TPBtA5000	6,3	164,93	42,94	21,68
		MAD5000	532,78	1353,46	862,69	173,71
		TPBtA1200	89,96	32837	3355,83	3346,23
		MAD1200	202,38	732,78	387,24	80,69
	Location	NEAR_ULUS	222,5	30732,03	9783,86	6996,76
		NEAR_KIZILAY	281,94	31454,39	9825,77	7201,96
		NEAR_METRO	170,92	18366,69	3265,83	3079,28
		NEAR_TRAIN	149,11	22148,53	4589,46	3945,03
		NEAR_INDUS	0	26788,58	10915,62	5083,27

For closeness and betweenness centrality analyses, sDNA software (Cooper, Chiaradia & Webster, 2016) was used. The results were spatially joined with the corresponding neighborhoods' polygons using ArcGIS software for mapping and analysis in the next phase. The variables involved in this study are as follows: MAD1200 and MAD5000 for closeness street centrality indices with search radiuses 1,2 km and 5 km respectively, and TPBtA1200 and TPBtA5000 for betweenness street centrality indices with search radiuses 1,2 km and 5 km respectively. For example, Mean Angular Distance (MAD1200) measures the average difficulty of travelling from one point to any other point within a radius of 1200 meters. In general, *the higher the MAD1200 value, the more difficult it is to access the area from the given point, indicating that it is "far" from other points rather than "close"* (Cooper, 2021). Betweenness analysis assumes that all entities in a network travel the shortest possible path, within a certain radius, to get from one place to another. For example, to calculate TPBtA1200, all trips that pass-through a given link, with a maximum trip length of 1200m, are counted. The equations for these measures are (Cooper, 2021):

$$\text{MAD} = \frac{\sum_{y \in R_x} \; d_M(x,y)W(y)P(y)}{\sum_{y \in R_x} \; W(y)P(y)} \tag{3.1}$$

where

- the angular distance along a geodesic defined by M, between an origin link x; a destination link y is denoted $d_M(x,y)$
- the proportion of any link y within the radius is denoted P(y)
- network weight of a line y is denoted W(y). By default, W(y)=1

$$\text{TPBtA} = \sum_{y \in N} \sum_{z \in R_y} \; OD(y,z,x) \frac{W(z)P(z)}{\text{total weight}(y)} \tag{3.2}$$

where

- the set of links in the global spatial system is denoted N
- W(z) are the network weights of the Geodesic end point z.
- the proportion of any link z within the radius is denoted P(z).
- total weight(y) is the total weight in radius from each y.
- geodesic endpoints are y and z, not x where the betweenness is measured. OD(y,z,x) reflect the end links of geodesics which are traversed half as often on average, as journeys begin and end in the link center on average. The contributions of 1/3 represent origin self-betweenness.

$$OD(y,z,x) = \begin{cases} 1, & \text{if x is on the first geodesic found from y to z} \\ 1/2, & \text{if } x = y \neq z \\ 1/2, & \text{if } x = z \neq y \\ 1/3, & \text{if } x = y = z \\ 0, & \text{otherwise} \end{cases} \tag{3.3}$$

3.3. Method of Analyses

Retail and food and catering businesses are found near employment because employees tend to walk to lunch or pick up merchandise on the way home. Additionally, visitors enjoy strolling on streets with plenty of commerce and services, including eating and drinking. Thus, understanding what drives the patterns of these services, and how policy and planning tools can improve them, is crucial for highly livable, mixed-use, and sustainable urban environments (Sevtsuk, 2014).

The term ‘urban vitality’ has been widely used in different studies to represent different understandings of socio-economic activities, as seen in the literature review section. In this regard, urban vitality was defined in this thesis as the intensity of socioeconomic activities in an urban area (Xia et al., 2020). Previous literature has shown that small catering businesses can be an indicator of the liveliness of urban places, although they cannot reflect all aspects of urban vitality (Ye et al., 2018). Urban areas where small food and catering businesses exist are considered vibrant because these businesses struggle to survive without significant pedestrian flow and intense urban activity. Furthermore, places, where small catering businesses develop, tend to be dense urban areas that encourage walking, resting, and other leisure activities.

Small catering businesses are more flexible and reflect the existing urban vitality condition compared to large catering businesses and shopping malls. Therefore, data on small food and catering businesses can be seen as an ideal reflection of the vitality of urban areas (Xia et al., 2020). For this reason, this thesis uses *small food and catering businesses to measure urban vitality* in Ankara Metropolitan Area.

3.3.1. Spatial analyses

To understand the spatial characteristics of the different variables in this thesis, different spatial pattern analyses were conducted: Using ArcMap 10.8, spatial distribution analysis was done to display how each variable was distributed over the space in the study area. Furthermore, Kernel Density Estimation (KDE) analysis was conducted to calculate small catering businesses’ density (per km^2) from POIs using a kernel function to fit a smoothly tapered surface to each point (Environmental Systems Research Institute [ESRI], 2016).

This helped identify the overall urban vitality distribution in the city. KDE is one of the most popular methods for analyzing the first-order properties of the distribution of point events because it is easy to understand and implement (Xie & Yan, 2008). In addition, hot spot analysis (Getis-Ord Gi*) was also done with various search radiuses using small catering businesses' data to define the centers of vitality in the city by identifying the statistically significant hot spots and cold spots using the Getis-Ord Gi* statistic (ESRI, 2018).

Moran's I and local Moran's I was calculated to assess whether there is a spatial dependency that affects the selected variables and their distribution. Specifically, Moran's I was calculated to further understand the spatial pattern of each variable; the value ranges from - 1 to 1, with the absolute value showing the degree of spatial autocorrelation. Additionally, local Moran's I was also calculated to distinguish different clusters of urban vitality with high-high values (HH) and low-low values (LL). High-high values (HH) refer to clusters of neighborhoods with high urban vitality values where the values of the neighboring neighborhoods are high. Low-low values (LL) refer to clusters of neighborhoods with low urban vitality values where the values of the neighboring neighborhoods are low. Outlier clusters of high-low values (HL), where neighborhoods with high urban vitality are surrounded by low values, and low-high values (LH), where neighborhoods with low urban vitality are surrounded by high values, were also differentiated (Li et al., 2022). These analyses were made to understand the spatial trends and distribution patterns of urban vitality and socio-spatial characteristics in the city.

3.3.2. Correlation and regression analyses

Pearson Correlation, Factor analysis, and Regression Models are statistical techniques used to analyze the relationship between two or more variables. Pearson correlation analysis was made using SPSS software to reveal the correlations among the different analysis variables. A Pearson correlation measures the strength of the linear relationship between two continuous variables. The value of the correlation provides information about the type and strength of the relationship. The correlations range between -1,0 (strong negative correlation) and 1,0 (strong positive correlation). A zero correlation would indicate that the two variables are not related at all (DeCoster & Claypool, 2004).

The general purpose of factor analysis is to summarize data so that relationships and patterns can be easily interpreted and understood. It is usually used to group variables into a limited set of clusters based on shared variance. It is used to identify the underlying dimensions of a construct or to identify the underlying structure of a set of variables (Yong & Pearce, 2013). The correlation and factor analyses were used to reveal the positive, negative or insignificant relationship between the analysis variables. Their results were important to explain the spatial relation between urban vitality and the other socio-spatial factors. They were also considered to reduce multicollinearity in the modeling process.

Different regression models were made to examine how sociodemographic characteristics, land use mix, and accessibility were affiliated with urban vitality in the city of Ankara. Regression models are mathematical equations used to predict the value of a certain quantity (dependent variable - e.g., density of food and catering businesses) based on other variables (independent variables - e.g., land use mix, and accessibility). They are used to identify relationships between different variables and make predictions based on those relationships (inferential statistics) (Sykes, 1993).

In regression models, variables that have non-linear relationships might generate inaccurate results. Therefore, transforming one or more variables by taking their logarithm can help improve the model's fit by shaping the distribution of the features into a more typical bell-shaped curve (normal distribution) (Andy, 2019). For this reason, the variable "Log_FD_km2", representing the logarithm of food and catering density, was used as an indicator of urban vitality (dependent variable).

Spatial regression models consider the spatial autocorrelation of the variables, which is the tendency for nearby points to be more similar to each other than points that are further away. OLS models, however, do not account for this spatial relationship and assume that each point is independent from the others, and therefore may not accurately predict outcomes in geographic areas. Therefore, using GeoDa software, unbiased spatial regression estimates that use a Maximum Likelihood approach (ML Spatial Lag and Spatial Error models) were also created (Anselin, Syabri & Kho, 2009). Figure 3.1. summarizes the analytical framework of this study.

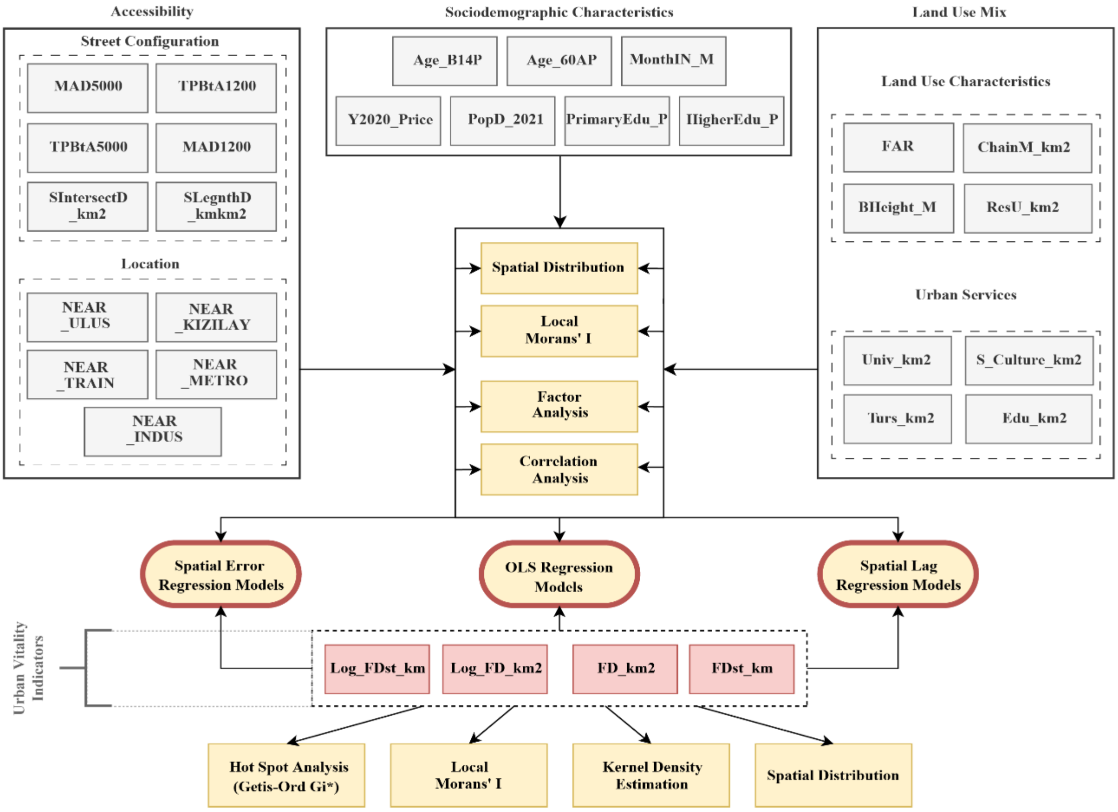


Figure 3.1. Analytical framework

4. RESULTS

The results section of the thesis presents the findings of the study. The results are organized into two main headings: (1) Spatial analysis of selected variables and (2) Correlation analysis and regression models.

The first heading, spatial analysis of selected variables, is further divided into four subheadings: Urban vitality, Sociodemographic characteristics, Land use mix, and Accessibility. These subheadings reflect different categories of variables that were examined in the thesis. The findings from these analyses provide insights into the spatial relationships between urban vitality and various socio-spatial characteristics in Ankara.

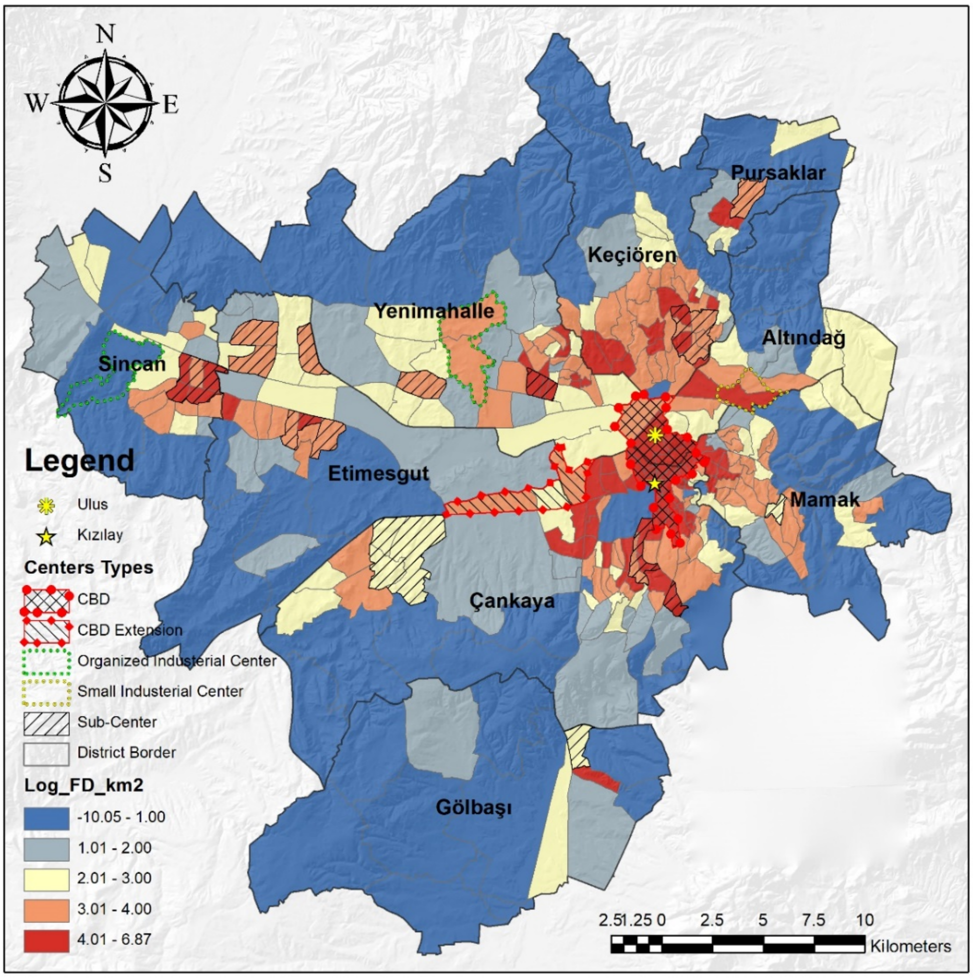
The second heading, correlation analysis, and regression models, presents the results of inferential statistical analyses that were conducted to examine the relationships between urban vitality and socio-spatial characteristics in more detail. The results of these analyses provide a deeper understanding of the factors that may influence urban vitality in Ankara and how they relate to each other.

4.1. Spatial Analysis of Selected Variables

This section presents the findings of the spatial analysis that was conducted to examine the relationship between urban vitality and various socio-spatial characteristics in Ankara. The variable "Log_FD_km2", which represents the logarithm of food and catering density, was used as an indicator of urban vitality and was analyzed using a variety of spatial analysis techniques, including spatial distribution analysis, kernel density estimation, Hot spot analysis, and Local and global Moran's I.

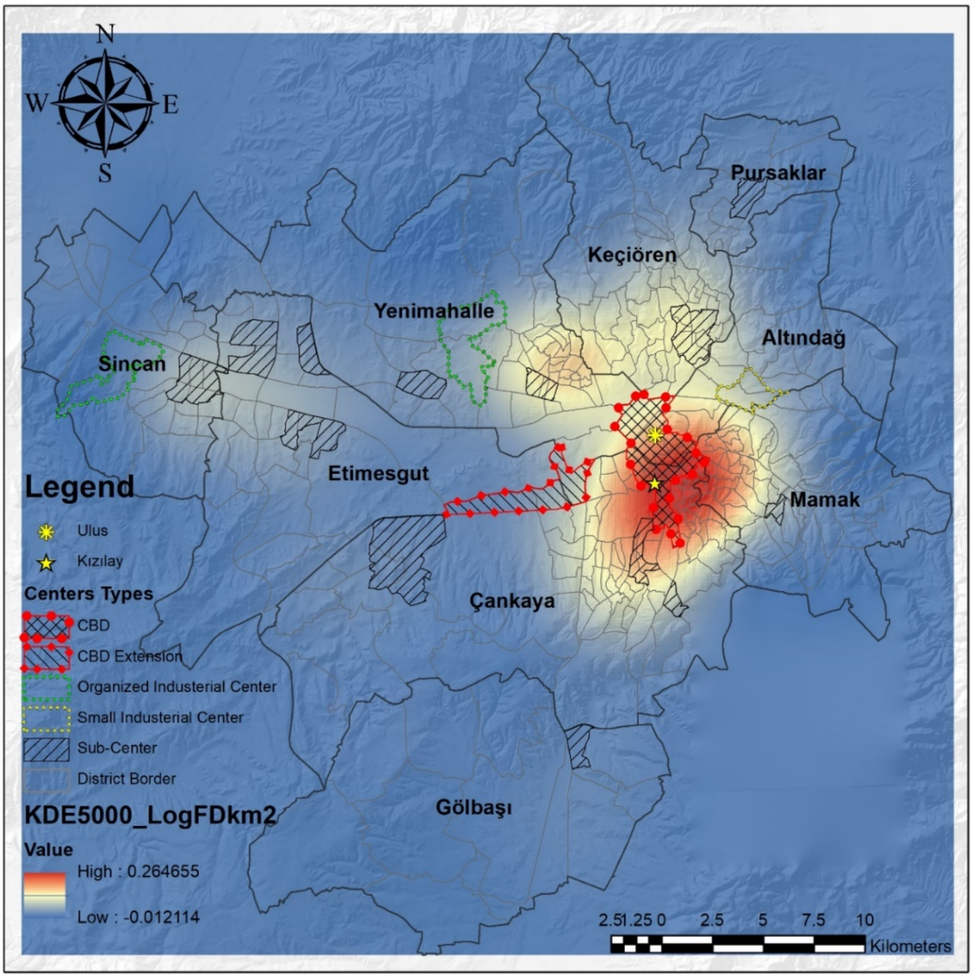
These analyses provide insights into the spatial patterns and trends of urban vitality in Ankara and how it may be influenced by socio-spatial characteristics. The results of the spatial analysis are presented in a series of maps that show the distribution and concentration of urban vitality across the city and identify any clusters or hotspots that may be present. In addition, statistical measures such as Moran's I are used to quantify the degree of spatial autocorrelation and to determine whether the patterns observed were significant. Overall, the spatial analysis of selected variables provided a comprehensive understanding of the relationship between urban vitality and socio-spatial characteristics in Ankara.

4.1.1. Urban vitality



Map 4.1. The logarithm of food and catering POI density.

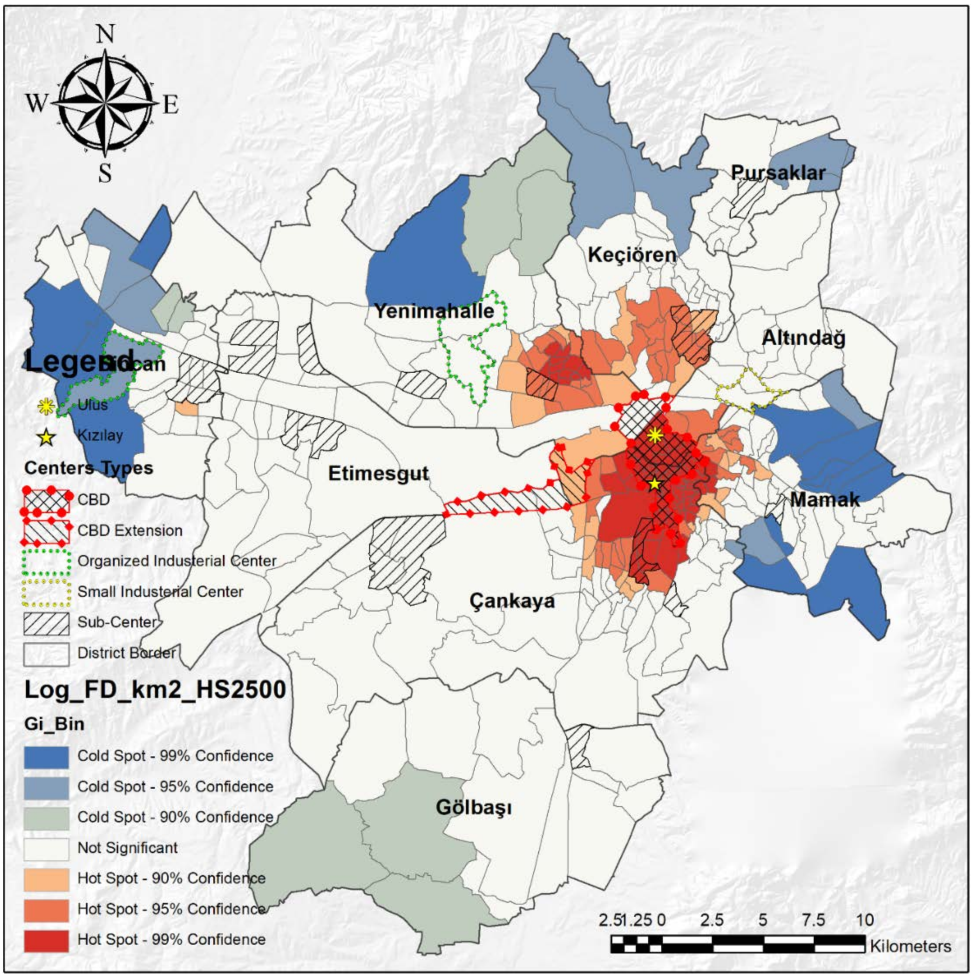
This section presents the findings of the spatial analysis that was conducted on the urban vitality variable "Log_FD_km2" in Ankara. Previous research has highlighted the role of small catering businesses in reflecting the liveliness of an area due to their dependence on pedestrian flow and intense urban activity (Sevtsuk, 2014; Ye et al., 2018; Xia et al., 2020). It has also been suggested that these businesses are more flexible than larger catering businesses and shopping malls in reflecting existing urban conditions. Therefore, the logarithm of food and catering businesses' density (Log_FD_km2) was analyzed using four different spatial analysis techniques: spatial distribution analysis, kernel density estimation, Hot spot analysis, and Local and global Moran's I.



Map 4.2. KDE of the logarithm of food and catering POI density.

The results of these analyses are presented in four maps: Map 4.1. shows the spatial distribution of "Log_FD_km2" across Ankara, Map 4.2. illustrates the kernel density estimate of this variable, Map 4.3. identifies hotspots of high or low "Log_FD_km2" values, and Map 4.4. displays the Local and global Moran's I. Together, these maps provide a comprehensive understanding of the spatial patterns and trends of food and catering density in Ankara and how they are related to socio-spatial characteristics.

Map 4.1. shows that areas with high values of the logarithm of food and catering businesses' density are present in the city center Kızılay and expanded to the north and south along the CBD. High values were also found in several districts across the city; They align with some planned subcenters in the city's 2023 master plan like Demetevler, Güçlükaya, Önder, Bahçelievler, Ayrancı, Sancak, Gaziosmanpaşa, Pursaklar Merkez, Mustafa Kemal, Koru, Kentkoop, Etimesgut Kazım Karabekir, Eryaman, and Sincan central neighborhoods (T.R. Ankara Metropolitan Municipality, 2023).

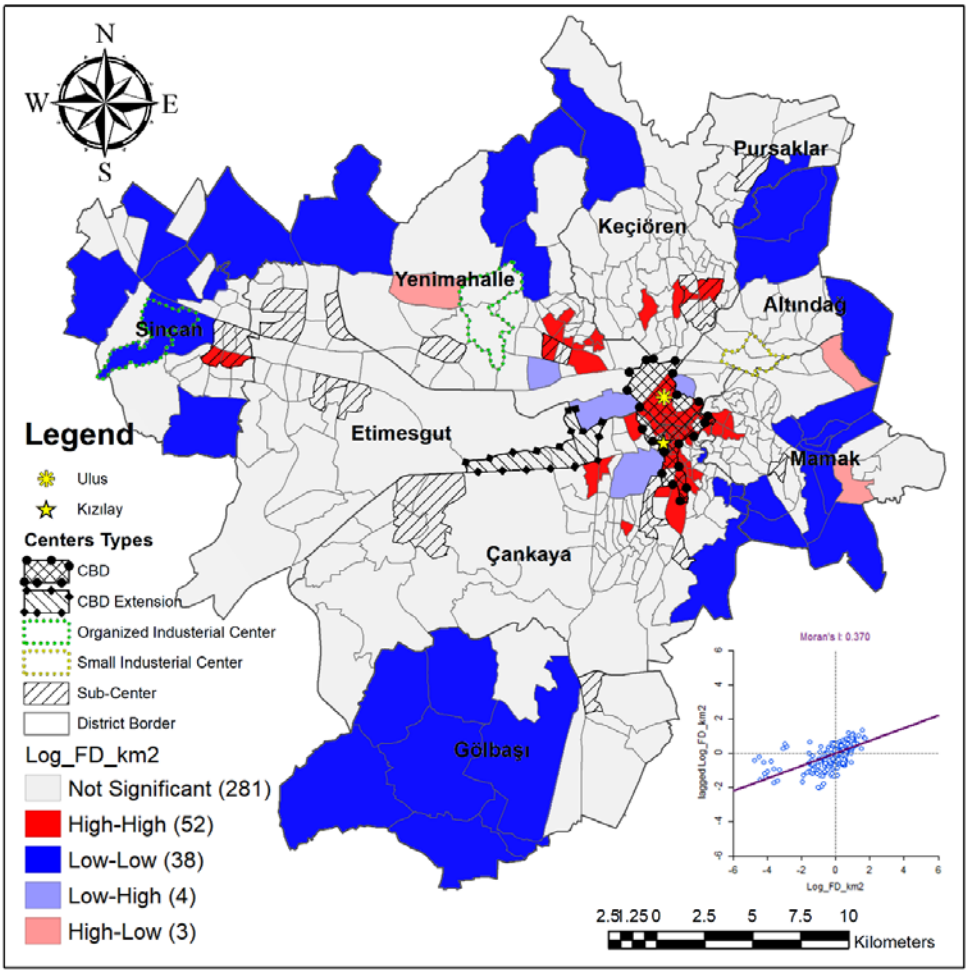


Map 4.3. Hot spot analysis of the logarithm of food and catering POI density.

Local Moran’s I and global Moran’s I were used to measure the degree of spatial autocorrelation or clustering of Log_FD_km2 across Ankara. Map 4.4. displays the Local and global Moran's I of "Log_FD_km2". The color of each region on the map indicates the level of correlation of Log_FD_km2 within that region, relative to its neighbors. Red and blue regions have a higher level of spatial autocorrelation (with similar values), while lighter regions have a lower level of autocorrelation. This analysis was used to detect patterns of clustering and hot spots. The scatterplot of Global Moran's I represents the autocorrelation of Log_FD_km2 across the entire city. It is used to detect the overall pattern in the data, such as a strong positive or negative spatial autocorrelation (clustering).

The global Moran's I statistics of Log_FD_km2 was 0,370, as shown on Map 4.4., indicating a strong spatial autocorrelation. Map 4.4. clearly demonstrates that the early-developed urban areas along the Ulus-Kızılay-Kavaklıdere-Gaziosmanpaşa axis (Northern to Southern Kızılay axis) had the highest concentration of Log_FD_km2 clusters. Map 4.3.

supports this finding with a hot spot in those areas at a 99% confidence level. The subcenters in Yenimahalle (Esentepe, Karşıyaka, Demetevler neighborhoods and their vicinity) and Keçiören districts (Güçlükaya, Tepebaşı, 19 Mayıs and their vicinity) also appeared as hot spots with confidence levels between 90%-99% and 90%-95%, respectively. In Sincan's subcenter, however, there was a hot spot at a confidence level of 90%.



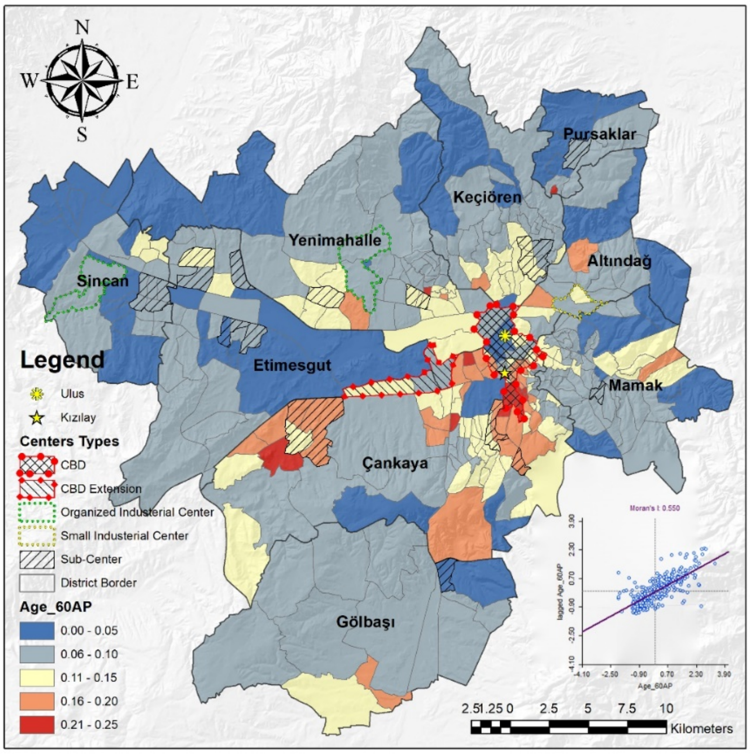
Map 4.4. Local and global Moran's I of the logarithm of food and catering POI density.

The Local Moran's I statistics (Map 4.4.) shows that high-high (high values surrounded with high values) and high-low (high values surrounded with low values) concentrations of Log_FD_km2 closely align with the subcenter development in the 2023 master plan as well. Maps 4.1, 4.2, 4.3, and 4.4 show that the peripheral neighborhoods across the city have the lowest Log_FD_km2 values due to their rural-urban-fringe nature and the city's compact urban development history, which was centered around the city center Kızılay (CBD).

The city also was found to experience disconnectedness between its CBD and its west axes due to the speculative development of urban patches and the existence of large single-use urban lands like military areas, university campuses, man-made forests, and large distribution centers, which can negatively impact the vitality of a city according to Jacobs (1961 cited in Sung et al., 2013). This is further illustrated in the kernel density estimation results (Map 4.2.) which showed that the relative density of Log_FD_km2 in the western side of the city is significantly low compared to the central areas around the CBD.

In summary, the spatial analysis of Log_FD_km2 showed that small catering businesses in Ankara are concentrated along the city center Kızılay and its adjacent areas (the CBD), and they mostly align with the planned subcenters in the 2023 master plan. The peripheral neighborhoods have the lowest Log_FD_km2 values due to their rural-urban-fringe nature and the city's compact urban development history. Disconnectedness between the CBD and the west axes was also detected due to the presence of large single-use urban lands.

4.1.2. Sociodemographic characteristics



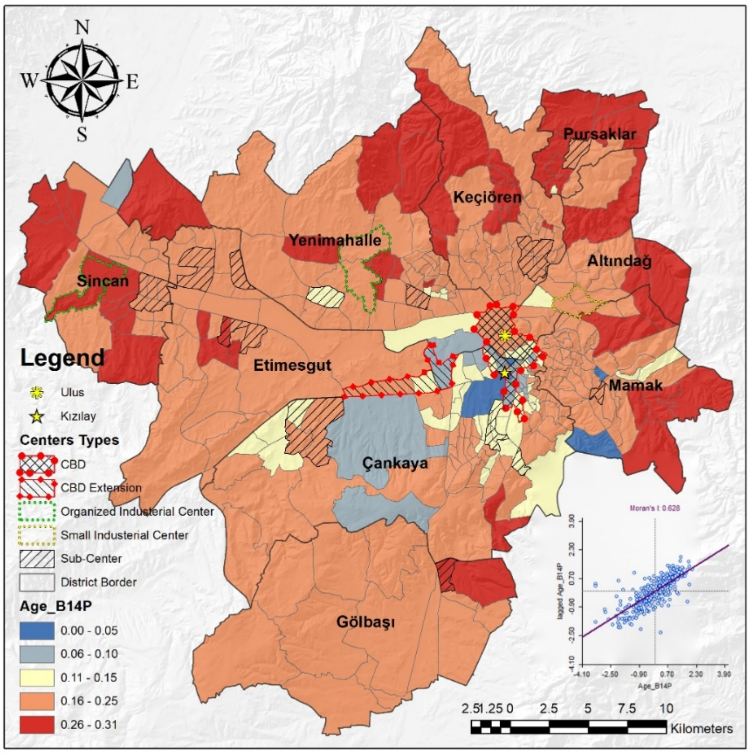
Map 4.5. The percentage of the aged population (60 and above).

As the population and economic activities of cities grow, the vitality of the urban environment is increasingly being regarded as an essential part of urban life. This section examines the relationship between urban vitality and sociodemographic characteristics in Ankara metropolitan area. It analyzes the spatial distribution, patterns, and clusters of specific sociodemographic characteristics such as the percentage of the aged population, the percentage of the young population, the percentage of the high-educated population, the percentage of the primary-educated population, population density, the average monthly income, and the average market values of the land.

The analysis showed that the percentage of the aged population (60 and above) (Map 4.5.) tends to cluster with high values in and to the south of the city center Kızılay and in the southwest of the city in Koru subcenter. The Moran's I value (0,550) indicates that neighborhoods with high percentages of the aged population tended to cluster together significantly in space. Moreover, the neighborhoods on the outskirts were found to have the lowest percentage of the aged population (60 and above). On the contrary, the neighborhoods with higher percentages of younger population (14 and below) were found to cluster strongly (Moran's I value 0,628) in the fringes of the city in all directions except for the southwest (Map 4.6.). Additionally, the centeral neighborhoods around the CBD had the lowest percentages of the young population (14 years old and below).

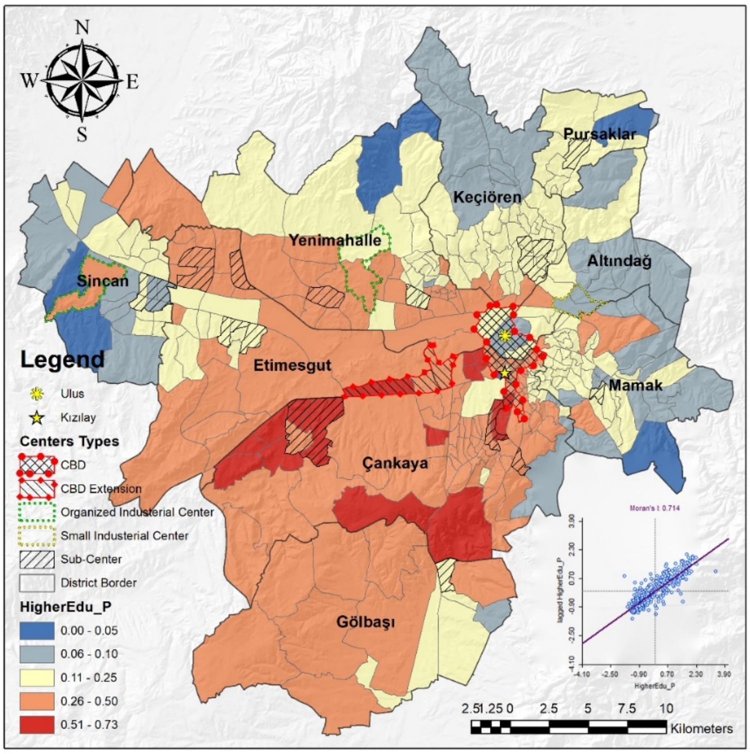
The analysis also showed that highly educated people tend to cluster significantly (Moran's I value 0,714) in the neighborhoods along the southwest corridor and in close proximity to the city center along the new CBD extension (Ozuduru et al., 2014) to the west (Map 4.7.). The smallest percentages, however, were found around the industrial center in Sincan, to the north of the industrial centers in Yenimahalle, and in the rural–urban fringes to the north, east, and southeast of the CBD, in the former areas of squatter houses. The neighborhoods with high percentages of the primary-educated population were also found to cluster significantly in space with Moran's I value of 0,609.

The spatial distribution of the percentage of the primary-educated population was the inverse of the distribution of the highly educated people; it was found high around the industrial centers, and in the rural-urban fringes to the north, east, and southeast of the CBD, and low to the south, west, and southwest of the CBD (Map 4.8.). Pearson correlation analysis (Table 4.1.) shows that these two variables are strongly correlated negatively at the value of -0,844.

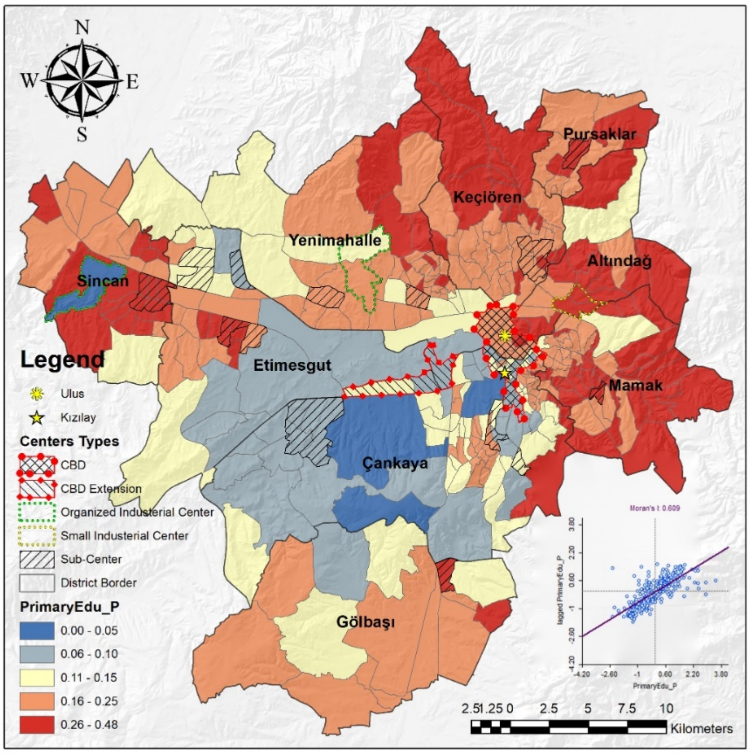


Map 4.6. The percentage of the young population (14 and below).

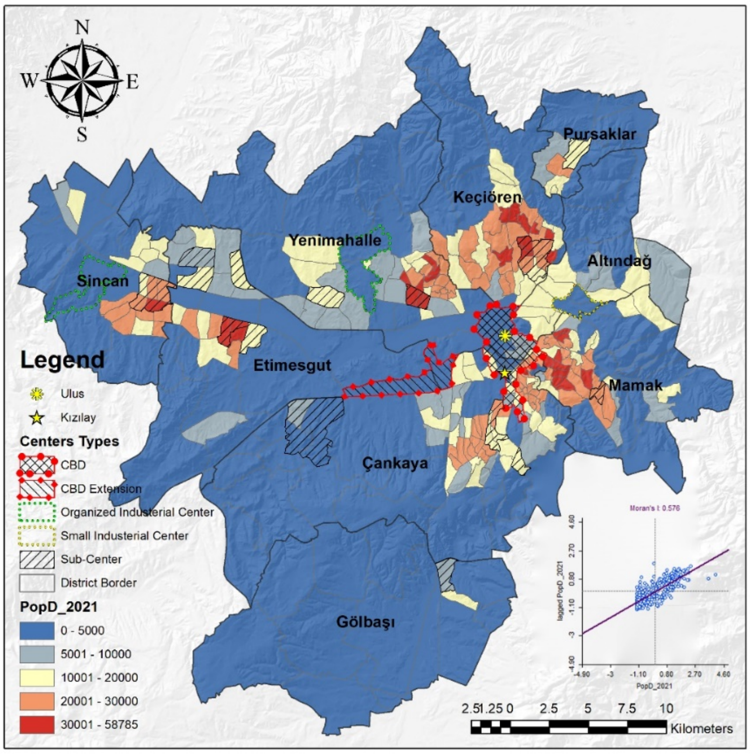
The analysis of population density in Ankara showed that neighborhoods with high population density are strongly clustered (Moran's I: 0,576) to the north, south, and east of the CBD in the subcenters of Keçiören, Yenimahalle, Çankaya, and Mamak, and in the subcenters of Sincan and Etimesgut districts in the west (Map 4.9.). Table 4.1. shows that population density in Ankara has a strong positive correlation with the density of land-use-mix related variables such as the average building heights (BHeight_M), the building area coverage ratio (FAR), street densities (SLegnthD_kmkm2 & SIntersectD_km2), residential units' density (ResU_km2), chain markets density (ChainM_km2), and the logarithm of food and catering densities (Log_FD_km2 & Log_FD_stkm). This shows that land use mix and high density supports creating vital urban environments (Gülden et al., 2008; Sung et al., 2015; Li et al., 2022). On the other hand, population density was found to have negative correlations with the distance from the important urban centers such as Ulus and Kızılay, and the industrial subcenters. Similarly, the distance from metro and train stations correlated negatively with population density (Table 4.1.). This means that neighborhoods with high population density are usually clustered close to these locations due to high accessibility opportunities to the various urban services and transportation hubs.



Map 4.7. The percentage of the high-educated population.



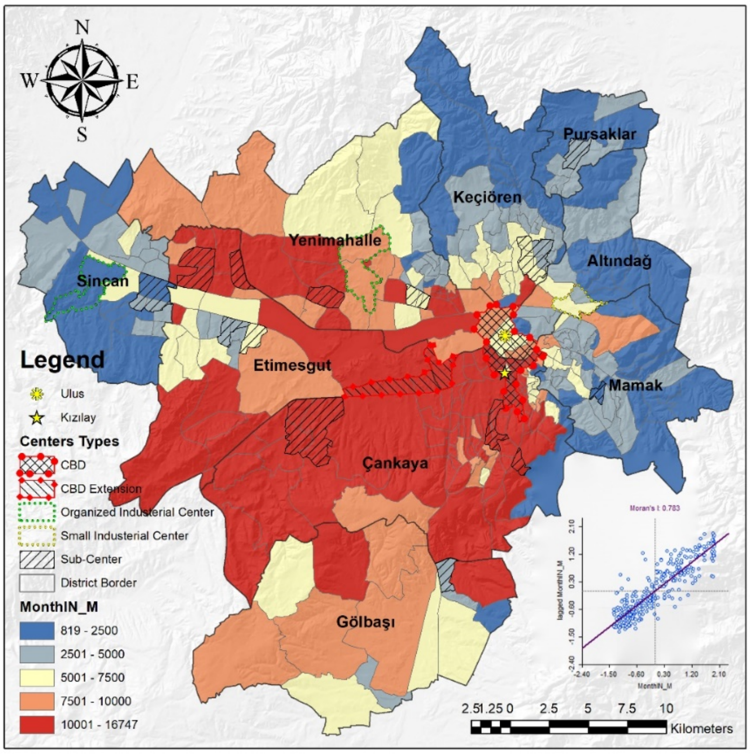
Map 4.8. The percentage of the primary-educated population.



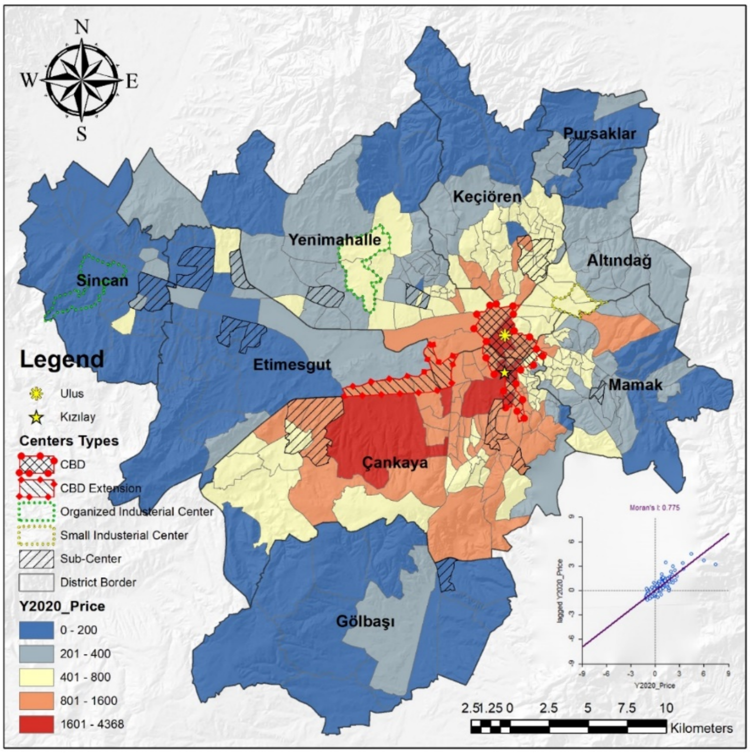
Map 4.9. Population density (per km^2) in 2021.

The neighborhoods with low population density can be divided into two groups: The first one includes the neighborhoods in the rural-urban fringes with less urban development. The second group includes the neighborhoods along the west and southwest development corridors (Map 4.9.) where irregular urban development (urban sprawl) and large land-use barriers like large distribution centers, university campuses, hospitals, man-made forests, military areas, and airports can be found. Such urban growth and land use types were found to affect urban vitality negatively in the literature (He et al., 2018; Sung et al., 2013; Sung et al., 2015).

The analysis also showed that high average monthly income positively correlates with higher education levels, senior population, taller buildings, and more expensive lands (Table 4.1.). Neighborhoods with high average monthly income were found to be strongly clustered (Moran's I: 0,783) in the CBD and in the west and southwest development corridors (Map 4.10.). On the other hand, neighborhoods with lower population income values were found around the industrial subcenter in Sincan and in the former slum areas in the north, east, and southeast of the CBD. Interestingly, the analysis of the land prices in Ankara showed that their spatial distribution is different from the spatial distribution of the development density in the city. More specifically, the neighborhoods with higher land prices are strongly autocorrelated (Moran's I: 0,775) and clustered in the CBD and its extension to the west (Map 4.11.).



Map 4.10. The average monthly income (Turkish lira).



Map 4.11. The average market values of the land (per m2).

Additionally, clusters of high land prices were observed in the southwest corridor development despite the low development density and the inadequate number of subcenters in that direction. This is due to the significant land speculation that followed the preparation of the 2015 development plan in 1986, which could not be implemented (Cengiz et al., 2022).

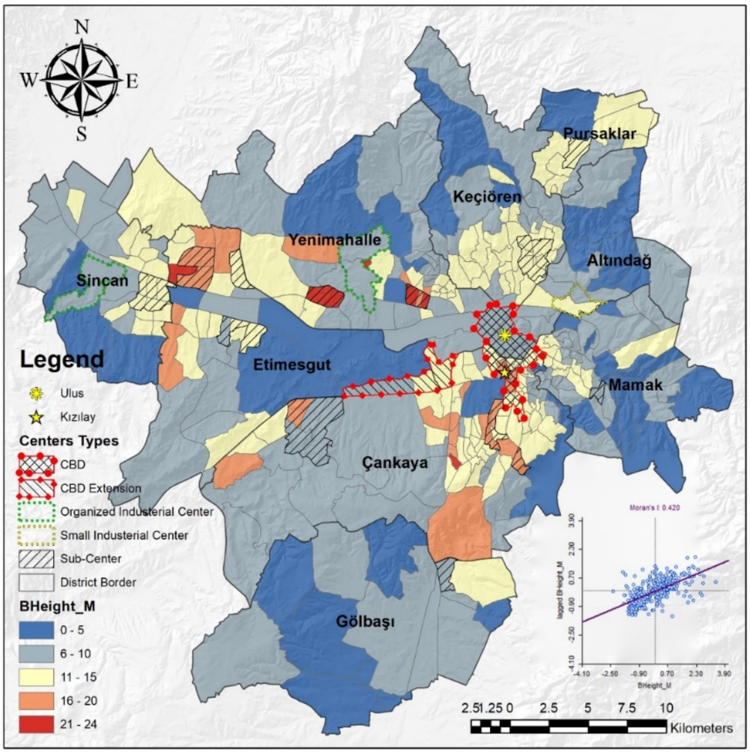
In summary, the analysis of sociodemographic characteristics revealed that population and economic activities in the city are spatially distributed and clustered according to the levels of urban vitality. It also showed that urban vitality is strongly correlated with sociodemographic characteristics in Ankara such as population density, education levels, and land prices.

4.1.3. Land use mix

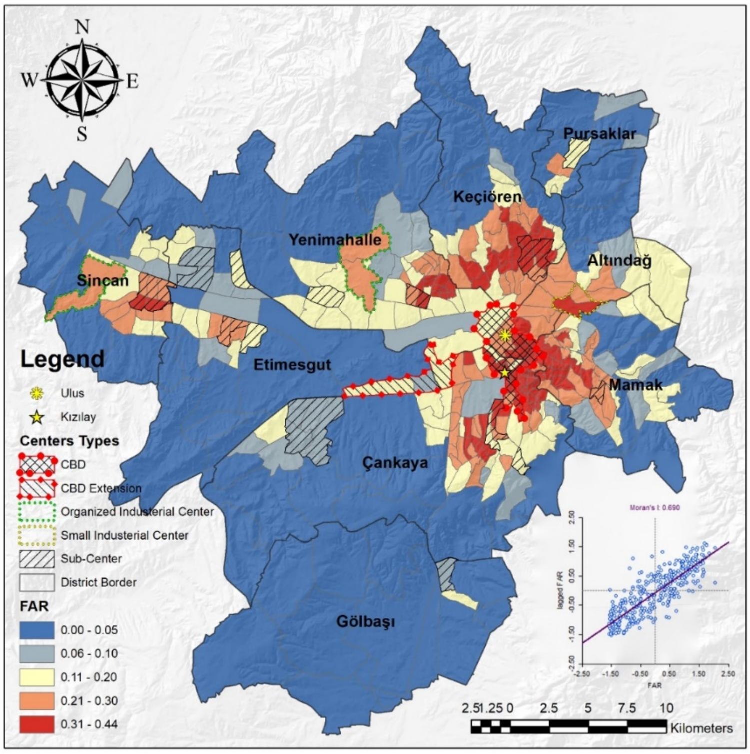
The spatial relationship between land use mix and urban vitality is an important topic of study in urban planning and development; Urban vitality is impacted by the availability of urban services, such as educational facilities, sports and culture facilities, and universities. To better understand the relationship between land use mix and urban vitality, it is important to consider the land use characteristics, such as the average of building floor numbers (Map 4.12.), the average building coverage area (FAR) (Map 4.13.), the density of chain markets (POI per km2) (Map 4.14.), and the density of residential units (per km2) (Map 4.15.). Additionally, it is important to consider the density of urban services, such as educational facilities (POI per km2) (Map 4.16.), sports and culture facilities (POI per km2) (Map 4.17.), and universities (POI per km2) (Map 4.18.). By examining these land use characteristics and urban services, it is possible to gain insight into the spatial relationship between land use mix and urban vitality.

Land use characteristics

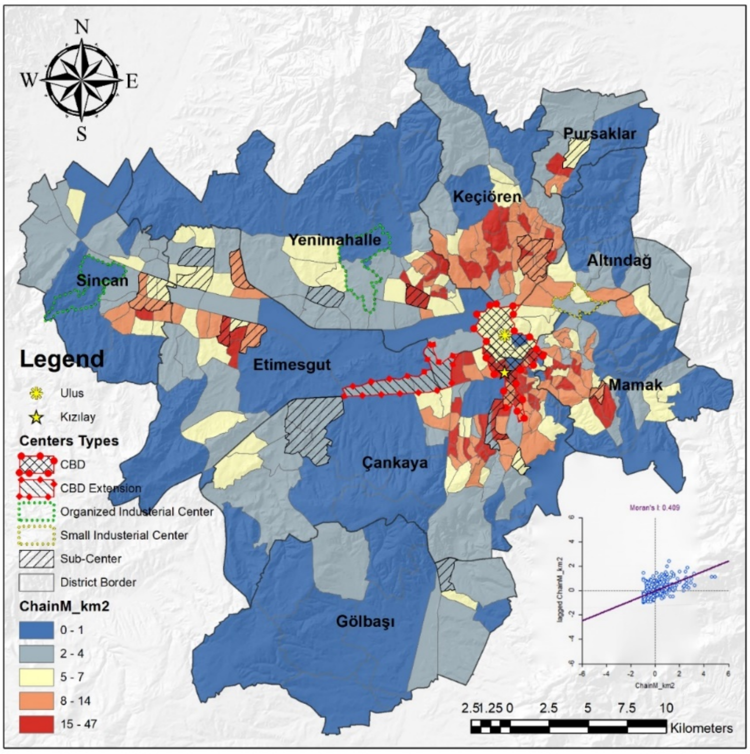
The analysis of building heights (BHeight_M) in Ankara showed that the average building height was 10 floors and the maximum height was 24 floors (Table 3.4.). Clusters of high values (16 - 24 floors) were found in the west and southwest development corridors. Low values (0 – 5 floors) were found in the least developed neighborhoods on the outskirts of the city and in some neighborhoods in the west corridor where there used to be a low building coverage ratio as shown in map 4.12. and map 4.13.



Map 4.12. The average of building floor numbers.



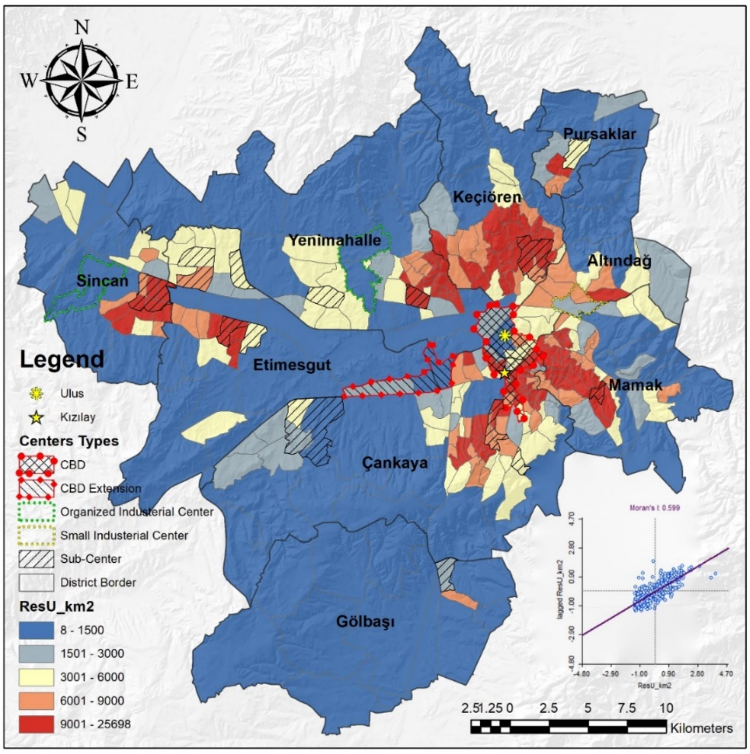
Map 4.13. The average building coverage area ratio (FAR).



Map 4.14. Density of chain markets (POI per km2).

The majority of neighborhoods with high population densities with more than 10 000 people per km^2 (Map 4.9.), near the CBD and the planned subcenters, were found to have relatively medium building heights, between 11 and 15 floors. On the other hand, relatively low-population-density neighborhoods, with less than 5000 people per km^2 (Map 4.9.), had lower average building heights, lower than 10 floors (Map 4.12.). Overall, the average building heights (BHeight_M) correlated significantly with the sociodemographic characteristics, land use mix and accessibility variables. Specifically, it had a strong positive correlation with population density, the percentages of the aged and high-educated population, average monthly income, average estimated land prices, building coverage ratio, street link density, proximity to metro and train stations, and the densities of the residential units, chain markets, education facilities, and food and catering businesses (Table 4.1.). Moran's I statistics value, 0,420, showed that the variable BHeight_M has a strong positive autocorrelation in space (Map 4.12.). This means that high values are clustered together, close to the CBD and the planned subcenters across the city.

The spatial distribution analysis of the average building area coverage ratio (FAR) in Ankara (Map 4.13.) showed a relatively similar distribution pattern to the logarithm of food and catering density (Map 4.1.), and the street link length density (Map 4.20.). In other words, neighborhoods with high FAR strongly clustered (Moran’s I: 0,690) in the neighborhoods with close proximity to the CBD, and the subcenters proposed in the 2023 plan across the city. The ones with lower FAR values were found in the rural-urban fringe surrounding the city and in sprawling suburban areas in the southwest development corridor (Map 4.13.).



Map 4.15. Density of residential units (per km2).

FAR also correlated significantly with the sociodemographic characteristics, land use mix and accessibility; It had a strong positive correlation with the densities of food and catering services, population, street links and intersections, residential units, chain markets, and educational facilities (Table 4.1.). Additionally, it was strongly correlated positively with betweenness street centrality in the driving mode, senior population percentage, average estimated land prices, and average building heights. On the contrary, FAR correlated negatively with distances from Kızılay, Ulus, the nearest metro or train stops, and the percentage of the junior population (Age_B14P) in Ankara (Table 4.1.).

In other words, high development intensity can be found around the CBD and the rail transportation stops in the city. Additionally, the sociodemographic characteristics of a neighborhood was found to be strongly related to its level of development intensity; Senior and higher-income populations mostly lived in the more vital neighborhoods with central and locational advantages such as proximity to the CBD, and high densities of urban services and land use mix. This usually leads to an increase in the quality of such urban areas. Thus, the demand and the land values of such neighborhoods also increase.

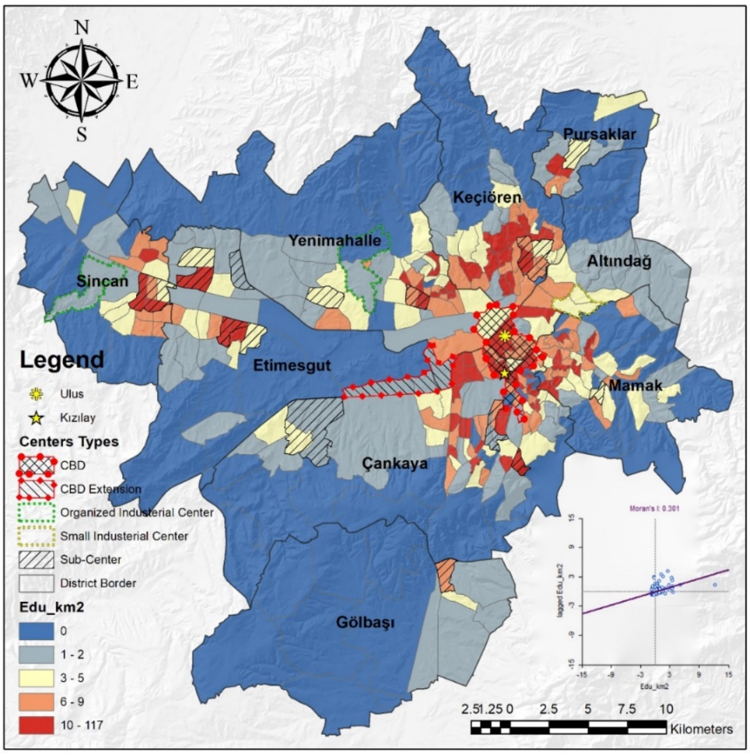
High densities of chain markets were also found to be autocorrelated in space (Moran’s I: 0,409). This trend can be seen in map 4.14. Neighborhoods with high densities of chain markets were found to be clustered in close proximity to the CBD especially where high building area coverage ratios were. This pattern was also found around the areas where subcenters were proposed in the master plan of 2023 across the city. Density of chain markets correlated significantly with land use characteristics and density of urban services in neighborhoods; High values of the variable significantly correlated with high FAR, high densities of food and catering services, street link and intersection, residential units, sports, culture and education facilities, and large building heights) (Table 4.1.). This means that urban areas with high development densities and urban services attracted the development of the chain markets to benefit from the vitality and liveliness of such areas.

It was also found that the density of chain markets correlated negatively with the distance from Kızılay and Ulus centers in addition to the distance from metro and train stops, i.e., neighborhoods that were far from the city centers and the public rail transportation stops in the city were less advantageous and did not attract chain markets’ development. Such areas can be found in neighborhoods on the outskirts surrounding the city and in the southwest development corridor (Map 4.14.).

Relatively similar spatial distribution patterns were observed for the analysis variables ResU_km2 and Edu_km2 which showed strong spatial autocorrelation with Moran’s I value 0,599 and 0,301 respectively (Map 4.15. & Map 4.16. respectively). This means that high densities and land use mix in the centers and subcenters of the city created the demand necessary for attracting many urban services and businesses. As a result, such urban areas enjoy the highest values of liveliness and vitality. On the contrary, the areas with low densities, land use mix, and accessibility in the rural-urban fringe and the southwest corridor, where sprawling suburban areas and land speculation exist, are less vital and attractive (He et al., 2018).

Urban services

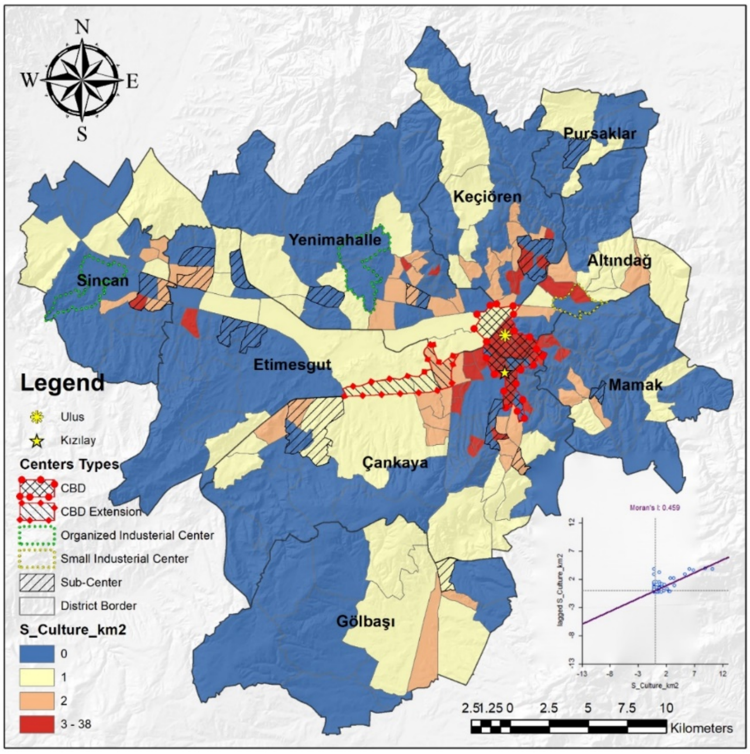
In addition to that, sports and cultural facilities were found to form spatial clusters in relatively close proximity to the planned subcenters across the city (Map 4.17.). A significant cluster of high values was observed in the CBD and its adjacent neighborhoods (Moran's I 0,459). The rest of the neighborhoods in the city had sparse values of sports and cultural facilities (0-2 per km^2). This show that the CBD of Ankara is the dominant cultural center, and the most active and vital urban area in the city. The spatial distribution analysis of the density of tourism facilities, however, did not show any significant pattern in the city (Moran's I 0,002).



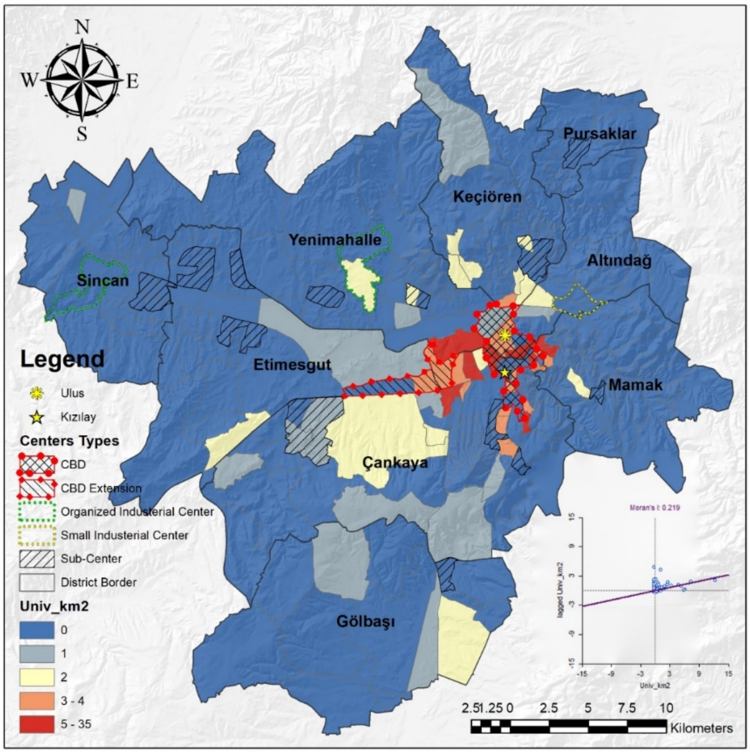
Map 4.16. Density of educational facilities (POI per km2).

The spatial analysis of the density of universities in Ankara presented that universities are autocorrelated in the city (Moran's I: 0,219, Map 4.18.). It showed that universities are mostly clustered in the CBD and the CBD extension axis. Additionally, two large campuses (METU and Bilkent) were found to be located in the southwest development corridor. This resulted in the discontinuity of the urban fabric and created gaps or "*border vacuums*" that affect the overall vitality of the city. Overall, although universities usually attract active age groups help make the city more lively and vital (Jalaladdin et al., 2012;

Paköz et al., 2022b), their improper geographical location may affect the overall vitality of the city negatively.



Map 4.17. Density of sports and culture facilities (POI per km2).



Map 4.18. Density of universities (POI per km2).

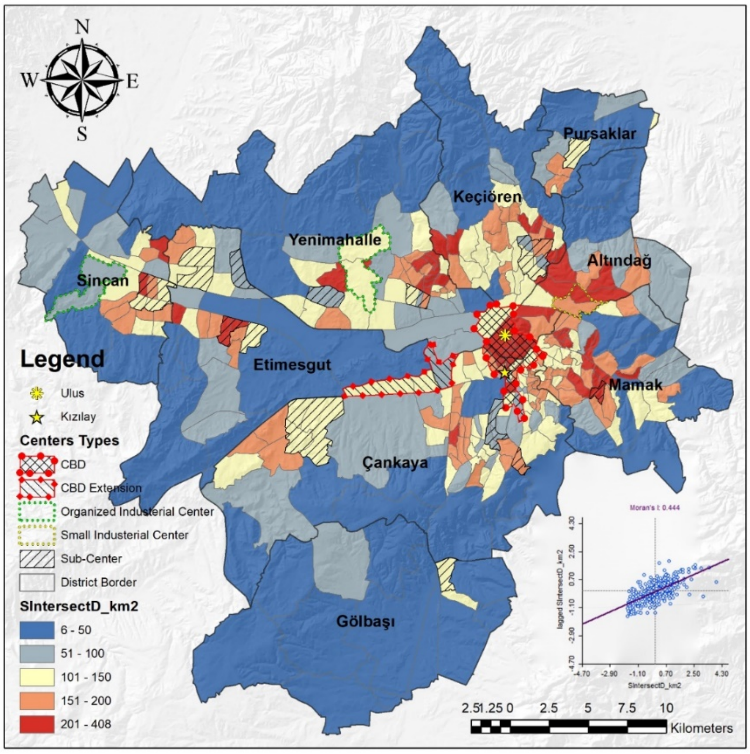
All in all, land use mix is an important determinant of urban vitality. Land use characteristics such as building floor numbers, building coverage area, density of chain markets, and density of residential units, as well as the density of urban services such as educational facilities, sports and culture facilities, and universities, all contribute to the relationship between land use mix and urban vitality. High densities of urban services and land use mix in the city centers and subcenters attract the development of chain markets and food and catering businesses, which in turn make the city more vital and attractive. On the contrary, areas with low densities, land use mix, and accessibility in the rural-urban fringe and urban sprawl in the southwest corridor are less vital and attractive.

4.1.4. Accessibility

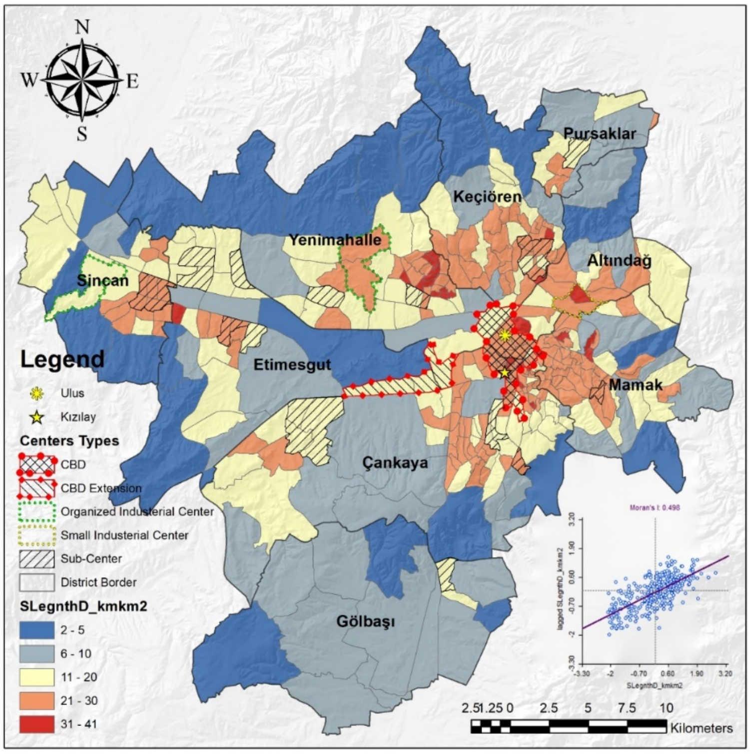
Previous literature showed that it is increasingly evident that urban vitality is strongly related to accessibility (Sung et al., 2013; Sung et al., 2015; Awwaad, 2017; Wang et al., 2018; Xu et al., 2018; Yue et al., 2019; Lang et al., 2020; Al-Saaidy et al., 2021; Li et al., 2022; Zhang et al., 2022). In this regard, access to and from different parts of the city, as well as mobility within the city, are key to understanding the spatial relationship between urban vitality and accessibility. This section examines two main aspects of accessibility, namely street configuration and location. Street configuration provides valuable insight into the density and length of street intersections and links, as well as closeness and betweenness centrality. Location offers a clear picture of the distance from key locations like Kızılay square in the CBD, Ulus square, industrial centers, and public transportation stops. Through a thorough analysis of these maps, it was possible to gain a better understanding of the spatial relationship between urban vitality and accessibility.

Street configuration

Map 4.19. and map 4.20. show the spatial distribution analysis of street intersections and street link densities in Ankara respectively. They were positively autocorrelated in space significantly (Moran’s I: 0,444 and 0,498 respectively). Their distribution patterns are very similar to FAR’s (Map 4.13.) and Log_FD_km2’s (Map 4.1.), i.e., street intersections and street link densities were found to be high in the CBD and subcenters where high development density exists and low in the rural-urban fringe and sprawling suburban areas to the southwest where less development density is found.

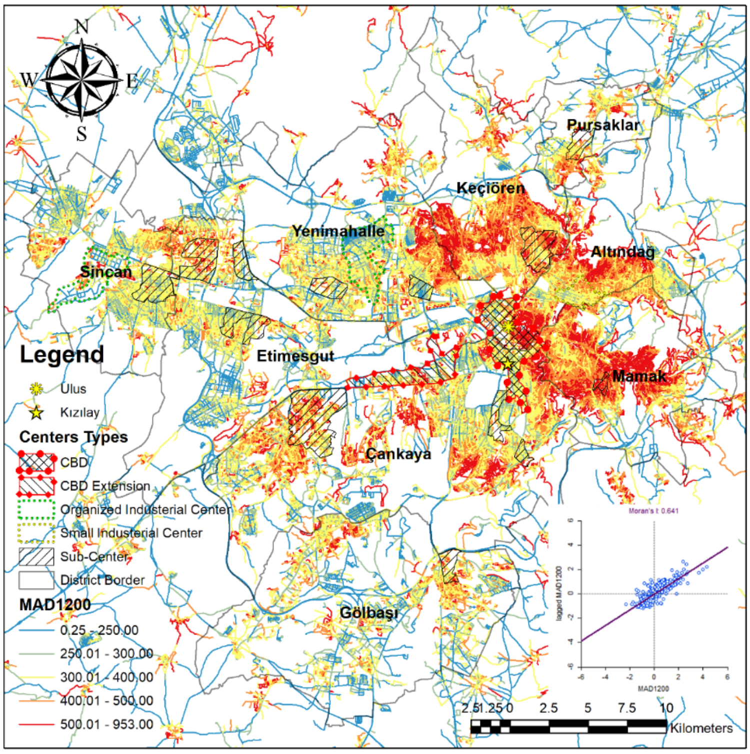


Map 4.19. Street intersection density (per km2).



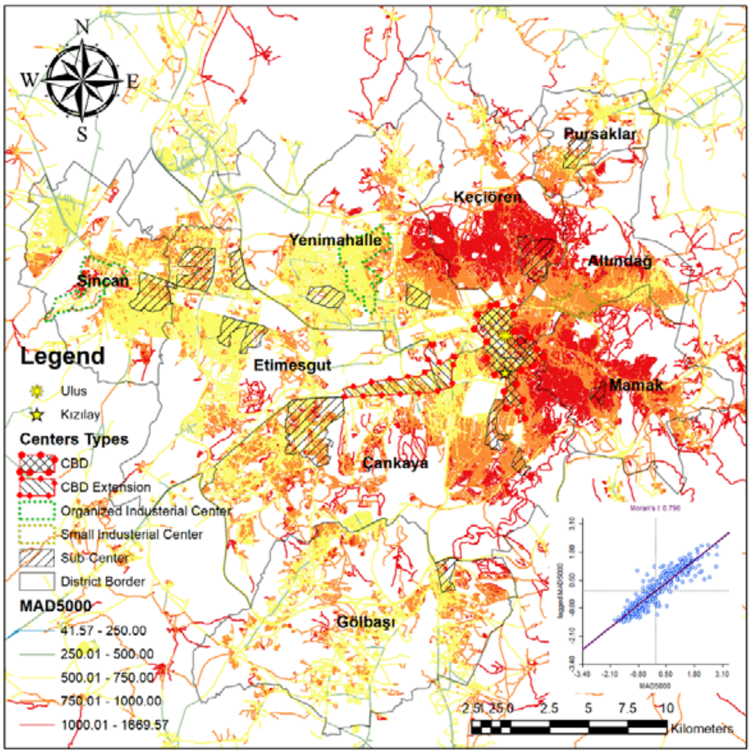
Map 4.20. Street link length (km) density (per km2).

In addition, the spatial analysis of closeness centrality in both walking and driving modes, as shown on Maps 4.21. and 4.22., respectively, revealed a high level of spatial autocorrelation with Moran's I values of 0,641 and 0,796, respectively. This indicates that the streets with high values of closeness centrality, which measure the accessibility of a street based on the proximity of other streets in the network, tend to cluster together geographically. The spatial distribution of closeness centrality showed that high closeness centrality values are primarily located in the eastern, northeastern, and northern sides of the CBD. This suggests that those parts of the city are more isolated or disconnected from the rest of the city in terms of its street network. On the other hand, the western part of the city has lower values of closeness centrality, indicating higher accessibility and ease of access according to Cooper (2021).

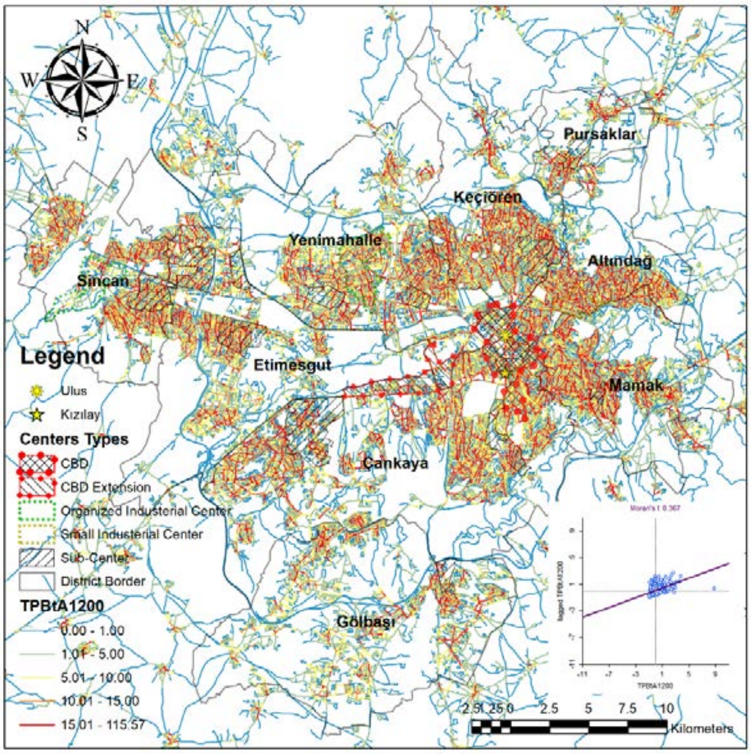


Map 4.21. Closeness centrality analysis in walking mode (1200 m search radius).

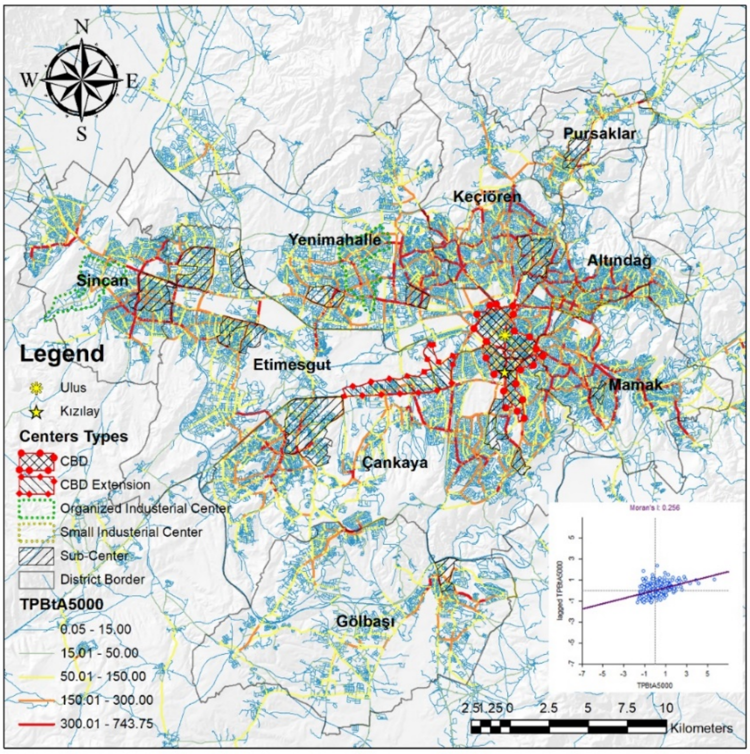
Betweenness centrality analysis in walking mode (Map 4.23.) revealed a high level of spatial autocorrelation with a Moran's I value of 0,367. This indicates that the streets with high values of betweenness centrality, which measure the number of times a street is passed-by connecting shortest routes, tend to cluster together geographically. These high values corresponded with the layout of secondary roads that play a crucial intermediary function in linking different parts of the city. On the other hand, the betweenness centrality analysis in driving mode (Map 4.24.) had a lower level of spatial autocorrelation with a Moran's I value of 0,256. This suggests that the streets with high values of betweenness centrality are more evenly distributed geographically. These high values corresponded with the layout of major roads that are more frequently used to connect different parts of the city.



Map 4.22. Closeness centrality analysis in driving mode (5000 m search radius).



Map 4.23. Betweenness centrality analysis in walking mode (1200 m search radius).

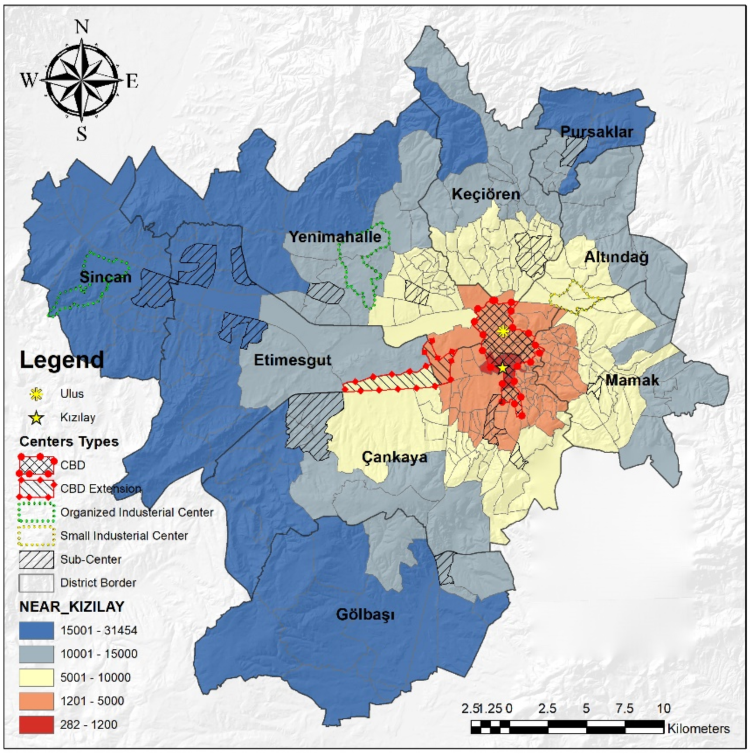


Map 4.24. Betweenness centrality analysis in driving mode (5000 m search radius).

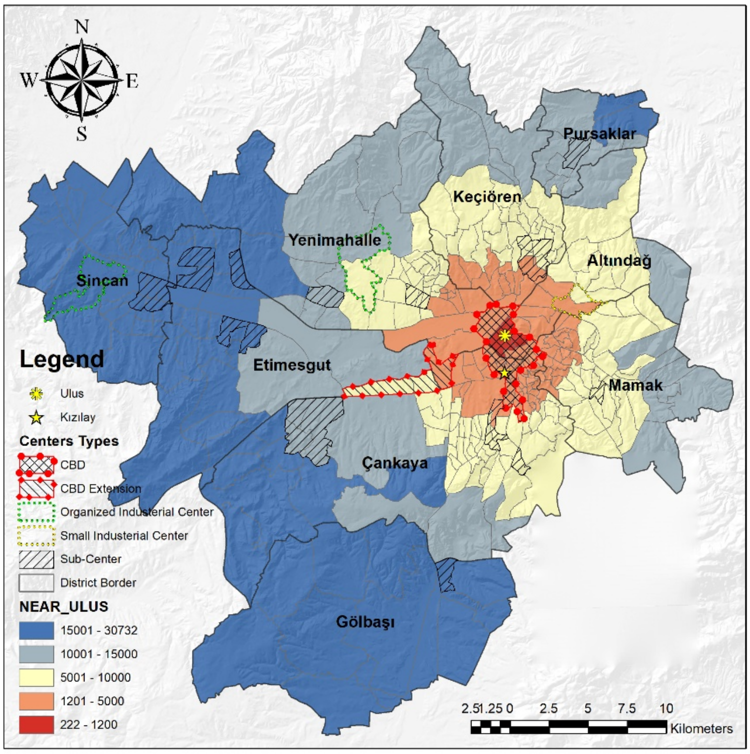
Overall, the street network pattern in Ankara shows that the urban pattern in the western and southwestern corridors is irregular and dispersed, which might affect the accessibility to and from the CBD negatively. This might impact the development process in the western and southwestern parts of the city due to the lack of business opportunities that prefer allocating as close as possible to the CBD. It also might lead to over-densification of the CBD, which can have negative consequences for the city's vitality and lead to various urban problems including traffic congestion, a decrease in the quality of life with residents experiencing more noise, pollution, and other forms of urban stress, and negative impacts on the local economy.

Location

In general, the socio-spatial analysis showed that the CBD is the dominant cultural and economic center in the city (Maps 4.25 & 4.26); It has the most diverse and mixed land uses, such as office buildings, governmental institutions, banks and financial institutions, hotels, shopping streets, shopping malls, and restaurants. The city centers Kızılay and Ulus are major elements of the CBD. They are located at the intersection of the main roads and the central metro stations (Maps 4.24 & 4.28). Kızılay has high development density with medium-to-high-rise buildings and is considered the main city center (Map 4.25.). Ulus, however, is the historical and cultural center of the city (Map 4.26.).

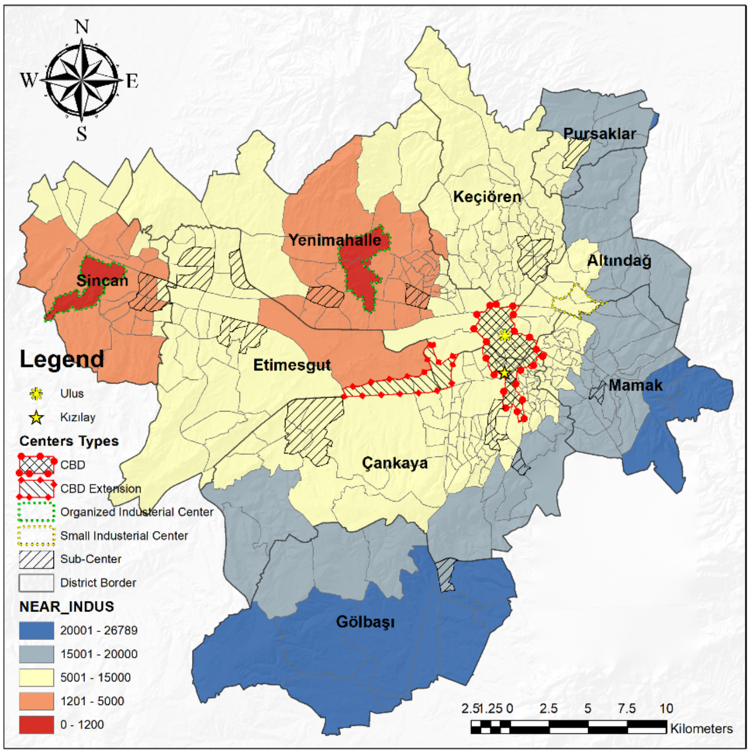


Map 4.25. Distance from Kızılay square in the CBD.



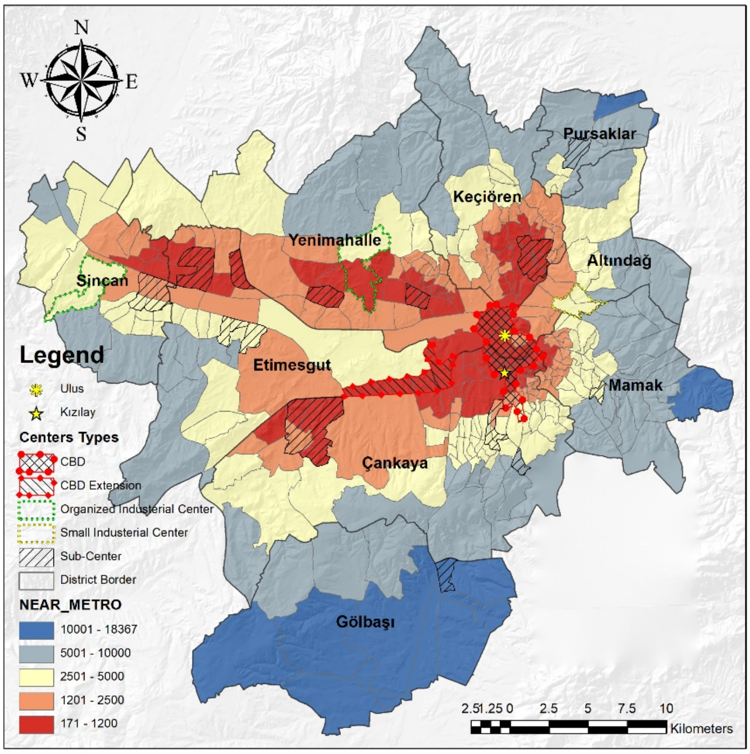
Map 4.26. Distance from Ulus square (Ataturk Statue) in the old center.

Ankara also have three large industrial subcenters (OSTIM for small-middle scale industries, and Ivedik and Sincan organized industrial zones for larger industrial manufacturing) (Map 4.27.). These subcenters were developed along the western axis to support the decentralization policies in the plan of 1982 (Batuman, 2013). This was supported by a suburban train network and a metro system. The suburban train connected the industrial subcenter in Sincan with the CBD and eastern part of the city (Map 4.29.). The metro network functioned as the backbone of the decentralization policies and outward expansion growth. It currently has three main functioning corridors: northern, western, and southwestern (Map 4.28.).



Map 4.27. Distance from the large industrial centers.

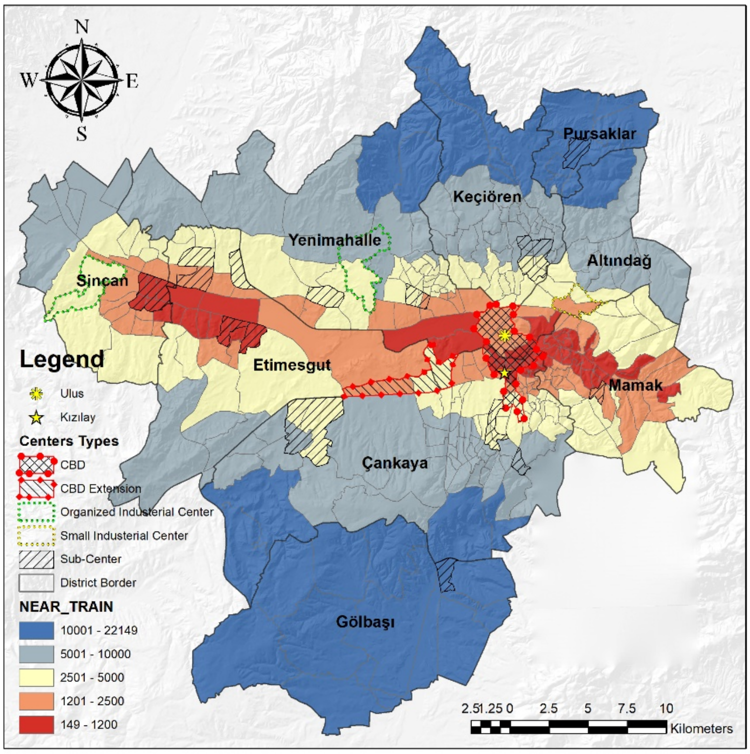
According to Babalik-Sutcliffe (2013), the western and southwestern corridors in Ankara have become the primary axes of the city's development. These areas exhibit distinct differences in their urban forms, with the western corridor displaying a higher degree of land use diversity and high building density, while the southwestern corridor is predominantly residential and has a lower population density. The analysis showed that the logarithm of the density of food and catering businesses strongly correlated negatively with the distance from Kızılay, Ulus, and metro and train stations. Despite that, the correlation between Log_FD_km2 and the distance to the industrial centers was relatively low and negative (Table 4.1.).



Map 4.28. Distance from the nearest metro stop.

This shows that proximity to the two city centers and the rail transportation stops have a positive correlation with urban vitality in Ankara. This implies that the accessibility of public transportation in the city plays a significant role in the spatial pattern of urban vitality in Ankara. It also shows that since Kızılay and Ulus are the main centers of different social and economic urban activities [transactions] (Montgomery, 1998), they function as the focal centers of urban vitality in the city.

Based on the analysis of street configuration and location, it can be concluded that accessibility is a major factor in determining the spatial pattern of urban vitality in the city of Ankara. The analysis showed that the street network centrality patterns support the accessibility of the CBD whereas the subcenters in the western and southwestern parts of the city are less accessible. Proximity to the two city centers, Kızılay and Ulus, and rail transportation stops had a positive correlation with urban vitality in Ankara. This suggests that the accessibility of public transportation in the city and proximity to the CBD play a significant role in the spatial pattern of urban vitality in the city. Furthermore, the proximity to the industrial centers did not have a significant correlation with urban vitality. This implies that the accessibility of industrial centers is not a major factor of urban vitality in Ankara.



Map 4.29. Distance from the nearest train stop.

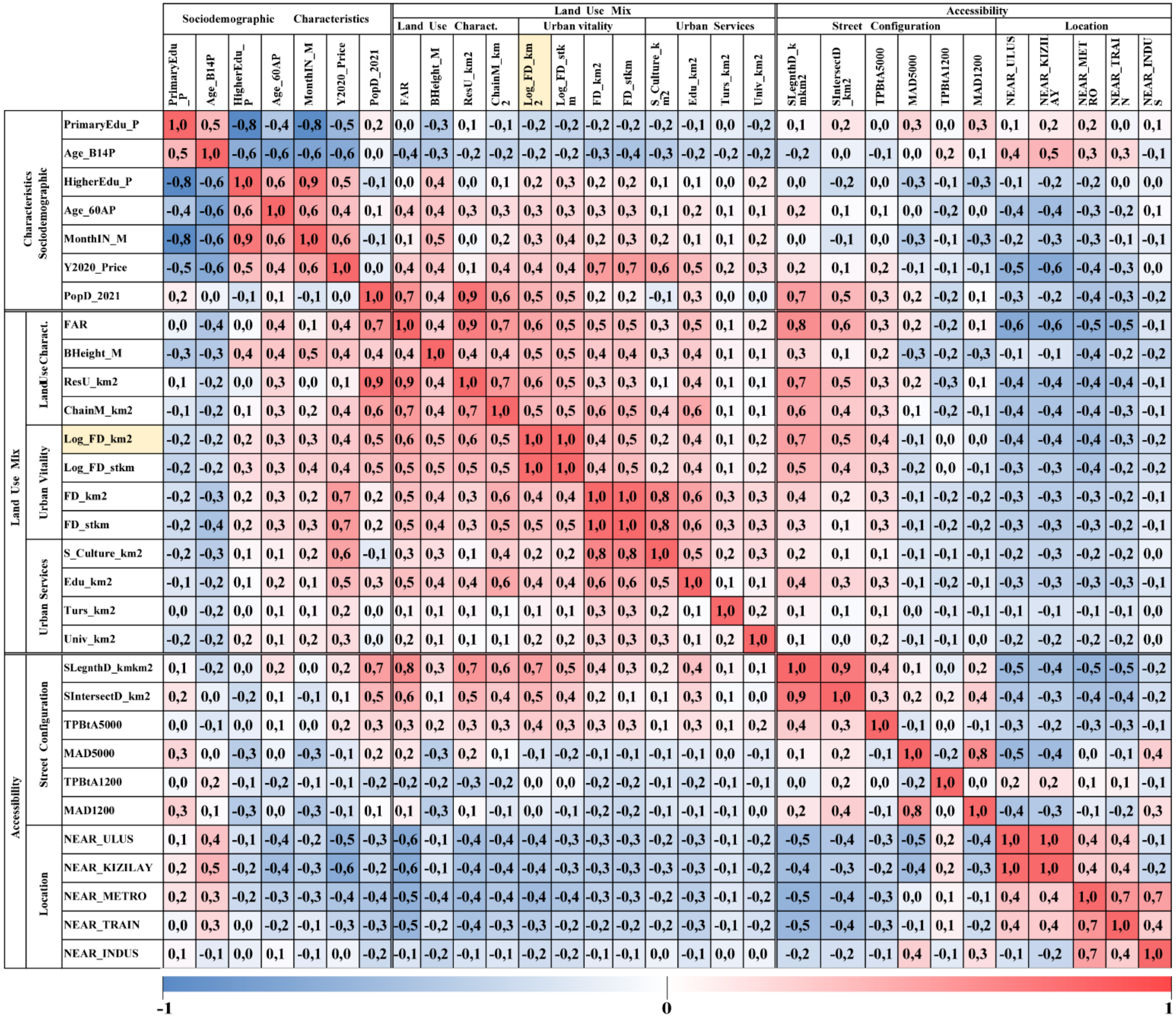
4.2. Correlation Analysis, Factor Analysis and Regression Models

In this thesis, Pearson correlation analysis was made using SPSS software to explore the correlations among the different analysis variables (Table 4.1.). Factor analysis was made to group variables into a limited set of clusters based on shared variance. The analysis resulted in creating 7 factors (loadings) as shown in Table 4.2. The first loading included mostly land use characteristics variables. The second loading, however, covered the socio-demographic characteristics. The third and sixth loadings were mostly about the density of urban services. And the fourth, fifth and seventh loadings included accessibility variables (Table 4.2.).

Regression models were created to examine how socio-spatial characteristics was related to the density of food and catering services that was used as an urban vitality indicator in the city of Ankara. The analysis resulted in 6 regression models with three different regression analysis types (2 OLS, 2 ML Spatial Lag, and 2 Spatial Error models (Table

4.3.)). Log_FD_km2 was used as the dependent variable in all the selected 6 models because it was found to generate the best statistical models compared to Log_FD_stkm, FD_km2, and FD_stkm. The selection of the independent variables participating in each model was made in respect of the analyses results of Pearson correlation (Table 4.1.) and factor analyses (Table 4.2.) to avoid multicollinearity problems. A stepwise regression method was followed to reach the best possible combinations of the independent variables in each model (Table 4.3.).

Table 4.1. Pearson correlation analysis.



			Sociodemographic Characteristics							Land Use Mix												Accessibility										
										Land Use Charact.				Urban vitality				Urban Services				Street Configuration						Location				
			PrimaryEdu_P	Age_B14P	HigherEdu_P	Age_60AP	MonthIN_M	Y2020_Price	PopD_2021	FAR	BHeight_M	ResU_km2	ChainM_km2	Log_FD_km2	Log_FD_stkm	FD_km2	FD_stkm	S_Culture_km2	Edu_km2	Turs_km2	Univ_km2	SLegnthD_kmkm2	SIntersectD_km2	TPBtA5000	MAD5000	TPBtA1200	MAD1200	NEAR_ULUS	NEAR_KIZILAY	NEAR_METRO	NEAR_TRAIN	NEAR_INDUS
Sociodemographic Characteristics		PrimaryEdu_P	1,0	0,5	-0,8	-0,4	-0,8	-0,5	0,2	0,0	-0,3	0,1	-0,1	-0,2	-0,2	-0,2	-0,2	-0,2	-0,1	0,0	-0,2	0,1	0,2	0,0	0,3	0,0	0,3	0,1	0,2	0,2	0,0	0,1
		Age_B14P	0,5	1,0	-0,6	-0,6	-0,6	-0,6	0,0	-0,4	-0,3	-0,2	-0,2	-0,2	-0,2	-0,3	-0,4	-0,3	-0,2	-0,2	-0,2	-0,2	0,0	-0,1	0,0	0,2	0,1	0,4	0,5	0,3	0,3	-0,1
		HigherEdu_P	-0,8	-0,6	1,0	0,6	0,9	0,5	-0,1	0,0	0,4	0,0	0,1	0,2	0,3	0,2	0,2	0,1	0,1	0,0	0,2	0,0	-0,2	0,0	-0,3	-0,1	-0,3	-0,1	-0,2	-0,2	0,0	0,0
		Age_60AP	-0,4	-0,6	0,6	1,0	0,6	0,4	0,1	0,4	0,4	0,3	0,3	0,3	0,3	0,3	0,3	0,1	0,2	0,1	0,1	0,2	0,1	0,1	0,0	-0,2	0,0	-0,4	-0,4	-0,3	-0,2	0,1
		MonthIN_M	-0,8	-0,6	0,9	0,6	1,0	0,6	-0,1	0,1	0,5	0,0	0,2	0,3	0,4	0,2	0,3	0,2	0,1	0,1	0,2	0,0	-0,1	0,0	-0,3	-0,1	-0,3	-0,2	-0,3	-0,3	-0,1	-0,1
		Y2020_Price	-0,5	-0,6	0,5	0,4	0,6	1,0	0,0	0,4	0,4	0,1	0,4	0,4	0,4	0,7	0,7	0,6	0,5	0,2	0,3	0,2	0,1	0,2	-0,1	-0,1	-0,1	-0,5	-0,6	-0,4	-0,3	0,0
		PopD_2021	0,2	0,0	-0,1	0,1	-0,1	0,0	1,0	0,7	0,4	0,9	0,6	0,5	0,5	0,2	0,2	-0,1	0,3	0,0	0,0	0,7	0,5	0,3	0,2	-0,2	0,1	-0,3	-0,2	-0,4	-0,3	-0,2
Land Use Mix	Land Use Charact.	FAR	0,0	-0,4	0,0	0,4	0,1	0,4	0,7	1,0	0,4	0,9	0,7	0,6	0,5	0,5	0,5	0,3	0,5	0,1	0,2	0,8	0,6	0,3	0,2	-0,2	0,1	-0,6	-0,6	-0,5	-0,5	-0,1
		BHeight_M	-0,3	-0,3	0,4	0,4	0,5	0,4	0,4	0,4	1,0	0,4	0,4	0,5	0,5	0,4	0,4	0,3	0,4	0,1	0,1	0,3	0,1	0,2	-0,3	-0,2	-0,3	-0,1	-0,1	-0,4	-0,2	-0,2
		ResU_km2	0,1	-0,2	0,0	0,3	0,0	0,1	0,9	0,9	0,4	1,0	0,7	0,6	0,5	0,3	0,3	0,1	0,4	0,1	0,1	0,7	0,5	0,3	0,2	-0,3	0,1	-0,4	-0,4	-0,4	-0,4	-0,1
		ChainM_km2	-0,1	-0,2	0,1	0,3	0,2	0,4	0,6	0,7	0,4	0,7	1,0	0,5	0,5	0,6	0,5	0,4	0,6	0,1	0,1	0,6	0,4	0,3	0,1	-0,2	-0,1	-0,4	-0,4	-0,4	-0,3	-0,1
	Urban Vitality	Log_FD_km2	-0,2	-0,2	0,2	0,3	0,3	0,4	0,5	0,6	0,5	0,6	0,5	1,0	1,0	0,4	0,5	0,2	0,4	0,1	0,2	0,7	0,5	0,4	-0,1	0,0	0,0	-0,4	-0,4	-0,4	-0,3	-0,2
		Log_FD_stkm	-0,2	-0,2	0,3	0,3	0,4	0,4	0,5	0,5	0,5	0,5	0,5	1,0	1,0	0,4	0,5	0,2	0,4	0,1	0,2	0,5	0,4	0,3	-0,2	0,0	-0,1	-0,3	-0,3	-0,4	-0,2	-0,2
		FD_km2	-0,2	-0,3	0,2	0,3	0,2	0,7	0,2	0,5	0,4	0,3	0,6	0,4	0,4	1,0	1,0	0,8	0,6	0,3	0,3	0,4	0,2	0,3	-0,1	-0,2	-0,2	-0,3	-0,3	-0,3	-0,2	-0,1
		FD_stkm	-0,2	-0,4	0,2	0,3	0,3	0,7	0,2	0,5	0,4	0,3	0,5	0,5	0,5	1,0	1,0	0,8	0,6	0,3	0,3	0,3	0,1	0,3	-0,1	-0,2	-0,2	-0,3	-0,3	-0,3	-0,2	-0,1
	Urban Services	S_Culture_km2	-0,2	-0,3	0,1	0,1	0,2	0,6	-0,1	0,3	0,3	0,1	0,4	0,2	0,2	0,8	0,8	1,0	0,5	0,2	0,3	0,2	0,1	0,1	-0,1	-0,1	-0,1	-0,2	-0,3	-0,2	-0,2	0,0
		Edu_km2	-0,1	-0,2	0,1	0,2	0,1	0,5	0,3	0,5	0,4	0,4	0,6	0,4	0,4	0,6	0,6	0,5	1,0	0,1	0,1	0,4	0,3	0,3	-0,1	-0,2	-0,1	-0,3	-0,3	-0,3	-0,3	-0,1
		Turs_km2	0,0	-0,2	0,0	0,1	0,1	0,2	0,0	0,1	0,1	0,1	0,1	0,1	0,1	0,3	0,3	0,2	0,1	1,0	0,2	0,1	0,1	0,1	0,0	-0,1	-0,1	-0,1	-0,1	-0,1	-0,1	0,0
		Univ_km2	-0,2	-0,2	0,2	0,1	0,2	0,3	0,0	0,2	0,1	0,1	0,1	0,2	0,2	0,3	0,3	0,3	0,1	0,2	1,0	0,1	0,0	0,2	-0,1	-0,1	0,0	-0,2	-0,2	-0,2	-0,2	0,0
Accessibility	Street Configuration	SLegnthD_kmkm2	0,1	-0,2	0,0	0,2	0,0	0,2	0,7	0,8	0,3	0,7	0,6	0,7	0,5	0,4	0,3	0,2	0,4	0,1	0,1	1,0	0,9	0,4	0,1	0,0	0,2	-0,5	-0,4	-0,5	-0,5	-0,2
		SIntersectD_km2	0,2	0,0	-0,2	0,1	-0,1	0,1	0,5	0,6	0,1	0,5	0,4	0,5	0,4	0,2	0,1	0,1	0,3	0,1	0,0	0,9	1,0	0,3	0,2	0,2	0,4	-0,4	-0,3	-0,4	-0,4	-0,2
		TPBtA5000	0,0	-0,1	0,0	0,1	0,0	0,2	0,3	0,3	0,2	0,3	0,3	0,4	0,3	0,3	0,3	0,1	0,3	0,1	0,2	0,4	0,3	1,0	-0,1	0,0	-0,1	-0,3	-0,2	-0,3	-0,3	-0,1
		MAD5000	0,3	0,0	-0,3	0,0	-0,3	-0,1	0,2	0,2	-0,3	0,2	0,1	-0,1	-0,2	-0,1	-0,1	-0,1	-0,1	0,0	-0,1	0,1	0,2	-0,1	1,0	-0,2	0,8	-0,5	-0,4	0,0	-0,1	0,4
		TPBtA1200	0,0	0,2	-0,1	-0,2	-0,1	-0,1	-0,2	-0,2	-0,2	-0,3	-0,2	0,0	0,0	-0,2	-0,2	-0,1	-0,2	-0,1	-0,1	0,0	0,2	0,0	-0,2	1,0	0,0	0,2	0,2	0,1	0,1	-0,1
		MAD1200	0,3	0,1	-0,3	0,0	-0,3	-0,1	0,1	0,1	-0,3	0,1	-0,1	0,0	-0,1	-0,2	-0,2	-0,1	-0,1	-0,1	0,0	0,2	0,4	-0,1	0,8	0,0	1,0	-0,4	-0,3	-0,1	-0,2	0,3
	Location	NEAR_ULUS	0,1	0,4	-0,1	-0,4	-0,2	-0,5	-0,3	-0,6	-0,1	-0,4	-0,4	-0,4	-0,3	-0,3	-0,3	-0,2	-0,3	-0,1	-0,2	-0,5	-0,4	-0,3	-0,5	0,2	-0,4	1,0	1,0	0,4	0,4	-0,1
		NEAR_KIZILAY	0,2	0,5	-0,2	-0,4	-0,3	-0,6	-0,2	-0,6	-0,1	-0,4	-0,4	-0,4	-0,3	-0,3	-0,3	-0,3	-0,3	-0,1	-0,2	-0,4	-0,3	-0,2	-0,4	0,2	-0,3	1,0	1,0	0,4	0,4	-0,2
		NEAR_METRO	0,2	0,3	-0,2	-0,3	-0,3	-0,4	-0,4	-0,5	-0,4	-0,4	-0,4	-0,4	-0,4	-0,3	-0,3	-0,2	-0,3	-0,1	-0,2	-0,5	-0,4	-0,3	0,0	0,1	-0,1	0,4	0,4	1,0	0,7	0,7
		NEAR_TRAIN	0,0	0,3	0,0	-0,2	-0,1	-0,3	-0,3	-0,5	-0,2	-0,4	-0,3	-0,3	-0,2	-0,2	-0,2	-0,2	-0,3	-0,1	-0,2	-0,5	-0,4	-0,3	-0,1	0,1	-0,2	0,4	0,4	0,7	1,0	0,4
		NEAR_INDUS	0,1	-0,1	0,0	0,1	-0,1	0,0	-0,2	-0,1	-0,2	-0,1	-0,1	-0,2	-0,2	-0,1	-0,1	0,0	-0,1	0,0	0,0	-0,2	-0,2	-0,1	0,4	-0,1	0,3	-0,1	-0,2	0,7	0,4	1,0

Table 4.2. Factor analysis

Rotated Component Matrix[a]							
	Component						
	1	2	3	4	5	6	7
PopD_2021	,886	-,140	-,068	,036	-,133	-,007	-,269
ResU_km2	,877	,016	,087	,149	-,132	,031	-,315
SLegnthD_kmkm2	,784	-,031	,173	,264	-,298	,040	,139
Log_FD_km2	,783	,279	,193	-,025	-,058	,184	,322
FAR	,773	,120	,256	,308	-,217	,073	-,189
Log_FD_stkm	,715	,315	,194	-,099	,007	,201	,325
ChainM_km2	,681	,096	,464	,038	-,046	-,104	-,218
SIntersectD_km2	,632	-,194	,097	,324	-,285	-,035	,355
BHeight_M	,451	,435	,240	-,320	-,123	,067	-,186
MonthIN_M	,038	,943	,124	-,114	-,038	,045	,050
HigherEdu_P	-,016	,927	,020	-,134	,004	,010	,016
PrimaryEdu_P	,075	-,847	-,069	,172	,065	,002	-,065
Age_B14P	-,034	-,700	-,246	-,253	,149	-,148	,199
Age_60AP	,244	,677	,093	,186	,006	,054	-,202
S_Culture_km2	-,020	,085	,893	,028	-,059	,152	,032
FD_km2	,241	,118	,888	-,039	-,038	,259	-,058
FD_stkm	,240	,185	,839	-,059	-,022	,316	-,079
Edu_km2	,378	,052	,690	-,002	-,121	-,129	-,061
Y2020_Price	,074	,558	,656	,195	-,100	,179	,083
MAD5000	,044	-,244	-,099	,813	,081	-,088	-,194
MAD1200	,025	-,281	-,149	,789	-,038	-,069	,100
NEAR_ULUS	-,316	-,289	-,198	-,754	,127	-,158	,037
NEAR_KIZILAY	-,287	-,389	-,225	-,751	,053	-,156	,067
NEAR_METRO	-,340	-,250	-,126	-,122	,829	-,084	,022
NEAR_INDUS	-,130	,020	,018	,426	,796	,015	-,058
NEAR_TRAIN	-,243	-,048	-,138	-,278	,753	-,129	,062
Turs_km2	,045	,004	,128	-,033	,010	,730	-,102
Univ_km2	-,013	,158	,182	,068	-,072	,604	,007
TPBtA5000	,395	-,039	,105	-,006	-,168	,440	,169
TPBtA1200	-,092	-,103	-,100	-,092	,018	-,051	,823

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
a. Rotation converged in 7 iterations.

A coefficient (*B*) in a regression model represents the change in the outcome variable (Log_FD_km2) for a one-unit change in the predictor variable (X) while holding all other predictor variables constant. For example, in the first model (SPATIAL LAG MODEL-1) a one-unit change in the variable Age_60AP leads to an increase in Log_FD_km2 by approximately 7,1 (Table 4.3.) while holding all other predictor variables constant. On the other hand, a one-unit change in the variable MAD5000 leads to a decrease in Log_FD_km2 by approximately 0,0022 while holding all other predictor variables constant. This can be applied to any predictor variable in any of the six models. A smaller standard error (*S.E.*) indicates that the estimate of the coefficient is more precise and less likely to be far from the true [population] value, whereas a larger standard error indicates that the estimate of the coefficient is less precise and more likely to be far from the true [population] value.

Table 4.3. Summary of the regression analyses' results

			SPATIAL LAG MODEL-1			SPATIAL LAG MODEL-2		
Categories		Variable	Log_FD_km2			Log_FD_km2		
			B	*S.E.*	*P*	*B*	*S.E.*	*P*
Sociodemographic		PopD_2021	0,00011	0,00001	0 ***	0,00009	0,00001	0 ***
		Age_60AP	7,09257	2,26799	0,00176 ***	4,29402	2,38586	0,07190 *
		Y2020_Price	0,00128	0,00023	0 ***	0,00055	0,00030	0,06956 *
Accessibility	Street Configuration	TPBtA5000	0,01093	0,00463	0,01809 **	0,00840	0,00463	0,06966 *
		MAD5000	-0,00220	0,00055	0,00006 ***	-0,00271	0,00071	0,00013 ***
		TPBtA1200	0,00015	0,00003	0 ***	0,00017	0,00003	0 ***
	Location	NEAR_METRO	-0,00004	0,00004	0,31113	-0,00003	0,00004	0,48816
		NEAR_KIZILAY				-0,00006	0,00002	0,00346 ***
Land Use Mix	Land Use Ch.	BHeight_M				0,07498	0,02990	0,01215 **
	U. Services	Edu_km2				0,01667	0,01208	0,16762
		LogL	-750,096			-743,222		
		AIC	1518,19			1510,44		
			SPATIAL ERROR MODEL-1			SPATIAL ERROR MODEL-2		
			Log_FD_km2			Log_FD_km2		
Accessibility	Street Configuration	SIntersectD_km2				0,00975	0,00173	0 ***
		TPBtA5000	0,01645	0,00476	0,00054 ***	0,01255	0,00463	0,00677 ***
		MAD5000	-0,00170	0,00073	0,01939 **	-0,00234	0,00069	0,00065 ***
		TPBtA1200	0,00016	0,00003	0 ***	0,00010	0,00003	0,00164 ***
	Location	NEAR_METRO	-0,00010	0,00005	0,02674 **	-0,00002	0,00004	0,64541
Land Use Mix	Land Use Ch.	ResU_km2	0,00029	0,00002	0 ***	0,00023	0,00003	0 ***
	U. Services	S_Culture_km2	0,07140	0,02841	0,01195 **	0,01437	0,03377	0,67053
Sociodemographic		MonthIN_M	0,00013	0,00003	0 ***	0,00012	0,00003	0,00010 ***
		Y2020_Price				0,00075	0,00033	0,02075 **
		LogL	-749,807185			-731,854314		
		AIC	1515,61			1483,71		
			OLS MODEL -1			OLS MODEL -2		
			Log_FD_km2			Log_FD_km2		
Land Use Mix	Land Use Ch.	ChainM_km2				0,02875	0,01644	0,08119 *
		FAR	13,76330	0,87111	0 ***	6,37591	1,53151	0,00004 ***
Sociodemographic		PrimaryEdu_P				-1,36117	2,09778	0,51684
		HigherEdu_P	3,52413	0,70622	0 ***	3,05476	1,20633	0,01175 **
Accessibility	Street Configuration	TPBtA5000	0,02162	0,00464	0 ***	0,01406	0,00469	0,00289 ***
		MAD5000	-0,00232	0,00060	0,00013 ***	-0,00354	0,00094	0,00019 ***
		TPBtA1200	0,00013	0,00003	0,00001 ***	0,00009	0,00003	0,00235 ***
		MAD1200				0,00259	0,00194	0,18328
		SLegnthD_kmkm2				0,11757	0,01994	0 ***
	Location	NEAR_ULUS				-0,00003	0,00002	0,14060
		NEAR_TRAIN				0,00004	0,00003	0,13627
		Adj. R2	0,523238			0,575164		
		LogL	-759,093			-734,226		
		AIC	1530,19			1492,45		

* *P* < 0,1   ** *P* < 0,05   *** *P* < 0,01

The first two models were spatial lag models (Table 4.3.). They tested the relationship between Log_FD_km2 and sociodemographic characteristics (Age, land prices, and population density), accessibility (Street configuration and location) and land use mix (Building heights and density of educational facilities).

The first model (SPATIAL LAG MODEL-1) revealed that sociodemographic characteristics and street configuration variables affiliated with the density of food and catering services significantly. Specifically, population density (PopD_2021), the percentage of the aged population (60 years old and above (Age_60AP)), the average estimated land prices (Y2020_Price), and betweenness centrality in the walking mode (TPBtA1200) were significantly associated with Log_FD_km2 positively at a confidence level of p < 0,01. Betweenness centrality in the driving mode (TPBtA5000) was also significantly associated with Log_FD_km2 positively at a confidence level of p < 0,05. On the contrary, closeness centrality in the driving mode (MAD5000) was significantly associated with Log_FD_km2 negatively at a confidence level of p < 0,01. However, the relationship between the distance from metro stations (NEAR_METRO) and Log_FD_km2 was not significant.

This means that, in this scenario, the vital urban environment in Ankara is characterized by high population density, high land values, a high percentage of the aged population, and high accessibility in both walking and driving modes (Table 4.3.). Higher population density can lead to a greater sense of community and more opportunities for businesses and social interaction, which can contribute to increasing the quality of the neighborhood. High land values can indicate a high demand for housing and other real estate in the area, which can be a sign of a desirable more accessible location with a greater number of amenities.

The second model (SPATIAL LAG MODEL-2) revealed that, in addition to sociodemographic characteristics and street configuration, location and land use characteristics also had a significant influence on the distribution of the density of food and catering businesses in Ankara. In specific, population density (PopD_2021), and betweenness centrality in the walking mode (TPBtA1200) were significantly associated with Log_FD_km2 positively at a confidence level of p < 0,01. The average building height in a neighborhood (BHeight_M) was also found to be positively correlated with Log_FD_km2 at a significance level of p < 0,05.

Similar to the previous model's result, this model also showed that the percentage of the aged population (Age_60AP), the average estimated land prices (Y2020_Price), and betweenness centrality in the driving mode (TPBtA5000) were significantly associated with Log_FD_km2 positively at a confidence level of p < 0,1. On the other hand, both closeness centrality in the driving mode (MAD5000) and the distance from the city center (Kızılay) were significantly associated with Log_FD_km2 negatively at a confidence level of p < 0,01. The association between the distance from metro stations (NEAR_METRO) and the density of educational facilities (Edu_km2) and Log_FD_km2 was not significant (Table 4.3.).

This scenario shows that the probability that a neighborhood in Ankara is vital increases when this neighborhood has a higher average of building floors and is closer to the city center. Being closer to the city center (Kızılay) can provide easier access to amenities and resources, which can improve the quality of life. Kızılay is a center of cultural, economic, and social activity, and being closer to it can provide more opportunities for entertainment, employment, and social interaction. Such advantages also lead to higher demands for land in these neighborhoods which leads to taller buildings and higher land prices (Table 4.3.).

The second group of models includes two spatial error models (Table 4.3.). They also tested the relationship between Log_FD_km2 and accessibility (street configuration and location), land use mix (land use characteristics and the density of urban services), and sociodemographic characteristics. This included certain variables such as the density of residential units, sports and cultural facilities, accessibility to metro stations, average monthly income and land prices, street centrality, and street intersections density.

The first model (SPATIAL ERROR MODEL-1) revealed that the density of the residential units (ResU_km2), the average monthly income (MonthIN_M), and betweenness centrality in the walking (TPBtA1200) and driving (TPBtA5000) modes were significantly associated with Log_FD_km2 positively at a confidence level of p < 0,01. Similarly, sports and cultural facilities (S_Culture_km2) were associated positively with Log_FD_km2 at a confidence level of p < 0,05. On the contrary, closeness centrality at the driving mode

(MAD5000) and the distance to the nearest metro station (NEAR_METRO) presented a negative association with Log_FD_km2 at a confidence level of $p < 0,05$ (Table 4.3.). In other words, in this scenario, the vital urban areas in Ankara have a high density of residential units, a high presence of sports and cultural facilities, and high street accessibility in both walking and driving modes. They are also inhabited by a wealthier population (Table 4.3.).

Similar to the spatial lag models' results (Table 4.3.), density was found to be one of the main criteria that are associated with the vital urban environments of Ankara in the SPATIAL ERROR MODEL-1. In particular, the density of both residential units and sports & cultural facilities significantly correlated with Log_FD_km2. The availability of sports and cultural facilities can provide opportunities for entertainment and recreation, and can also foster a sense of community and social interaction, which help enhance the quality of life in the city. In addition to that, the presence of a wealthier population indicates a higher standard of living and access to more resources and opportunities, which can be a sign of the improved quality of the urban environments in vital urban areas. The results of this model also revealed that accessibility, land use mix, and sociodemographic characteristics are important factors of vital urban areas.

The second model (SPATIAL ERROR MODEL-2) revealed that the density of the residential units (ResU_km2), betweenness centrality in both the walking (TPBtA1200) and the driving (TPBtA5000) modes, the average monthly income (MonthIN_M), and the density of street intersections per km^2 (SIntersectD_km2) were significantly associated with Log_FD_km2 positively at a confidence level of $p < 0,01$. The average estimated land prices (Y2020_Price) was also found to be positively correlated with Log_FD_km2 at a significance level of $p < 0,05$. However, closeness centrality at the driving mode (MAD5000) was significantly associated with Log_FD_km2 negatively at a confidence level of $p < 0,01$. In spite of that, sports and cultural facilities (S_Culture_km2) and the distance to the nearest metro station (NEAR_METRO) did not show a significant association with Log_FD_km2 in this model.

In this scenario, dense residential neighborhoods that enjoy high street centrality and connectivity due to their locational advantages within the street network of the city are most likely among the most vital neighborhoods of the city. At the same time, these neighborhoods are mostly inhabited by wealthier people and have higher land values. The results of this model also infer that the high density and accessibility of neighborhoods make them vital and attractive to wealthier people because of the evidence of their high urban quality. Consequently, this leads to an increase in their land values.

The ordinary least square (OLS) models (Table 4.3.) examined the relationship between Log_FD_km2 and the land use and sociodemographic characteristics, the street configuration, and location. More specifically, they tested the educational levels of the population, street centrality, building coverage, street density, closeness to the old city center (Ulus) and to the nearest train station, and the density of chain markets as independent variables.

OLS MODEL -1 showed that higher educational levels (HigherEdu_P), higher building coverage (FAR), and higher betweenness centrality in the walking (TPBtA1200) and driving (TPBtA5000) modes were significantly associated with higher Log_FD_km2 values in Ankara at a confidence level of p < 0,01. On the other hand, closeness centrality at the driving mode (MAD5000) presented a negative association with Log_FD_km2 at a confidence level of p < 0,01 (Table 4.3.). The results of this model also confirm that urban vitality in Ankara is closely related to street configuration, building density (land use characteristics), and the sociodemographic characteristics of its inhabitants.

The second model (OLS MODEL -2) revealed that higher betweenness centrality in the walking (TPBtA1200) and driving (TPBtA5000) modes, higher building coverage (FAR), and higher street link density (SLegnthD_kmkm2) were significantly associated with higher Log_FD_km2 values in Ankara at a confidence level of p < 0,01. In addition to that, higher educational levels (HigherEdu_P) and higher density of chain markets (ChainM_km2) were significantly associated with higher Log_FD_km2 values in Ankara at a confidence level of p < 0,05 and p < 0,10 respectively.

On the other hand, closeness centrality at the driving mode (MAD5000) presented a negative association with Log_FD_km2 at a confidence level of p < 0,01. However, high percentages of primary school graduates (PrimaryEdu_P), distance from Ulus (NEAR_ULUS), distance from the nearest train station (NEAR_TRAIN), and closeness centrality in the walking mode (MAD1200) did not present any significant association with Log_FD_km2 (Table 4.3.).

This scenario shows that dense residential neighborhoods that enjoy high street centrality and accessibility are most likely to be among the most vital neighborhoods of Ankara. They are mostly inhabited by highly educated people and have a higher density of chain markets. The presence of chain markets provides easy access to goods and services and contribute to the overall economic vitality of the area. In addition, high street centrality and accessibility can make it easier for people to access resources and amenities and promote a sense of community and social interaction.

To evaluate these results, the Akaike information criterion (AIC) was adopted instead of the R-squared value because it is more suitable for spatial regression models. A lower AIC value indicates better model performance (Anselin et al., 2009). The AIC of the SPATIAL ERROR MODEL-2 was only 1 483,71, which was the lowest compared to the other models, indicating better goodness of fit. The highest AIC value (1 530,19), however, was reported in OLS MODEL-1. Despite that, the models in this study presented a decent goodness of fit relative to the study by Li et al. (2022).

In summary, this study examined the relationship between urban vitality and socio-spatial characteristics in the city of Ankara. Pearson correlation analysis and factor analysis were used to explore the correlations among the different analysis variables. Regression models were then created to examine how socio-spatial characteristics was related to the density of food and catering services that was used as an urban vitality indicator.

The results revealed that sociodemographic characteristics, accessibility (in terms of street configuration and location), and land use mix (in terms of density and urban services) were significantly associated with the density of food and catering businesses. Consequently, it can be said that these factors significantly affect the vitality of urban areas. The Akaike information criterion (AIC) values indicated that the models presented a decent goodness of fit. In other words, the AIC values indicated that the models had a satisfactory level of accuracy.

5. CONCLUSION

This thesis shows that the socio-spatial characteristics in Ankara significantly correlated with urban vitality. Specifically, sociodemographic characteristics, street configuration and location (accessibility), and density and urban services (land use mix) were significantly associated with the urban vitality indicator used in this study (the density of food and catering businesses). Among the variables with positive effects, the importance of having an adequate population density to maintain the vitality of a place was confirmed, which is consistent with the results of previous studies (Gülden et al., 2008; Sung et al., 2015; Li et al., 2022). The high density of residents also promotes the survival of small businesses in neighborhoods and provides more potential for people.

The results also showed that the building intensity-related variables significantly correlated positively with the urban vitality indicator. In specific, high densities of residential units, buildings, streets, and taller buildings were proven to correlate positively with the urban vitality factor which can be considered an advantage of the compact development of the city center. In addition to that, the results presented that the density of chain markets also correlated positively with the urban vitality factor. This clearly supports the assumption that vitality and viability are linked together because vital places attract more people which in turn attract businesses and investments to increase their profits (Montgomery, 1998; Ravenscroft, 2000). This leads eventually to a higher quality of services in the area and, thus, higher quality of the urban area. That was also supported by the positive relationship that was found between the high density of sports and cultural facilities, and the density of food and catering businesses.

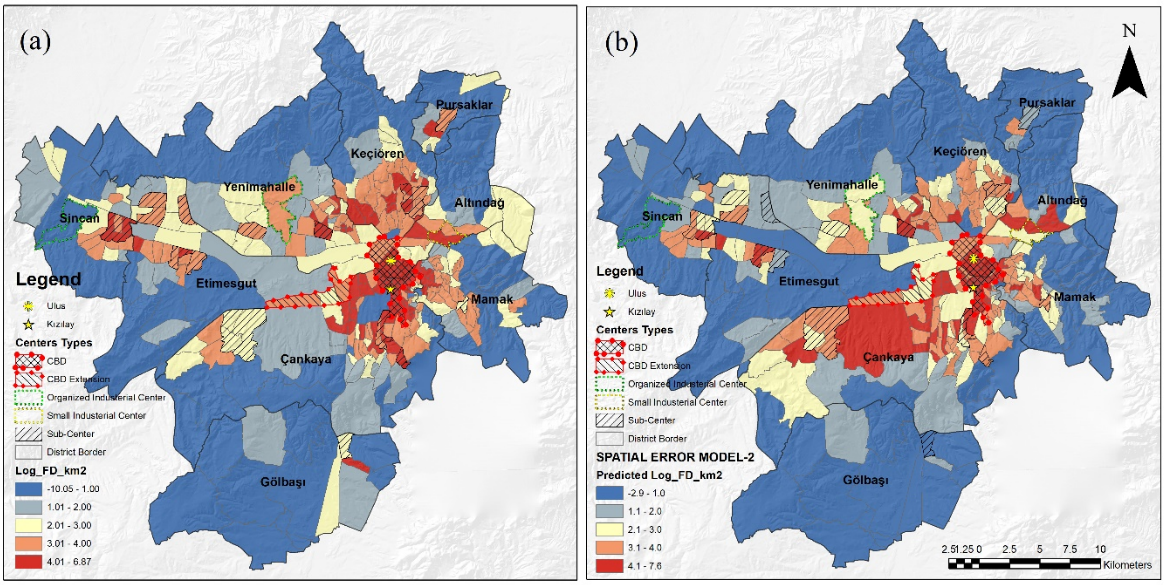
In line with these findings, this study also revealed a distinctive relationship between sociodemographic characteristics and urban vitality in Ankara. In particular, it was found that high income, land prices, and education levels in addition to high ratios of the older population were associated positively with the urban vitality factor. This shows that the population in Ankara is relatively segregated based on sociodemographic characteristics such as education and income levels; where older, richer, and highly educated populations are clustered in the most vital urban areas in the south, west and southwest of the CBD, where the average land prices is high, while poorer and primarily educated people are clustered in the rural-urban fringe. These results clearly support the claim that urban vitality and viability are interrelated (Montgomery, 1998; Ravenscroft, 2000).

It was demonstrated by the thesis that older urban areas tend to have a higher overall level of vitality than those recently developed. Although there was not a specific variable in the regression models that indicated that, this inference can be reached when synthesizing the development history of Ankara with the results of food and catering business’s density pattern (Maps 3.1, 3.2 & 4.1); As mentioned earlier, the city was originally planned as a compact one (Ozuduru et al., 2014) and in 1952, Kızılay, was officially recognized as the CBD of the city (Batuman, 2013). The analysis results showed that the CBD and its environs had the highest levels of urban vitality, which could be due to the high land use mix, compact urban development, and the relative early establishment (Awwaad, 2017; Xu et al., 2018; Xia et al., 2020; Al-Saaidy & Alobaydi, 2021).

This conclusion is supported by the results of the regression models which showed that the distance to Kızılay correlated significantly with the urban vitality indicator negatively (Table 4.3.). This means that the vitality of a neighborhood increases the nearer it is to Kızılay and decreases the further it is away. This result emphasizes the important role of old buildings in promoting a vital neighborhood as Jane Jacobs (1961) pointed out (as cited in Li et al., 2022). Sung et al. (2015) also related the presence of old buildings to encouraging human participation in urban areas, showing that residents of communities with older histories are more likely to go out for walks and for different purposes. These old communities encompass collective memories, eventually evolving as a local culture that forms the basis of the city's image and vibrancy, and brings uniqueness to urban spaces, evoking the identity of people in a place, and in turn enriches the city's collective memory (Montgomery, 1998).

The analysis also showed that accessibility factors such as location attributes and street configuration correlated significantly with the urban vitality indicator. While large distances from Kızılay and Ulus centers showed a significant negative association with the urban vitality factor, the distance to the industrial zones in the city did not present any significant correlation. This result does not support the findings of Gülden et al. (2008) who found that in the quarters, where the manufacturing industry and wholesale areas increased, a negative change occurred in urban vitality in Istanbul (Gülden et al., 2008). It was also found that large distances from metro stations were significantly associated negatively with the density of food and catering businesses (Table 4.3.). This indicates that, compared to the train line, the metro network is more extensive and better planned to serve and support the centers of vitality in the city.

Street configuration factor results showed that betweenness centrality was significantly associated with food and catering density in both walking and driving modes. This indicates that streets with high betweenness centrality (i.e., intermediate streets) tended to be more vibrant and active; A location with high betweenness has a greater likelihood of attracting "through traffic" or passers-by, which is why companies prefer to locate there in order to benefit from the high volume of potential customers (Yue et al., 2019). Additionally, these streets may have a sense of security due to the social activities that keep people's "eyes on the street" (Jacobs, 1961, as cited in Yue et al., 2019).



Map 5.1. Observed (a) and predicted (b) values of Log_FD_km2 for SPATIAL ERROR MODEL-2

Closeness centrality, however, had a significantly negative association with food and catering density in the driving mode only and had no significant association in the walking mode. As Cooper (2021) states: “*Closeness … measures the difficulty, on average, of navigating to all possible destinations in radius x from each link. Technically then it’s a form of farness, not closeness: this only means that big numbers mean ‘far’ instead of ‘close’*”. As a result, the analysis of the streets network of Ankara revealed that the most accessible streets, especially for drivers, were also the most vibrant and vital. This finding implies that the street configuration (accessibility) is a major factor in creating vibrant and successful urban environments.

The Akaike information criterion (AIC) value of SPATIAL ERROR MODEL-2 (1 483,71) indicated that the model presented the best goodness of fit compared to the other models. In other words, the AIC value indicated that the model had a satisfactory level of accuracy. Maps 5.1. (a) and (b) present a comparison between the observed and predicted values of Log_FD_km2 for the SPATIAL ERROR MODEL-2 across the study area. The pattern displayed in both maps is quite similar, with accurate predictions of the Log_FD_km2 values in the CBD and its environs to the north, south, and east, as well as in the subcenters in Yenimahalle, Etimesgut, and Sincan districts to the west of the city (Map 5.1.). Interestingly, the urban vitality indicator (Log_FD_km2) in the southwest development corridor was predicted to be significantly high, in contrast to the observed values. This suggests that urban sprawl and land speculation have had a negative impact on the development of the area, resulting in sparse lifeless suburban patches.

Accordingly, to enhance the vitality of the southwest development corridor in the Ankara Metropolitan Area, improving land use mix and accessibility are recommended. The urban planning authorities can implement policies that promote a higher density and mix of land uses, such as residential, commercial, educational, and sports and cultural facilities, within the same neighborhood. This can help to create vibrant public spaces that promote social interaction and increase foot traffic. The urban planning authorities can also implement policies that utilize proximity to metro stops, increase street and intersection densities, and utilize street centrality. This can facilitate ease of movement and provide opportunities for greater social interaction and economic activity. Improving the quality and safety of pedestrian infrastructure can also help to increase the attractiveness and accessibility of the area.

This thesis study validates previous theories and reveals potential links between urban vitality and socio-spatial characteristics, helping to support sustainable urban development. Urban planners should prioritize high development and urban services' density, and high accessibility, and avoid zoning practices that lead to urban sprawl. Finally, multistakeholder considerations should guide the planning and management of urban areas to achieve the best results.

In summary, this thesis empirically explored the relationship between urban vitality and the socio-spatial characteristics in Ankara Metropolitan Area by using the density of food and catering businesses as an indicator of urban vitality. Specifically, finding the answers to the following questions was the main objective of this study: What is the relationship between sociodemographic characteristics and urban vitality in Ankara Metropolitan Area? How does land use mix and spatial characteristics of neighborhoods influence urban vitality in Ankara Metropolitan Area? What is the impact of accessibility factors on urban vitality in Ankara Metropolitan Area? And what policies and implications can be recommended to improve the vitality of Ankara Metropolitan Area?

To answer these research questions several quantitative analysis methods were adopted: Spatial distribution analysis, Kernel Density Estimation (KDE), hot spot analysis (Getis-Ord Gi*), Moran's I, and local Moran's I were used to understand the spatial pattern of the socio-spatial factors in Ankara. Pearson correlation and factor analysis were made to discover the relationship pattern between the variables of the study. Regression (OLS, ML Spatial Lag, and Spatial Error) models were made to examine how the socio-spatial characteristics were associated with urban vitality in Ankara by taking Pearson correlation and factor analysis results into consideration to reduce the multicollinearity problem. Spatial regression models (ML Spatial Lag, and Spatial Error) were made because they consider the spatial autocorrelation of the variables. OLS models, however, do not account for this spatial relationship, and therefore may not accurately predict outcomes in geographic areas.

The results showed that urban vitality indicator mainly clustered at the CBD and some planned subcenters across the city. It was found to be significantly associated with sociodemographic characteristics, land use mix (density and urban services), and accessibility factors (street configuration and location).

To enhance the validity of the findings presented in this thesis, further research that employs a more comprehensive urban vitality index can be conducted across diverse neighborhoods to compare their vitality scores at the neighborhood level in Ankara. In addition to quantitative measures, qualitative indicators such as residents' perceptions of safety and security, the vibrancy and activity levels of public spaces, the availability and quality of public transportation options, the diversity and inclusivity of the population, the presence of street art, public events, and community gatherings, as well as the overall sense of community and social connectedness can offer valuable insights into the overall health and vitality of the neighborhood. By combining both quantitative and qualitative measures, a more sophisticated understanding of urban vitality can be achieved, which can inform future urban planning and policy decisions.

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