Assessing the Walkability of Tehran Organic Street Network Based on the Network's Form

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Abstract

Walkability pertains to the allure and opportunities for pedestrians within a city, enabling citizens to efficiently navigate and engage with their urban environment in alignment with their preferences and values. This study concentrates on evaluating the walkability of organic street networks in Tehran, Iran, a city grappling with multifaceted urban challenges, including traffic congestion, environmental pollution, and irregular urban development.

The research embarks on an exploration of the nuanced semantic differences associated with walkable streets and neighborhoods in Iran. This examination considers the profound cultural and traditional influences shaping urban design and the structural fabric of localities. Within this context, the study delves into the characteristics of organic street networks and their intricate interplay with various facets of walkability, all while taking into account the distinctive form inherent in these organic street networks. An extensive analysis encompasses dimensions such as safety and security, accessibility, connectivity, comfort, the quality of the built environment, and the overall attractiveness of these organic street networks.

The dissertation, presenting a qualitative research study, meticulously evaluates street networks and walkability in Tehran, Iran. Employing a descriptive, theoretical, and analytical approach, the research adopts a case study methodology, encompassing two levels of analysis: the district level (Mahale) and the street level. Various research methods, including GIS mapping and analysis, expert interviews, and user questionnaires, converge to provide a comprehensive evaluation of street and network form. Extensive data collection spanning from October 2018 to November 2022 involves exhaustive library research, on-site observations, and documentation. For better comprehensibility of the significant results, the dissertation focuses on case studies from six selectively chosen neighborhoods representing organic street networks.

In conclusion, Tehran's diverse organic street networks exhibit distinct characteristics that significantly influence walkability. Overall, the present research was able to identify nine prominent forms of organic street networks[1]. Original organic street networks in the city's historic quarters offer good accessibility and charm, yet feature hazardous routes. They are distinguished by the presence of trees, contributing to aesthetic appeal, providing shade, and fostering a connection to nature. Historic areas excel in accessibility and connectivity but contend with narrow streets and a high concentration of commercial activities, affecting pedestrian comfort and security. Integrated grid-organic street networks offer commendable connectivity and an inviting environment with natural elements. Integrated tributary-organic street networks offer good

[1] The different types of organic street networks have been described in Chapter 3, Section 3.8.7.5, titled "Typology of the Organic Street Networks".

accessibility but have a lower street formation density and limited visual connectivity. Semi-public spaces are also less prevalent in this network. Integrated grid-tributary-organic street networks create an open and spacious ambiance but rely more on private vehicles and exhibit limited visual connectivity. Imitated organic street networks feature tree-lined sidewalks, and a commercial character, but grapple with restricted accessibility, lower walkability rates, and negative feedback due to extensive building scale.

Consequently, critical factors influencing the walkability of Tehran's organic street networks encompass security, attractiveness, and comfort. Security, entailing protection from crime and theft, plays a pivotal role in promoting pedestrian activity across all organic street network types. Attractiveness, encompassing elements like trees, greenery, water features, and architectural aesthetics, contributes to the overall appeal and aesthetic quality of neighborhoods. Comfort, inclusive of street comfort, lighting conditions, and topographical suitability, ensures a pleasant pedestrian experience. Other factors, such as vehicular safety, accessibility, connectivity, and the quality of the built environment, also hold relevance but carry lower priority than security, attractiveness, and comfort.

Addressing these multifaceted factors and seamlessly integrating traditional elements with contemporary requirements presents Tehran with an opportunity to cultivate more pedestrian-friendly environments and enhance walkability within its organic street networks. Furthermore, the evaluation methodology developed in this research serves as a tool for researchers, facilitating walkability assessments grounded in street network configurations, regardless of geographical location or street network type.

Zusammenfassung

Fußgängerfreundlichkeit bezieht sich auf die Attraktivität und die Möglichkeiten zum zu Fuß Gehen in einer Stadt, die es den Bürgerinnen und Bürgern ermöglicht, ihre urbane Umgebung gemäß ihren Präferenzen und Werten effizient zu durchqueren und zu nutzen. Diese Studie konzentriert sich auf die Bewertung der Fußgängerfreundlichkeit von organischen Straßennetzen in Teheran, Iran, einer Stadt, die mit vielfältigen urbanen Herausforderungen wie Verkehrsstaus, Umweltverschmutzung und ein unregelmäßiger städtischer Entwicklung konfrontiert ist.

Die Forschung unternimmt eine Erkundung der nuancierten semantischen Unterschiede, die mit fußgängerfreundlichen Straßen und Stadtvierteln im Iran einhergehen. Diese Untersuchung berücksichtigt die tiefgreifenden kulturellen und traditionellen Einflüsse, die die städtische Gestaltung und die strukturelle Beschaffenheit der Orte prägen. Innerhalb dieses Kontexts taucht die Studie in die Merkmale der organischen Straßennetze ein und beleuchtet ihr komplexes Zusammenspiel mit verschiedenen Aspekten der Fußgängerfreundlichkeit, wobei die charakteristische Form dieser organischen Straßennetze berücksichtigt wird. Eine umfassende Analyse umfasst Dimensionen wie Sicherheit und Schutz, Zugänglichkeit, Vernetzung, Komfort, die Qualität der gebauten Umgebung und die Gesamtattraktivität dieser organischen Straßennetze.

Die Dissertation präsentiert eine qualitative Forschungsstudie, die die Straßennetze und die Fußgängerfreundlichkeit in Teheran, Iran, akribisch bewertet. Unter Verwendung eines beschreibenden, theoretischen und analytischen Ansatzes bedient sich die Forschung einer Fallstudienmethodik, die zwei Analyseebenen umfasst: die Bezirksebene (Mahale) und die Straßenebene. Verschiedene Forschungsmethoden, darunter GIS-Mapping und -Analyse, Experteninterviews und Nutzerumfragen, kommen zusammen, um eine umfassende Bewertung der Straßen- und Netzwerkform zu ermöglichen. Die umfangreiche Datensammlung, die von Oktober 2018 bis November 2022 erfolgte, umfasste umfangreiche Literaturstudien, Beobachtungen vor Ort und Dokumentation. Für eine bessere Nachvollziehbarkeit der signifikanten Ergebnisse, fokussiert die Dissertation sich auf Fallstudien aus sechs gezielt ausgewählten Vierteln, die organische Straßennetze repräsentieren.

Abschließend weisen verschiedene Arten von organischen Straßennetzen in Teheran unterschiedliche Merkmale auf, die die Fußgängerfreundlichkeit erheblich beeinflussen. Insgesamt konnte die vorliegende Forschung neun prominente Formen von organischen Straßennetzen identifizieren[2]. Originale organische Straßennetze in den historischen Teilen der Stadt bieten gute Zugänglichkeit und Charme, weisen jedoch gefährliche Strecken auf. Sie

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[2] Die verschiedenen Arten von organischen Straßennetzen wurden in Kapitel 3, Abschnitt 3.8.7.5, mit dem Titel "Typologie der organischen Straßennetze", beschrieben.

zeichnen sich durch das Vorhandensein von Bäumen aus, die zur ästhetischen Anziehungskraft beitragen, Schatten spenden und eine Verbindung zur Natur herstellen. Historische Gebiete glänzen in Bezug auf Zugänglichkeit und Vernetzung, haben jedoch enge Straßen und eine hohe Konzentration von kommerziellen Aktivitäten, was sich auf den Komfort und die Sicherheit der Fußgänger auswirken kann. Integrierte Gitter-organische Straßennetze bieten eine lobenswerte Vernetzung und eine einladende Umgebung mit natürlichen Elementen. Integrierte Nebenfluss-organische Straßennetze bieten gute Zugänglichkeit, weisen jedoch eine geringere Straßenbildungsintensität und begrenzte visuelle Vernetzung auf. Halböffentliche Räume sind in diesem Netzwerk ebenfalls weniger vorhanden. Integrierte Gitter-Nebenfluss-organische Straßennetze vermitteln ein offeneres und geräumigeres Ambiente, sind jedoch stärker auf private Fahrzeuge angewiesen und weisen eine begrenzte visuelle Vernetzung auf. Imitierte organische Straßennetze zeichnen sich durch baumbestandene Gehwege, und einen kommerziellen Charakter aus, haben jedoch mit eingeschränkter Zugänglichkeit, geringeren Fußgängerfreundlichkeitsraten und negativem Feedback aufgrund der umfangreichen Gebäudeskala zu kämpfen.

Demnach sind entscheidende Faktoren, die die Fußgängerfreundlichkeit von organischen Straßennetzen in Teheran beeinflussen, Sicherheit, Attraktivität und Komfort. Sicherheit, einschließlich Schutz vor Kriminalität und Diebstahl, spielt eine entscheidende Rolle bei der Förderung der Fußgängertätigkeit in allen Arten von organischen Straßennetzen. Attraktivität, zu der Elemente wie Bäume, Grünanlagen, Wassermerkmale und architektonische Ästhetik gehören, trägt zur Gesamtattraktivität und ästhetischen Qualität der Stadtviertel bei. Komfort, einschließlich Straßenkomfort, Beleuchtungsbedingungen und topografischer Eignung, gewährleistet eine angenehme Fußgängererfahrung. Andere Faktoren wie Verkehrssicherheit, Zugänglichkeit, Vernetzung und die Qualität der gebauten Umgebung sind ebenfalls relevant, haben jedoch eine geringere Priorität als Sicherheit, Attraktivität und Komfort.

Durch die Bewältigung dieser vielschichtigen Faktoren und die nahtlose Integration traditioneller Elemente mit zeitgemäßen Anforderungen bietet sich Teheran die Möglichkeit, fußgängerfreundlichere Umgebungen zu schaffen und die Fußgängerfreundlichkeit in seinen organischen Straßennetzen zu verbessern. Darüber hinaus kann die in dieser Forschung entwickelte Bewertungsmethode anderen Forschern dabei helfen, die Fußgängerfreundlichkeit auf der Grundlage von Straßennetzkonfigurationen zu bewerten, unabhängig von geografischem Standort oder Straßennetztyp.

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Niku Khaleghi

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1. Introduction

The attractiveness of a city, as well as its opportunities and contexts for walking, is commonly referred to as walkability (Dörrzapf et al., 2019). This concept represents one of the essential components of urban life quality, enabling citizens to navigate and utilize the city according to their needs and values. Walkability encompasses both the pleasure of walking as a physical activity and its role as a means of transportation to reach destinations. Recognizing the positive impact of walkability on urban health and sustainability, enhancing the walkability of cities and urban spaces has become a key objective of urban public policies, prompting numerous recent studies and research (Gallin, 2001; Fancello et al., 2020). In line with these efforts, this study assesses the walkability of organic street networks in Tehran, Iran. The subsequent sections outline the primary concerns addressed in this research.

1.1. The Statement of Problem

Evaluating the walkability of Iranian organic street networks presents a multifaceted challenge. Key issues include semantic differences in walkability and neighborhood concepts and urban development challenges. The organic network's undefined nature, lack of management framework, and limited differentiation from literal streets compound these challenges. Furthermore, it primarily exists in Tehran's historical core, making modification complex due to cultural significance and high land value. Urban growth has transformed traditional courtyard houses into dense multi-story buildings, further complicating efforts to balance cultural heritage and modern needs in Tehran's unique urban fabric. This section aims to address these complexities more in detail.

Spatial Hierarchical and Walkable Neighborhoods

Due to Iran's long history of Islamic culture and beliefs, Iranian traditions are deeply rooted in this cultural heritage. This influence is also reflected in the urbanization and structure of localities and neighborhoods. Consequently, the definition and expectations of walkable neighborhoods in Iran differ from other geographical, historical, and sociocultural contexts.

Traditional urban design in Iran categorizes urban spaces into public, semi-public/semi-private, and private domains. As a result, certain concepts, such as security, legibility, easy access, and permeability, are defined at different levels. Public spaces aim to provide comfort, convenience, and security for all users, including residents and visitors. Conversely, semi-public/semi-private and private spaces are designed to offer a sense of security and legibility primarily for the neighborhood residents.

Traditional Iranian urban design emphasizes the series of spatial transitions of a neighborhood. According to the religious and cultural background of Iranians, entering a house involves passing through a sequence of spaces; starting from a public space (the doorway), moving to a semi-public space (Hashti - a sitting area where one waits to meet someone from the family), then through a generally straight corridor to semi-private spaces (guest room and living room), and finally, via a winding corridor that limits the view into the private spaces (bedrooms and kitchen).

This hierarchical approach is also observed in street networks of the Iranian organic structure. A person moves from a public space (main street) to a semi-public space (a side street), then to a semi-private space (neighborhood units located in an alley), and finally to a private space (doorway and home). Historically, the intricate layout of these paths, along with numerous openings to the streets (windows and doors) and strong social relations among neighbors in a neighborhood, provided security and a sense of belonging for residents. However, it posed challenges in terms of the presence of strangers in this network.

In the case of strangers entering semi-public, semi-private, and private spaces, the lack of path legibility and the absence of a significant number of pedestrians make navigation difficult, leading to feelings of insecurity and discomfort. This intentional design process aimed to prevent the entry of strangers into neighborhoods (Falamaki, 2006).

Furthermore, in the central core of neighborhoods, semi-public spaces incorporate a variety of urban materials and structures more prominently than other areas. This implies that regulations for monitoring urban construction in this sector may be weaker, which aligns with the principle of diversity in traditional Iranian urban design. The spacing, length, enclosing components of the space (floor, walls, and ceiling), and materials used contribute to creating an attractive environment for pedestrians. Simultaneously, considering the complexity of readability in the pedestrian network, these elements serve as way markers to assist residents in navigation, resulting in spaces with varying dimensions.

Traffic and Environmental Challenges

Like many megacities, Tehran faces traffic problems, environmental pollution, and irregular urban development patterns. The history of Tehran reveals that the rapid construction of American-style grid streets during industrialization and modernity (1935-1955) played a significant role in the pedestrian movement-related issues that emerged in the city. With the city's expansion and multi-centered nature, the public transportation network's inefficiency, particularly in old contexts and the historical core, has led many citizens to rely on private cars. This shift in transportation habits has caused lifestyle changes and increased physical and mental health issues due to reduced physical activity, traffic congestion, and environmental pollution (Bahreini and Khosravi, 2010).

To mitigate the adverse effects of excessive private car usage, new urban policies aim to restore the importance of walking in people's lives. Although other solutions, such as promoting cycling and improving public transportation, may also be considered, Tehran's experiences have shown mixed results. The expansion of cycling infrastructure has faced challenges due to societal, religious, and traditional beliefs, particularly concerning women's cycling in public spaces. Additionally, the city's high traffic volume poses safety concerns for cyclists. Consequently, efforts to create cycling infrastructure in the center of Tehran between 2002 and 2005 were halted during the initial stages, and the developed network did not receive the expected acceptance (Amani, 2021). Regarding the expansion of the public transportation system, Tehran's enormous population strains the existing network's capacity. While the Bus Rapid Transportation (BRT) network and metro lines provide adequate capacity and quality service, they still fall short of meeting the city's overpopulation demands (Nassereddine and Eskandari, 2017).

Public spaces in Tehran, including streets, have different definitions and roles than in Western countries, owing to political, cultural, and social backgrounds. Utilizing these spaces for political purposes other than official public occasions, such as processions on Qods Day, is prohibited and can result in legal consequences (Khalkhali, 2004). However, encouraging people to spend time in the streets while adhering to the country's laws should be an essential consideration in urban design and planning projects to improve walkability in Tehran.

Enhancing Walkability in Historic Organic Districts in Tehran

Since the 1990s, Tehran has implemented plans and projects to enhance walkability in various areas, particularly in historical and old districts. The primary focus on these older neighborhoods is attributed to the organic structure of their street network. Nowadays, with the city's expansion and the substantial presence of vehicles on these narrow and winding streets, traffic and urban issues in these areas surpass those in newer neighborhoods (Ayazi, 2013).

According to archaeological findings (Karimi, 2014), Tehran has a settlement history spanning seven thousand years. It was designated as the capital during the Qajar era (1821 A.C.) and has retained this status to the present day. During the Qajar era, numerous palaces and gardens were constructed. The street network design took into account the movement of pedestrians and their four-legged companions (horses and mules used for transporting goods) to facilitate swift travel to their destinations. As the street network's pattern was not pre-established, the streets lacked a straight and elongated shape, often narrow, winding, and leading to various cul-de-sacs.

The Typology of Organic Street Networks In Tehran

Certain researchers have likened the city of Tehran to a living organism that should grow following time and logic (Ardalan and Bakhtiar, 1973). However, when a rapidly developing city like Tehran undergoes fast-paced growth, its street networks, which serve as spaces accommodating and guiding the flow of urban life, often struggle to adapt and develop properly, leading to various development challenges. Notably, Tehran experienced its most rapid development during the modernity era between 1935 and 1955 (Abadian, 2018). During this period, the grid street network pattern widely used in America was implemented in Tehran to quickly provide infrastructure for a large influx of immigrant laborers who settled in Tehran. However, this approach failed to consider the socio-cultural differences between the two countries. The integration of the grid system with the existing organic street pattern, the construction of new neighborhoods adjacent to older structures with distinct patterns, and the expansion of the grand Bazaar in the historical core of the city all contributed to the challenges posed by the organic structure during the city's modernization efforts. As a result, new forms of organic networks emerged from the combination of the grid system and the organic pattern, referred to as the "Integrated Organic Street Network" in this research. This integration incorporates the grid system along with other networks, such as Tributary and Radial.

Following the social structure challenges encountered by the grid networks and the failure to establish or sustain neighborhood social patterns, some theorists emphasized the importance of attending to the organic texture to restore a sense of belonging and security in the new urban surfaces of Tehran (Vance, 1970; Soltanzadeh, 1993; Mashhadizadeh Dehaghani, 1999; Tavassoli, 2002; Khaksari et al., 2007; Kalantari and Pourahmad, 2014; Haghighat Naeini and Ashrafi, 2022; Haeri, 2016). However, in 1961, during the construction of some modern and new settlements, architects and engineers combined Iranian urban design principles with new urban design theories from America and Europe to reevaluate the organic structure of urban spaces while incorporating modifications and honoring the principle of spatial hierarchy (Technical Deputy of Region 2 Municipality, 2019). This fusion gave rise to a new form of the organic structure referred to as the "Imitated Organic Street Network" in this research.

Diverse Perspectives Regarding the Definition of Organic Street Network

Although numerous challenges are associated with the movement of organic networks in Tehran, there is a lack of detailed studies on the form of the network. Furthermore, there is no consensus on a comprehensive and specific definition of the organic street network in Tehran.

The definition of the organic network is not universally agreed upon. Some researchers argue that this type of network is pedestrian-oriented, emphasizing walkability, while others view it as conflicting with the necessary safety and security principles for pedestrians. The table below presents various definitions of the organic network (or organic texture) provided by different researchers.

Table 1.1. Definitions of organic street network in literature

Researcher(s)	Definition
James E. Vance, 1970	These networks are opposed to pre-programmed networks-a system of function and development over time.
Leonard S. Fishman 1982	The organic network emerged slowly as the result of many individual decisions.
Anne Vernez Moudon and Richard K. Untermann, 1987	Organic streets have always had a purpose and responded to a need.
Christopher Alexander, 1987	It is in relationship with biological forms. It is not an analogy. It is, instead, an accurate vision of a specific structural quality.
Yadollah Farid, 1989	A system that humans do not participate in through its design, planning, regulation, and formation. It has been done by chance. Its narrow streets and alleys are intertwined with twists, turns, and curves.
Bill Hillier and Alan Penn, 1992	It has grown over a long period. It optimizes critical aspects of movement and land-use patterns.
Michael Batty and Paul Longley, 1994	They are formed from many individual decisions at a much smaller scale than planned cities. They are usually less monumental, less focused, and less regular.
Asghar Nazarian, 1995	Non-geometric texture
Naser Mashhadizadeh Dehaghani, 1999	It was created based on the needs of the time, place, culture, geography, etc. They follow a certain logic and do not have a chaotic and irregular system.
Spiro Kostof, 1999	It has its roots in modern biology and the concept of living organisms. It can begin with an analogy between the visual characteristics of cities and natural organisms.
Hossein Soltanzadeh, 1993	Organic streets have been formed gradually, spontaneously, often indirectly, and winding.
Marc Barthélemy and Alessandro Flammini, 2008	Its design is like a microscopic image of the cellular structure of an animal body or a plant. The streets have curvature and their width is different. At different distances, open spaces are seen irregularly and discontinuously.
Anne Matan, 2011	It is sometimes referred to as 'traditional' city design based on the idea that many traditional cities developed 'organically'.

This study posits that organic street networks function as dynamic organs within the city, evolving within the spaces between the built environment and the natural surroundings. These networks have adjusted their configurations to accommodate the needs and preferences of their primary users, predominantly residents. However, due to the rapid pace of urban development and technological advancements, along with the swiftly changing user demands, the adaptability of organic street networks struggles to keep pace.

As most researchers suggest, an organic network is primarily based on pedestrian needs and demands that arise during its formation and development. Consequently, the definition of the organic network can vary depending on the specific region, as people in different areas have diverse needs, beliefs, demands, and preferences for comfort. What may be perceived as insecurity in one location could be considered a safe and secure space in another. Therefore, it is essential to define the organic network of its study area based on the norms and expectations of its users. Therefore, this research regards the desires and demands of the residents as the criteria for assessing the factors influencing walkability.

Challenges in Managing Tehran's Organic Street Network; Balancing Heritage, Culture, and Modernization

On the other hand, there is no specific framework for intervening in the organic network when it comes to urban management in Tehran. Existing laws and regulations primarily focus on streets in their literal sense and do not differentiate between various networks with distinct characteristics. For instance, when examining the current plans and projects aimed at improving walkability in Tehran, general policies often include pedestrianization, inspired by European cities' experiences, as well as attempts to create more direct routes by shortening streets and increasing the number of intersections, following the American grid network model. However, this study highlights that there is no specific evaluation of the grid system's efficiency in the historical context of Tehran. Implementing projects that reshape the organic street network and replace it with a grid system without conducting sufficient studies has not yielded successful outcomes (P. Shahabiyan, personal communication, September 11, 2022).

Moreover, the organic structure is predominantly observed in Tehran's old context or historical core. These areas possess historical and heritage value, including the world heritage site of Tehran Golestan Palace, and the land value is high. As a result, encroaching upon the existing texture is challenging and expensive. The current form of the organic network has developed over many years, taking into account the local context and topography. The gradual growth of the city in the past allowed urban development to permeate the core of neighborhoods with winding and narrow streets, creating a human-oriented structure for residents. This deepened the sense of attachment among most residents, who considered the neighborhood as a semi-private part of the city that belonged to them and their neighbors. The culture and traditions of the people in these areas were closely tied to the urban context (Hatami Khanghahi et al., 2020; Ahmadi et al., 2014).

With population growth and the need for more space for activities and housing, traditional courtyard houses of the organic networks have been demolished and replaced by multi-story buildings. This expansion and verticalization have resulted in high construction and population density in most parts of Tehran, making it even more challenging to alter the form of the network, as the buildings are intertwined with its structure. Therefore, it is necessary to explore how to address this type of urban fabric while considering the contextual values in line with traditional Iranian urban planning principles.

1.2. Literature Review

Research Fields

In general, many studies conducted in the field of walkability have considered its role in transportation (Thielman et al., 2015; Tiwari, 2015; Kaplan et al., 2016; Litman, 2018; Kim et al., 2020), in health (Dygryn et al., 2010; Toronto Public Health, 2012; Mena et al., 2017; Lee and Dean, 2018; Edwards and Dulai, 2018; Ussery et al., 2018), and social studies (Du Toit et al., 2007; Rogers et al., 2011; Hanibuchi et al., 2015). These studies are not directly related to this research except for commonalities such as the initial definitions of pedestrian, walking, walkability, orientation, etc. The most related field is the research that evaluates the walkability of a built environment (Dygryn et al., 2010; Maghelal and Capp, 2011; Tribby et al., 2016; Litman, 2018; Knapskog et al., 2019; Dörrzapf et al., 2019; Blecic et al., 2020). These studies have mostly investigated the impact of the built environment on walkability by considering functional, physical, and spatial characteristics (Handy et al., 2002; Cervero et al., 2009; Van Dyke et al., 2011; Sundquist et al., 2011; Siqueira Reis et al., 2013; Schlossberg et al., 2015; Tran, 2016; Vale and Periera, 2016; Zuniga-Teran et al., 2017; Dennis Wei et al., 2019; Reisi et al., 2019; Rebecchi et al., 2019; Barros et al., 2017). However, in most of these studies, criteria and indicators such as land use, safety, security, quality, and urban facilities have been used to investigate the built environment's impact. In contrast, the form of the street network (in terms of urban street morphology), as one of the main physical features of the street network, has rarely been considered.

On the other side, most research on the built environment's impacts on walkability has been conducted in pedestrian-friendly countries. In the context of cities and countries that are planned and designed under the dominance of vehicle-oriented policies and are dealing with the problems caused by them, these kinds of studies are more necessary.

The literature review in Iran shows that these studies mostly focus on evaluation of walkability in different scales of neighborhoods and cities (Shahivandi and Qalenoui, 2012; Akbarzadeh Moghadam Langroudi et al., 2016; Rezazadeh et al., 2016; Abolfazli et al., 2016; Rezaei Jafari et al., 2017; Roostayi and Naseri, 2018; Abdollahi et al., 2018; Shahabian, 2018; Khodabandehlou et al., 2018; Kalantar and Shahabian, 2018), impacts of walkability on urban transportation system (Hassanzadeh et al., 2016; Soleimani Moghadam et al., 2018; Gholami et al., 2022), on social interactions and urban vitality (Shokouhi Dolatabadi, 2010; Mohammadi and Kholousi, 2012; Pourmokhtar, 2013; Ghanipour and Kord Jamshidi, 2014; Pourahmad et al., 2016; Fasihi et al., 2019; Sadri et al., 2018; Zoghdar and Nazemi, 2020; Saremi et al., 2021), physical and psychological health of citizens (Bahreini and Khosravi, 2010; Shaterian et al., 2018) and limited studies have been conducted regarding the impact of the built environment on walkability (Bahrami, 2013; Nikpour et al., 2016; Pourahmad et al., 2017). The last category, as the most related theme to this research, examines criteria such as accessibility, path continuity, safety, comfort, sense of place, and social interactions, as well as indicators such as residential density, commercial usage ratio, communication network usage ratio, etc. Consider, two research gaps were evident; first, the studies inside Iran are a kind of extraction from the studies outside Iran and are primarily aimed to evaluate walkability based on the criteria proposed in foreign studies and are not localized with the characteristics of a general Iranian-Islamic environment. Secondly, the form of the street network has rarely been considered.

Tehran Urban Policies

An examination of urban policies and the comprehensive Tehran plan reveals that walkability has been given due consideration in recent years. However, these policies primarily focus on pedestrianization, and research has predominantly investigated the impact of pedestrianization on the quality of urban life (Rezaei, 2012; Shieh et al., 2014; Habibi and Haghi, 2015; Khaleghi, 2018). Some studies have also considered social indicators such as security and social interactions (Pourahmad et al., 2017), transportation factors like access to pedestrian bridges, public parking, and public transportation (Soleimani Moghadam et al., 2018; Gholami et al., 2022), and the physical and spatial aspects of streets including views, urban elements, access, safety, comfort, dynamics, attractiveness, sense of place, and variety of uses (Habibi and Haghi, 2015; Rezazadeh et al., 2016). However, there is a lack of specific laws or frameworks addressing the treatment of different urban networks, such as the organic network, about pedestrianization or walkability assessment.

Furthermore, while some researchers have mentioned the organic street network in their studies, only a few have utilized it as a case study. In some cases, the term "worn-out texture" has been used to describe the organic structure of neighborhoods (e.g., Tajedini and Mirsaid Ghazi, 2013). This network has evolved without a predetermined plan, and it appears that changes to the network continue to occur organically. As a result, many researchers and decision-makers believe that reviewing this network in collaboration with urban planners is necessary to establish a structured approach, with the grid system often being proposed as an alternative (Ayazi, 2013).

Organic Street Network Subcategories

In terms of the subcategories of organic networks, there have been references to their classification in Iranian and English resources. One Iranian article by Azizi and Azari (2020) mentioned two categories: "organic form with low changes" and "organic form with high changes." This categorization was used to analyze the relationship between urban forms and social sustainability in Tehran's neighborhoods. Since walkability can also be linked to social stability in neighborhoods, the research indirectly indicated the relationship between walkability and urban form, considering indicators such as land use, density, number of blocks, and centrality in urban open spaces across four neighborhoods in Tehran.

Similarly, Yoo and Lee (2017) explored the urban form that initially had an organic structure but later integrated with a grid structure. Although this source did not directly consider the subcategories of organic networks, it examined the changes in organic networks in Barcelona, Spain. Moreover, Spiro Kastoff (2017) discussed different types of organic networks found in Italy, which have emerged in response to the region's topography and shared principles of formation and expansion. The philosophy behind their creation and development was unplanned, based on people's needs, and considering climatic and environmental characteristics.

Organic Network and Walkability

In the reviewed research, some researchers have directly or indirectly mentioned the relationship between organic networks (or streets in an organic context) and one or more main factors or elements of walkability. The following table shows a summary of these elements and the research methodologies.

Table 1.2. Studies carried out regarding the organic street network and its relationship with walkability elements

Walkability evaluation factor or Element	Organic Street Network characteristics based on the researchers
Connectivity	continuous and dense texture (organic pattern); several cul-de-sacs streets; different streets' length up to several hundred meters; straight or curved streets; a series of twists and turns (Amanpour et al., 2015).
	Several cul-de-sacs; curved streets; limited continuity and connection of the streets (Hillier and Vaughan, 2007).
	Narrow streets (Shieh, 2009).
	Mostly in old parts of the cities; Suitable for pedestrians (Mousavi et al., 2016).
	Pedestrian-oriented structure (Yoo and Lee, 2017).
Safety and Security	Lots of twists and turns; Insecurity in the local context due to limited visibility and readability (Greene, 2003).
	Curved streets; several cul-de-sacs Limited entry for strangers into the neighborhood (Hillier and Vaughan, 2007).
	Insecurity due to excluding the strangers (Jacobs, 1961).
	Closed complexes; hinder the natural movement of people; exclusion of strangers; Insecurity in public spaces (Carmona et al., 2012).
	Insecurity in comparing with grid networks (Rahmana and Hosseinian, 2014).
	Based on environmental and defense factors; Provide safe public spaces (Amanpour et al., 2015).
Accessibility	Easy accessibility for the neighbors; functional importance; spatial balance; Efficiency in the space (Sazandeh et al., 2018).

	Easy access to the destination (Habibi, 2017).
Access to public transport	Compatibility with pedestrian movement; winding streets; cul-de-sacs streets; Hard access to public transportation inside the organic networks (Tajedini and Mirsaid Ghazi, 2013).
Comfort	A dense and compact texture; winding and indirect street; Protecting pedestrians from cold and hot winds and creating a degree of comfort (Fadaki and Roshani, 2013).
Human Scale	Concerning the climatic; Considering human-scaled built environments (Jamei et al., 2021).
Hierarchy of the spaces	Private, public, semi-public, and semi-private urban zones (Jamei et al., 2021).

1.3. Aim and Research Questions

This study aimed to comprehensively evaluate walkability in Tehran's organic street networks based on their form and configuration. This research encompassed several key objectives and methodologies:

- Defining Organic Street Networks and Walkability in Iran: To establish a solid foundation, the research began by defining the concepts of organic street networks and walkability within the Iranian context.

- Identifying Walkability Factors: The research identified and defined seven critical factors for evaluating walkability: safety against motorized traffic, security against crime, accessibility, connectivity, climate comfort, quality of the built environment, and attractiveness. These factors were chosen for their potential susceptibility to configuration-related influences in street networks.

- Locating Organic Street Networks: The research conducted a thorough study of the street networks in various districts of Tehran to pinpoint the locations of organic street networks. This step was essential for subsequent analysis.

- Exploring Traditional Urban Design Principles: The research delved into Iranian traditional urban design principles that manifest within organic street networks, highlighting their cultural and historical significance.

- Categorizing Organic Street Networks: The study categorized organic street networks into three main subcategories: original, integrated, and imitated organic street networks, each with unique characteristics.

- Analyzing Walkability Factors: The research conducted an in-depth analysis of walkability factors by considering different elements and indicators across six different districts in Tehran, each representing a distinct type of organic street network.

- Methodology for Walkability Evaluation: To facilitate the comparison of walkability evaluations among different neighborhoods, the research devised a scoring system. This system involved defining specific evaluation criteria, assigning relative weights to these criteria based on expert opinions, and employing a scoring scale ranging from poor to outstanding. This scoring system was applied to data collected through GIS analysis, expert interviews, and questionnaires from residents.

- Overall Walkability Score: For each neighborhood, the study calculated an overall walkability score by multiplying the scores for each criterion by their respective weights and summing them up. This score provided a comprehensive measure of walkability for each studied neighborhood.

- Practical Scoring System: Additionally, the research aimed to offer a practical scoring system that could support decision-making and facilitate comparisons among different neighborhoods regarding walkability.

To achieve the goals of the current study, several research questions have been discussed. These questions delve into the various aspects of street network form, including safety against motorized traffic, security against crime, accessibility, connectivity, climate comfort, quality of the built environment, and attractiveness. Additionally, the study will explore the influence of gender perspectives on walkability perceptions of organic street networks and the role of green spaces and natural elements in enhancing walkability and user preferences. The following questions will guide the research:

1. How does the configuration and form of organic street networks in Tehran impact walkability in different neighborhoods?

2. What are the key characteristics and principles of Iranian traditional urban design that are observable in organic street networks, and how do these principles contribute to walkability?

3. What are the distinctions between original, integrated, and imitated organic street networks in Tehran, and how do these distinctions influence walkability factors?

4. How do factors such as safety against motorized traffic, security against crime, accessibility, connectivity, climate comfort, quality of the built environment, and attractiveness vary across different types of organic street networks in Tehran?

5. Do gender perspectives influence perceptions of the walkability of organic street networks?

6. How can a scoring system be effectively developed to compare walkability evaluations among different neighborhoods, and what criteria and indicators should be considered in this system?

7. What are the implications of the research findings for urban planning and design in other research areas, and how can they inform strategies to improve walkability in the city's organic street networks?

By addressing these research questions and hypotheses, this study aims to provide valuable insights into the definition and characteristics of the organic street network and its relationship with the walkability of the unique context of Tehran while offering a new methodology to critically assess walkability in the context of urban planning, which can guide researchers in other parts of the world.

1.4. Research Method and Structure

The study is an applied research and its approaches are descriptive, theoretical, and analytical research. The study follows the case study approach as an evaluation method of research.

Since the project's goal is to investigate the street networks, the research has been done on two scales, the district (Mahale) and the street. In this case, the street and network form can be investigated and evaluated. Apart from that, walkability in the research literature also has different dimensions and scales, which should be considered simultaneously at the micro-scale (street level) and medium-scale (network) to evaluate it accurately.

The research has an applied nature, in the first stage, the existing studies and documents, including library sources, maps, and urban projects of Tehran, plans and programs carried out in connection with the two main issues of the organic street network and walkability, geographical maps and aerial photos related to organic textures have been studied.

To measure and evaluate the research, three main methods have been chosen. First, mapping and analysis with the GIS software are the primary research methods. The data for GIS has been analyzed based on the available data from the Tehran Municipality documentation archive, OpenStreetMap (OSM), Esri Images, and Google Street View. In some cases, the editing has been done based on observation. The produced maps have been edited in Photoshop and InDesign software. To use the OSM maps, the plans have been edited in Illustrator software.

The second method has been an interview with the experts. At first, the expert panel was used to evaluate the qualitative data for the research. However, due to the different time plans of the interviewees and the challenges of setting an online meeting, the panel was canceled and personal interviews were planned. The results are evaluated in Software R (4.2.2) [see appendix A].

The last method was questionnaires from the users of the sites. The questionnaire had 23 questions, including two open and 21 multi-choice questions with a semi-structured form [see appendix B]. The evaluation was conducted in SPSS Statistics 29.0 [see appendix C].

The research timeline for this project started in October 2018 and involved two years of library research and literature review. The data collection process took place from September 2021 to November 2022. The observation and documentation of case studies were conducted over seven months, including November to December 2021, March to June 2022, and August 2022. This allowed for the inclusion of both hot and cold seasons in Tehran. Approximately 600-700 photos and 10-15 videos were recorded for each neighborhood. Some of the photos were obtained from the city cameras' archive videos. The images were captured at different times of the day, including during the active hours of the shops (6-7 AM), working time (9-10 AM), midday and lunchtime (12-1 PM), end of the active time (5-6 PM), and night (10-11 PM). Videos were recorded only during the daytime due to lighting quality and safety concerns. It should be noted that photos were taken without including people to respect their privacy.

The research faced challenges related to the COVID-19 pandemic and the political situation in Iran during the project's implementation. Conducting interviews and collecting questionnaire responses encountered difficulties due to internet shutdowns in the country in September 2022. Although there were plans to conduct interviews with 12 experts, only five interviews (three Iranian and two foreign experts) could be conducted in the end. The interviewees were selected based on their research background related to the project, and they were the authors of references mentioned in the literature review. The inclusion of foreign experts ensures a broader perspective and helps to mitigate potential biases that may arise from sociocultural ideas prevalent among local experts. By involving experts from different cultural backgrounds, the results obtained from their opinions are more likely to be independent and less influenced by local sociocultural factors. On the other side, foreign experts can provide different insights and alternative viewpoints. Their diverse experiences and expertise bring a different set of knowledge and approaches to the table, allowing for a more comprehensive analysis of the research topic. The experts who participated in the interviews were Mr. Hamed Abedini (Architect and lecturer), Prof. Dr. Phil. Leo Schmidt (Monument conservator, art and architectural historian), Dr. Pooyan Shahabiyan (Associate professor), Prof. Dipl.-ing. James Miller Stevens (Urban planner), and Dr. Kianoosh Zakerhaghighi (Associate Professor).

The interviews were conducted as open discussions, where experts expressed their thoughts and opinions about each neighborhood based on the provided photos. For each neighborhood, a PDF file containing 10-20 figures of the area was prepared and shared with the experts via email, WhatsApp, or Skype. The selected photos aimed to be representative of the neighborhood, showcasing elements such as slopes, different street types, and adherence to traditional Iranian urban design principles. The interviews were recorded, and notes were taken during the meetings. After each session, the interview keywords were identified, coded, and scored based on evaluation criteria.

Due to political unrest and the conflict in the country since September 2022, it was deemed unsafe to distribute questionnaires randomly to the users of the streets in the selected neighborhoods as initially planned. Therefore, the questionnaires were sent to relatives, family members, and friends residing in those neighborhoods, requesting them to fill out the forms based on their knowledge and experiences.

These adaptations were necessary to ensure the safety and feasibility of data collection in the challenging circumstances faced during the research project. The following table illustrates an overview of the different categorical variables in absolute and relative frequencies.

Table 1.3. An overview of the different categorical variables in absolute and relative frequencies

		Quantity	%
Mahale	Chizar	12	14.8%
	Darrous	16	19.8%
	Dr. Hooshyar	8	9.9%
	Qeytariyeh	17	21.0%
	Sanglaj	9	11.1%
	Shahrak-e Qarb	19	23.5%
Gender	Woman	44	54.3%
	Man	37	45.7%
Age	Less than 21	9	11.1%
	21-35	32	39.5%
	36-45	22	27.2%
	46-50	13	16.0%
	more than 61	5	6.2%
	no	37	45.7%
On average, how many times a week do you go walking or walk to your destination? (number of times)	2	1	1.2%
	2 to 3 times	5	6.2%
	3	5	6.2%
	3 to 4 times	46	56.8%
	5	1	1.2%
	more than 5 times	7	8.6%
	more than 10 times	16	19.8%
On average, how many hours a day are you a pedestrian in this neighborhood? (in hours)	less than 30 minutes	15	18.5%
	30 minutes	2	2.5%
	1 hour	37	45.7%
	1and half hours	9	11.1%
	1 to 2 hours a day	1	1.2%
	2 hours	9	11.1%
	2 to 3 hours a day	8	9.9%

In addition, the research contains six examples from six different neighborhoods in Tehran, Iran, including organic street networks. The sampling method was purposeful to include the neighborhoods more representative of their features. With this aim, the neighborhoods with high slopes have been omitted because of the high impacts of topography (mostly neighborhoods near natural features like mountains and rivers). On the other side, it is considered that the case studies represent the neighborhoods that are mainly residential, not industrial, and have urban structures (not the rural areas that, in the last years, have been integrated into the city). In addition, the neighborhoods have been chosen so that direct contact with the local citizens was possible for the author. Based on these principles, the case studies are located primarily (except two) in old and historic parts of the city. The other cases are related to the newer developed patterns (integrated with tributary and the imitated organic street network).

Chizar is chosen as an example of an original organic network in the old part of Tehran. The neighborhood has an old organic structure and many long-term citizens. Sanglaj is a case study for the original organic structure in historic Tehran, as it was less integrated into the Grand Bazaar than the neighbors were. Moreover, due to the City Park, there is more possibility to stay inside urban spaces as a pedestrian. Shahrak-e Qarb, as an example of the imitated organic network, had been chosen. It was one of the first neighborhoods that had this network and an Iranian architect with the influences of American architects and companies planned it. Qeytariyeh and Darrous are located next to each other, making the comparison easier as they have the same infrastructure but different street networks. On the other side, Dr. Hooshyar, as one of the examples of an organic-tributary, had been chosen because there was no neighborhood in the north part of the city with this structure. In addition, it brings the opportunity to have more parts of the city in the study.

There were no specific instruments or tools to do this research. The primary tool was a desktop with Adobe Illustrator 2020, Photoshop CS6, InDesign CS6, QGIS Desktop 3.22.3, and AutoCAD 2021 software. The Interviews were done via WhatsApp and Skype.

The concept of walkability is inherently subjective, as individuals have unique demands, desires, and expectations from the built environment when it comes to walking. Consequently, evaluating walkability accurately requires studying all users of the streets. In Tehran, neighborhoods consist of diverse groups of people with varying social and political backgrounds, income levels, educational attainments, cultural values, and beliefs. Recognizing this diversity, the research aimed to exclude indicators associated with people's backgrounds to minimize the influence of factors other than the form of street networks.

However, it is important to note that despite efforts to mitigate biases, the evaluation of the built environment in the research involved people, including interviewees and questionnaire respondents. As a result, their backgrounds may have still influenced their evaluations, even when they were experts in the field. Additionally, unintended personal interpretations might have emerged since the author selected and captured photos and explained the research objectives to street users and experts. In certain cases, experts' prior knowledge of specific neighborhoods may have led to preconceived judgments influenced by the socio-cultural context rather than solely considering the form of street networks.

To follow the aims of the study, the research has been divided into five chapters, including:

Chapter 1: Introduction - The first chapter provided an overview of the research, including the background, rationale, objectives, research questions, methods, and overall structure of the study.

Chapter 2: Walkability in Tehran - The second chapter focused on the topic of walkability in Tehran. It explored the position of pedestrians in Iranian urban planning policies and examined the concept of walkability. The chapter also discussed the evaluation indicators, criteria, methods, and tools used in international and Iranian studies related to walkability.

Chapter 3: Tehran Organic Street Networks - The third chapter delved into the various street network types in Tehran. It began with a brief introduction to Tehran and its twenty-two districts. The chapter then explored the definition of streets, classification of streets, components of street networks, and different street network types. Special attention was given to the definition and typology of organic street networks. Lastly, the chapter provided insights into the historical formation, development, characteristics, and components of subcategories of the organic street network in Tehran.

Chapter 4: Assessing Walkability of Organic Street Network in Tehran - The fourth chapter presented case studies from three subcategories of organic street networks in Tehran. Walkability evaluations were conducted, specifically focusing on the form of street networks in six different neighborhoods. The evaluation process resulted in identifying and prioritizing factors and their indicators based on their effectiveness in enhancing walkability.

Chapter 5: Conclusion - The fifth and final chapter summarized the key findings of the research and provided recommendations to improve the intervention process for enhancing walkability in different organic urban street networks. The chapter offered insights and suggestions for future interventions and developments in these areas to promote walkability.

2. Walkability in Tehran

This chapter has conducted an extensive review of the existing literature to explore the concept of walkability, its influencing factors, and various evaluation methods. The research methodology employed in this chapter involved thorough library studies, examination of plans and projects, and the analysis of relevant city laws and principles. It is important to note that many terms associated with walkability have international and general meanings and definitions, including in Iranian resources.

Given the diverse geographical, political, social, and cultural contexts, the definition of walkability can vary significantly. Thus, particular attention has been given to studying the walkability of the specific framework of Iranian principles, explicitly focusing on the city of Tehran. By examining walkability through this lens, the research aims to provide a context-specific understanding of the concept, considering the unique characteristics and considerations of the Iranian urban environment.

2.1. Walking and Pedestrian Spaces in Iran

Walking is a fundamental and essential form of human movement, serving as a means of transportation for a significant portion of the population, particularly in developing countries (Aziz et al., 2018; Gehl, 2011). It offers individuals the opportunity to observe their surroundings, engage with urban spaces, and experience the vibrancy and vitality of life while interacting directly with the local environment (Wey and Yin, 2013). Walking is also considered a socially equitable mode of transportation, accessible to people across different social classes, genders, and age groups. It serves dual purposes: functional mobility to reach destinations and leisurely activities such as pleasure, entertainment, sports, and physical exercise (Owen et al., 2007), which can often overlap. Moreover, walking as a way of urban life holds significance, where individuals walk without a specific goal or destination, simply to be present on the street and engage in seeing and being seen (Kashanijou, 2018).

The history of urbanization in Iran dates back five thousand years (Khodayousefi, 2013). As agriculture and animal husbandry emerged, cities expanded due to the availability of reliable food sources. The initial cities featured inner walls defining their territories. Similar to other ancient cities, Iranian cities were designed to accommodate pedestrians and their social and religious affiliations. Pedestrians constituted the majority of users, and the primary mode of movement was on foot, shaping the formation of streets and urban spaces based on the scale and needs of pedestrian mobility. Cities were planned and developed in a way that walking was the predominant means of travel, and the use of animals or carts for goods or passenger transportation did not necessitate a distinct separation between pedestrian and vehicular spaces. This pattern of movement established a connection between the city and its residents and bestowed a social and cultural character upon the urban streets and spaces (Soltanzadeh, 1993).

Traditional cities in Iran encompassed various elements such as residential buildings, bazaars, mosques, schools, squares, streets, and government centers, all strategically located for easy accessibility. Consequently, the volume and length of daily walking trips in these areas were relatively limited. This was primarily due to the functional specialization of urban elements and the optimal placement of these elements. Residential neighborhoods served as hubs for living and social interactions, forming the basis of intra- and inter-neighborhood relationships. The street network connected the neighborhood center to residential areas, while sub-networks of residential contexts facilitated inter-neighborhood movement. Beyond internal neighborhood streets, smaller and shorter streets interconnected smaller neighborhoods, eventually leading to shared spaces or residential units. This hierarchical arrangement shaped the organic street networks. In each neighborhood, facilities and amenities essential to residents were strategically located within walking distance, allowing residents to fulfill their daily or weekly needs without extensive travel. The neighborhood center, fulfilling the spiritual and recreational needs of residents, served as a gathering space for leisure activities. Streets in ancient cities demonstrated an organized and harmonious relationship with urban elements, accommodating the material and spiritual requirements of society as the city gradually grew and developed. Climatic, defensive, aesthetic, social, economic, and religious factors, along with considerations of water routes, land division, ownership disputes, and housing arrangements, contributed to the formation of Iranian organic streets. The diversity of factors shaping street networks and the multifunctionality of structural elements of traditional cities resulted in various roles and functions being assigned to urban streets and networks. In addition to facilitating movement between different urban spaces, streets also served as venues for social and political events, social interactions, trade, the creation of memories, and the expression of collective sentiments (Bonine, 1979; Fakuhi, 2015).

In traditional Iranian urban structures, bazaars were constructed along pedestrian passages. Essentially, bazaars comprised covered streets lined with shops on both sides. As these spaces expanded linearly, they occupied surrounding areas and converted them into necessary functions. Consequently, the inner courtyards of shops transformed into streets, facilitating the organic expansion of the street network within the bazaars. With the advent of automobiles in cities and the need to transport goods using vehicles, streets became increasingly congested, posing challenges to pedestrian movement. Starting from the mid-20th century, a concept emerged in European cities aimed at reducing the dominance of automobiles in historical city centers to preserve old structures and revive social life. In Iran, this approach received less attention and was implemented with a delay compared to European countries. Since the 1980s and 1990s, measures have been gradually taken to improve, renovate, and reconstruct old structures based on the experiences gained in Europe (Pourahmad et al., 2015).

Pedestrian spaces play multiple roles, contributing to a sense of belonging and enhancing the quality and livability of a place, including:

- Perceptual role: Enhancing citizens' mental image by highlighting social, historic, and memorable places.

- Social and cultural role: Strengthening the cultural fabric and fostering social interactions in urban spaces.

- Economic role: Stimulating economic development and exerting social and physical impacts on the surrounding environment.

- Leisure role: Contributing to urban circulation by providing spaces for relaxation, play, entertainment, recreational green areas (Kashanijou, 2015), commercial-recreational activities, and showcasing cultural works (Pakzad, 2015).

- Environmental role: Reducing sources of air and noise pollution, enhancing safety, developing green spaces, alleviating density and overcrowding, particularly in administrative centers, and creating tranquil residential areas (Ashuri, 2009).

Distance plays a crucial role in individuals' initial decision to walk, and the acceptable walking distance varies based on individual characteristics (e.g., gender and age) and transportation features (e.g., purposeful or leisurely). Most people consider walking distances of up to 10 minutes (equivalent to approximately 800 meters) acceptable to reach their destinations. However, in larger cities like Tehran, the acceptable walking distance limit can extend to 20 minutes (approximately 1500 meters). For reaching public transport stations and completing such trips, the acceptable walking distance typically ranges from 400 to 800 meters, depending on the type of public transportation system (rapid or regular) (Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020a). Pedestrians tend to prefer the shortest straight-line paths and often avoid elevation changes and the use of overpasses and underpasses (Ministry of Transportation, Ministry of Road and Urban Development, 2020b).

2.2. Walkability

2.2.1. The Definition of Walkability

The terms "walking" and "walkability" are increasingly important in urban planning and design. It is important to note that these two terms have distinct meanings: "Walking" refers to a form of physical activity, while "walkability" pertains to the physical environment in which walking occurs. In urban studies, the built environment encompasses streets, landscapes, and buildings of a neighborhood (Rezazadeh and Latifi Oskouei, 2015).

Although there is no universally agreed-upon definition of walkability in Iranian resources, it can be summarized as the extent to which a place welcomes pedestrians (Martino et al., 2019). Walkability refers to how the built environment encourages people to walk by providing comfort, convenience, and safety. It involves connecting individuals with diverse purposes and goals in a conducive environment and creating visual attractions along street networks (Southworth, 2005). Furthermore, the significance of walkability lies in enabling different user groups to navigate the environment without experiencing physical, mental, and social harm. This inclusivity involves considering different age groups and social classes, ensuring each group can coexist without suffering injuries (Choi, 2012).

In a 2015 research, Forsyth tried to categorize the definitions presented in research and general discussions in terms of walkability. The following table shows a summary of his classification.

Table 2.1. Classification of walkability definitions in different literature themes and their elements (Forsyth, 2015)

Walkability research theme	Walkability Element	Description
Characteristics	Passability	Walkability means being able to cross from one point to another on foot concerning the configuration of the streets, the origin, destination, and the form of the city.
	Compactness or proximity	It means pedestrian routes focus more on destinations and distance.
	Safety	Walkability means creating a safe and comfortable space for walking concerning environmental justice and physical activity.
	Attractive	Walkability should have features such as vegetation, suitable infrastructure for pedestrians, calming traffic measures, lighting, and various facades of buildings to the area attractive for walking.
Walkability outputs	Lively and Sociable	A walkable space has a sense of liveliness, sociability, and high social interactions.
	Sustainable Transport Option	Walking, as one of the sustainable transportation options, can combine crucial economic and social dimensions and consumption of energy.
	Exercise-Inducing	A walkable environment induces or supports exercise.
A proxy for better design	Multidimensional and Measurable	The walkability dimensions can be measured; e.g. safety, access, connection, density, etc.
	Holistic solution	Walkability indicates prime urban areas that cause redevelopment, population growth, and high livability.

Nonetheless, there is no universal hypothesis for designing pedestrian-friendly spaces that can be applied across different environments with diverse cultural, geographical, and social backgrounds (Southworth, 2005). These socio-cultural differences contribute to specific preferences regarding the geography of pedestrian spaces. For instance, pedestrians may prefer walking on straight and wide streets in one environment as they feel more secure and free in such spaces (Isaacs, 2001). Conversely, in another environment, pedestrians may prefer shorter streets with more intersections and changes in direction, finding long and straight streets dull and unappealing (Gehl, 1987).

In the majority of Iranian urban planning literature, the concept of walkability is introduced with Nosal's definition (2009), which describes walkability as the degree of desirability of the built environment for various activities such as living, shopping, meeting, spending time, and enjoying an area (Rezazadeh et al., 2016). However, it is important to note that the purposes of social activities and enjoyment in urban areas are highly influenced by cultural, traditional, religious, and political norms and policies. According to Iranian principles, norms, and traditions, urban spaces are not typically designed to accommodate large gatherings of people for extended periods, and there may be considerations that deem certain spaces inappropriate for women to linger in (Hamedanian and Ghadermazi, 2022; Arjmand, 2017).

In contemporary Iranian society, the presence of women in urban spaces is considered inevitable (Rezazadeh, 2010). However, historically, urban spaces in Iran were predominantly male-dominated until the 1970s. The introduction of modernity brought about changes in the role, function, and expectations of public spaces, allowing for the presence of women alongside men (Habibi, 2013; Najmabadi, 2005). After the Islamic revolution, the convergence of traditional family values with social norms and the acceptance of women's presence and social activities outside the home led to further evolution in this regard. However, the extent of women's presence and activity in urban spaces varies depending on individual characteristics, social structures, and ideological perspectives (Amir Ebrahimi, 2006). Therefore, it is necessary to consider gender and age characteristics, as well as the physical and mobility abilities of pedestrians, in the definitions related to walkability in Iranian streets to present a more comprehensive definition that incorporates the tradition, religion, and modernity of society.

Some Iranian resources have adopted the definition of King and his colleagues (2003) to assess walkability in urban spaces. This definition considers walkability as the average amount of walking and the number of pedestrians in a place (Shahivandi and Qalenoui, 2012). This definition appears to be a better indicator for estimating the level of walkability in Iranian urban spaces since it provides an index of the actual presence of people in the built environment, regardless of socio-cultural, economic, political, and religious factors.

In another study, climate comfort in Iranian-Islamic cities was addressed by creating covered streets (Sabbat). The study emphasized the importance of locating frequently used facilities within accessible distances from homes and workplaces and proposed the concept of active neighborhood centers and appropriate areas to achieve this goal (Safarirad and Shams, 2016).

A more comprehensive definition of walkability for streets in Iran can be derived by summarizing definitions from other studies, referring to urban spaces that are desirable and attractive to pedestrians, providing them with a sense of comfort, convenience, and security. Such spaces should foster a lively atmosphere through interconnected street networks that offer suitable access routes to various destinations, accommodating users of different ages and gender groups, socio-cultural and economic backgrounds, and physical and mental abilities (Moini, 2006; Asgharzadeh Yazdi, 2010; Soltan Hosseini et al., 2011).

2.2.2. Factors Affecting Walkability

Walkability factors can be approached from various perspectives. Many of these factors depend on the type and context of the research, including the geographical and political background, traditional, cultural, social, and religious beliefs of the community being studied, as well as the limitations and possibilities associated with conducting the research and the researcher's objectives. Before 2013, more than 200 English-language research projects and studies had been conducted on neighborhood design factors and their impact on walkability (Talen and Koschinsky, 2013).

From a general standpoint, these factors include the continuity of streets in the street network (Koohsari et al., 2015 and 2017; Southworth, 2005; Burton and Mitchell, 2006; Sallis et al., 2004; Frank et al., 2005), the proximity index (Sallis et al., 2004), the type of street network (Ozbil, 2013), connection to other traffic services, variety of uses, security, quality of infrastructure and street conditions, and legibility of the path (Southworth, 2005), the time required for walking and how to access (Saelens et al., 2003; Burton and Mitchell, 2006), urban traffic situation, crime statistics, sense of security and safety in the area, congestion, noise, air pollution, people's expectations, building density, environment design elements, the attractiveness of the path, the quality of lighting in the hours of darkness, mainly after midnight, climate, and weather (Handy, 2005; Ewing and Handy, 2009; Ariffin and Zachary, 2013; Krizek, 2010; Campos et al., 2003). Additionally, traditional architectural features such as high density, diverse land uses, and a grid structure (Ozbil et al., 2019; Marshall and Garrick, 2010; Timperio et al., 2006; Handy, 2005; Hoehner et al., 2003), along with shorter block lengths (Handy, 2005; Saelens et al., 2003; Berrigan et al., 2010), the possibility of choosing more direct and shorter paths (Saelens et al., 2003), the density of intersections (Frank et al., 2005), and the number of intersections (Rodriguez et al., 2006; Montgomery, 2013; Handy, 1996) all influence the walkability of a neighborhood.

Some studies have indicated that individuals in older, established neighborhoods tend to walk more distances from origin to destination than those in car-oriented neighborhoods and suburbs (Bernick and Cervero, 1997). This may be related to the living conditions of individuals residing in these neighborhoods, where many old districts gradually become dilapidated and economically disadvantaged areas, and their residents often belong to lower social classes compared to residents of newer neighborhoods. Additionally, a significant proportion of individuals in these areas do not own personal vehicles. Furthermore, these localities often encounter difficulties accessing public transportation due to their organic street network, which can further contribute to higher levels of walking in these areas. Similarly, the curved and generally narrow streets in these neighborhoods result in a lack of parking spaces, which may also explain the lower interest in private vehicle ownership among the majority of residents.

In the table below, based on the classification of Ranasinghe and colleagues (2016), factors affecting walkability in urban areas in Iranian and international resources have been listed.

Table 2.2. Factors affecting walkability based on literature (adopted from Ranasinghe et al., 2016)

Factors affecting the walkability of urban neighborhoods	Sources
Social and demographic factors include age, gender, ethnicity, education level, occupation, income level, amount of assets, number of colleagues or employees, and physical and movement abilities to walk and own a personal car.	Frank et al. (2021), Torun & Peponis (2012), Cerin et al. (2006)
Variety of uses (residential, commercial, educational and recreational, executive and managerial, and agricultural)	Frank et al. (2021), Ayşe& John (2012), Ewing & Cervero (2010), Saelens & Handy (2008), Forsyth et al. (2007), Sallis et al. (2004), Cervero & Kockelman (1997)
Accessibility (permeability, number of sidewalks, condition of sidewalks, covered access, number of obstacles, development pattern, local access, access to destinations)	Frank et al. (2021), Knapskog et al. (2019), Farrokhian & Ardalani (2017), Sapawi & Said (2012), Gehl (2011), Bahreini (2010), Krizek (2010), Brown & Werner (2007), Leslie et al. (2006), Moini (2006), Cerin et al. (2006), Frank et al. (2005)
Connectivity (continuity and connection of streets, number of intersections in a certain area, street pattern, connection between uses, number of buses in a day, connection of different transportation networks, efficiency of transportation services, size of blocks, length of blocks)	Frank et al. (2021), Cambra & Moura (2020), Knapskog et al. (2019), Moradpour et al. (2018), Pourahmad et al. (2018), Scoppa et al. (2018), Ozbil et al. (2015), Torun & Peponis (2012), Bahreini (2010), Saelens & Handy (2008), Leslie (2007) , Moini (2006), Krambeck & Shah (2006), Cerin et al. (2006), Southworth (2005), Frank et al. (2005), Saelens et al. (2003)
Street network configuration	Knapskog et al. (2019), Ozbil et al. (2015)
Density (residential building density, employment density, route density, population density, ratio of retail sales)	Frank et al. (2021), Torun & Peponis (2012) , Leslie (2007), Southworth (2005), Frank et al. (2005), Saelens et al. (2003)
Companionship (walking with another person, pet, number of acquaintances or relatives in a certain area)	Troy & Grove (2008)
Weather (preferred walking time, number of rainy days)	Frank et al. (2021), Saelens & Handy (2008)
Convenience and comfort (path cleanliness, variety of activities in a certain area, number of houses with openings facing the street, navigation signs, human scale, legibility and clarity of the path, characteristics of sidewalks, obstacles on the walking path, ambient noise, dirty air Continuity of sidewalks, sidewalk width, sidewalk asphalt coating, home access street width, how to maintain and protect the sidewalk, shade and cover against rain	Frank et al. (2021), Cambra & Moura (2020), Knapskog et al. (2019), Pourahmad et al. (2018), Shatu & Yigitcanlar (2018), Farrokhian & Ardalani (2017), Habibi & Haghi (2016), Akbarzadeh Moghadam Langroudi et al. (2016), Shieh et al. (2014), Shahivand & Ghalenoi (2013), Mohammadi & Kholousi (2012), Torun & Peponis (2012), Gehl (2011), Litman (2010), Krambeck & Shah (2006),

and bad weather, clear path, car parking facilities, parking price, store 24 hours in the area, the length of the walking path, covered sidewalks, the presence of suitable meeting spaces)	Cerin et al. (2006), Saelens & Handy (2008), Leslie et al. (2006), Southworth (2005)
Safety and security (personal safety, the number of visible signs of crime in the area, the number of reported crimes, inappropriate activities and uses, abandoned and unused spaces, the number of people in the area, the speed of vehicles, signals Noise reduction, the number of stray dogs, sufficient lighting in the streets, the percentage of the possibility of being caught in the environment, the visibility, obstacles and canopies that prevent proper visibility, the existence of escape routes, the level of sound security, citizen supervision, hierarchy Access, safety against vehicles, the presence of women and children in the environment (during the day and at night), the number of people with physical and mobility disabilities in the environment (during the day and at night)	Knapskog et al. (2019), Dennis Wei et al. (2019), Pourahmad et al. (2018), Moradpour et al. (2018), Shatu & Yigitcanlar (2018), Roostayi & Naseri (2018), Farrokhian & Ardalani (2017), Habibi & Haghi (2016), Shahivand & Ghalenoi (2013), Ariffin & Zachary (2013), Sapawi & Said (2012), Torun & Peponis (2012), Mohammadi & Kholousi (2012), Bahreini (2010), Saelens & Handy (2008), Foster & Giles (2008), Troy & Grove (2008), Brown et al. (2007), Krambeck & Shah (2006), Moini (2006), Southworth,(2005), Leslie et al. (2005), Frank et al (2005), Saelens et al. (2003)
Beauty and attractiveness (attractive and remarkable architecture, the presence of trees in the street, the presence of water fountains, sports spaces, diversity in the route, narrow and busy streets, green scenery on one side of the street, the presence of natural green spaces, squares, the density of parks, The complexity of the landscape, the transparency of the structures of the street body, the appropriateness of the form of the buildings)	Frank et al. (2021), Sapawi & Said (2012), Bahreini (2010), Saelens & Handy (2008), Moini (2006), Southworth (2005)
Facilities for pedestrians (the presence of sidewalks, the infrastructure for the disabled, the presence of a pedestrian crossing, the number of bus stops, local public parks, street lighting, the presence of food and beverage outlets, the number of waterways along the route, urban furniture, the quality of facilities in public parks)	Li et al. (2023), Frank et al. (2021), Knapskog et al. (2019), Habibi & Haghi (2016), Schlossberg et al. (2015), Shieh et al. (2014), Ariffin & Zachary (2013), Senevirathna & Morrall (2013), Shahivand & Ghalenoi (2013), Torun & Peponis (2012), Leslie et al. (2006)

The factors affected by the street networks' form include safety (against vehicle accidents), security (against crimes and harassment), accessibility, connectivity, comfort (from climate conditions and weather), the quality of the built environment, and attractiveness. In the following section, these factors are discussed from the perspective of traditional Iranian urban design.

1. Safety refers to pedestrian safety against vehicles and traffic, both in physical and psychological terms. The feeling of safety in an urban space is as important as being physically safe from drivers' movements. The complexity of a street network can affect driver speeds and behaviors, as well as pedestrian feelings and behaviors. Pedestrians require at least a 6-meter-wide street to pass safely alongside moving vehicles. Therefore, streets narrower than 6 meters pose safety risks. Traditional Iranian urban design principles, such as the continuity and connectivity of streets, interlinking, and hierarchy, influence safety and the feeling of safety in a network. Semi-public spaces within a network have fewer vehicles and are mostly used by neighbors, contributing to safety. Additionally, the presence of narrow and curved streets within an organic network can deter speeding. Finding directions can also be challenging for non-local drivers in an organic network.

2. Security has both psychological and physical meanings. Feeling secure and safe in an urban area against other users is essential. Physical security involves protection against dangers and crimes that pedestrians may face from other urban space users. Legible areas with fewer dark corners enhance security. The principle of space hierarchy in a street network limits the presence of strangers and enhances security. Local centers and semi-public spaces encourage people to interact, further increasing security. Knowing there are alternate routes in case of danger improves the feeling of security. Intersection density and the betweenness index indicate the number of route options. Visibility from other street users or buildings enhances security. Lighting, although not directly related to street network form, plays a role, particularly in modernized areas with increased building heights. Contrasting building heights and the presence of low-level buildings impact street area lighting. Local users with varying daily routines must also be considered for appropriate lighting.

3. Accessibility means the walkable network should be accessible to all users. Walking space width, path slope, and network access indicators are relevant to network form. Traditional Iranian urban design principles restrict accessibility to non-residents in semi-public and private spaces. Node count, including intersections and cul-de-sacs, measures accessibility. Node density accounts for different study area sizes. Walking space width in Tehran should exceed 6 meters for easy, safe urban street access. This indicator also affects pedestrian safety against vehicles. Topography can positively or negatively impact accessibility for specific user groups like the elderly or physically disabled.

4. Connectivity measures the degree of street connectivity within a network and connections to neighboring networks. The continuity and connectivity, contrasting, spatial unity and diversity, interlinking, stasis, dynamism, and combination of spaces principles improve street network connectivity. Physical and visual connectivity are two aspects of street network connectivity. Physical connectivity is assessed using beta and eta indexes, representing link-to-node ratios and average link lengths. Beta indicates higher walkability, offering more route options, while eta inversely relates to walkability. Visual connectivity relies on high buildings, landmarks, and the skyline for navigation. Topography affects visual connectivity.

5. Comfort is influenced by street network form. Comfort elements provide better walking conditions for pedestrians, including shade provided by street structures or trees. In Tehran's organic structure, streets often have roofs for shade. Several factors that provide comfort also enhance attractiveness. Human scale, nature consideration, spatial continuity, scale, proportion, spatial unity, diversity, contrasting, stasis, and dynamism principles impact street network comfort. Street orientation to the qibla (northeast/southwest) is optimal in Tehran for providing shade and wind protection. Climate comfort is studied in this research, considering urban elements, trees, narrow streets for shade and precipitation protection, topography, and street orientation.

6. Quality of the Built Environment encompasses all physical features used by pedestrians, such as sidewalks and obstacles within street spaces. Some factors are affected by street network form, including street dimensions, size, scale, street and block lengths, and intersection counts. These indicators reflect urban form and compactness, highlighting the investigated area's morphological characteristics. Walking distance or path length significantly influences pedestrian behavior. Pedestrians prefer the shortest route, so increasing walkability means aligning pedestrian paths closely with the shortest path and creating shortcuts. The sense of confinement during network walking is related to street height and width ratios, where higher ratios increase confinement.

7. Attractiveness is influenced by street network form, particularly in organic networks. Factors like views, nature integration, winding streets, perspective distance, shadow variety, and contrast in spaces contribute to attractiveness. Human scale, scale and proportion principles, static and dynamic streets, and empty and full urban spaces impact attractiveness. Tehran's organic network integrates old structures, nature, and contrasting spaces, contributing to attractiveness.

2.2.3. Methods and Tools for Assessing Walkability

Given the significance of walking and its impact on urban life, researchers have developed various methods for assessing and measuring both the subjective and objective aspects of walking on different scales. Evaluating walkability at the street or neighborhood level can provide valuable insights into the social impact of walking, as urban planning and design often occur on a macro scale, while the lived experience and events happen on a micro-scale (Gehl, 2010).

There is still no consensus on the most preferable and reliable walkability measurement tool (Dannenberg and Wendel, 2011). A review by Moudon and Lee in 2003 found that no single tool could comprehensively capture all dimensions of the environment related to walking and cycling. These tools each focus on specific characteristics of the environment, resulting in approximately 200 different variables considered across various research studies (Moudon and Lee, 2003).

Walkability assessment methods can be categorized into two main groups: quantitative and qualitative measurements. Quantitative measurements are typically used for metropolitan-scale studies and consider factors like population, building density, street length, block and street intersection density, land use diversity, and street network patterns. Qualitative factors, on the other hand, often pertain to the micro-scale, focusing on street-level or neighborhood-level elements, including street features, street quality, and other pedestrian-oriented aspects. Qualitative indicators encompass street quality, sidewalk continuity, street tree presence, building facades, accessibility, destination attractiveness, street aesthetics, security levels, dynamics, cleanliness, sense of place, and comfort. The micro-scale is crucial because details at this level are visible and impactful for pedestrians (Talen, 2002).

Various quantitative and qualitative methods and tools are employed in walkability assessment, including literature reviews (Day and Boarnet, 2006), direct observation and documentation, computer analysis using tools like GIS (Geographic Information System), Space Syntax, ALOS

(Accessibility Level of Service), SPACES (Space Syntax Automated Calculation of Environment Space), Remote Sensing, Spatial Web Technology, etc. (Koohsari, 2016; Lamiquiz and Lopez-Dominguez, 2015; Baran et al., 2008; Talavera-Garcia and Soria-Lara, 2015; Lwin and Murayama, 2011; Day et al., 2006; Roozkhosh et al., 2020; Bhattacharyya and Soumen, 2013; Kalantar and Shahabian, 2018; Pikora et al., 2002; Telega et al., 2021), interviews (Ewing and Handy, 2009), and questionnaires (Emery et al., 2003; Saelens et al., 2003). The following table provides a summary of the methods and measurement tools used in literature reviews, categorized based on factors for assessing walkability related to the physical characteristics of street networks.

Table 2.3. Factors affecting walkability and the evaluation methods based on literature review

Walkability factor	Method	Type	References
Safety and security	Observation, statistical data, interview, questionnaire	Qualitative	Knapskog et al. (2019), Dennis Wei et al. (2019), Shatu & Yigitcanlar (2018), Moradpour et al. (2018), Roostayi & Naseri (2018), Pourahmad et al. (2018), Farrokhian & Ardalani (2017), Habibi & Haghi (2016), Ariffin & Zachary (2013), Shahivand & Ghalenoi (2013), Torun & Peponis (2012), Sapawi & Said (2012), Mohammadi & Kholousi (2012), Bahreini (2010), Saelens & Handy (2008), Foster & Giles (2008), Troy & Grove (2008), Brown et al. (2007), Krambeck & Shah (2006), Moini (2006), Southworth,(2005), Leslie et al. (2005), Frank et al (2005), Saelens et al. (2003)
Connectivity[3]	Software (often GIS), statistical data	Quantitative	Frank et al. (2021), Cambra & Moura (2020), Knapskog et al. (2019), Moradpour et al. (2018), Pourahmad et al. (2018), Scoppa et al. (2018), Ozbil et al. (2015), Torun & Peponis (2012), Bahreini (2010), Saelens & Handy (2008), Leslie (2007), Krambeck & Shah (2006), Cerin et al. (2006), Moini (2006), Southworth (2005), Frank et al. (2005), Saelens et al. (2003)
Quality of the built environment (Street network)	Observation, software, interview, questionnaire	Quantitative /Qualitative	Knapskog et al. (2019), Ozbil et al. (2015)
Comfort	Observation, interview, questionnaire	Qualitative	Frank et al. (2021), Cambra & Moura (2020), Knapskog et al. (2019), Pourahmad et al. (2018), Shatu & Yigitcanlar (2018), Farrokhian & Ardalani (2017), Akbarzadeh Moghadam Langroudi et al. (2016), Habibi & Haghi (2016), Shieh et al. (2014), Shahivand & Ghalenoi (2013), Mohammadi & Kholousi (2012), Torun & Peponis (2012), Gehl (2011), Litman (2010), Saelens & Handy (2008), Krambeck & Shah (2006), Cerin et al. (2006), Southworth (2005), Leslie et al. (2006)
Attractiveness	Observation, interview, questionnaire	Qualitative	Frank et al. (2021), Sapawi & Said (2012), Bahreini (2010), Saelens and Handy (2008), Moini (2006), Southworth (2005)

[3] intersection density, street density, block density, cul-de-sac density, average block length, median block length, connected node ratio, link node ratio, alpha index and gamma index.

3. Tehran Organic Street Networks

To address the research objectives, this chapter delves into walkability across different scales, encompassing the walkable city, neighborhood, street network, and individual streets. The specific focus lies on the streets and street networks within Tehran. As the configuration of a street network is intricately shaped by a city's topography and historical development, we begin with a concise exploration of Tehran's geographical context, tracing the city's origins and the historical evolution of its street network. This contextual background serves as a foundation for introducing the typology of street networks in various neighborhoods of Tehran. It is essential to clarify that the street network under consideration in this research pertains exclusively to the structure of neighborhood street networks, excluding highways, freeways, and ring roads. This distinction is drawn because the primary emphasis of this study is on investigating walkability, a concept that is not directly applicable to vehicle-dominated spaces such as highways.

3.1. Geographical Context of Tehran

Tehran, the capital of Iran, is geographically situated between 51 degrees, 17 minutes to 51 degrees, 33 minutes east longitude and 35 degrees, 36 minutes to 35 degrees, 44 minutes north latitude. The city is nestled between the southern slopes of the Alborz mountain range and the flat plains of Shahriar and Varamin in the south and southwest. The location of Tehran can be categorized into three primary regions from north to south.

The first region encompasses the northern heights of the city in Shemiran, forming the city's northern boundary. From this area, one can enjoy panoramic views of the entire city of Tehran.

The second region includes the slopes of Mount Alborz, featuring foothill elevations. Within this region, you'll encounter various elevated areas such as Darakeh, Hesarak, Sohanak, Saadat Abad, Dezashib, Lavizan, Mahmoudieh, Qeytariyeh, Elahiyeh, Amaniyeh, Tarasht heights, Abbas Abad, Yousefabad, Amir Abad hills, and their surrounding neighborhoods, including Evin, Tajrish, Niavaran, and Dawoudiyeh. These two regions of Tehran, characterized by their diverse geographical and natural attributes, have significantly benefited from the organic street network, which has adapted over time to harmonize with the environment. This intricate network allows users to navigate through lowlands, highlands, and elevated areas, taking the most direct routes.

Due to the intricate nature of this system, developed through environmental adaptation, making substantial alterations proves to be incredibly challenging, if not impossible. As a result, many parts of these areas have preserved their organic character.

The third region corresponds to the central city of Tehran (Hamidi, 2000).

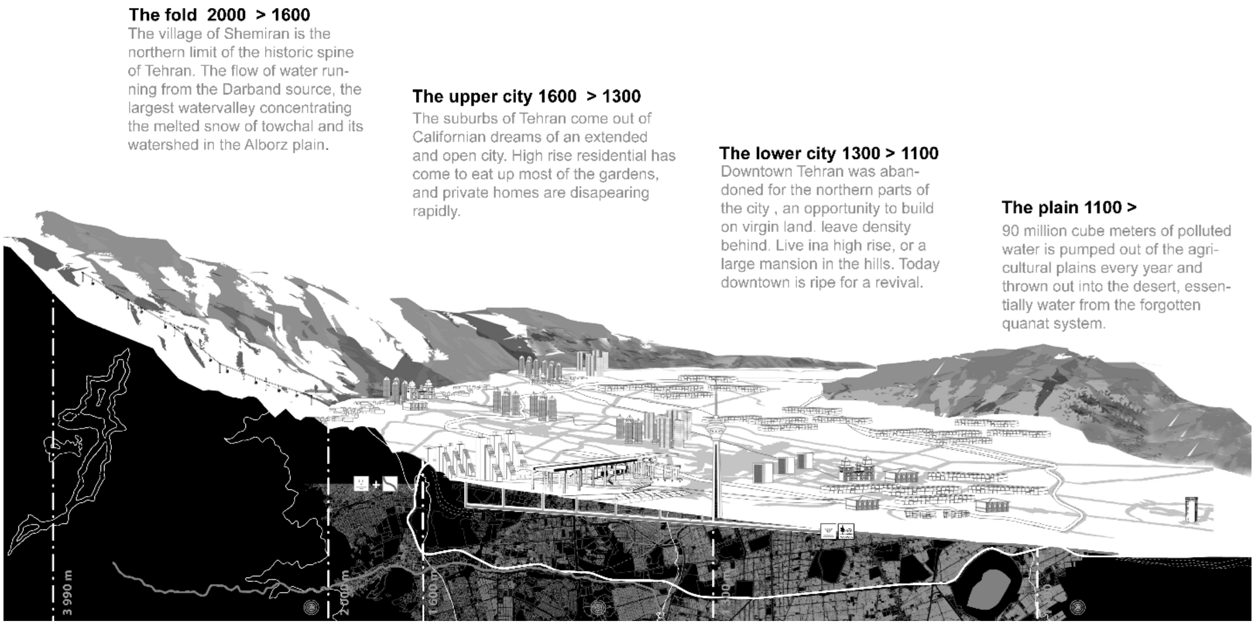


Figure 3.1. Schematic topography and the underground water in Tehran (Hydrocity, 2012)

3.2. The Emergence of Tehran and the Expansion of Street Networks

The city of Ray, situated to the south of Tehran, held significant importance in Iran until the Safavid era (Shiraziyan, 2012). As the city's importance waned and considering the favorable climate of the Tehran region, which was then a village with an organic rural street network, as well as its religious significance due to the presence of Imamzadeh Yahya, Sayed Ismail, Imamzadeh Zeyd, Imamzadeh Saleh, and Shah Abdulazim, the Safavid kings' attention shifted to this area (Hamidi, 2000).

In the year 1553 A.D., Shah Tahmasb initiated the construction of the Safavid fortifications around Tehran, which featured 114 towers (symbolic of the number of surahs in the Quran) and four gates. These gates were strategically located on the main streets linking the city to neighboring towns. The central core of the city was the bazaar, which, along with the Jame Mosque and the Royal Citadel, constituted the city's three essential components. The city was comprised of these key elements and four neighborhoods. Over time, the movement of people between these spaces defined pathways that gradually evolved into organic street networks. During this period, the city's fortifications were designed with straight lines, which often aligned with the natural topography of the surrounding areas. However, the remaining streets developed organically, a characteristic that can still be observed to varying degrees in present-day Tehran, particularly in the areas around the Tehran Grand Bazaar.

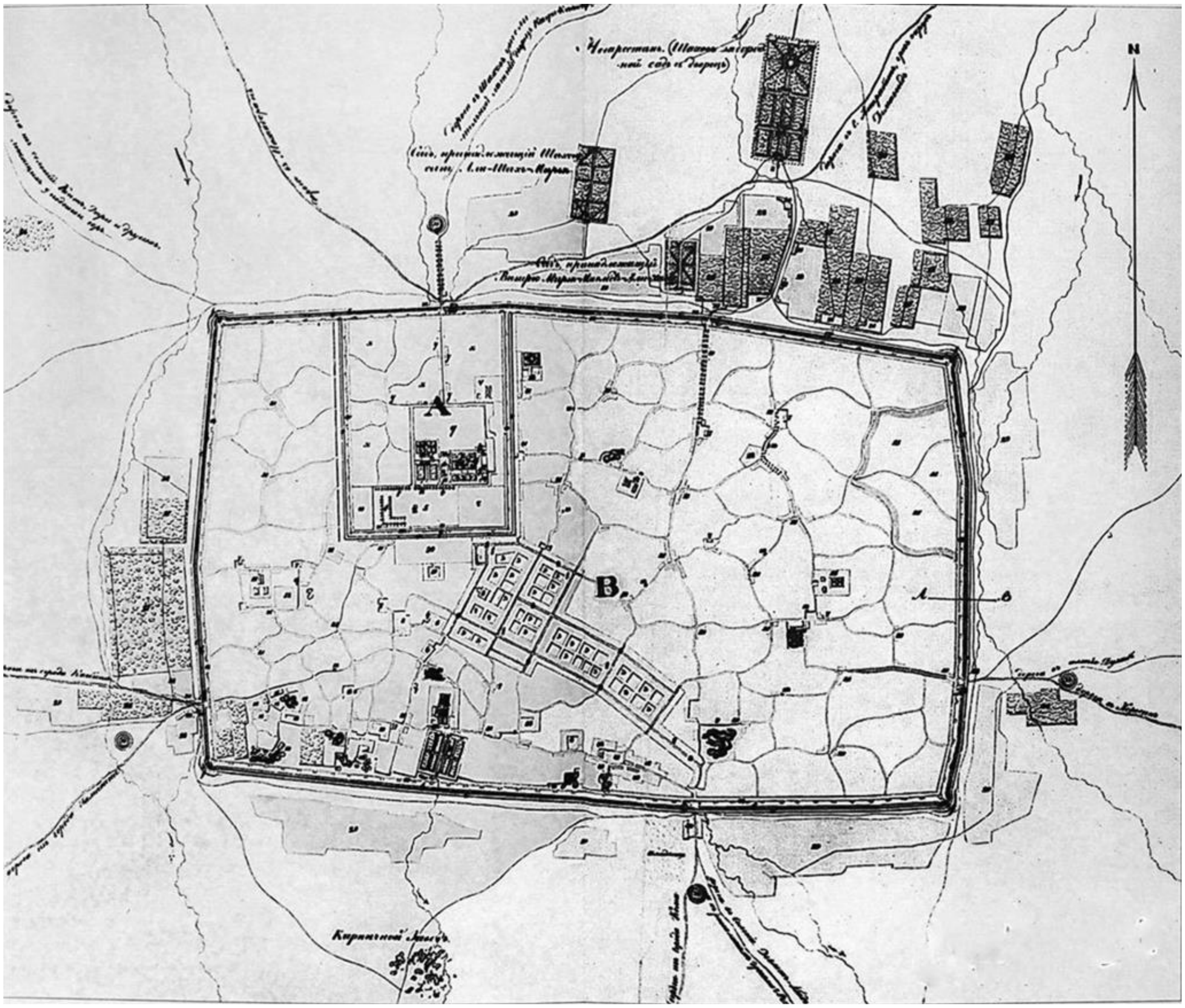


Figure 3.2. The first map of Tehran is known as the Nazkov map. Tahmasbi fence and four gates of Tehran are marked on this map. A Russian group under the supervision of Nazkov drew this map in 1826 (Shiraziyan, 2012)

During the Safavid period (1501-1736 A.D.), the primary urban structure of the city was linear, consisting of the mosque and the government citadel. The presence of two pivotal gateways, Shah Abdolazim Gate and Qazvin Gate, contributed to this linear layout, which in turn influenced the street network pattern. The city's access points exhibited a hierarchical organization, with the central axis of the city aligning with the location of essential elements. This linear arrangement persisted even as the street network itself displayed an organic character.

Subsequently, during the Afsharid and Zand dynasties (1736–1747 and 1751–1779 A.D.), Tehran underwent expansion and development, following the Isfahanid style rooted in Islamic beliefs. Some scholars argue that after the adoption of Islam, the street networks in Iranian cities shifted more towards organic patterns due to the influence of the new religious beliefs, emphasizing respect for nature and a human-centered approach. This marked a departure from the grid-like street networks that were common in various regions during the Achaemenid and Sassanid periods, as evidenced by historical records (Labibzadeh and Hamzenejad, 2018).

Consequently, Tehran's street network acquired an irregular and organic configuration, characterized by numerous three-way intersections, and this pattern persisted until the Qajar era. During the Qajar period, a grid layout was introduced for the main thoroughfares, facilitating direct access to the city center and its key elements from any part of the city via straight streets. Meanwhile, the side streets retained their organic character (Hamidi, 2000).

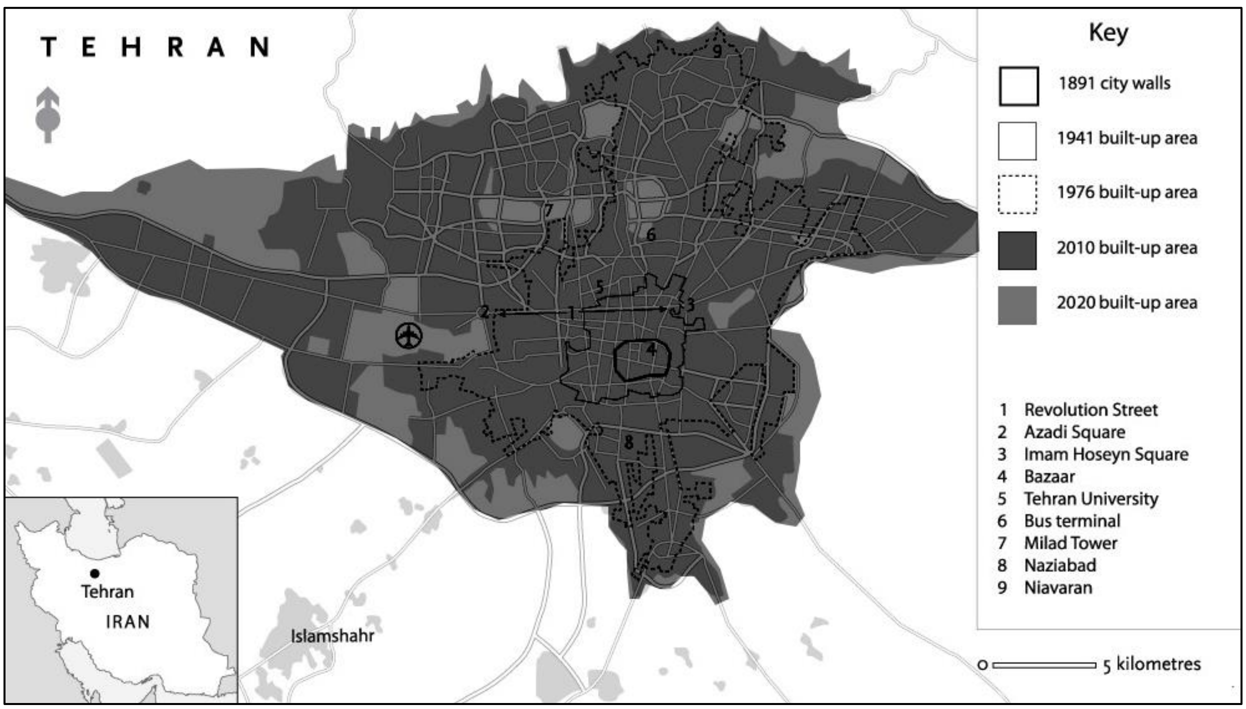


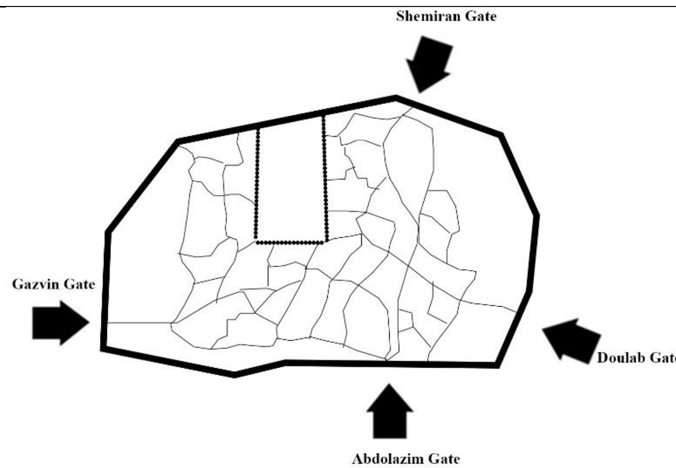
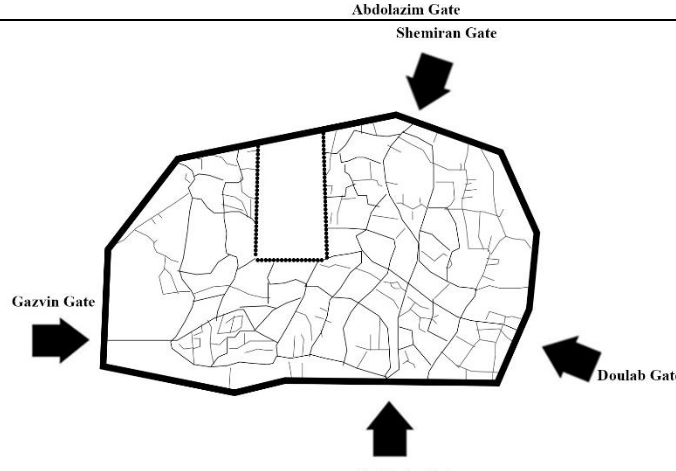
Figure 3.3. Tehran development from 1848 until 2020 (map source: Bayat, 2010 modified by author)

During the 1st and 2nd Pahlavi periods (1925-1979 A.D.), these streets were paved in emulation of European cities. While this development accelerated access to different parts of the city, it resulted in the destruction of the old urban fabric in many areas. Additionally, during this period, the automobile emerged as a significant mode of transportation, prompting a redesign of the streets to accommodate and expedite vehicular traffic. This transformation had a profound impact on the historic street network, necessitating the widening of commuter routes to establish direct and faster connections to Tehran's key elements. Tehran, now a multi-centered city, adapted to these changes.

In the same era, the city's defensive walls were dismantled in 1930 A.D., and its main streets were aligned with the former wall's axis. Existing streets were extended, and new ones were constructed. This period witnessed continued urban development with the establishment of neighborhoods like Tehranpars, Narmak, Tehran Vila, Shahrara, Gisha, Ekbatan, Lavizan, and Shoush. Notable roadways such as Parkway, Shahneshahi (now Shahid Modares Highway), Afsariyeh, Ayubi, and many others, along with residential areas, emerged during this era.

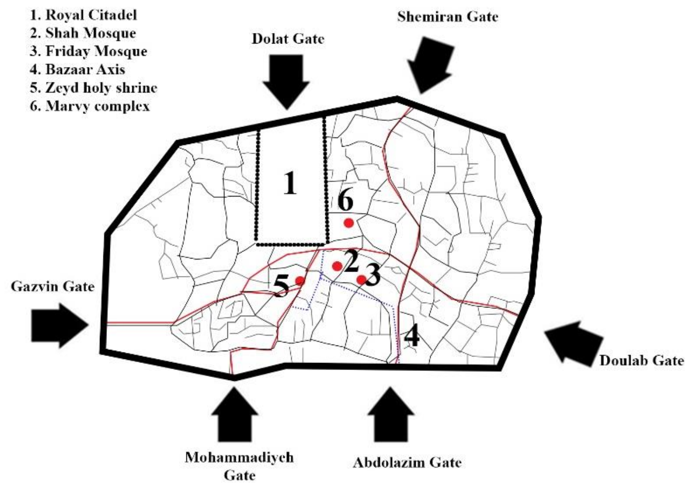
Following the Islamic revolution, a period marked by the Iran-Iraq war led to a hiatus in Tehran's development for nearly a decade. However, post-war, the city resumed its expansion, with new streets and green spaces being added (Saeednia, 1991). The table below illustrates the changes and developments in Tehran's street networks throughout its history.

Table 3.1. Urban development process in Tehran structure (Author, 2021)

Era	Description	Map
Before 1537	A Safavid village in the north of Ray with organic rural streets, without towers and ramparts (Shahri, 1978)	
1524-1576 The reign of Shah Tahmasb	The construction of the tower, rampart, and gate in 1554 (Habibi, 2007)	
1786 Choosing Tehran as the capital of Iran by Agha Mohammad Khan Qajar	The beginning of the modern decision-making process in urban planning (Habibi, 2007)	

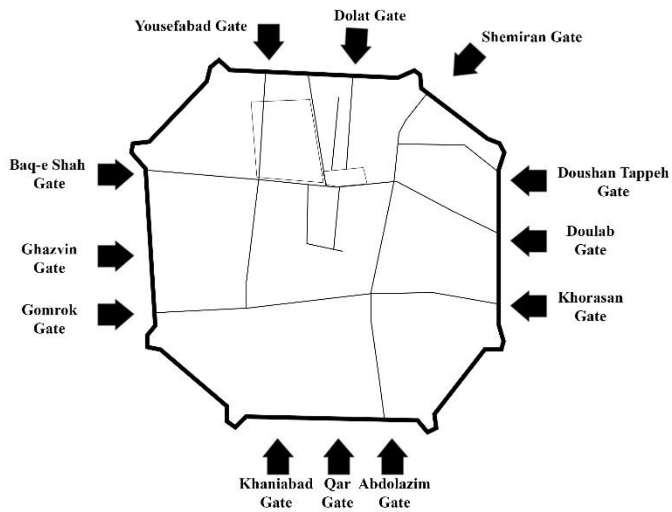
1797-1843
During the reign of Fath Ali Shah

Changing the landscape of Tehran by constructing religious and government buildings; The beginning of modernity (Behzadfar, 2011)



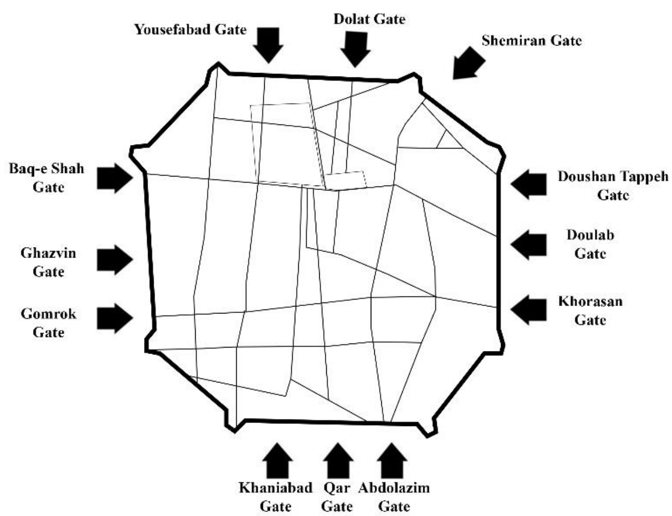
1848-1896
Nasserite Government

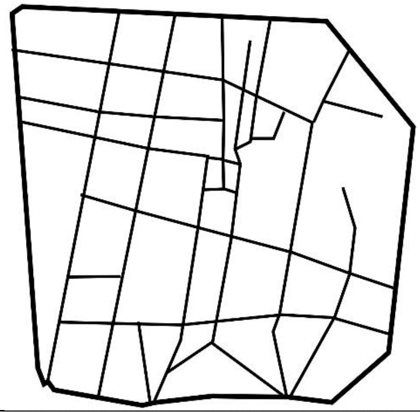
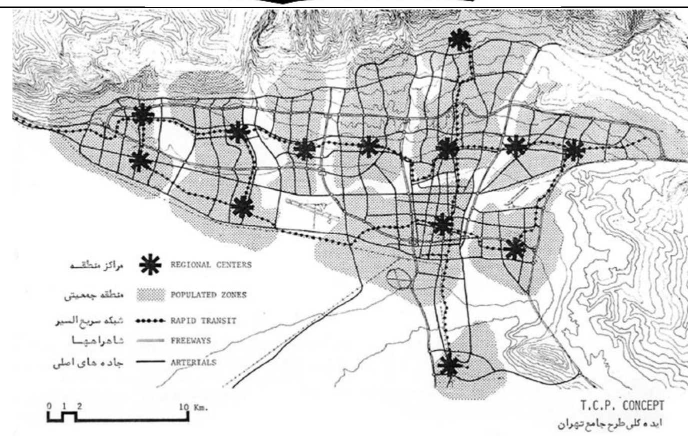
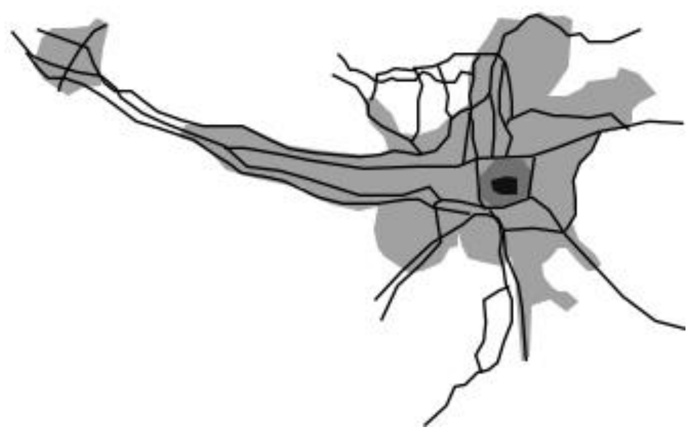
Preparing a new plan for Tehran; The acceleration of urban modernity (Behzadfar, 2011)



1921-1941
The reign of Reza Shah Pahlavi

Law on the construction and development of streets in 1930, 1933, and 1939; Preparation of the street map for Tehran to build new streets in Tehran in 1930; Construction of sidewalks (Shabani and Kamyab, 2012)



	The demolition of the old Naserid Fortification began in 1932; Building a boulevard instead of the walls (Habibi, 1989); A new plan for Tehran in 1937 under the supervision of foreign consultants; The influence of international modernity movement; Grid texture; Separation of urban functions (Habibi, 1989)	
1941-1978	development of the city formation of slums and shantytowns around Tehran land reforms in 1963 (Abadian, 2018); Master plan of 1968 by Farmanfarmaian and Victor Gruen; The linear extension of Tehran to the west; Introducing the concept of neighborhood in Pikan Shahr and Ekbatan (Jafari and Hein, 2020)	
The era after the Islamic revolution (since 1979)	facilitating the allocation of land and housing subsidies in Tehran; Canceling the regulations related to the 25-year boundary limit approved in 1968; unprecedented growth and development of Tehran of and outside the boundary (Habibi, 2007); Finding worn-out textures after the Iran-Iraq war; The activities of Tehran's reconstruction organization in 1994 (Habibi, 2007); The establishment of district 22 municipality in 1997 (Behzadfar, 2011)	

3.3. Political Divisions of Tehran

In 1968, Tehran's inaugural master plan marked a pivotal moment in the city's development, as it underwent a significant expansion, extending its boundaries to encompass an area of 181 square kilometers. Concurrently, Tehran was subdivided into twelve distinct regions. However, following the Islamic revolution, the city's administrative divisions transformed, resulting in an increase in the number of regions to a total of 22. Presently, Tehran sprawls across an expansive area of 730 square kilometers, encompassing not only these 22 regions but also 134 municipalities, which include Ray and Tajrish. In total, there are 353 neighborhoods within the city. This extensive growth has propelled Tehran to become the 25th most populous city globally and the 27th largest in terms of land area (Tehran Municipality website, 2021).

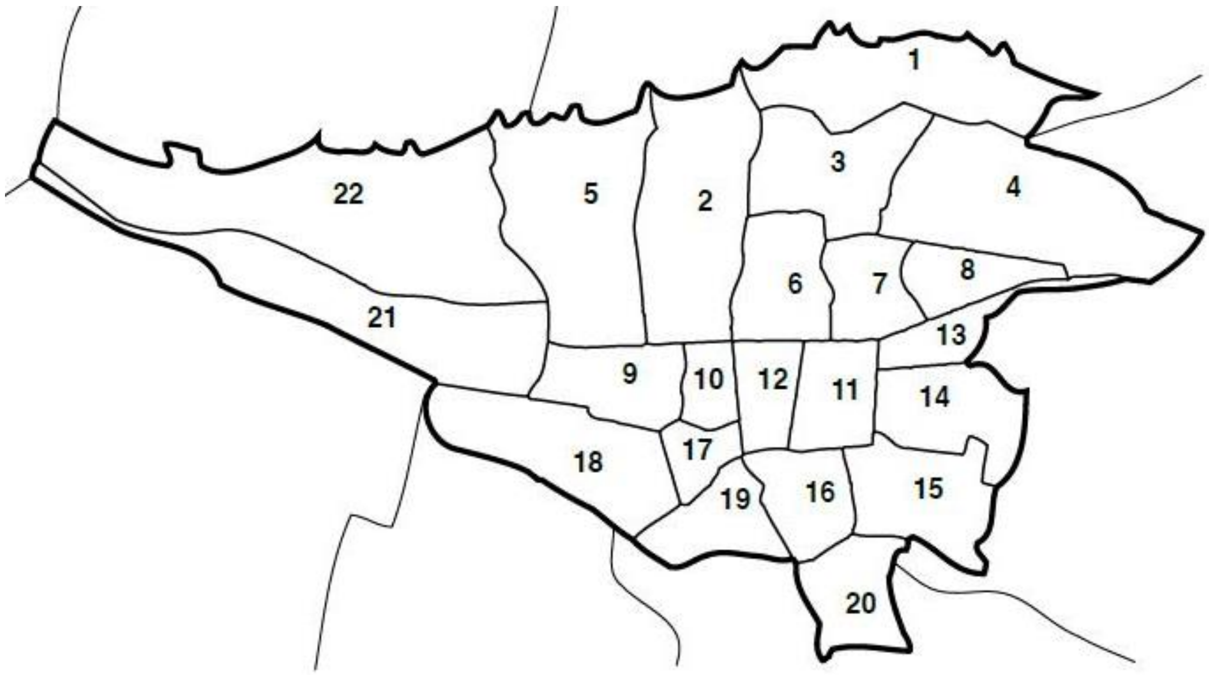


Figure 3.4. Different districts based on the location on the map of Tehran (Tehran Municipality website, 2021)

Each district possesses its unique characteristics. Many current regions, particularly in the north and west, were originally rural or industrial areas. During the capital's expansion, these areas served as housing for immigrants, gradually transforming their structures. The remnants of their rural and industrial features can still be observed. Each district comprises several neighborhoods (Mahale). It is worth noting that the political boundaries and the number of neighborhoods (districts) and municipalities are subject to constant change.

Table 3.2. Tehran 22-region area, population, and main features regarding their structure (Tehran Municipality website, 2021)

District	Area (m^2)	Population	Info
1	46,612,194	493,889	- Contains many organic street networks due to the location and geographical features - Contains old villages and gardens north of the city - Rural streets have been paved and asphalted causing a quasi-rural texture. - Organic texture in combination with modern buildings
2	47,005,370	692,579	- Contains Alborz mountain and water canals
3	29,216,831	330,004	- Dance is in terms of construction and street layout - The organic street network to a large extent
4	61,554,522	917,261	- Contains dams and a forest park - Extensive industrial areas in the east - The old texture contains an organic street network
5	53,161,331	856,565	- Cold and mountainous climate due to its location in the foothills - Construction during the last three decades

			- New buildings and apartments and relatively regular street networks
6	21,367,428	250,753	- The urban texture of the area is mostly newly built in recent decades and the grid system
7	15,335,212	312,002	- The urban texture of the area is newly built, but with poor quality and contains many grid street networks
8	13,156,442	425,044	- Old texture with narrow streets and alleys and a small number of green spaces - Many mixed street networks
9	19,746,502	174,115	- Old and worn-out texture - Contains tehran symbol, azadi tower, the existence of mehrabad international airport, tehran's west terminal - Mixed and grid street networks
10	8,185,467	326,885	- Dating back to 1925 - Dense urban structure and texture, high population density, and lack of proper green spaces
11	12,031,459	308,176	- Contains many political and military centers and embassies - Grid and organic street networks
12	16,007,106	240,909	- Old district of Tehran; known as "Tehran's historic texture" - Contains Tehran Grand Bazaar - A large part contains organic street networks
13	12,862,735	253,054	- Old and worn out - Lack of green spaces
14	14,552,708	489,101	- Old urban context
15	27,740,625	659,468	- Grid street networks
16	16,515,696	267,678	- Old and worn-out texture - Contains tehran railway station and the south terminal
17	8,251,825	278,354	- Worn-out texture - Contains many qantas
18	37,869,105	419,24 9	- Established in 1980; developed with the increasing number of immigration - The old part contains a rural organic street network - Contains workshops and factories and kan river
19	20,341,427	255,533	- New with a grid structure and street network
20	23,580,300	367,600	- Shahr-e Rey (Ray city); one of the oldest civilizations in Iran - Many historical monuments - Organic street network - Contains Shah Abdulazim
21	51,525,318	186,319	- Built-in 1960-1970 - Residential and industrial contexts - Grid, mixed, and organic street networks
22	59,003,253	175,398	- Newly built area, dating back to the last three decades - Aim to become a tourist hub of the city

3.4. Urban Street Design, Classification, and Historical Significance

Urban streets prioritize social roles and accessibility in their design, giving pedestrians, cyclists, and public transportation users priority. Different components of a street include pedestrian crossings, pavements, alleys (with a maximum width of 12 meters), main streets (with a minimum width of 12 meters), cul-de-sacs, and roundabouts (Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020a).

Examining the concept of streets in Iranian literature reveals that streets served more than just a means of passage and had multiple functions. In a comprehensive research study, Atashinbar and

Motadaen (2018) explored historical sources and documents to understand the meaning and concept of streets. They argue that the purpose of streets in Iran has declined since the end of the Qajar era. Consequently, contemporary streets have adopted their purpose from Western urban planning, deviating from the original Iranian meaning. The central concept of streets in Iran carries a religious context tied to water, gardens and the beliefs of Iranians. Therefore, streets should not be transformed into mere passageways (Atashinbar and Motedaen, 2018).

According to the regulations approved by the Ministry of Housing and Urban Development, urban streets are categorized into three groups: first-grade arterial streets, second-grade arterial streets, and local streets (main and secondary), including cul-de-sacs. First-grade arterial streets prioritize the movement of motor vehicles in their design and operation. Access control is a fundamental geometric characteristic of these streets, with no consideration for social roles. Therefore, pedestrians and cyclists should only cross these streets at designated points. These streets primarily serve extra-urban functions and are classified as freeways, highways, and through streets. Freeways are streets where cross traffic is separated, allowing for fast traffic flow except during accidents and traffic jams. Intersections on freeways are all uneven, and entry and exit are strictly controlled. Highways, similar to freeways, have physically separated traffic flow on both sides, ensuring continuous traffic flow for significant distances. Some highways may have level crossings with a minimum distance of 2.5 kilometers (Shahali and Sanaei, 2010). Second-grade arterial streets also prioritize the quick movement and access of motor vehicles. Pedestrian movement across these streets is controlled to maintain this priority. Second-grade arterial streets form the main urban street networks (High Council of Urban Planning and Architecture of Iran, 1991).

Local streets are further divided into primary and secondary categories, serving as access routes. Main local streets have a maximum speed limit of 30 kilometers per hour. Access routes should also retain their social function, allowing pedestrians to cross the street freely. These access routes constitute the final classification of the communication network and provide access to residential units and complexes (Arani et al., 2022). The focus of this study primarily centers on local streets.

Historical streets are typically found in city centers and hold significant value. These streets are often narrow and curved, limiting vehicle access. The presence of historically significant buildings is another characteristic of these streets. Preserving the elements of historical streets and preventing the destruction of their valuable texture is crucial. If rules related to local and arterial streets threaten the historical streets' integrity, they should not be applied. In such cases, the rules and regulations of the Ministry of Cultural Heritage, Tourism, and Handicrafts should guide actions. Designing streets of historical structures should adhere to the regulations for protecting historical structures, including considerations such as preventing vehicle traffic from entering historical contexts, revitalizing bazaars, traditional crossings, historical and cultural axes, maintaining existing proportions in terms of movement and accessibility, organizing communication routes based on pedestrian priority, preserving the interconnected structure of historical contexts by avoiding unnecessary streets, and using materials that align with historical authenticity in street surfaces and structures. Restricting vehicular traffic, limiting loading and unloading activities, and creating pedestrian-friendly environments contribute to improving the livability of urban environments. Historic streets with limited width often incorporate shared spaces, where the priority of travel methods shifts from motorized vehicles to walking, cycling, and crossing the street becomes entirely free (Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020a). Shared spaces typically lack pavement markings, traffic lights, signs, and obstacles, making drivers more cautious. It is advisable to avoid altering the physical characteristics of historical streets, such as their width. Criteria for arterial, collecting, and local streets, such as minimum street width, cannot be generalized to historical streets. Additionally, if a valuable building exists at the corner of an intersection in a historic street, considerations related to sight triangles that may alter the building should not be applied (Monazzam et al., 2021).

3.5. Tehran's Historic, Middle, New, and Worn-Out Textures

The texture of a city refers to the arrangement and interconnection of its spaces and elements, which are influenced by natural factors such as topography and climate of the city limits. These spaces include urban blocks and neighborhoods, which can have different degrees of compactness and organization (Tavassoli, 2000).

Understanding the type of texture and quantitatively measuring the filled and empty surfaces, exploring the quality of mass and space contiguity, and identifying the shape-spatial system is necessary to assess the regularity of filled and empty spaces. Different layers of urban texture can be distinguished based on the stages of growth and spatial and physical development of cities. In large cities in Iran, there are seven types of urban textures: historical texture or the primary core of the city, old texture, middle texture, new texture, peripheral texture, satellite texture or textures with discontinuous expansion, and textures formed with the expansion of the metropolis along with the creation of new cities (Mashhadizadeh Dehaghani, 1994).

In Tehran, six textures have been identified: old, historical, middle, relatively new urban texture, modernized texture in the western and northern outskirts of the city, and the worn-out texture of the city, which has adapted to a fine-grained, impenetrable, and resistant texture (Habibi and Houcadi, 2005). However, for this research on the urban street network, rural contexts integrated into the city or those that significantly differ have been excluded from the study. The division of textures in this research focuses on four types: old (including historical), middle, new, and worn-out.

The **old texture** encompasses the Naserid Tehran, including the Tahmasbid region. It holds the historic core of Tehran, consisting of valuable buildings that define the city's identity, such as Sanglaj, Bazaar, Oudlajan, Imamzadeh Yahya, and Chale Meydan. The connecting streets built in this area currently play a significant role in the spatial organization of Tehran. The central core of this area features an organic street network (Farhadikhah and Ziari, 2021).

The **middle texture** serves as a transitional zone between the new developments of Tehran and the old historic core of the city, particularly in the last half-century. Residential, service, cultural-recreational, and health contexts have contributed to the development of new spaces in Tehran over the following decades. Examples of this development include northern neighborhoods such as Yousefabad, Amirabad, Gisha, Sattarkhan, Narmak, and Imam Hossein. This expansion differs significantly from the old texture in terms of appearance, landscape, construction pattern, and resident groups. The regular and relatively wide grid pattern, different construction materials, and a varying number of floors are notable characteristics. Although the development of the last few decades has shifted the area's function more towards services and public functions, most of the city's service elements are still located in this middle texture area (Ahmadifard et al., 2022).

The **new texture** encompasses the entire city, but the areas in the northwest, east, southwest, and southeast of Tehran are particularly characterized by ongoing construction. Building permits issued between 2006 and 2010 indicate a significant amount of construction in regions 2, 4, 5, 8, 14, 15, and 18 compared to other areas of the city (Farhadikhah and Ziari, 2021).

Overall, there is a comprehensive mixing of urban textures in the majority of Tehran, making it difficult to categorize specific districts as purely old, middle, or new. District one serves as a clear example, housing a mixture of organic textures inherited from gardens and villages, as well as newly constructed residential textures. The predominance of the organic urban texture is most prominent in areas surrounding the north axis of Qods-Tajrish, Maqsoudbeik, and Elahiyeh in the south and the axis of Niavaran and surrounding neighborhoods in the east. The development of modern residential complexes, particularly next to the long-standing garden-residential booths of foreign delegations scattered across this district, is a prominent feature.

The **worn-out texture** is characterized by social, economic, and cultural issues and complications. These neighborhoods exhibit valuable residential roots with cultural, social, and architectural richness but suffer from extreme wear and tear, inadequate access to urban and health services, social and security problems, and vulnerability to natural disasters. They also face challenges adapting to contemporary urban life and development due to structural and infrastructural problems. The classification of worn-out textures includes three categories: textures with cultural heritage, urban textures lacking cultural heritage, and marginal textures representing informal settlements. Worn-out textures are further classified into three categories: textures with cultural heritage, urban textures lacking cultural heritage, and marginal textures (informal settlements).

Interventions in these textures are classified into three groups based on the level of historical, social, and cultural values: improvement, renovation, and reconstruction (Cheshmi et al., 2020).

The worn-out texture is determined by three conditions: instability (50% of buildings in the block are unstable), impermeability (at least 50% of the block's streets are less than 6 meters wide), and smallness (at least 50% of the buildings in the block have an area of less than 200 square meters). It is worth mentioning that the width of streets alone should not be the sole criterion for considering a texture as worn-out. Instead, the structural and communication characteristics of the streets should be considered (Abbaszadegan et al., 2011). However, some researchers consider urban textures with an organic street network, characterized by low width and permeability, as worn-out textures based on specific indicators (Sorour, 2018). Accordingly, widening streets has been chosen as a solution to address this problem. Critiques of this approach highlight several points. Firstly, accessibility and mobility factors in urban streets can differ, meaning that a wide street may have high mobility but be inaccessible. In contrast, a narrow street can be accessible and busy (Rismanchian and Bell, 2010). Secondly, studies on worn-out structures indicate that the issue is not solely related to street occupancy levels, as the percentage of street occupation in these structures tends to be higher than the average of other streets. The main problem lies in the inappropriate distribution of streets throughout the texture, resulting in the formation of numerous inefficient streets (Andalib, 2006).

In summary, the study of urban textures in Tehran reveals various types, such as old, middle, new, and worn-out. Each texture has distinct characteristics regarding architecture, development, and social function. The inclusion of worn-out textures, often associated with an organic street network, highlights the need to critically examine solutions like widening streets to address their unique challenges.

3.6. Street Network Components and Functionality in Urban Contexts

In the approvals and urban bylaws of Iran and Tehran, a specific definition of the street network is not provided. Shahali and Sanaei conceptualized the street network by comparing it to the human body system, where the veins represent the street network connecting different parts of the city to the center, similar to how veins and capillaries connect body parts to the center of the body. "The street network forms the main structure of the city, and the movement of people and goods of this system can be likened to the flow of white and red blood cells in the veins. The realization of various city functions and movement depends on the street network" (Shahali and Sanaei, 2010).

A street network consists of various components depending on the research theme. From a graph perspective, it comprises nodes and lines. As an urban element, it includes paths such as streets, alleys, rivers, cul-de-sacs, nodes or intersections (Pakzad, 2005), edges, districts, and landmarks (Lynch, 1960). Vehicles play a significant role in the street network, encompassing various types of transportation, such as private vehicles, public transportation, bicycles, and motorcycles. Stations and terminals are transfer points where people and goods are exchanged between different areas (Shahali and Sanaei, 2010). Additionally, a control system manages and regulates the street network, ensuring the optimal movement of vehicles and people. This system includes rules and regulations to facilitate efficient transportation (Mahmoudi Pati, 2006).

3.7. Typology of Street Networks

There are various typologies of street networks (Marshall, 2005), each developed for specific research purposes. Some are geographically specific, while others are more general. This research aims to identify an appropriate typology for Tehran's street networks by studying available typologies from international and national resources. These references include Marshall (2005), Southworth and Ben Joseph (2003), the Organization of Municipalities and Villages of Iran (2010), the Deputy Ministry of Transportation, the Ministry of Road and Urban Development (2020), and Gharib (2007). These choices were made due to these categories' comprehensive nature and frequent citations in Iranian studies.

Marshall (2005) provides a macro-level classification of street network types, including linear, tributary, radial, and grid networks, which cover a significant portion of existing street networks. Additionally, Marshall offers the ABCD typology: Type A represents a city's central core with an organic pattern that aligns with the research objectives. Type B symbolizes planned additions to the city with a grid form, similar to the combination of organic and grid street networks in this research. Type C represents suburban areas with radial streets, which can be associated with organic networks connected to grid or tributary and radial street networks. Type D exhibits "modern hierarchical" patterns, resembling a designed organic street network.

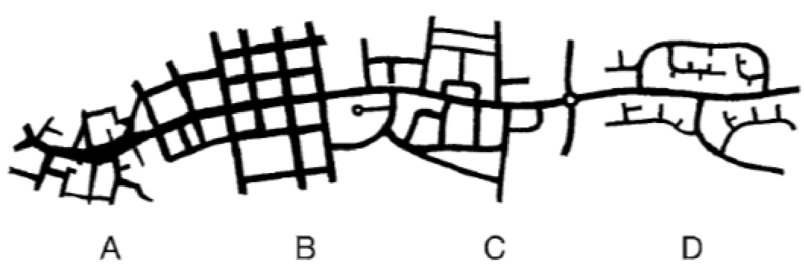


Figure 3.5. The typology presented by Marshall (Marshall, 2005)

Southworth and Ben-Joseph (2003) classify street network patterns into five general categories: lattice pattern, fragmented parallelism, complex parallelism, loops and lollipops, and lollipops on a stick (Southworth and Ben-Joseph, 2003). Examination of this street network reveals grid streets, various types of organic and grid street networks, and their combinations with other networks.

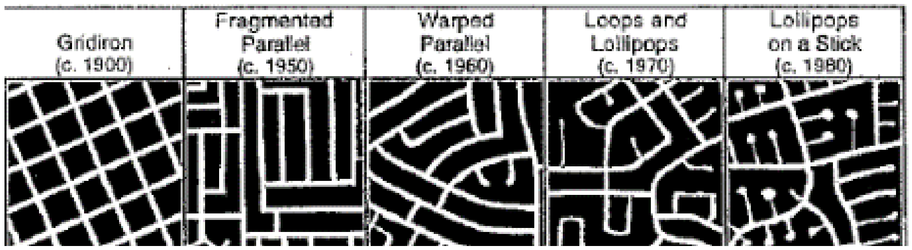


Figure 3.6. The typology presented by Southworth and Ben-Joseph (Southworth and Ben-Joseph, 2003)

Limited Iranian sources have categorized street networks in Iran, so foreign authorities' categories have been summarized. The study sources do not include a street network specific to Iranian-Islamic urban planning. For example, the geometric design of urban streets approved by the Organization of Municipalities and Villages of the Ministry of Interior of Iran (2010) introduces three types of street networks: radial, grid, and ring systems. The radial system branches off from a central core, while the grid system includes numerous nodes or intersections that disrupt the density and balance of the system. The ring system is formed to decentralize radial networks by adding wide and circular streets (Urban and Rural Management Research Institute, Organization of Municipalities and Rural Districts of Iran, 2010).

On the other hand, the Urban Street Design Regulations (2020) introduce only two models of the street network: "connected" and "tree," with other systems considered subsets of these two networks. In the tree model, streets are separated from a central trunk, usually a highway, forming branches. Main branches connect to the trunk as arterial streets, while smaller branches connect to the larger ones, leading to streets and local connections. The tree model's disadvantage is longer trips compared to a connected network, and it concentrates all trips at one point. Public transportation systems struggle in the tree model due to the disembarkation point being distant from destinations, hindering the definition of direct and efficient lines. Intersections in this model are classified as cross, non-level, lighted, uncontrolled, streamed, and local streets, often with cul-de-sacs. The tree model promotes speed but increases congestion and decreases movement rates. In the connected pattern, there are more and shorter routes to reach destinations of the street network compared to the tree pattern. The streets in this model are not classified similarly to the tree model and do not significantly differ in performance and physical characteristics. Intersections in the connected pattern are usually designed on the same level in urban areas, allowing all movements. Correlated patterns for the street network can have different shapes and structures, including grid, radial, irregular, and curved forms (Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020a).

According to the Urban Street Design Regulations (2020) definition, the organic street network, the focus of this research, can exist in connected and tree categories. The interconnected street network with a curved structure and the interconnected street network with an irregular form are two examples of interconnected street networks that can include the organic street network. The presence of curves in the street network leads to greater variation in block sizes compared to a grid structure. In the absence of a regular organizer, the street network develops irregularly solely to create connections between essential points. Gharib (2007) categorizes street networks into the radial grid (including hexagonal grid, diagonal grid, and square grid), ring (including inner and outer rings), and tributary systems (Gharib, 2007).

3.8. Tehran Street Network Typology

As discussed, there are various possibilities for categorizing street networks. In the mentioned resources, not all presented networks are necessarily visible in a single city. To conduct this research, a typology has been chosen to categorize the street networks after studying them in 353 different neighborhoods in Tehran. The selected typology includes the following categories: grid, tributary, radial, linear (adjacent to natural terrain features such as mountains or rivers, as well as airports), integrated networks (combinations of two, three, or four different types of networks), and the organic network. While many of the mentioned resources do not explicitly refer to the organic network as a separate category of street networks, it is widely recognized as the primary type of street network in most old cities and is mentioned in the sources. However, like international sources, no standard definition is provided for the organic network.

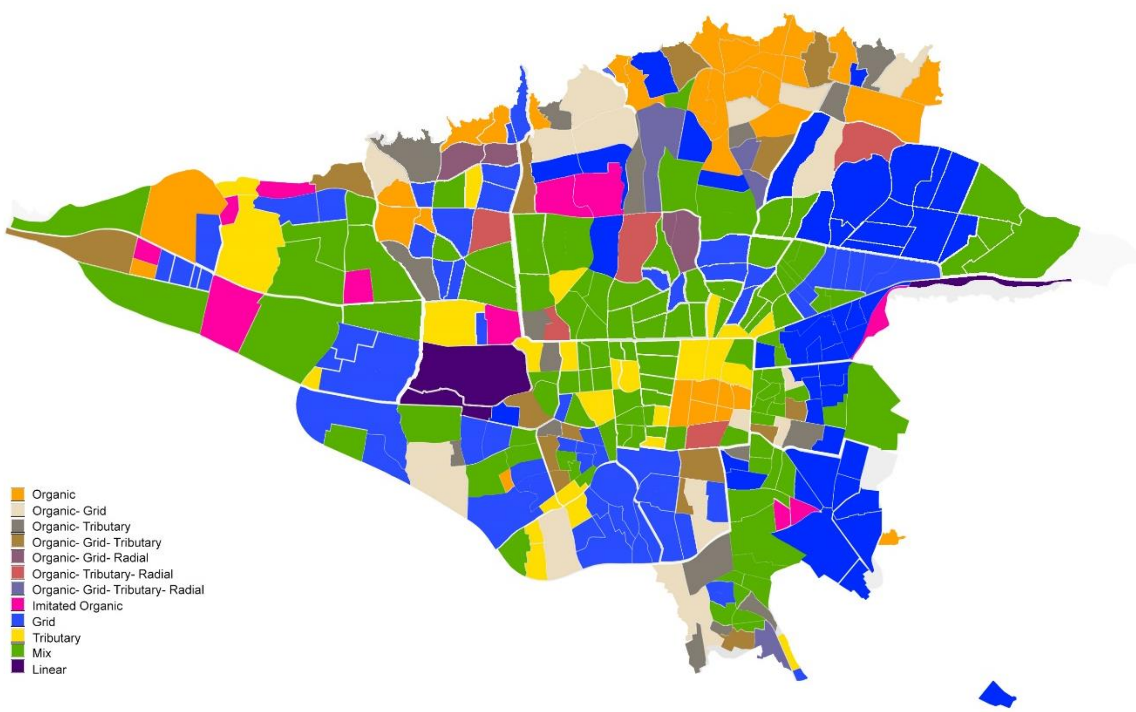


Figure 3.7. Variety of street networks in Tehran (author, 2022)

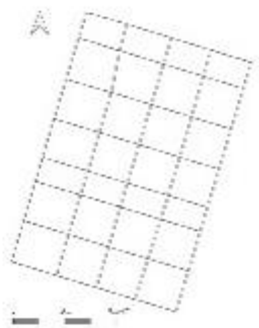
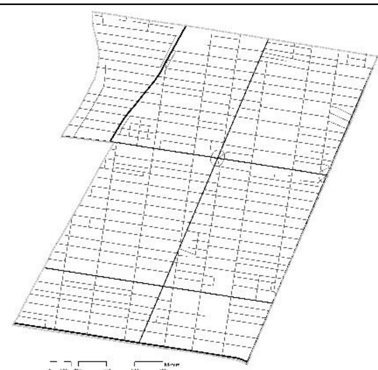
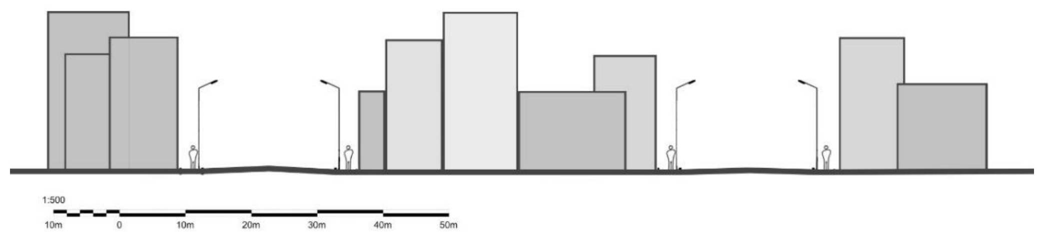
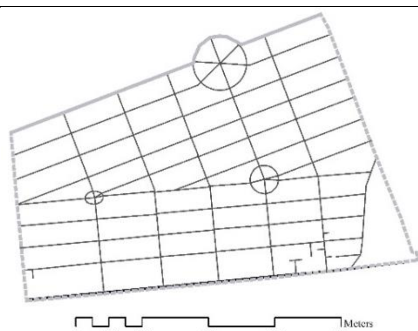
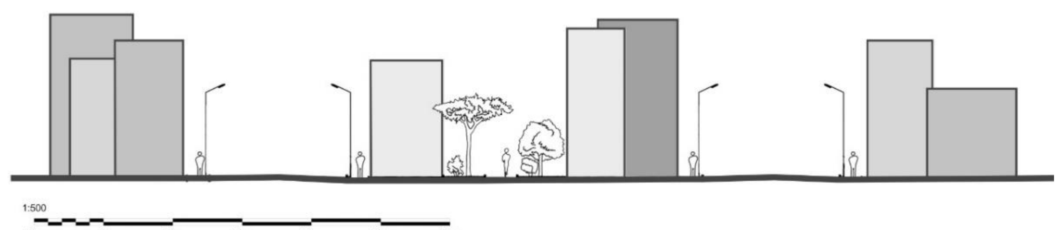
3.8.1. Grid Street Network

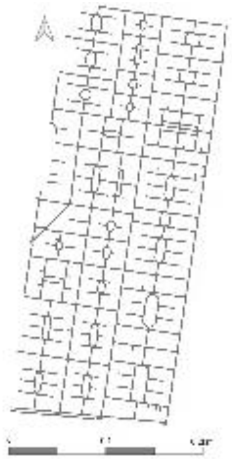
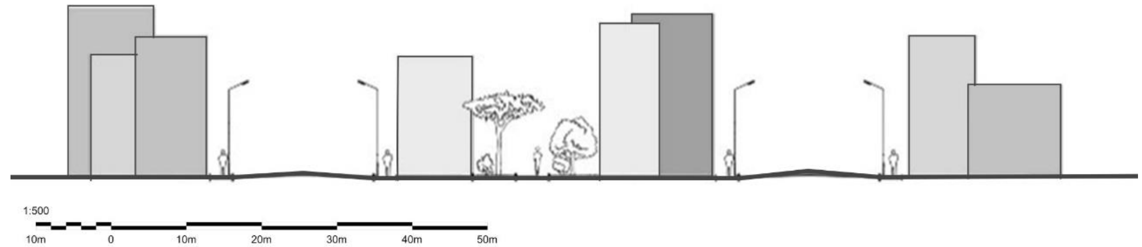
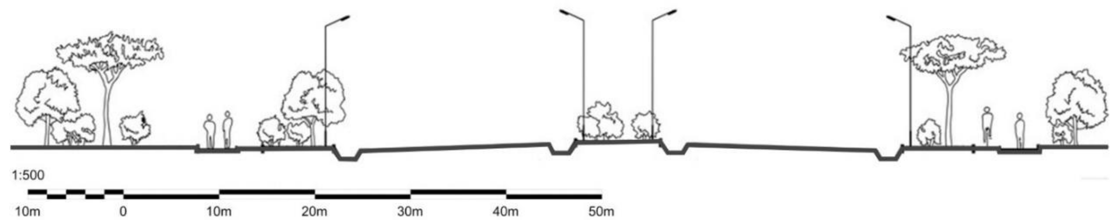
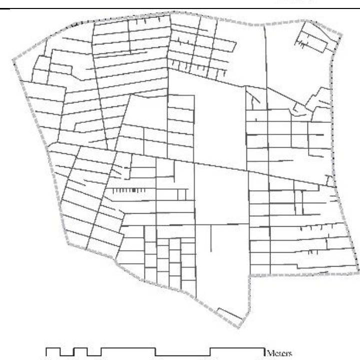
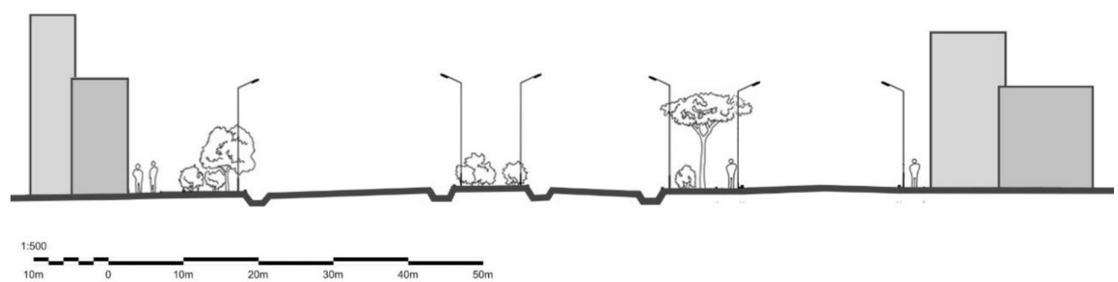
The grid street network in Tehran is characterized by the intersection of straight streets at approximately 90-degree angles, forming a perpendicular pattern. The intersections are relatively close to each other, and the blocks are relatively short in length. This network configuration, with numerous intersections, facilitates access and connectivity with other networks, making it a popular urban transit network for rapid development (Wu et al., 2021). The development of the grid street network in Tehran dates back to 1910, aligning with the city's modernization and the introduction of automobiles. The flexibility in creating new intersections and adjusting block lengths and widths compared to other networks contributes to its popularity. Given Tehran's ongoing inward migration, this network proves to be a suitable solution for planning new streets in low-density or newly constructed neighborhoods, allowing for the rapid achievement of higher building densities at minimal costs. Consequently, the grid network has been integrated with other networks or has served as the foundation for urban designs in the new regions of Tehran.

Analyzing the distribution map of the grid network and comparing it with Tehran's expansion map from previous decades reveals that most neighborhoods with a grid network were established between 1941 and 1956. This period coincided with the invitation of foreign architects and urban planners, particularly from France and Belgium, to collaborate in Iran. For instance, the Narmak neighborhood in Tehran was designed and constructed by French architects in 1951. In the second stage, between 1956 and 1976, further developments were added to Tehran, especially in the southern and southwest areas that were initially industrial and workshop spaces but have since been transformed into residential, office, and commercial areas.

The various types of grid street networks in Tehran are classified in the table on the following page, considering their design characteristics and timeframe. These networks vary in block shapes, including square, oval, rectangular, elongated rectangles, field openings in the center for recreational purposes, square or rectangular green spaces in the center, incomplete grids, or irregular grids. The unfinished grid networks typically feature a tributary network of the existing area, enhancing transportation and urban services over time. During new residential or commercial construction and urban reforms, the grid shape is generally maintained; however, there may still be cul-de-sacs that need to be connected to adjacent streets in plans, indicating an incomplete network. The irregular grid network exhibits connections between multiple grids due to previous structures or terrain features, resulting in the combination of rectangular and square grids or grids with different angles of placement, even within a single neighborhood. The distribution map below showcases the presence of grid networks throughout Tehran, covering approximately 21,937 hectares, which accounts for 30.26% of the total area of Tehran, excluding highways and freeways. The following table illustrates examples of grid street networks in Tehran.

Table 3.3. Different grid street networks in Tehran based on their shape

Street Network	Mahale - District	Street Network Diagram	Street section
Grid Square 1	Oqaf- District 4		
Grid Rectangular 1	West Tehranpars- District 4		
Grid connected Rectangular	Piroozi- District 13		

Grid with space openings in the center	Madaen-District 5		
Unfinished grid	Abouzar-District 15		
Irregular Grid	Deylaman-District 20		

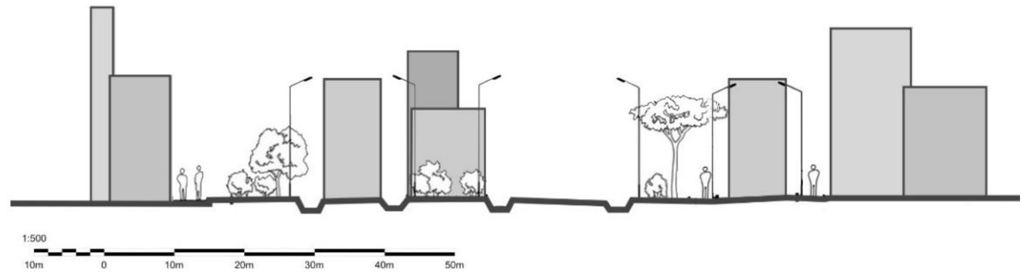
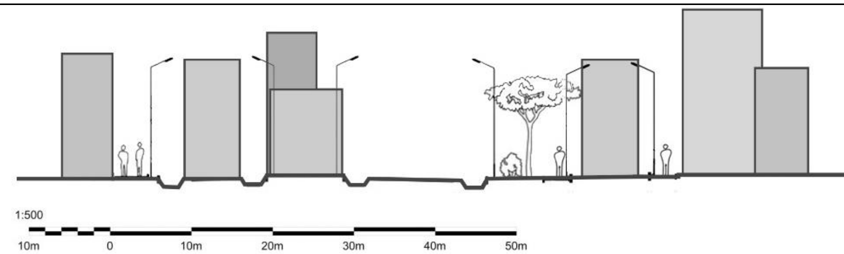
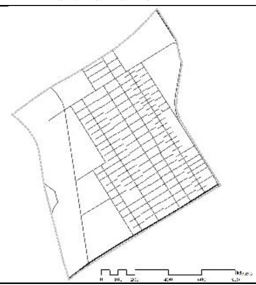
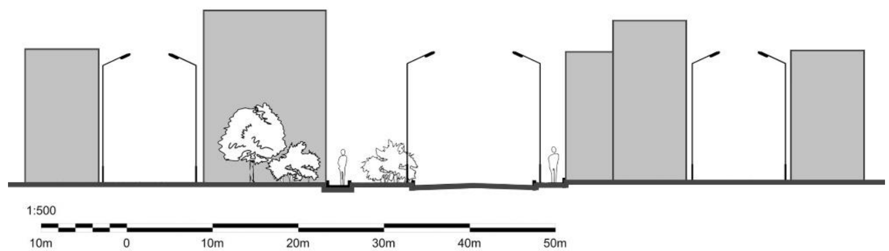
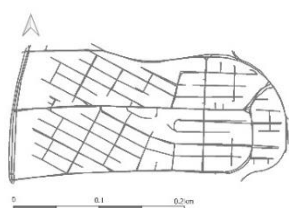
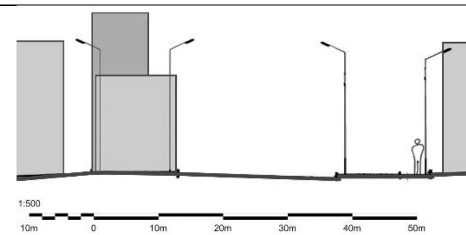
3.8.2. Tributary Street Network

A tributary street network is another prevalent type of street network in Tehran, characterized by side streets branching off from a main street axis. These side streets typically end in cul-de-sacs, leading to individual houses or clusters of houses. In Tehran, these networks have largely evolved into grid networks due to the limited access and movement of the network, primarily resulting from the presence of cul-de-sacs. The conversion of a tributary network into a grid network is possible by connecting the ends of two cul-de-sacs with parallel streets. Many neighborhoods in Tehran exhibit tributary networks that have partially transformed into grid networks, often observed as a sub-category of the integrated street network. Occasionally, the side streets in parallel streets are not aligned in a straight line, resulting in the formation of angular streets upon connection. The map below displays the location of the tributary street network in Tehran.

Upon analyzing this map alongside Tehran's expansion map, it becomes evident that most tributary networks are situated in areas that historically had an organic street network. With the passage of time and the implementation of construction reforms and urban renewal projects, these tributary networks have evolved into straight streets without meandering paths. However, a significant number of cul-de-sacs from the organic network persist in their structure.

In the southern and southwest regions of Tehran, the formation of tributary networks can be attributed to the presence of workshops located outside the city, which are now connected to Tehran. Based on the trajectory of Tehran's street network development, it appears that the tributary network will gradually phase out from the typology of Tehran street networks, giving way to the predominance of grid street networks. The table below provides examples of tributary street networks in Tehran.

Table 3.4. Different tributary street networks in Tehran based on their shape

Street Network	Mahale - District	street network diagram	Street section
Simple Tributary Network	Beryanak – District 10		
	Baharestan – District 12		
Connected Tributary	Abdol Abad- District 19		
Tributary rotation around an axis	Shahid Bagheri – District 22		

3.8.3. Radial Street Network

The radial street network refers to a configuration where multiple streets extend outward from a central node in various directions. This central node can be a square, block, or urban element like a park or green space, an urban monument, or even a landmark building. The radial network is rarely observed in isolation in large cities and is typically integrated with other street networks. This network can coexist in Tehran with a grid, tributary, tributary-grid, or organic street network. Examples of such combinations can be found in the section on integrated street networks and the subsection focusing on the integrated organic street network.

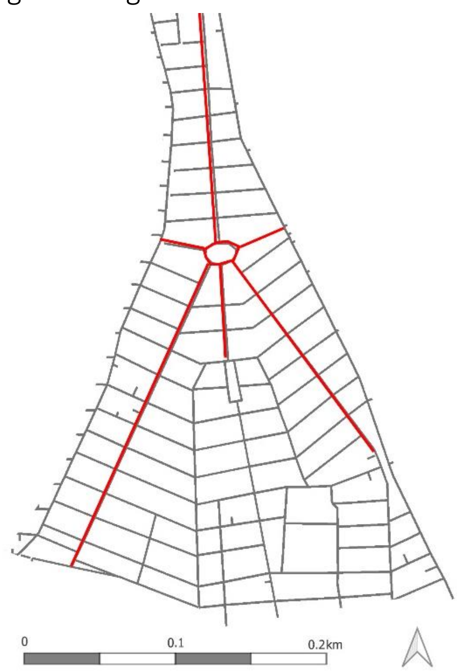


Figure 3.8. The shape of a radial street network in Tehran (Yousefabad, District 6)

3.8.4. Ring Street Network

The ring street network in Tehran historically encompassed urban spaces such as city blocks or ramparts, providing a circular pattern of streets. However, in present-day Tehran, this network pattern is not prevalent in urban neighborhoods. While some curved streets of the tributary street network have been constructed to improve street connectivity, none form a complete ring shape at the neighborhood level, except for a single instance in District 22 of Tehran. This case spans 163 hectares and combines elements of the grid and tributary street networks. Aside from this exceptional case, the ring network is primarily observed at the city scale, including highways, freeways, and ring streets. This research does not specifically focus on the ring street network and therefore does not include detailed studies on this category of streets.

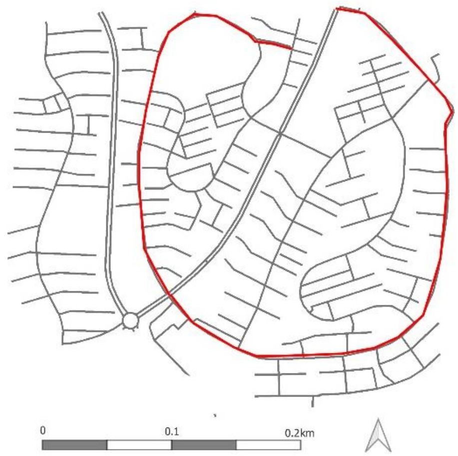


Figure 3.9. The shape of a ring street network in Tehran (Shahrak-e Qarb, District 2)

3.8.5. Linear Street Network

The linear street network is typically found adjacent to natural land features such as mountains, seas, lakes, and forests. It can also be observed near specialized industrial or military centers and intercity or international transportation routes like airports or railways. In the case of Tehran, the presence of an airport, railway, military and industrial areas, mountains, and hills in the north and east has resulted in a linear network in three city neighborhoods at the neighborhood scale. However, similar to the ring street network, the linear network has been excluded from the scope of this research project. The map below illustrates the layout of the linear street network in Tehran.

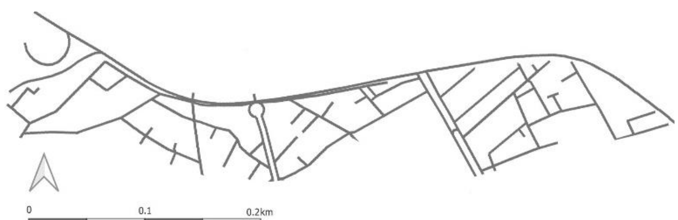


Figure 3.10. The shape of a linear street network in Tehran (South Mehrabad, District 19)

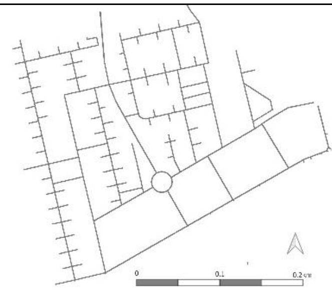
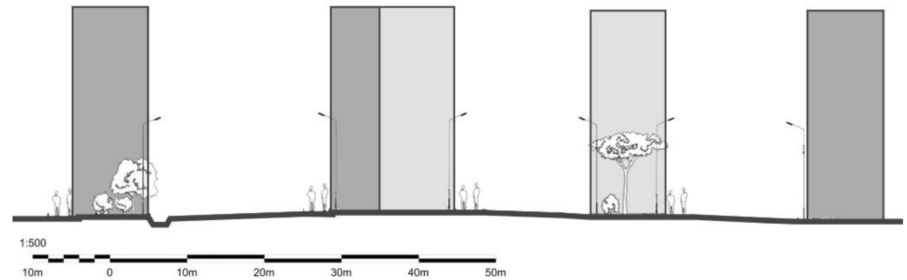
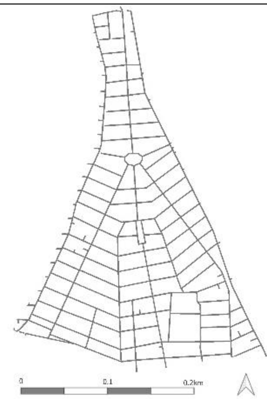
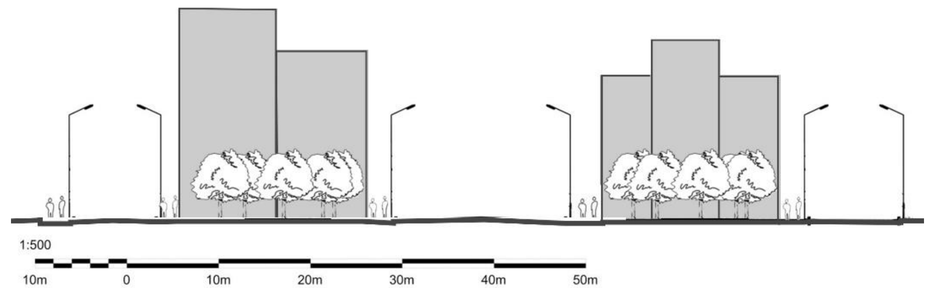
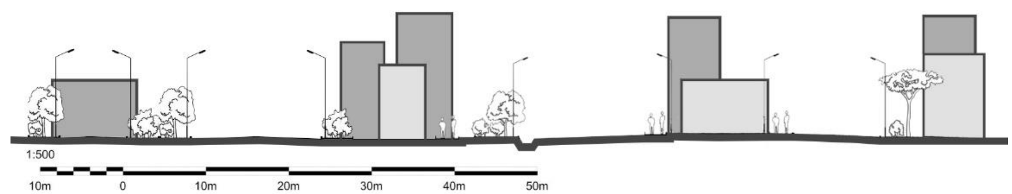
3.8.6. Integrated Street Network

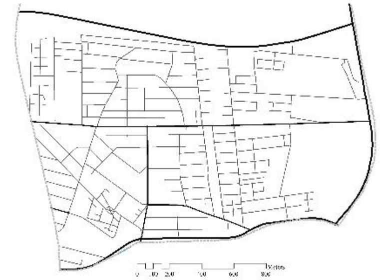
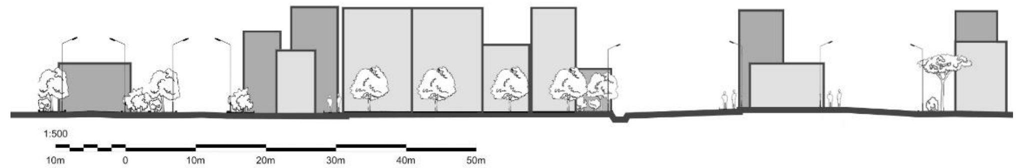
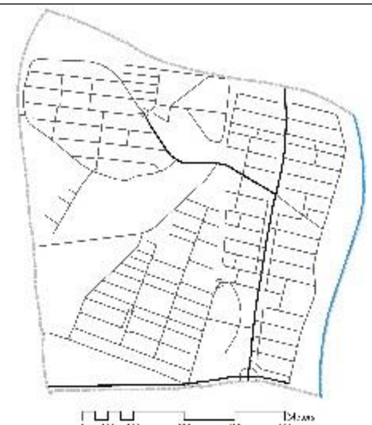
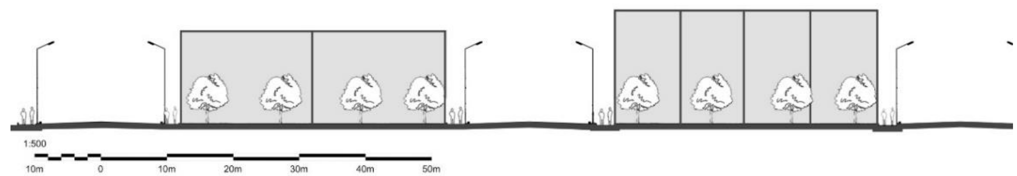
Due to Tehran's rapid and extensive development, the street network structure in both old and new neighborhoods has undergone significant changes. Street improvements have been implemented in various neighborhoods of Tehran, regardless of the original type of street network. As a result, many neighborhoods now feature a combination of different street networks. These integrated networks often involve a mix of one or two networks with a grid network.

The urban planning approach in Tehran focuses on widening streets, straightening their alignment, increasing the number of intersections, and reducing the number of cul-de-sacs. These measures indirectly transform the existing networks into grid street networks, as mandated by the Street Development Law of 1941.

Based on the findings of the current research, approximately 19,759.26 hectares (27.26%) of the street networks in Tehran neighborhoods are categorized as integrated street networks. Among them, about 14,818.1 hectares (20.44%) belong to the grid-tributary network, 2,075.56 hectares (2.86%) to the grid-radial network, 123 hectares (0.17%) to the tributary-radial network, and 2,579.63 hectares (3.56%) to the grid-tributary-radial network. Approximately 163 hectares (0.22%) are also attributed to the grid-tributary-ring street networks. The following map illustrates the distribution of these integrated networks in Tehran. It should be noted that the integrated street network, in combination with the organic street network, is presented as a subset of the organic street network in the subsequent section. The table below provides examples of these network types.

Table 3.5. Different integrated street networks in Tehran based on their shape

Street Network	Mahale - District	Street network diagram	Street section
Grid-Tributary	North Kiyanshahr- District 15		
Grid-Radial	Yousefabad- District 6		
Tributary- Radial	Darvazeh Shemiran – District 12		

Grid- Tributary-Radial	Shahrak-e Azmayesh – District 2		
Grid- Tributary-Ring	Zibadasht-District 22		

3.8.7. Organic Street Network

The organic street network is a foundational street system in many cities worldwide. However, due to its age, historical changes, and integration with other networks, there is no standardized definition for this network type. Despite its significance, the organic street network has received less attention from researchers and has often been excluded from discussions on street networks.

In Tehran, neighborhoods with organic street networks face traffic flow and urban infrastructure challenges. As a response, there have been suggestions to transform and modify these networks to resemble grid systems or to prioritize pedestrianization. However, any interventions in this type of network should be informed by a comprehensive understanding of its origins, formation, and unique characteristics. Without proper research, interventions may not effectively address existing problems and could potentially create new challenges by disregarding the contextual aspects. It is important to recognize that the organic street network has evolved based on the needs and preferences of its residents.

The primary focus of this research is to evaluate the walkability of the organic street networks in Tehran. This section delves into a detailed study of this street network type and its subsets in Tehran neighborhoods. To ensure consistency and coherence in understanding the organic network, the research primarily relies on Iranian sources and domestic case examples. This approach ensures that the central concept of the network and its conceptual foundations remain aligned. It is important to note that the original organic street network is emphasized in the definitions, features, and components.

3.8.7.1. Definition of Organic Street Network

The organic network, or, according to Asghar Nazarian, "non-geometric texture," is a network that is not planned by designers or based on the regulation of human thought. Instead, the development of the network has been done by coincidence (or try and fail), and its streets are narrow, interwoven with twists and turns. The width of a street along a path can be changed many times, providing open spaces irregularly. The whole network counts as a discontinuous system at different distances (Farid, 1989).

According to Mashhadizadeh, these urban networks are not chaotic. These cities have created such networks during their formation and development according to the spatial, temporal, cultural, geographical, etc. requirements. In their time, these streets could provide the necessary services to the citizens in the shortest time and distance (Moshhadizadeh Dehaghani, 1994).

In general, in an organic texture, cellular system, balanced diversity, neighborhood connections, stability, interdependence, and return to the natural world are considered (Azimi et al., 2013).

Nevertheless, it can be said that if urban development allowed the necessary time for the growth of an organic structure in a natural way, this structure, like a living ecosystem, could adapt itself to the sociocultural infrastructure of society and the needs of pedestrians again. However due to the lack of this structure to time and trial and error to achieve the most optimal possible design, such a possibility does not exist in the current situations of the cities.

Organic streets were formed gradually and based on try and fail. Most of these streets have been indirect and winding. Some of these streets had many turns in a certain length, and it has been observed in some cases that a street was known by the name of its number of turns, such as the "Yazdah Pich [Eleven Turns]" and "Haft Pich [Seven Turns]" in Isfahan. These streets were not designed, they lacked an independent space from the surrounding environment and buildings. In other words, the length of the street was formed and emerged following the construction of various spaces on both sides of the street, and without them, the street lacked an enclosed and defined space. Moreover, an organic structure is based on the ability and power to own a space, qanat, and water routes (Soltani Mohammad and Yousefi, 2018), Important centers include Emamzadeh, Neighbors' meeting points (H. Abedini, personal communication, October 18, 2022). The issue has become a pause space, and the areas have been expanded to welcome more people. This process has changed the form of the organic street network constantly. The street space is between the buildings on both sides and integrated into its surroundings. Therefore, the physical and spatial identity of such streets depends on the structures around them, and the changes and transformations of the structures around each crossing can always change its physical and spatial characteristics (Soltanzadeh, 1993). In another definition, it can be said that the pattern of the organic street network is often observed in areas with more recorded history. In this context, there is no preconceived thinking, and the street network is often formed based on the pedestrian traffic and elevation of the area. It is partially connected with the surrounding areas. Another feature of this context is the spatial privacy and the cul-de-sacs streets. Due to its undesigned nature, the organic network creates irregular streets, and since the connection network is an essential factor in the formation of mass and buildings, these parts also form an uneven combination (Boroumand, 2010).

As mentioned in the first chapter, the definitions of the organic street network in study sources inside and outside of Iran are different and sometimes contradictory. The table below summarizes Iranian authorities' descriptions of this type of network.

Table 3.6. Definition of organic street networks based on Iranian literature

Researcher	Definition
Yadollah Farid, 1989	An organic (turbulent) system is a system that humans do not participate in through its design, planning, and regulation. Its formation of a city has been done by chance. Its narrow streets and alleys are intertwined with twists, turns, and curves.
Asghar Nazarian, 1995	Non-geometric texture
Naser Mashhadizadeh Dehaghani, 1999	The old networks of Iran cannot be called chaotic because they were created according to the needs of the time, place, culture, geography, etc., through the formation and development process and were subject to the conditions of their time. So they follow a certain logic and do not have a chaotic and irregular system.
Hossein Soltanzadeh, 1993	Organic streets have formed gradually and spontaneously, and often indirectly and windingly.

As can be seen, only Mashhadizadeh Dehaghani has mentioned the intangible characteristics, and other researchers have limited themselves to stating the physical and external features.

3.8.7.2. Formation and Development of Organic Street Network

Walking is the oldest form of human movement. However, after the industrialization and modernization of cities, especially in the Middle East, cities were designed and transformed into a car-oriented pattern. During the 1930s, urban planners and decision-makers in Tehran used Haussmann's 19th-century plan for Paris as a model. Haussmann had made extensive changes in Paris by building wide "boulevards" instead of the previous narrow streets. Tehrani designers also used the comprehensive street designs of Daniel Burnham's 1909 Chicago design as a model. In Tehran, following these patterns, the Nasserid walls around the city, which were used as fortifications for almost 150 years, were destroyed in the second half of the 19th century. Following this, straight and broad streets were built. Overall, Tehran lost its traditional identity due to the ease of transportation (Abrahamian, 2010). This part provides a brief history of the formation and development of organic street networks.

From the Beginning of Urbanization in Iran to the Islamic Period (9th B.C. to the End of the 15th Century)

Iranian cities have a heritage spanning centuries and millennia. With the establishment of the first independent government in Iran, the Medes government, there arose a need to create a capital city that would serve as the center of government and a gathering place for various groups. Hegmataneh was deliberately constructed as a city to meet this demand (Mashhadizadeh Dehaghani, 1994). In the urban morphology of Iranian cities, the Medes era is regarded as the starting point for the development of urban structure. Since that time, governmental and market elements have been evident in the primary structures of cities alongside residential areas (Lotfi, 2004). Consequently, during the Median dynasty, the street network of the city was pre-planned. This spatial arrangement continued to evolve through subsequent periods, with cities typically serving as central hubs of government and ruling power.

During the Achaemenid period, city creation had administrative and political motivations. These cities were primarily established under the influence of kings and were less shaped by environmental factors. As a result, urban planning during this period was based on predetermined plans.

The Seleucids era witnessed the fusion of Greek and Iranian cultures, which manifested its influence on urban planning and architecture through the creation of new cities in the style of Hippodamus. The grid patterns known as hippodames were utilized during the Parthian era, inheriting the forms of cities founded in the Seleucid era. Grid patterns were the prevailing method in urban planning during the Parthian period.

In the Sassanid period, ample evidence suggests that cities were constructed with pre-existing plans, and practicality consistently favored regular planning. These plans were often represented as squares and rectangles with internal grids or as concentric circles (Mashhadizadeh Dehaghani, 1994). The pre-Islamic era saw relatively less use of organic street networks in urban planning.

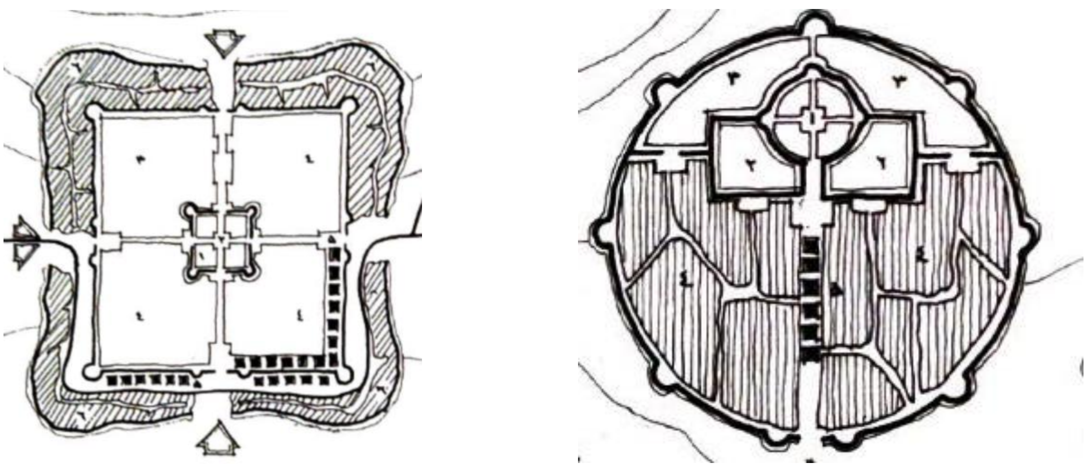


Figure 3.11. The shape of the city during the Parthian (left) and Sasanian eras (right) (Habibi, 2004)

From the Islamic Era to the Modernization Era (16^{th} to the End of the 18^{th} Century)

In the Islamic era, with the dominance of Islam in Iran, the mechanisms of cities gradually became more complex, and the cities themselves became physically fortified (Lotfi, 2004). While the foundation of urban culture can be traced back to the Sassanid era, it is essential to recognize the significant role of Islam in redefining social, economic, and political relations. During this period, the old cities either willingly or under coercion opened their gates to the Islamic state. These cities absorbed the essence of the Islamic worldview without undergoing major physical transformations. This absorption of Islamic influence resulted in the creation of new elements and the replacement of old ones, such as the construction of the Grand Mosque or shifts in urban demographics. Cities followed a policy of spontaneous expansion during this time (Habibi, 2004).

In addition to these aspects, it is crucial to acknowledge that changes in the environment and human habitat during this era and the previous period were driven by human needs as well as geographical and climatic conditions. These changes, while following cultural patterns, customs, and implicit societal laws, were also influenced by natural factors like topography and climate. One of the fundamental development patterns during the Islamic era was the establishment of water supply networks known as "Qanat", designed to deliver water to the fields surrounding villages and cities. These water supply networks gradually became models for urban development and played a significant role in shaping the morphology of cities and villages, leading to the creation of new neighborhoods and structures. This principle can be observed in the layouts of cities such as Yazd, Mehriz, Meybod, and Isfahan.

The hierarchy of streets in the network of Islamic-era cities was also of great importance. According to Rapaport, rather than merely facilitating movement and access, the street hierarchy was designed to control movement behavior. This hierarchy encompassed entirely private spaces (houses), semi-private spaces (benches in front of doors and cul-de-sacs), semi-public spaces (secondary streets), and public spaces (main streets, markets, mosques, and squares) (Mashhadizadeh Dehaghani, 1994).

In terms of form, Iranian cities during the Islamic era can be likened to medieval cities. Streets were laid out in an organic fashion, often adjacent to churches and markets, with houses arranged in a spontaneous order.

Overall, the Safavid period in the post-Islamic era can be considered the most successful period of Iranian urban planning. During this era, fully conscious efforts led to a successful fusion of geometric and organic design principles in Iranian city planning for the first time. The prosperity of cities during this period was not achieved through the reconstruction of old cities but by establishing new urban complexes alongside ancient cities. Therefore, the Safavid style during this era did not subject ancient cities to extensive renovations. The Safavid period in Iran's history coincided with the European Renaissance (Daniel, 2001).

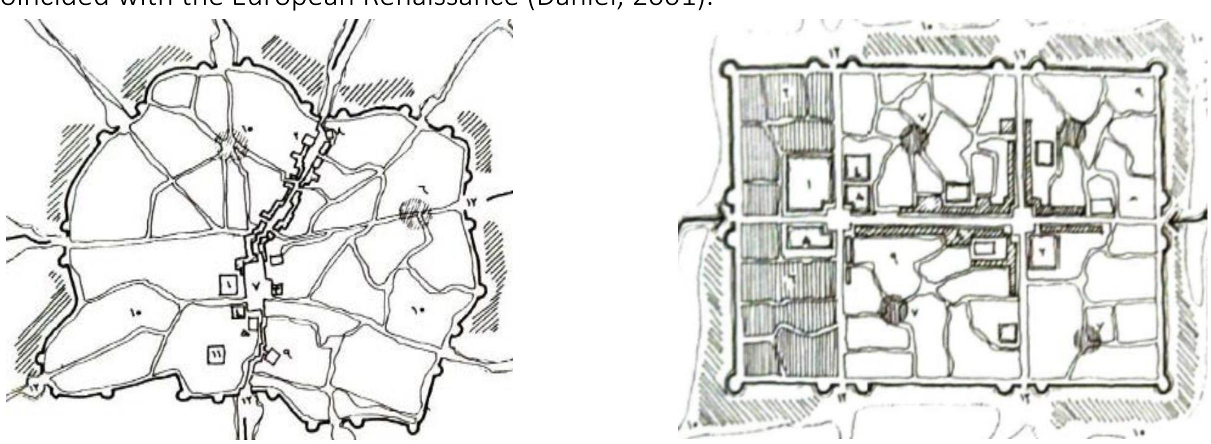


Figure 3.12. The shape of the city in the Islamic era, Safavid (left) and Seljuq (right) (Habibi, 2004)

Changes and Reforms in the Era of Modernity and Industrialization (Late 18th to the Early 20th Century)

What came under the title of a new era of urban development was nothing but a reflection of the urban development results from the West (Mashhadizadeh Dehaghani, 1994). During the Qajar period and especially from the time of Fath Ali Shah's rule (1795- 1925), Iran was affected by global trends. The conditions resulting from the Industrial Revolution heralded the birth of the industrial world and the formation of powerful governments that, relying on deep reforms in various social, economic, political, and structural fields, sought to discover and dominate the world. In this way, the influence of the factors of foreign countries and the new cultural fusion that took place also showed itself in architecture and urban planning. Physical changes at the level of cities, especially Tehran, related to the emergence of new urban elements such as Dar al-Funun school and Tekiyeh Dolat (open-roof theater). In this era, there is no severe damage to the organic street network left over from the previous era. New streets of Tehran are also built in the place of ditches. Bab Homayun Street, Nasiriyehand Akbarabad are among them. In this period, the streets were a place for recreation, trade, buying, and selling. It is from this period that the neighborhood represents social distinctions. The old neighborhoods maintain their spatial organization and organic street network, but the new neighborhoods are formed next to the newly built streets. The emergence of the street concept with commercial functions and new activities, such as cafes, restaurants, etc., on both sides of the street changed the traditional face of the Iranian city. It damaged the traditional texture of the neighborhoods (Lotfi, 2011). At this point, most people in society continued to live in traditional spaces and old urban contexts. This change and transformation provided the foundations of the decay of the organic street network and ancient contexts. Still, the urban development approach of this time does not cause severe damage to the life of the street network and the organic and traditional texture (Habibi, 2004).

From Modernity to Postmodernity (the Early to the Mid 20th Century)

The culmination of the phenomenon of modernism took place during the first Pahlavi era, and it was decided that the new life model and modernism of the West should be implemented in the cities of Iran. Tehran was the first try. Changes were formulated and approved in urban planning regulations to find a favorable environment. The first urban development plan prepared this way was approved in 1930, known as the street map. Immediately after that, in 1931, the destruction of Tehran's ramparts, the creation of ring streets in 1932, and the law on the widening and development of streets (1932) were implemented. These scenarios in Iran, since the Iranian city had never followed the path of several hundred years of medieval life to the urbanization of the industrial world and was not affected by the consequences of this gradual process, caused the physical and functional structure of the Iranian city to fall apart and the stable foundations of life to crumble (Farid, 1989).

Regarding the organic street network of Tehran, with the approval of the laws of 1932 and subsequent laws, it became less and less until, in 1937, Tehran's new plan was prepared by the Ministry of Interior under the supervision of foreign consultants. This plan was entirely influenced by the international currents of the "Modern Movement." Grid texture and separation of urban functions based on zoning were the basic concepts for this plan (Habibi, 2004). Consequently, the street network and organic textures were disjointed and lost physical solidarity. In this period, affected by the entry of automobiles into the city, instead of building numerous streets that are proportional to the scale and in harmony with the natural shape and accesses of the old part (the continuation of the organic street network), many wide and straight streets have been constructed, and the old parts of the city have been cut into pieces (Lotfi, 2011). The stages of destruction of the old texture started with the creation of squares in the center of cities and perpendicular streets in (+) shape (Mashhadizadeh Dehaghani, 2014).

During the second Pahlavi era, American architecture and urban planning thought spread. Truman's four principles and their implementation in some cities of Iran is a manifestation of this story. Also, planning thinking is brought up in the country. The establishment of the planning organization in 1948 is a sign of these sparks at the national level. Following this movement, the first urban plan for 1948-1955 was drawn up, and a type of social reform in which urbanization was strengthened was spread throughout the country (Farid, 1989). For the first time, the concept of "future expansion of the city" is formed, and after that, the act of speculation on land and later buildings enters the urban equation. The result of these movements turned the fertile land into a suitable breeding ground for the movement of capitalism. Construction became popular in them, and the system of geometrical division of the land and the creation of designed streets and the construction of complexes A new city in the form of construction bank activities led to the formation of Narmak, Yousefabad, Manzariyeh, etc. neighborhoods in Tehran.

In 1957, the preparation of conductor design for several cities was proposed after the formation of the technical office and then the conductor design office in the Ministry of Interior. The results of these plans, considering the dominance of the thinking of geometric streets in the city, did not achieve anything but dimming and weakening the organic street network in the cities (Lotfi, 2008). After the land reforms in the third development plan in 1963 and the expansion of urbanization as its significant consequence, the preparation of comprehensive urban plans was put on the agenda. During these projects, which were generally carried out with the cooperation of foreign consultants, the old and new contexts of the cities are discussed. The comprehensive plans were not interested in maintaining the organic street network in the cities, especially in their ancient context. For example, in the comprehensive plan of 1969 Tehran, known as the Gruen-Farmanfarmaian plan, with the dominance of modernist thinking, a network of highways and urban streets is envisioned for the city in a grid form (Mashhadizadeh Dehaghani, 2014).

From Postmodernity Until Today (From the Mid-20th Century)

It can be acknowledged that the postmodern era in Iran started in the 1970s. The emergence of currents against the prevailing social, economic, and political situation in this decade shows a change in the general attitude. From the point of view of architecture and urban planning, the emergence of buildings such as the City Theater (Theater-e Shahr) and Vahdat Hall, as well as the introduction of authentic projects, show the whispers of postmodernism in Iran. The impact of the plans proposed in the postmodern era in the form of structural-strategic plans and regeneration and originality plans on the remaining organic street network in cities has not been investigated much. But since the purpose of these plans has been to add authenticity to the existing texture through urban revitalization, to improve the quality of life by securing and strengthening the buildings, to create new job opportunities, and so on, it seems that it does not involve severe adjustments and damages in the organic street network and deals with a more flexible view of the old texture of the cities.

3.8.7.3. The Configuration of Organic Street Network

The organic street network is not just a set of connected streets; Rather, due to the age and how this network was formed and expanded, its structure is more closely related to the lives of visitors and users of the network than other networks. The hierarchical structure of this network has turned it into a space like a home for the residents. So, the residents of the neighborhoods with an organic street network (if the basic urban facilities are available) feel more belonging to their neighborhoods rather than other types of networks (Saraei, Ashnoi, and Roosta, 2016).

With the same word, the concept of neighborhood and interrelationships among neighbors are more prominent (Salaripour et al., 2018). Also, due to age, this network contains more cultural, social, and political content than other networks. It is common to find historical, cultural, religious, and social centers, elements, or monuments in many streets of the organic network. Therefore, intervention in the organic street network should consider all the characteristics of this network. Otherwise, although a plan can be appropriate in itself to improve walkability (and, on a larger scale, improve the quality of life in the neighborhood), considering the deep integration, memory, sense of place, and connections between citizens and the network, any changes without considering the type of network and its component can lead to the migration of old residents, lack of sense of belonging, abandoning and physical destruction and gradually, the destruction of historical and social memory of the city. In this section, the form of the organic street network and its elements have been studied to determine their importance, considering its tangible and intangible values. In this regard, it should be noted that the definition of urban space in Iranian architecture and urban planning is different from urban open space; Because urban space has a particular function and activity, while urban open space refers to a space such as a park or green space (Tavassoli, 1997).

A study by Strano and his colleagues (2012) examines the evolution of unplanned street networks and their implications for urban planning. The study focuses on the growth of Groane, an area outside Milan, Italy, and provides a quantitative analysis of how the street networks in the region have evolved. The researchers used historical maps dating back to 1833. They constructed digital maps to analyze the development of Groane from agricultural land to a residential and industrial area and eventually into a postindustrial suburb. Through network analysis of the digitized map, the researchers observed that the street network became more uniform in size and density over time. They also noted a shift in the predominant shape of the network from triangular to rectangular. The study identified two processes of urban growth: exploration and densification. Exploration refers to the extension of new streets into rural areas, while densification involves filling gaps in the existing network. The authors found that densification tended to make the grid more orderly and square, while exploration was less predictable. Despite significant changes in transportation modes over the years, the original road layouts remained mostly intact. Older streets tended to be more central in modern times, and the study suggests that connectivity analysis could help urban planners understand how people use space and optimize street networks. The findings of the study provide empirical support for the idea that natural rules may guide the self-organization of cities and offer insights into the potential for enhancing organic growth in urban planning. However, it is noted that factors such as cultural design preferences, building shapes, and small-scale planning efforts may have influenced the street network's evolution in Groane. The implications of street patterns on various aspects of urban life, such as local economies, physical activity levels, public transportation use, crime rates, and social inequality, are also mentioned (Strano et al., 2012).

A study conducted by Nilsson and Gil in 2019 discovered that the distribution of connections in a city's street network follows a power law distribution for cities that have primarily grown organically. However, this pattern is not observed in cities that have been extensively planned. This finding is significant because a power law distribution indicates the presence of multiplicative growth processes. Moreover, the results obtained from the quantitative classification method align well with earlier qualitative morphological classifications of cities (Nilsson and Gil, 2019).

Generally, an organic street network has two types of physical features; first, the general characteristics, and second, the depended characteristics that are related to its sociocultural and geographical concept – which is Iran in this research. The following is a list of physical characteristics in the general concept of streets and street networks.

- **The street configuration:** The streets can be categorized based on their form and shape; for example, straight, curved, loop, spine, or connector (Marshall, 2005; Boeing, 2019).

- **The street length:** Street Length means the total length of streets in the Development Area. Streets less than 600 meters can be converted into pedestrian paths, provided they are at least three meters wide (Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020[4]).

- **The street width:** Lane width should be considered for the overall assemblage of the street. In Tehran, the width of crossing lines on arterial streets equals 3 to 3.3 meters. The width of 3 meters is used in areas where the traffic volume of trucks and buses is less than 10%, and the design speed is less than 50 km/h. The width of 3.3 meters facilitates higher speeds and increases the movement of heavy vehicles. The width of the left and right turn lanes at intersections is also recommended to equal 3 meters (Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020).

- **The height of the street walls:** The height of the street means the height of the walls of the street. The street is defined as a three-dimensional space completed by the surrounding buildings' walls. In newer designs, the height of neighboring buildings is the same, and generally, in more modern neighborhoods, it is higher due to the high value of the land. Generally, the height of the walls is from twice the width of the street to four times. If the buildings are located on a slope, the distance between the middle point of the roof of the building and the middle point of the intersection of the building and the ground is defined as the height of the street wall. The height of walls along a street changes most of the time. The average height of the walls is considered the wall height of a street.

[4] Volume 5. Urban streets

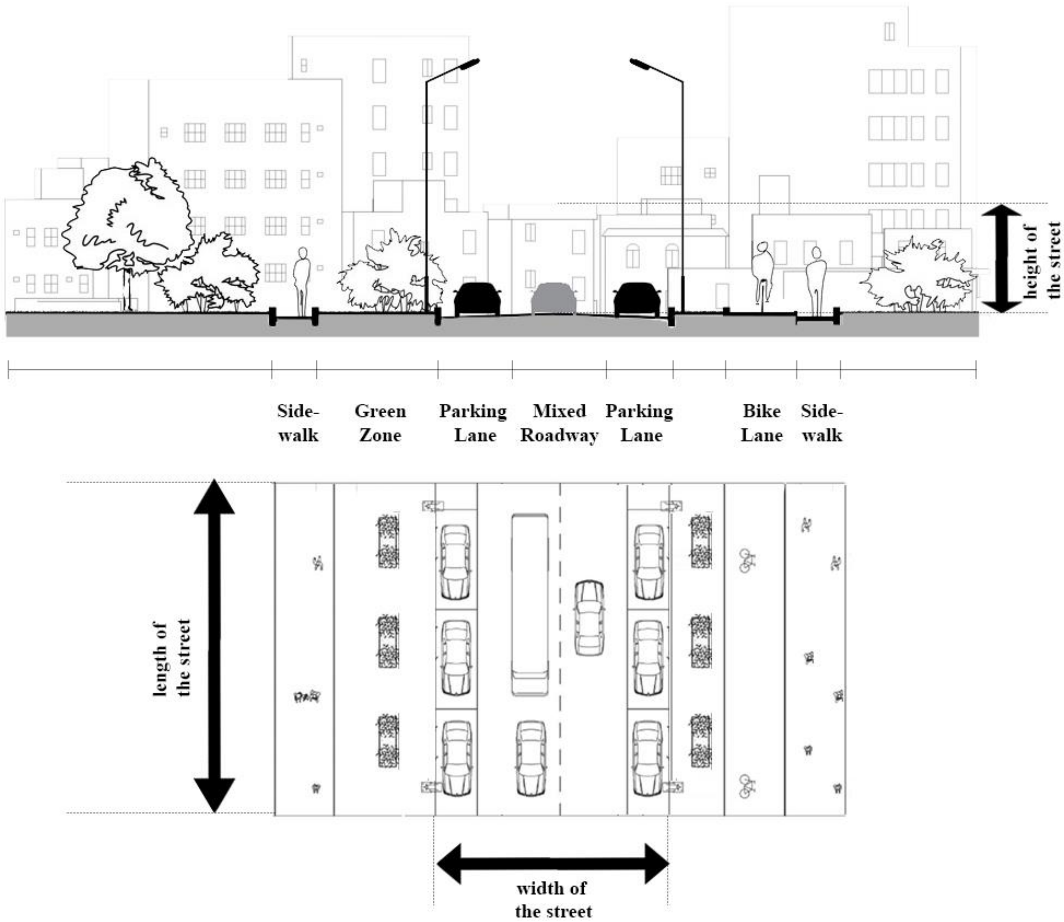


Figure 3.13. Configuration of a street (Author, 2023)

- **The average distance among the nodes in a street network (intersection or cul-de-sac):** The point where the streets (Links) meet each other is called an intersection (Node). Intersections can be the intersection of two or more primary or side streets. In the street network graph, the sum of the distance between each two intersections divided by the number of intersections is considered the average distance between the intersections in the graph (Boeing, 2017).

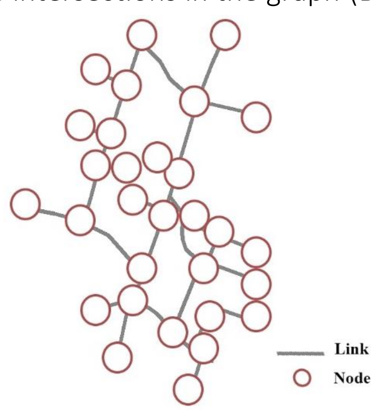


Figure 3.14. A graph of a street network (Author, 2023)

- **The size of the blocks in a street network:** An urban block is the basic unit of a city's urban fabric and is essential in mediating between the public and private spheres. Urban blocks are defined as the space of the street pattern of a city that is subdivided into land lots for the construction of buildings. It may consist of a single building structure or an area with several buildings that vary in size, detached structures surrounded by nature, or intricate labyrinths (Figueroa, 2006).

- **The full-empty spaces ratio:** Full and empty spaces do not exist in the street network graph because only connections (streets) and nodes (intersections) and exchanges between them are meaningful. However in an urban space where the street network is located, some spaces are built and have a total volume, such as buildings, which are called filled spaces. Next to these spaces and to give them meaning, empty spaces are placed. A space does not represent an undecided and unused space but is not built with a purpose. It is intended for various activities such as sitting, communicating, passing by, or watching the city's events or a pause space. The ratio between filled and empty spaces is obtained by dividing the total area of empty spaces by filled spaces. The higher this ratio (if there are meaningful empty spaces), the more suitable the urban space is for pedestrians.

- **The orientation of the street network:** The topic of orientation is more meaningful for buildings. But the direction of the streets of a street network is also essential. Because proper orientation leads to climate comfort. Citizens use a space that has a comfortable climate. Also, the direction of the street is effective in the amount of street lighting. In general, in Tehran, the closer the orientation of the streets is to the southwest direction, the more optimal conditions there are concerning the amount of street lighting and its climatic comfort (Boeing, 2019).

The above features consider all the street networks in any location. As the form of the organic street network is firmly integrated into the lifestyle of the citizens of its geographical place, it also contains unique physical features that can be differently defined in each region. One of the essential features of the organic street network is its emergence and expansion in a relatively long period based on the needs of the neighborhood residents. This issue includes organic networks in Tehran. Since this type of network has been used more after the arrival of Islam in Iran, the principles related to religion and traditional and religious beliefs can also be observed in its characteristics. Moreover, Tehran has been formed based on the Isfahanid style; In this style, the street network and streets of a neighborhood have been created based on respect for nature, human scale, and spatial continuity.

- **Respecting nature**: it should not be forgotten that the organic street network has formed considering the ground and underground water sources and the trees, especially the old trees. As there were no written and documented plans for developing and expanding the streets in organic structures, the routes used most by the pedestrians have been chosen as the main structure of the network. As the people did not cut the trees to make their commuting easier, the organic form also respected the elements of nature. The routes to the water sources had mainly shaped the neighborhood's main street. The other city elements have been placed respectively in this street to make the best of the routes, regarding reaching the destinations in the shortest time.

Figure 3.15. Respecting the nature in organic street networks (Jamaran (left) and Darake (right), Tehran, District 1) (Author, 2021)

- **Human scale:** it considers the three-dimensional measures of the streetscapes. In other words, the streets' length, height, and width inside the organic network have considered the scale of the pedestrians as the primary users of the streets. A pedestrian should be able to have a good view during walking time and not feel enclosed in the space. The urban elements should be designed and created in the pedestrian's view horizon, including the street walls.

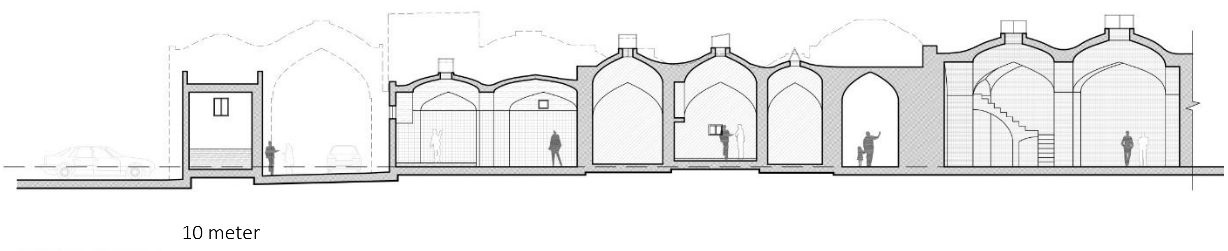


Figure 3.16. The elements of the organic street networks are human-scaled (A section of a street in the organic structure of Tehran Grand Bazaar, District 12) (Author, 2007)

- **Spatial continuity:** it is one of the most essential principles in the structure of Iranian cities. This principle means the spatial connection between the city center, neighborhood centers, main crossings, and urban nodes. This principle makes every urban space a part connected to the spatial structure of the whole city. On the other hand, the size and shape of urban spaces in Iranian design should be subject to the population, needs, and the type of desired activities of the residents of a neighborhood (Habibi, 2010). It means if the neighborhood had fewer residents, the neighborhood center would be smaller. Route discovery in this style is a conceptual principle that, by combining with the principle of spatial continuity, tries to privatize the neighborhoods (Habibi and Seyed Berenji, 2013).

- **The principle of continuity and connectivity**: although the organic street network is not pre-designed, the formation and changes of its structure are the results of many trials and errors over the years. The principle of continuity and connectivity of urban spaces is well observed in a neighborhood with an organic street network. This principle means the connection of the center of the neighborhood through the main streets, which include the most important spaces and buildings in a neighborhood. Nevertheless, the more intersections per square kilometer and the level of access to public transportation, the more people choose to walk to reach their destinations. The connection of the street network is directly related to the pattern of the streets. The finer and more connected the street pattern is, the smaller the blocks and the more connected the paths. In old neighborhoods with a continuous and dense texture, the organic street network often leads to the emergence of cul-de-sacs streets to provide access to residential or other architectural units. Their length is different; sometimes, it continues up to several hundred meters. The streets are straight or curved with twists and turns. In other words, this street network pattern encourages the creation of cul-de-sacs and curved paths, reducing the streets' continuity and connection. The degree of continuity of the access network can be calculated by counting the number of three, four, or more intersections per unit area (Molaei et al., 2021).

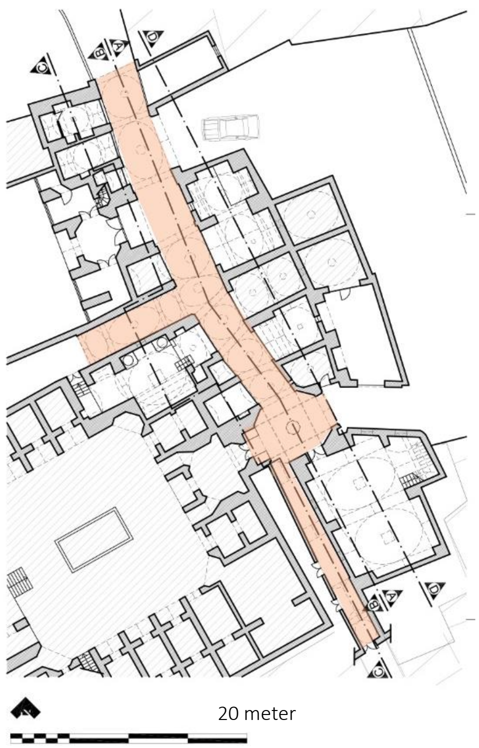


Figure 3.17. Spatial continuity of a neighborhood organic structure (Kashan, Iran) (Soltanzadeh et al., 1996)

- **Principle of privacy and confinement**: It is according to the time of its formation in different neighborhoods, followed by the residents' religion, traditions, and beliefs at that time. This has caused a similarity between the creation of space in an urban environment and a house; In this way, the composition of the interior spaces of houses in Iranian architectural culture is mainly in the form of a central courtyard that is closed with peripheral spaces. The parts enclosing the courtyard space are the rooms. The house's yard with a pond and four gardens and its enclosing rooms is very similar to an urban open space in the center of the neighborhood (Markaz-Mahale) with a pond in the center, platforms, arches, and pavilions around it. Based on this principle, urban spaces in Iranian design are divided into three groups: public, semi-public, and private. The private spaces form the territories of the house and the yard, and the public spaces are related to the primary and secondary streets and squares. A territory between the two previous spaces, a semi-private-semi-public space that includes cul-de-sacs streets, sitting platforms in front of house doors, and the center of neighborhoods. These spaces are forgotten in recent urban design approaches. Eliminating these spaces will reduce social relations among neighbors because there is no place to create and strengthen such relationships. These spaces can also increase security in the neighborhood and among neighbors by increasing the number of eyes on the street in many ways. The territory of a space can be determined by creating a difference in level, turning in the path of movement, planting trees, creating a wider street, or even building a façade (Pakzad, 2005).

- **Spatial hierarchy:** each principle can affect other features of the network.; for example, the feature of access of a network can be related to the degree of its integration, the type of territory, the principle of connectivity, and spatial continuity. Access to the organic network is generally possible from the main streets around the network but also inside the network. Most streets are defined as a long route from which branches reach the side streets and the doors of the houses. Therefore, access to this network is limited, except in cases where a person enters from outside the network through one of the main entrances. It is also difficult to change the route inside it due to the limited number of alternative routes and the large number of cul-de-sacs. It should be mentioned that considering the accessibility feature in the organic street network, facilitating movement and access to the center of the network (neighborhood center) was not the goal. The existence of a spatial hierarchy from completely public spaces (squares, mosques and religious schools, public baths, bazaars, etc.) to completely private areas (houses) leads to the restriction of access and movement of the network so that the behavior and movement of passers-by can be controlled and managed; because the old neighborhoods are generally created from distinct groups based on ethnicity, religion, trade, etc., and the residents have a particular interest and attachment to their neighborhood (Mashhadizadeh Dehaghani, 2014), so this feature limits the entrance and movement of strangers of the network. This is also related to the level of readability and transparency of this type of street network, which is complicated and confusing for non-residents; due to the role of traditional and religious beliefs and the desire to hide from strangers (Mashhadizadeh Dehaghani, 1994).

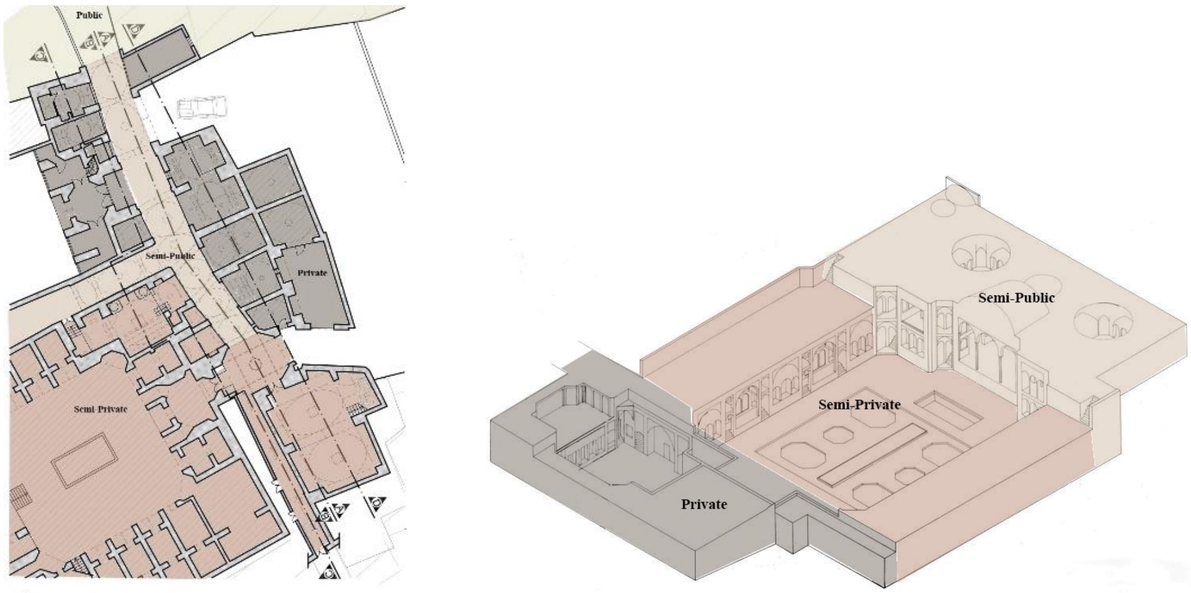


Figure 3.18. The principle of privacy – hierarchy of spaces in traditional Iranian houses and a neighborhood (Kashan, Iran) (Soltanzadeh et al., 1996)

- **Enclosure:** it is related to the streets' dimensions, size, and form, how to access the inside of the network, and the type of parts that enclose the streets and openings inside the organic network. Enclosed spaces may differ in terms of dimensions and size, form, way of access, and enclosing walls. The principle of enclosure somehow gives human scale to urban spaces and divides large dimensions and sizes into smaller spaces (Pakzad, 2005).

- **The principle of contrasting:** it mentions the spaces that differ in length, width, height, elements, and components that enclose the space. This causes the emergence of streets with different widths and lengths, urban nodes with small and large dimensions, and covered and open streets in the same neighborhood. This principle contributes to the attractiveness of the space, legibility, and comfort (Habibi, 2010; Motevalli and Sheikh Azami, 2013).

Figure 3.19. Contrasting subjects the dimension of the street and street walls, materials, colors, etc. (Tehran, District 12)

- **Principle of static and dynamic (pause and movement):** the neighborhood center acts like a magnet inside the interwoven network to invite and encourage people to reduce movement speed and pause in urban space to make social communications. Existing spaces that encourage people to slow down or stay inside the urban areas are the goals of the principle of static and dynamic. This principle creates an ecological balance for pedestrians to interact in the space, rest, and build social relationships while traveling a path and reaching from the origin to the destination. It encourages people to travel a longer route on foot due to the resting possibilities along the way

(Tavassoli, 1997). The pause spaces can be in the form of a square, a network node with or without a platform, a bench for sitting, a fountain, a green space, a park, a building with a social-cultural use such as a mosque, an urban element or even an empty open space. These spaces can be embedded in the outer wall of the network (such as the Tehran Grand Bazaar neighborhood and Sabzeh Maidan) or inside it (such as Ekhtiyariyehand Arghavan Park).

Figure 3.20. A pause spot in Sanglaj neighborhood in Tehran (Author, 2022)

- **Principle of scale and proportion**: The creation of pause and movement spaces of the network has been done considering the scale and proportion; because these spaces were designed by humans and at the height of the pedestrian's eye view and therefore there was a balance between the height of the wall and the width of the street. Therefore, space should not be so large that pedestrians lose the possibility of visual contact with their surroundings, and it should not be so small that being in it causes fear of the enclosed place. Unlike Western studies, no specific ratio has been considered for this scale, and it is regarded as a qualitative measure. This is because in Iran's hot and dry climate, in many cases, narrow streets due to the shading of the walls on the pedestrian routes provide better weather conditions and a more desirable space (Tavassoli, 1997; Motevalli and Sheikh Azami, 2013). This principle prevented the uniformity of connecting spaces and streets and is related to the contrasting principle. Accordingly, the streets in the organic network are wide and narrow, covered, or open. Considering the hot and dry climate of Tehran, the covering of streets adds to the comfort and convenience of the street, and the creation of shade in parts of the street also contributes to its attractiveness and beauty at different times of the day. What is essential in this principle is that the pedestrian should be able to recognize these changes with his eyes while walking through the network, and at the same time, the human scale of the space should not be distorted.

Figure 3.21. Sabat (covered street) in Sanglaj Neighborhood in Tehran (Author, 2022)

Nevertheless, the organic network has been formed based on the pedestrian-oriented approach. Because of the neighborhood's small size, the lifestyle of most residents, and the short distance between the origin and the destination at the formation, the general public commuted by walking. Due to the structure of the organic street networks, even today, cars in neighborhoods with organic texture face problems (Ayazi, 2013).

3.8.7.4. The Components of Organic Street Network

Spaces and elements of an organic network have had a more or less organized and regular relationship because these spaces have formed along the streets, under the influence of patterns and the behavior and culture of the people of the society as well as the historical parts were not formed with a fast rhythm like many cities today. On the contrary, they emerged in harmony with society's material and spiritual needs and with gradual growth and development (Soltanzadeh, 1993). Each model of the street network has a system and hierarchy of access. The street network of the old cities of Iran, which generally consists of an organic street network pattern, typically includes the following components[5] of a neighborhood.

[5] In defining the components of a network, the five urban elements of the Kevin Lynch (1960) have been considered.

Figure 3.22. Street hierarchy in Chizar neighborhood, Tehran (Author, 2023)

Main Streets

These streets served as continuous routes connecting the principal elements of the neighborhood. Some of these streets extended from one neighborhood's gate to another. In most cases, these streets traversed multiple neighborhoods, as exemplified by Chaharbagh Street in Isfahan. In certain instances, there were more than two intersecting axes.

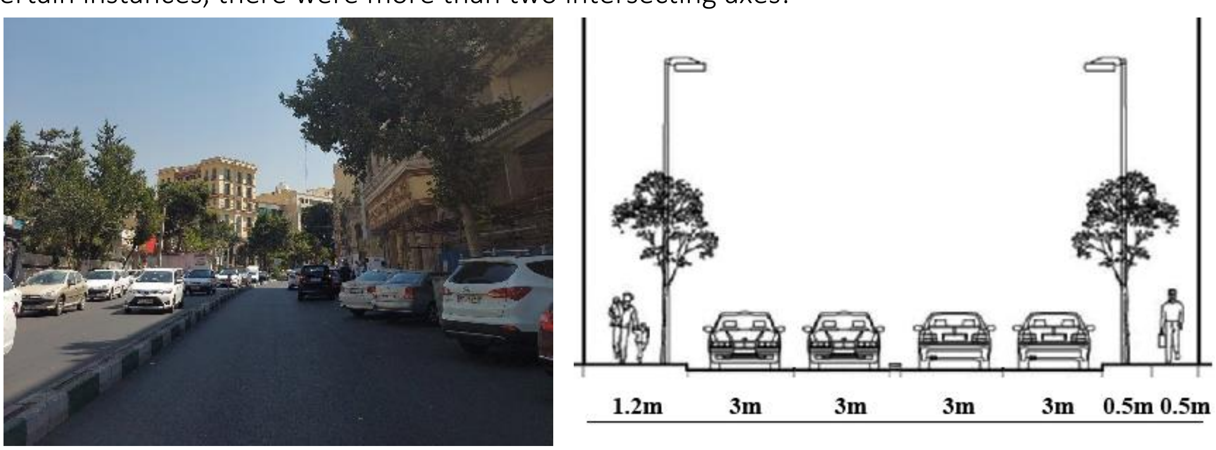


Figure 3.23. A main street in Chizar Neighborhood, Tehran (Author, 2022)

Secondary Streets

All the streets that connected the main streets or those built to provide access to a part of a neighborhood or several residential or urban units are considered secondary streets. These streets were shorter than the main streets, but the area covered by a side street was diverse. Some of these streets connected two neighborhoods, while some were only of one neighborhood's territory. The shape of these streets is straight and winding.

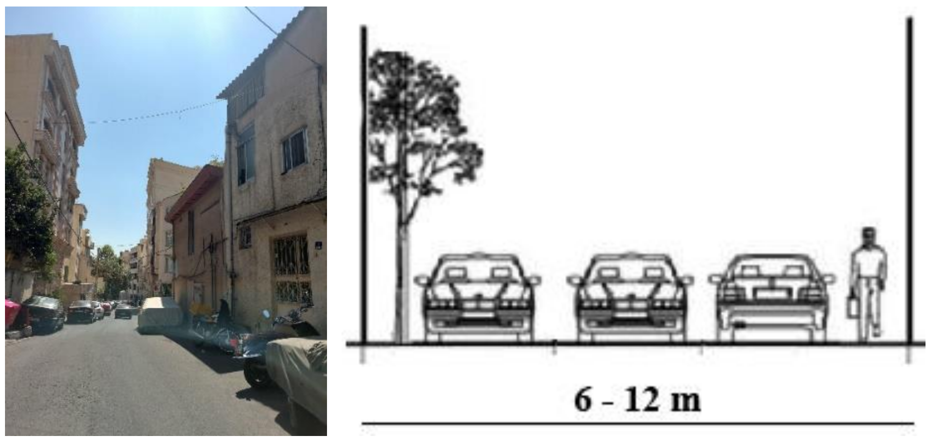


Figure 3.24. A secondary street in Chizar Neighborhood, Tehran (Author, 2022)

Gozar (Passage)

Gozar is an old name for the local street that shaped the skeleton of the neighborhood street network, and the other neighborhood elements have been placed around it (Habibi, 2003). Based on the research, Gozar gives meaning to the network's physical connectivity, has a semantic relation to the public spaces, and gives identity to the spaces (Abedini and Ayvazian, 2022).

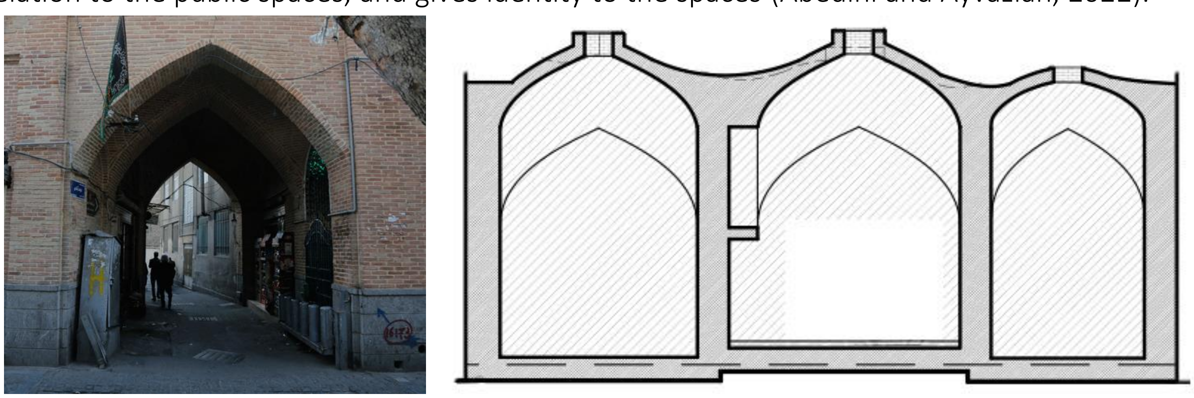


Figure 3.25. A Gozar in Sanglaj Neighborhood, Tehran (Author, 2022)

Cul-de-sacs

The construction of networks in cities with a continuous and dense texture with gradual and organic growth led to the emergence of many cul-de-sacs streets to provide access to several residential or other architectural units. The length of these cul-de-sacs streets is very different and reaches from a few meters to fifty meters and, in some cases, up to several hundred meters. Many of them are straight streets, but the curved cul-de-sacs are also not unusual in an organic street network.

Figure 3.26. A cul-de-sacs street in Dr. Hooshyar Neighborhood, Tehran (Author, 2022)

Garden Alley (Kuche Bagh)

It means the streets formed between gardens of a city (or outside the city) to pass through them or access them or other urban and non-urban spaces. Many of these streets follow the garden's boundaries; They are more or less straight. The width of most of them is small because the volume of traffic on them is also low.

Figure 3.27. Garden alleys in Darake Neighborhood, Tehran (Pourahad and Mousavi, 2021)

Square

Square means a platform at the intersection of two or more streets. Squares are usually used for street vendors, daily markets, demonstrations, meeting the neighbors, pausing and spending time inside urban spaces, etc. In some squares, lawns, fountains, memorials, and statues are built and placed for beautification. It can also contain some urban furniture like benches and trash bins. The squares can have a local or urban meaning. On a local scale, there is more like a neighborhood center and can be identified by widening the width of the streets; in this case, it does not have to cross two or more streets.

Figure 3.28. A square in Tehran (Azadi Square) (Hosseinivalad, 2019) and Rasht (Saat Square) (Memarnews, 2017)

Node

Nodes are the location of the intersections between two or more links (streets) together. The node includes other elements such as cul-de-sacs, street conjunctions, and squares. A square is also a node but also has a function. However, a node does not necessarily carry out a process and can be just a traffic point.

Figure 3.29. An intersection between a street and a cul.de.sacs in Chizar Neighborhood, Tehran (Author, 2022)

Markaz Mahale (Center of the Neighborhood)

There has been at least one neighborhood center in each of the old neighborhoods. These spaces are principally the meeting point of the neighbors and are of two types in terms of structure and shape. First, in the form of a Gozar, which was a little wider than other streets in the location of commercial and social spaces. The second type of neighborhood center is in the form of a square. These squares were often located at the intersection of several streets or next to the neighborhood's main street. Around some of them, there were several shops to supply daily and weekly essential goods to the neighborhood residents. Also, the mosque, bath, water tank, and other neighborhood public spaces were built next to this center.

Figure 3.30. Markaz Mahale in Sanglaj Neighborhood, Tehran (Author, 2022)

Water Quelle

As water is one of the most crucial issues in some countries, there were public spaces concerning water in each neighborhood. These spaces have also been used as meeting and pause points. There are many different types of water quelle spaces in an urban area, such as Qanat outlet, Ab-Anbar (water tank), Yakhchal (icehouse), and Hamam (public bath).

Figure 3.31. A water tank (Omuor, 2019), a Qanat outlet (IRNA, 2019), and an icehouse (Omuor, 2019) in Tehran

Edge

The edge evokes a stretch that has recognizable signs. Edges can be objective or subjective. Concerning accurate edges, two categories of natural edges, such as rivers, mountains, and valleys, or artificial edges, such as bridges, buildings, or highway bodies, can be referred to. Subjective edges include things like the skyline or even historical edges that don't exist today, like old city walls and fortifications.

Landmark

Landmarks, like edges, can be objective or subjective. Objective signs can help in the orientation of a network. Moreover, landmarks give identity to a neighborhood. They can have local, urban, national, or even international value. Subjective landmarks can refer to a historical event in a specific location or an origin birthplace of a prominent personality in a neighborhood.

Figure 3.32. A national (Milad Tower) and a local landmark (Ali-Akbar Imamzadeh) in Tehran (Author, 2018)

Religious Centers

Religious centers are among the most visited spaces in many countries and cities, especially in old neighborhoods. These spaces also function as pause and meeting points for the neighbors, which can be seen during different times of the day for praying, meeting, presenting, or pausing. Some of these spaces in Tehran are Mosques, Churches, takyeh, Hosseiniyeh, Synagogues, Saqa-Khaneh (literally a public water tap in memory of Imam Hossein in Shia), and religious schools.

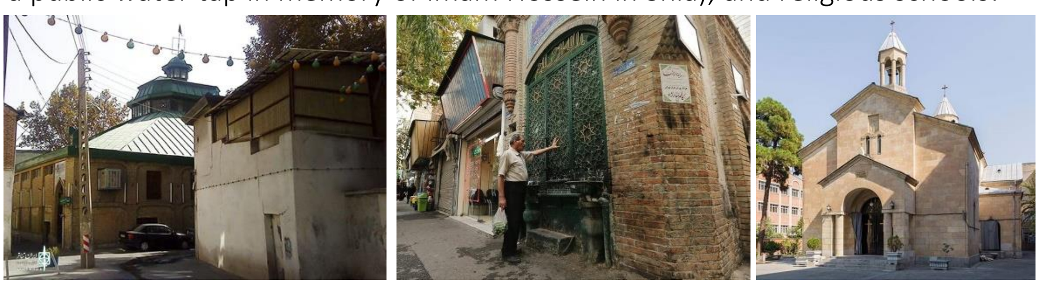


Figure 3.33. A Takyeh (Sheykhi, 2016), a Saghakhane (Fararu, 2022), and a church (Vanaei, 2015) in Tehran

3.8.7.5. Typology of Organic Street Networks

After analyzing the street network patterns in Tehran, it came out that 34 of 353 neighborhoods (in 22 regions) have organic street patterns, at least in some parts. A table has been prepared to separate the existing neighborhoods in each region and their street network pattern(s), which is given in full in appendix E of the thesis.

Accordingly, in this section, a list of the organic street networks is arranged into three groups: the main (original) organic street network, the integrated organic street network with another type(s) of network(s), and the imitative street network. The following map shows the distribution of this type of street network and its subsets in Tehran's neighborhoods.

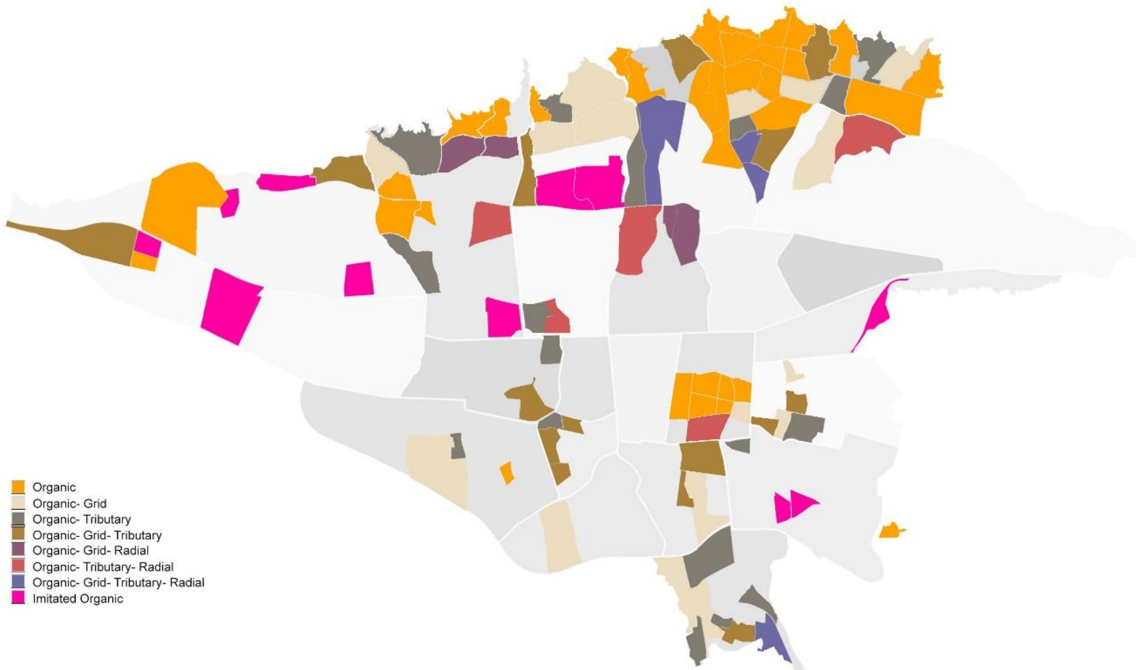


Figure 3.34. Neighborhoods with organic street network in Tehran (author, 2022)

3.8.7.5.1. Original Organic Street Networks

The original organic street network refers to the street network pattern formed over time-based on human needs and is also affected by economic, social, and physical factors. This model of the street network in Iranian cities existed in the old context of the cities as well as the historical parts.

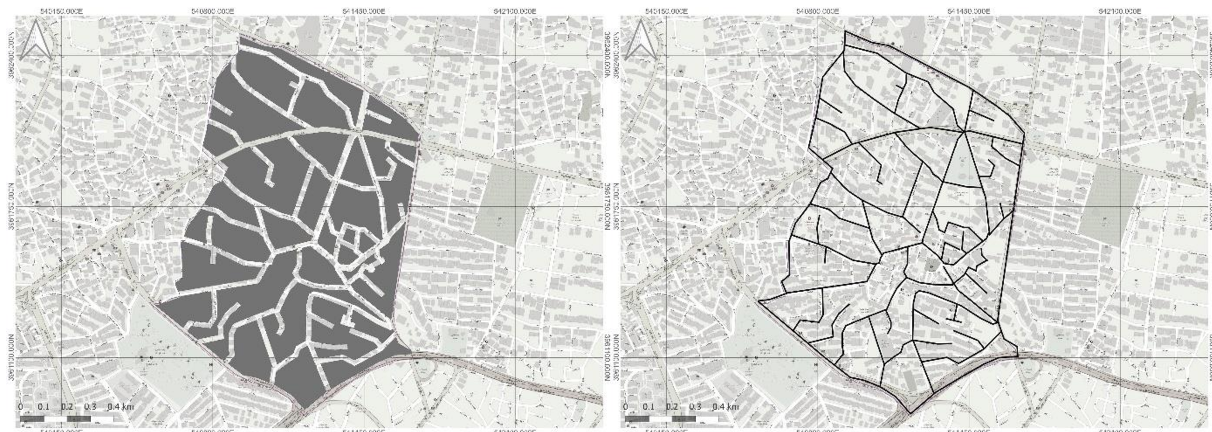
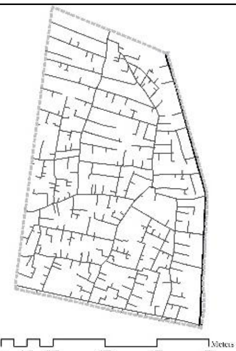
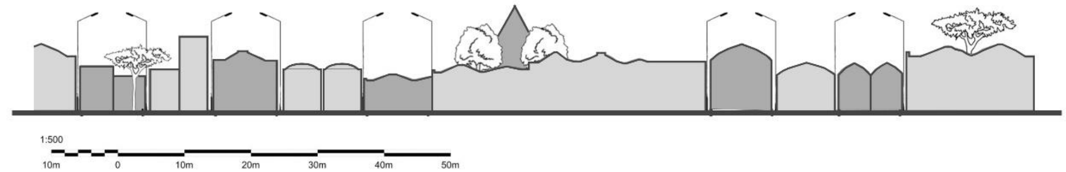
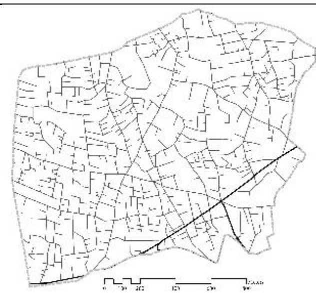
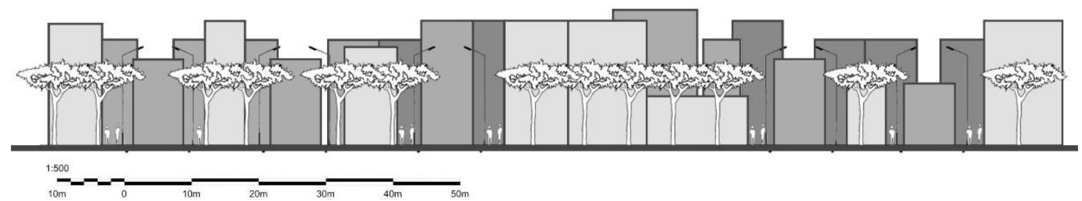
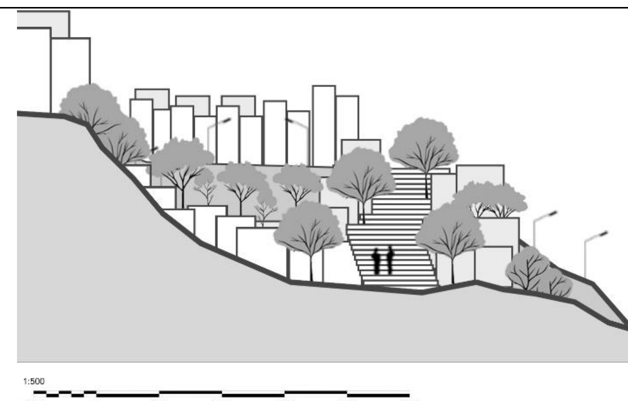


Figure 3.35. The blocks and street centerlines of an Original Organic Street Network (Author, 2022)

In Tehran, the main organic street network has generally been created for several reasons; Either these neighborhoods are located in areas near natural features such as mountains or rivers, or they are among the first territory of the city, which shows the history of the site. In addition to these two cases, there are parts in the current limits of Tehran that previously belonged to the villages around the city and have a network of rural organic streets. This network is most recognizable in the old neighborhoods, the historical center, and Tehran's edge of natural features. The map below shows the presence of the main organic street network in each of the twenty-two districts of Tehran. About 65.78 hectares (12.63 percent) of Tehran's street network belong to this category.

Although the remaining organic street network in Tehran can be seen in the city's northern areas and its historical center, Tehran and its surrounding areas, which are part of the city today, had an organic foundation too. However due to the possibility of extensive construction in other areas of the city, this network is not visible in its original form in different regions today. The lack of changes in this network in the northern parts of the city is because these parts were used as summer cottages until recent years (around the 1970s), and the constructions have been carried out over the last 50 years. For this reason, this part of the city's growth has been slower than other parts of Tehran. On the other hand, this part of Tehran is located on the slopes of the Alborz mountain range, and its topographic conditions have not allowed many changes and developments. When joining these parts to Tehran, its foundation was formed, and changes required many costs. Although the street network has not changed, these areas' high-rise construction and modern architecture create an unbalanced image of skyscrapers among the narrow, long, and curved streets. The following table shows examples of this type of network in Tehran. Based on the location, three models of the main organic network can be defined in the historical context, in the old context, and next to the land's natural features.

Table 3.7. Original organic street network types based on their shape

Street Network	Mahale - District	Street network diagram	Street section
Original Organic Street Network in Historic Center	Emamzadeh Yahaya – District 12		
Original Organic Street Network in Old Texture	Hekmat – District 1		
Original Organic Street Network next to the natural features of the land	Farahzad – District 2		

3.8.7.5.2. Integrated Organic Street Networks

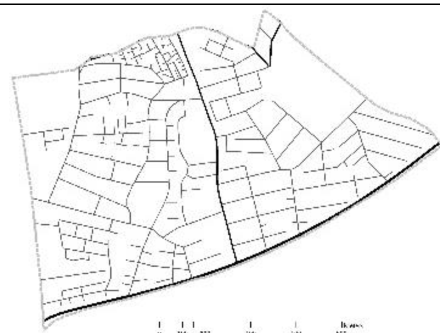
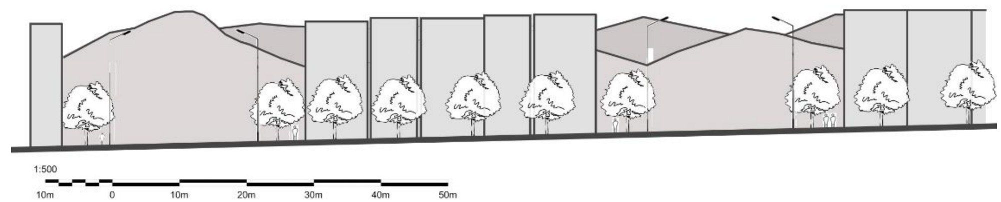
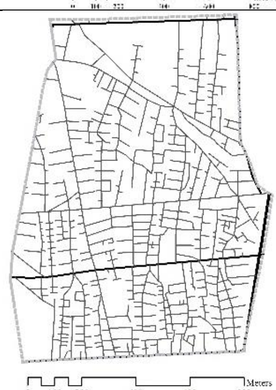
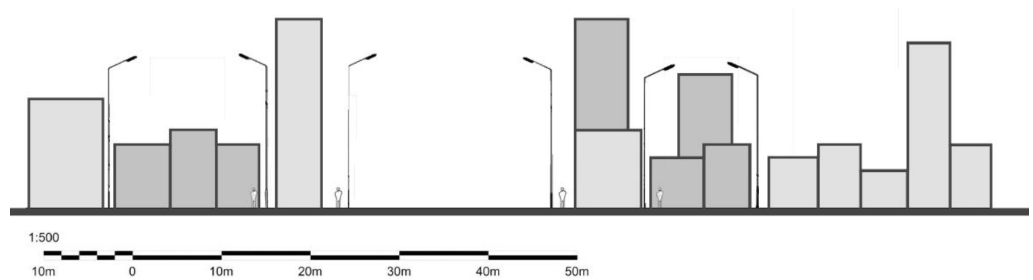
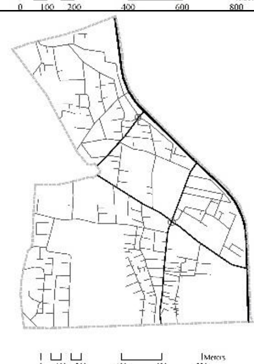
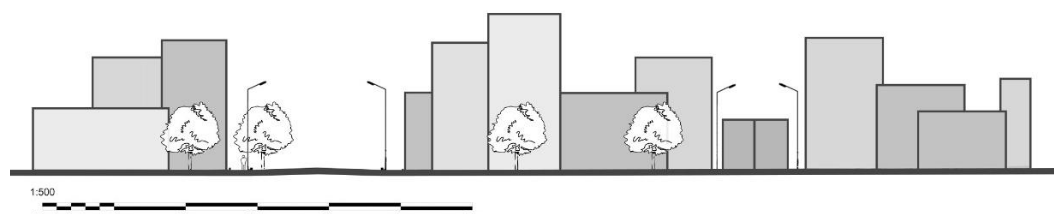
The expansion of urbanization and reforms carried out mostly between 1921 and 1961 were affected by modern views and Western ideologies. Streets characterized by ease and speed in implementation and maximum land use appeared in big cities. This approach became the basis of severe interventions and physical changes in the old textures of cities. In this way, perpendicular streets were drawn along the entrance and exit of the city, and the ancient context behind it also changed in some cases along with these streets, and some were left as it was. The organic street network combined with the grid network has a root in the early years of the current century. These measures in the 60s and 70s, with the expansion and intensity of urban development scales, caused physical changes in the street networks.

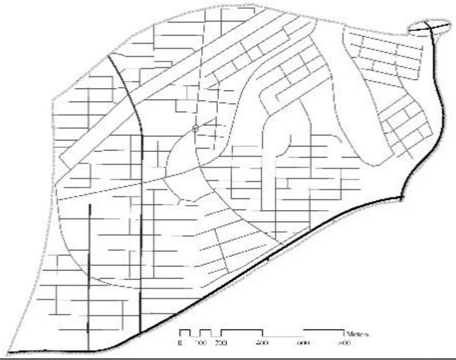
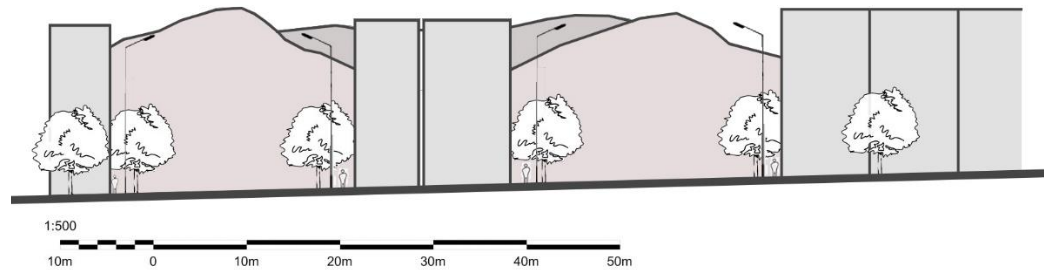
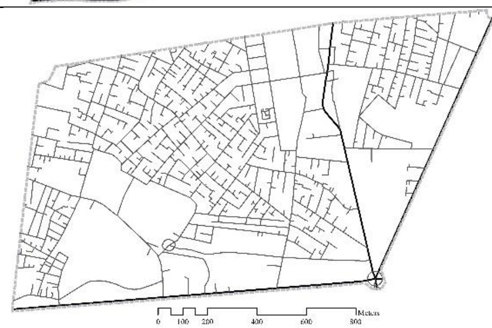
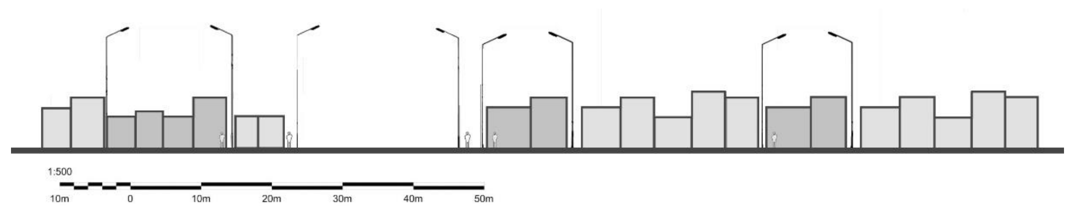
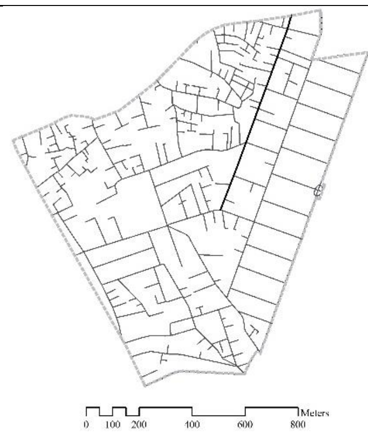
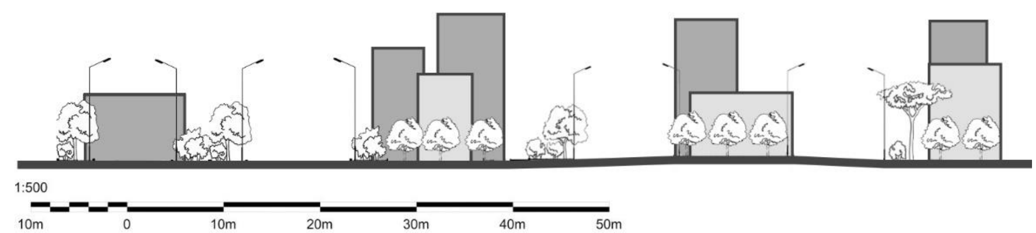
Figure 3.36. The blocks and street centerlines of an Integrated Organic Street Network (Author, 2022)

The meaning of integrated street network is one that had an organic street network in the past and is now integrated with another network(s) over time and through reforms and changes. As many urban planners and designers consider the network of grid streets to be pedestrian-oriented, stable, and suitable for providing services and access as well as readable (Lotfi and Bakhtiyari, 2013), this network, regardless of the main texture of the area, it is injected into the textures in the modifications of urban streets. For this reason, most integrations seen in the organic network of Tehran neighborhoods are integrated with the grid network. Sometimes, due to the lack of a proper budget, improvements or local repairs, or changes in land reforms, such as the retreat of houses to widen streets in line with new constructions, integration of the organic network with the unfinished grid street network or the tributary network can also be seen. Other cases are rare and result from building the highways and ring streets. According to the analysis, about 14865.81 hectares (24.15 percent) of Tehran's street networks belong to this category.

As can be seen from the above table, the most significant amount of integrated organic networks are, respectively, the integrated organic network with a grid system of about 5374.4 hectares and 36.15%, with grid and tributary networks of about 3492.48 hectares and 23.09%, with the tributary network about 3387.93 hectares and 22.95%, with grid, tributary and radial networks about 1033 hectares and 6.95%, with tributary and radial networks about 881 hectares and 5.97%and with grid and radial networks about 697 hectares and 4.61% of the total area of the integrated organic network of the neighborhoods in Tehran. Since the last three networks are scarce in Tehran and mainly include the ring streets, they will not be included in the division of the mentioned types of integrated organic networks in the rest of the project. The table below shows examples of the three types of integrated organic street networks in the neighborhoods of Tehran.

Table 3.8. Integrated organic street network types based on their shape

Street Network	Mahale - District	Street network diagram	Street section
Organic-grid	Gheytariyeh-District 1		
Organic-tributary	Dr. Hooshyar-District 9		
Organic-Grid-tributary	Teymuri-District 2		

Organic-Grid-Radial	North Janat Abad-District 5		
Organic-tributary-Radial	Harandi-District 12		
Organic-Grid-Tributary-Radial	Gholhak-District 3		

The expansion of this type of network in the northern areas of the city (north-northwest) can be justified due to the problems and challenges of changing the street network. In this case, the old structure remains organic, and the new constructions follow another approach. Neighborhoods with a network of integrated organic streets in the south-southwest regions, as well as Wardavard neighborhood in the west, due to their annexation to Tehran in recent years (last 20 years), have not had many changes in construction and renovation and, according to the statistics livelihood of the residents of these areas, it has not been possible for them to renovate the buildings because of the high costs. In case of expansion of constructions in these areas, taking into account the laws of land reform in Tehran to increase the width of the streets and reduce the curvature of the streets, these neighborhoods will also lose their organic form of streets. In the historical area of Tehran, the changes in the street network have generally been made by the private ownership of areas close to the Tehran Grand Bazaar to facilitate the movement of goods and vehicles, especially cargo trucks. This became more intense during the pedestrianization of Panzdeh Khordadand Naser Khosrow Streets, and as a result, streets were added to the network, which changed the form of the network to an integrated network.

3.8.7.5.3. Imitated Organic Street Networks

The pattern of the organic street network is considered the dominant pattern in old cities. This pattern of the network has features such as irregular, winding streets, the existence of hierarchy in the components of the streets, being influenced by the needs and the natural state of the land, formation over time, etc. Since the organic network is created over time, this network cannot be used in the design principles of the street network of new developments and modifications of the old structure. However, the principles of this network can be used in planning new streets. Among these principles, we can mention the extension and non-interruption of the old urban structures and following the natural and organic lines of the environment (Tarashi and Qaraei, 2015). The result of following these principles and implementing them at the level of cities can be considered as an imitated organic street network.

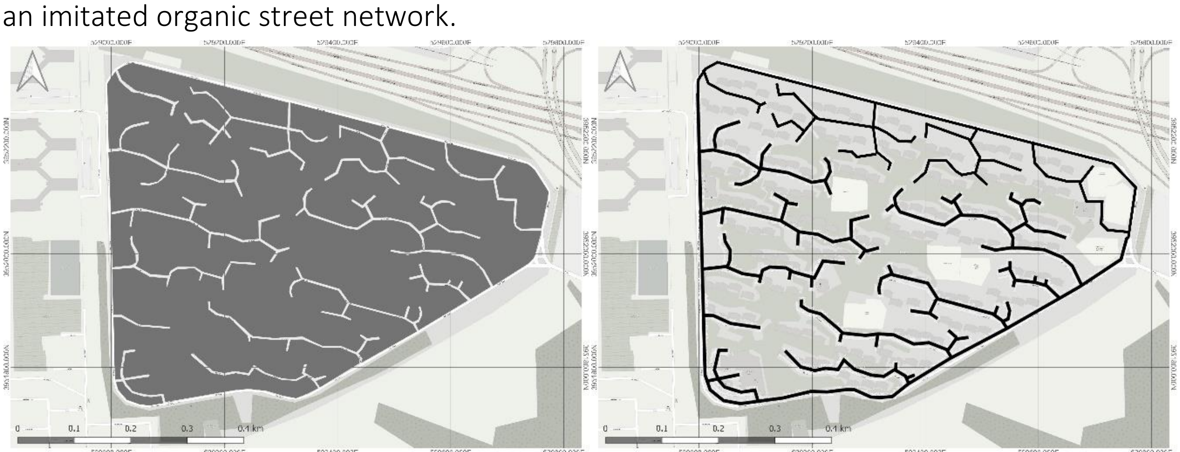
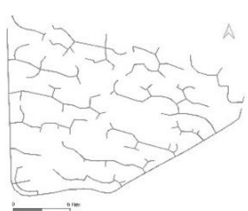
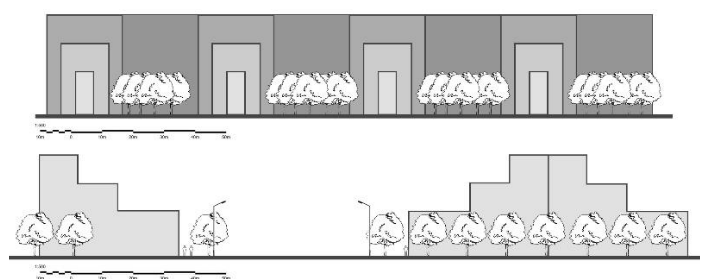


Figure 3.37. The blocks and street centerlines of an imitated organic street network (Author, 2022)

The imitative organic street network appeared in Tehran from the 1940s to 1970s. This era coincided with the postmodern movement and attention to the past among foreign urban planners, and designers invited to Tehran for design. In this period, some reputable Iranian architects collaborated with American, German, Belgian, and other architects and engineers to design and implement plans and projects. The organic street network has been considered a symbol of traditional urban design. The imitated organic network has been defined to improve neighbors' social relationships and strengthen the neighborhood-oriented approach. This type of network follows the physical characteristics of the organic street network and pays attention to the hierarchical principle of streets. It is a designed network that adapts the features of the original network according to the needs of the neighborhood's citizens. There are reforms to improve access and service, such as widening the streets. As this concept started in America, the main principles of this network follow the American urban design style. But like the original street network, many features should be adapted to where the network will be planned and built. Initially, the imitated organic street network had been planned for the residential blocks to create a small town inside an urban district. Some of these towns have low-density villa buildings with a maximum of three-story floors. Still, most of them have high-rise and luxury residential towers due to the demand and the high income and social level of the target population to live in them. The analysis shows that about 2278.92 hectares (3.7 percent) of Tehran's street network belong to this category. The following table shows an example of this type of network.

Table 3.9. Imitated organic street network type based on the shape

Street Network	Mahale - District	Street network diagram	Street section
Imitated Organic Street Network	Apadana-District 5		

4. Assessing the Walkability of Organic Street Networks in Tehran

After studying the foundation elements of the research, it is necessary to understand how the configuration of organic street networks affects walkability factors. The following table illustrates the walkability assessment factors based on the elements of the street network configuration. To measure the walkability factors, tangible and intangible indicators, the measuring method, and the scale of the study have been mentioned.

Table 4.1. Walkability assessment factors, elements, indicators, methods, and scale in Tehran organic street networks

Factor of walkability	Element of the street network	Indicator	Method	Scale
Safety against moving traffic	The width of the streets	The possibility to separate pedestrian and vehicle spaces; the width of the street more than 6 meters	Mapping based on GIS, Questionnaire	Street
	The form of the streets	Physical and visual barriers due to the form of the street – the topography	Mapping based on Questionnaire	Street
Security against crime and harassment	Hierarchy of spaces	Existing semi-public spaces	Mapping based on Questionnaire	Network
		Accessibility from one street to the others (betweenness)	GIS data	Network
	Street configuration	Eyes on the street - Blind corners, Indefensible spaces	Mapping based on Questionnaire	Network
	The form and height of the streets	Street lighting	Questionnaire data	Network
Accessibility	Number of intersections	Calculating the number of intersections	GIS data	Network
Connectivity	Principle of continuity and connectivity- Physical connectivity	Beta and Eta indexes	GIS data	Network
	Principle of continuity and connectivity- spatial continuity- Visual connectivity	Street and street network landmarks	Mapping based on GIS and Questionnaire	Network

Climate comfort	Contrasting, human scale, orientation, principle of scale of proportion	Constructional elements to consider the climate such as Sabat, roof, specific flooring and using steps because of topography, trees as street elements, and the shadow of the street facades and orientation of the streets inside the network	Mapping based on GIS and Questionnaire data	Network
The quality of the built environment	Human Scale/ Scale and proportion	Creating a sense of proper enclosure by respecting the ratio of height to width	Mapping based on Questionnaire	Network
	Permeability	Number of dead ends	GIS data	Network
		The number of intersections and the small distance between intersections	GIS data	Network
	Readability	The ability to detect branching paths from a street	Questionnaire data	Network
Attractiveness and beauty	View	The level of visibility of the skyline and natural elements	Mapping based on GIS	Network
		Creating shade due to the presence of the roof and sabbat and the narrow width of the path	Questionnaire data	Network
	Greenery	Trees on the streets, old trees	Questionnaire data	Network
	Water	Rivers, Qanats, and water channels	Questionnaire data	Network
	Sounds	Sounds of traffic, water, nature, life	Questionnaire data	Network
	Smell	Smell of nature, water (positive and negative), city	Questionnaire data	Network
	Buildings – Street walls	Old and important neighborhood/city places and buildings, holy and religious places and buildings	Questionnaire data	Network
	Variety/ Principles of contrasting	Visual analysis	GIS data	Network
		Opening and different widths of the streets	Mapping based on GIS	Network
		Proportion between full and empty spaces	GIS data	Network
		A variety of old street elements were used including Sagha Khaneh and Gozar, Kuche-Baq, street roofs, and Sabat and arch	Interview and Questionnaire data	Network

Walkability is constantly introduced as an ability to walk on a street. As the street network contains many streets, walkability must be seen in the network. But as mentioned before, considering the principles of the hierarchy of spaces in traditional Iranian urban design, an organic network in Iran has been formed in two scales of the inner and outer neighborhood. The internal parts include semi-public and semi-private spaces for the users, and their entrance is not desirable. To respect Iranian principles, the neighborhoods have been studied based on the neighbors' points of view. If a space is not walkable for the neighbors, it is also unsuitable for the other users.

In this section, the case studies have been introduced based on their physical characteristics considering the traditional Iranian urban design principles.

4.1. Case Studies

According to the case study approach of the research, six neighborhoods (Mahale) of Tehran, which have the original (old part of the city (Chizar) and historic center (Sanglaj), integrated (organic – grid (Qeytariyeh); organic – tributary (Dr. Hooshyar); organic – grid – tributary (Darrous)) or imitative organic structure (Shahrak-e Qarb [Qarb Town]), have been selected for further investigation. The following map illustrates the location of these neighborhoods in Tehran.

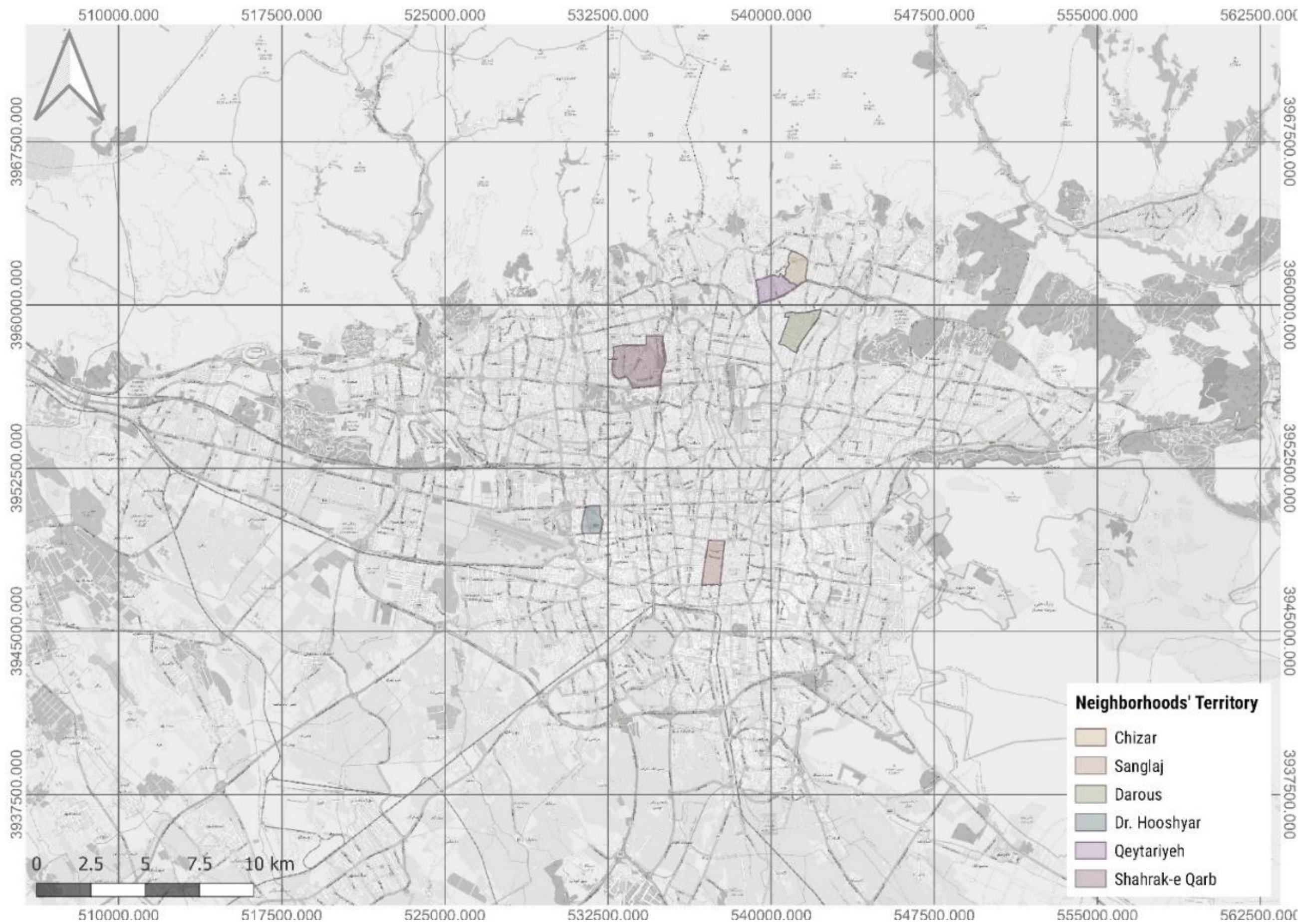


Figure 4.1. The location of the selected neighborhoods in Tehran (Author, 2022)

4.1.1. Chizar Neighborhood (Original Organic Network in Old Tehran)

The Chizar neighborhood is located in district one of Tehran municipality in the north of the city. This neighborhood is also considered one of the old neighborhoods, which originally was a village in the north of Tehran. It became connected to the city as it expanded and became a part of Tehran. The neighborhood covers an area of 120 hectares[2].

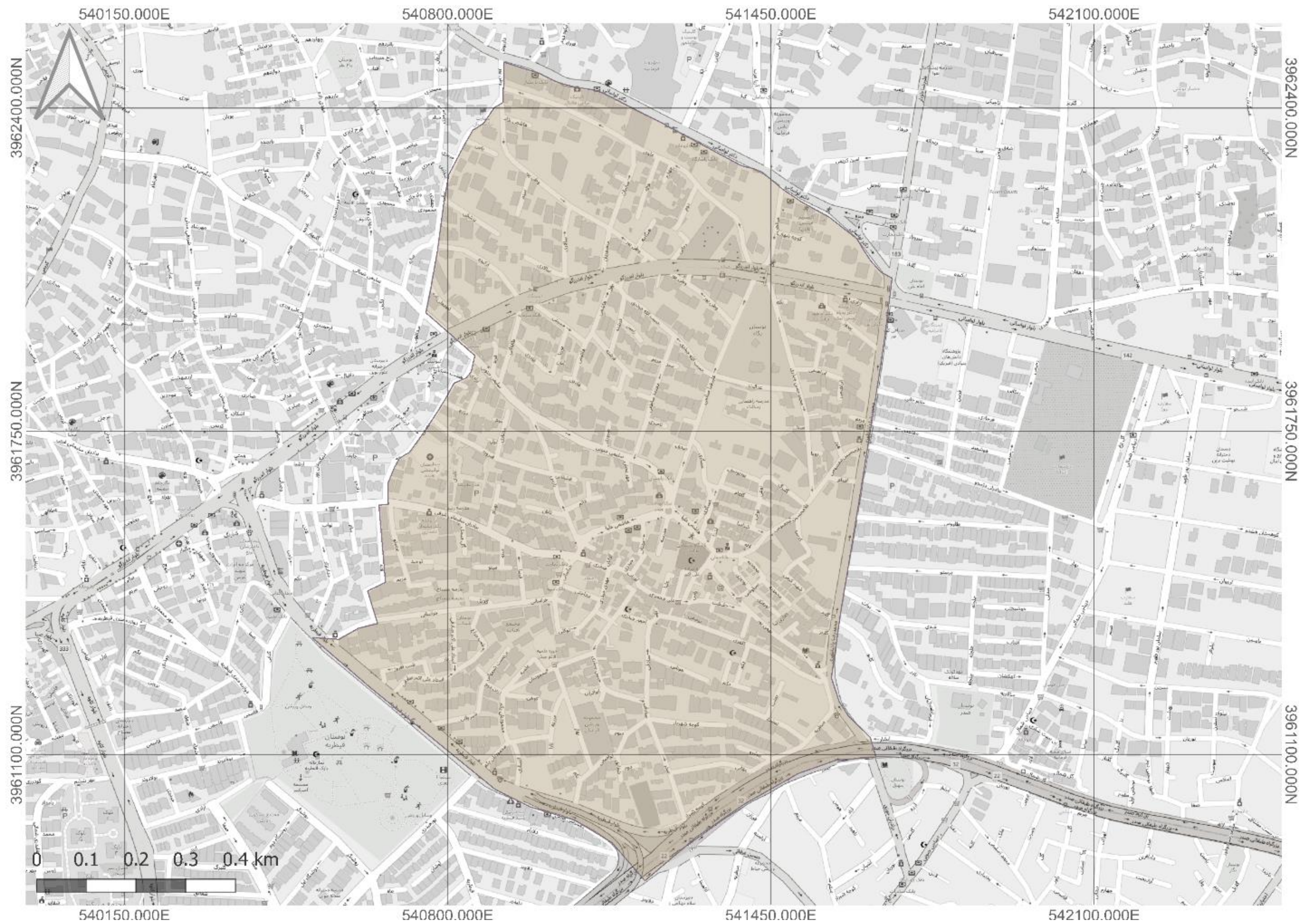


Figure 4.2. The territory of the Chizar Neighborhood (Author, 2022)

The neighborhood's layout has been influenced by the historical small ownership system, the routes of two qanats (underground aqueducts), and the presence of the religious center of Imamzadeh[6] Ali-Akbar. The historical ownership system has left traces in the form of protrusions and recesses in street walls, where some owners expanded their property area by seizing street space.

Figure 4.3. The organic street network and the location of two qanat routes in Chizar (Zarifmanesh, 2023)

[6] Holy shrine

The neighborhood's expansion takes the shape of a triangle, originating from the core around Imamzadeh Ali Akbar. It extends in three different directions, reaching Imamzade Ismael in the southeast, the mountain in the north, and the royal garden in the southwest. The two qanat routes also contribute to its underground expansion. While many gardens have been replaced by high-rise buildings due to increased demand for living in the neighborhood, the organic street network still retains its original form, closely tied to the area's topography and natural characteristics.

Figure 4.4. The density of buildings and the neighborhood center (Imamzadeh Ali Akbar) (Aslani, 2022)

The neighborhood under study possesses several distinctive characteristics. It is known for its small blocks, resulting in a high population density. This compact nature fosters a strong sense of community and intimacy among residents. The streets are often narrow, curved, and jagged in their layout. This unique street pattern is influenced by recent construction practices and regulatory adherence, preserving the original street structure, including old trees, religious and historic sites.

Additionally, remnants of old gardens still exist within the neighborhood, influencing its design. These remnants create open communal spaces for residents, offering areas for relaxation, recreation, and social gatherings. If accessible to the public, these open spaces serve as focal points for residents to connect with nature and engage in various activities.

The combination of small blocks, high density, narrow and curved streets, and open spaces shaped by remnants of old gardens creates a unique and dynamic urban environment. This mix of elements fosters diversity and liveliness, offering residents various experiences and opportunities for interaction. Furthermore, the distinctive street layout and integration of open spaces promote walkability and encourage residents to explore the neighborhood on foot. Although challenging for vehicular traffic, the narrow and meandering streets create a pedestrian-friendly atmosphere, making it pleasant and convenient for residents to navigate on foot. This emphasis on walkability contributes to a healthier and more sustainable community, reducing reliance on private vehicles and promoting active lifestyles.

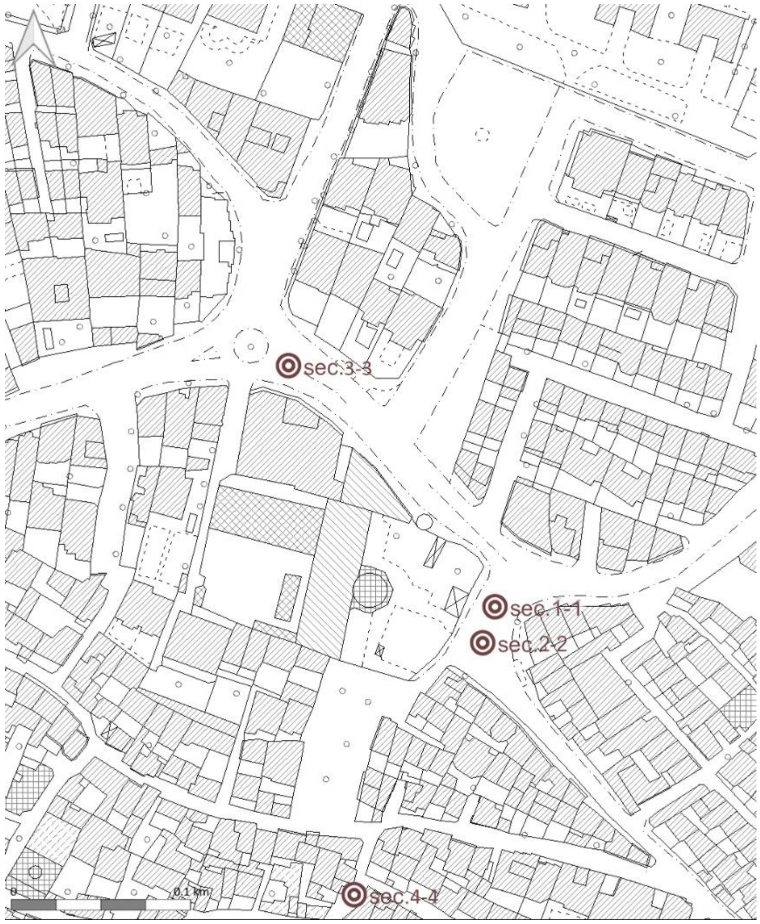


Figure 4.5. The site plan of the main center of the Chizar Neighborhood

In summary, the Chizar neighborhood's small block size, high density, intricate street layout, and the presence of open spaces shaped by old gardens combine to create a vibrant and engaging urban environment. These features not only contribute to the neighborhood's unique aesthetic appeal but also enhance its livability, fostering a strong sense of community and promoting sustainable modes of transportation. The neighborhood's character, influenced by historical elements and contemporary design choices, offers residents an enriching and enjoyable living experience.

Figure 4.6. Section 1-1 (left) and 2-2 (right) of the center main and secondary streets in the Chizar Neighborhood with pavements

Figure 4.7. Section 3-3 of a curved secondary street in Chizar Neighborhood without pavement

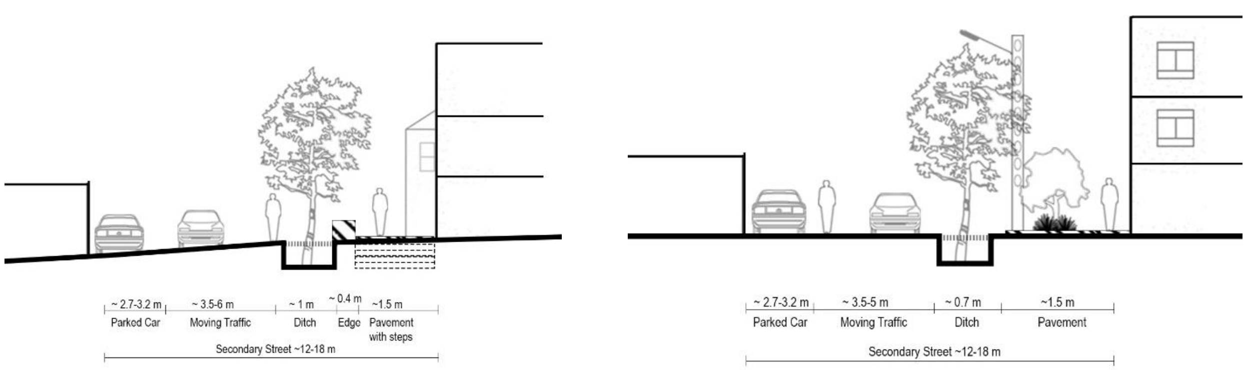


Figure 4.8. Section 4-4 (left) and 5-5 (right) of the secondary streets in the Chizar Neighborhood with pavements

Chizar has a unique topography, resulting in steep streets that require considerable effort to traverse. However, the presence of steps along the walkways makes it easier for people to navigate the steep terrain.

In addition to challenging walkways, the neighborhood is known for its lush greenery, largely thanks to active qanats in the area. Qanats are underground aqueducts used for irrigation in arid regions. They bring water from underground sources to the surface, enabling vegetation to thrive even in desert-like conditions. The abundance of trees adds to the neighborhood's natural beauty and provides shade from the sun, making it a more pleasant place to live. Despite the challenges of navigating the terrain, the beauty and benefits of the lush greenery make it a desirable place to live.

Figure 4.9. Topography in Chizar streets (Havashem, 2018)

4.1.2. Sanglaj Neighborhood (Original Organic Network in Historic Core)

Sanglaj is one of the five neighborhoods in old Tehran, located in District 12 of Tehran Municipality. Originally, this neighborhood was the site of Safavid gardens. As Tehran transformed into a city and developed, Sanglaj also took on a residential role. The key elements of this neighborhood include a mosque, a school, a qanat (underground aqueduct), a bathhouse, a church, a caravanserai, religious centers (Tekiyeh and Saqakhaneh), numerous water storage tanks (Ab Anbar), a natural refrigerator (Yakhchal), and a military barracks. The neighborhood covers an area of 103 hectares[2].

Figure 4.10. The territory of Sanglaj neighborhood (Author, 2022)

Initially, Sanglaj lacked an Islamic center, which led to limited residency by Tehranis. It was primarily a residential neighborhood for Christians. The presence of multiple qanats, water reservoirs, and an abundance of water contributed to the neighborhood's appeal in the early Qajar era (late 18th century), promoting its greenery.

Figure 4.11. The organic street network in Sanglaj (Author, 2022)

Following World War II, a significant portion of Sanglaj faced destruction, ushering in a transformative period in its history. Amidst the rebuilding efforts, something remarkable emerged:

the establishment of Tehran's first public park. Over time, the architectural style of this neighborhood aligned with other areas of Tehran. Houses were designed and constructed similarly to those in neighboring districts, contributing to the city's cohesive visual identity. However, what sets Sanglaj apart is its ability to retain an organic texture. Despite physical similarities to other parts of Tehran, Sanglaj has maintained its unique and authentic character. This preservation of its organic texture can be attributed to two critical factors: the rich heritage values within the community and deliberate limitations on alterations to its historic fabric. Residents and authorities recognize the importance of safeguarding the neighborhood's distinct character and honoring its cultural and historical significance. Consequently, interventions and modifications are carefully regulated, ensuring the authenticity of the neighborhood's organic texture remains intact.

Figure 4.12. Site plan of a center in the Sanglaj Neighborhood

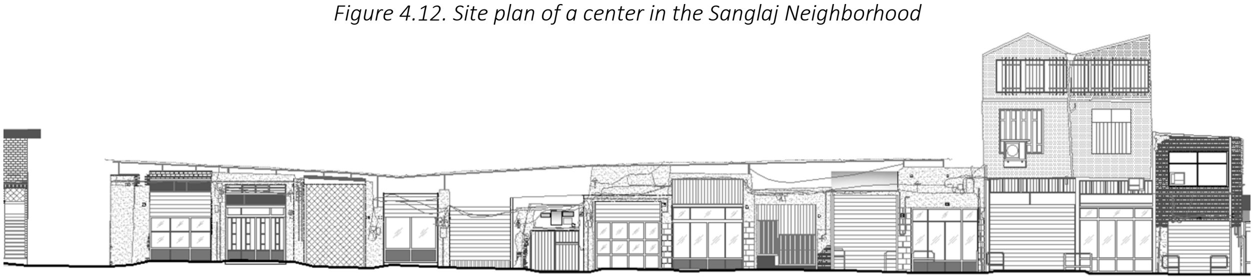


Figure 4.13. Section 1-1 in the Sanglaj Neighborhood

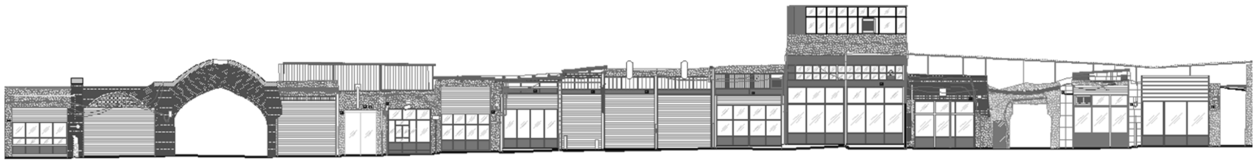


Figure 4.14. Section 2-2 in the Sanglaj Neighborhood

Figure 4.15. Section 3-3 (left), 4-4 (middle) and 5-5 (right) in the Sanglaj Neighborhood

Presently, the structural integrity of the neighborhood is significantly compromised, with numerous deteriorating spaces scattered throughout. This situation is primarily attributed to the neighborhood's proximity to the bustling Tehran Grand Bazaar. Over time, a considerable portion of residential houses in this community has been sold or rented to bazaarians in need of storage space for their goods. As a result, the original residents have gradually relocated to northern neighborhoods, leaving behind a void that temporary accommodations for bazaar workers have filled. This transition has brought about a notable shift in the neighborhood's social fabric. The diverse community that once thrived here has been replaced by a predominantly transient population of bazaar workers. These workers, seeking convenient and temporary housing near their workplace, have occupied the vacant houses. Consequently, what was once a vibrant and tightly-knit community now grapples with an influx of temporary occupants who lack the long-term investment typically associated with residential neighborhoods. These changes have far-reaching effects, impacting not only the neighborhood's physical appearance but also its social dynamics and sense of community. The absence of permanent residents has eroded the neighborhood's sense of belonging and collective identity, leading to reduced community engagement and civic participation. The once-rich tapestry of shared experiences, traditions, and cultural practices has become fragmented, making the task of fostering a cohesive and connected community increasingly challenging.

Despite the current state of disrepair and social transformation, there remains hope for the neighborhood's revitalization. Efforts are underway to raise awareness about the area's challenges, advocating for the preservation of its architectural heritage and the restoration of its structural integrity. Local organizations and concerned citizens are working to reclaim the neighborhood's original charm and reinstate it as a vibrant residential community.

Figure 4.16. The density of buildings in Sanglaj neighborhood (Author, 2013)

The impact of this transition is evident in the neighborhood, as once-thriving residential spaces have become dilapidated and neglected. Lack of maintenance and regular repairs has resulted in the deterioration of structural quality throughout the area. Many buildings show signs of wear and tear, with crumbling facades and neglected interiors reflecting the gradual decline of the neighborhood's overall aesthetic. The neighborhood is characterized by an exceptionally high density of buildings, resulting in a crowded and tightly packed urban environment. Blocks in the neighborhood are relatively small, and streets meander in narrow and curved paths. Although there is no distinct central focal point, the streets widen near the church, subtly indicating the prominence of the local landscape.

Regarding height, most buildings in the neighborhood are three to four stories tall. However, the overall construction quality leaves much to be desired, with many structures exhibiting deterioration and wear, requiring extensive repairs or complete reconstruction. These buildings, showing their age, bear the marks of time, and their dilapidated condition contributes to an overall impression of neglect and decay. The condition of the streets' flooring, roofing, and pavement is particularly subpar. Most side streets feature crumbling asphalt, creating an uneven and deteriorated surface. Furthermore, the facades of the routes suffer from damage, dirt, and even partial burn marks, further adding to the overall sense of disrepair and neglect.

Unfortunately, green spaces are scarce in this neighborhood, depriving residents of vital areas for recreation and respite. The absence of parks and gardens exacerbates the sense of urban congestion and adds to the challenges faced by the community. Additionally, the qanat canal, once an essential water source and a potential site for natural beauty, has fallen into a state of ruin and disrepair, further compounding the neighborhood's struggles.

Figure 4.17. The construction quality in Sanglaj neighborhood (Amirhasani, 2017)

4.1.3. Qeytariyeh Neighborhood (Integrated Organic – Grid)

Qeytariyeh is a historic neighborhood located on the outskirts of Tehran. It originally started as a peripheral village and gradually integrated and developed into the city over time. A portion of this village was situated atop a hill. The neighborhood's inception can be traced back to 1946, and by 1969, it had experienced significant growth with the establishment of residential areas and a network of main streets.

During the Qajar era, Qeytariyeh Castle served as a seasonal residence for people, as fortifications were no longer necessary for the village, and the military center had shifted to the northern part of Tehran. Unfortunately, the Qeytariyeh Castle fell into disrepair and was in ruins before the Islamic Revolution of Iran in 1979. In that transformative year, the neighborhood underwent substantial development, and the hill's open spaces were completely built upon, leaving no vacant areas within its confines. Presently, Qeytariyeh encompasses an area measuring 155 hectares[2].

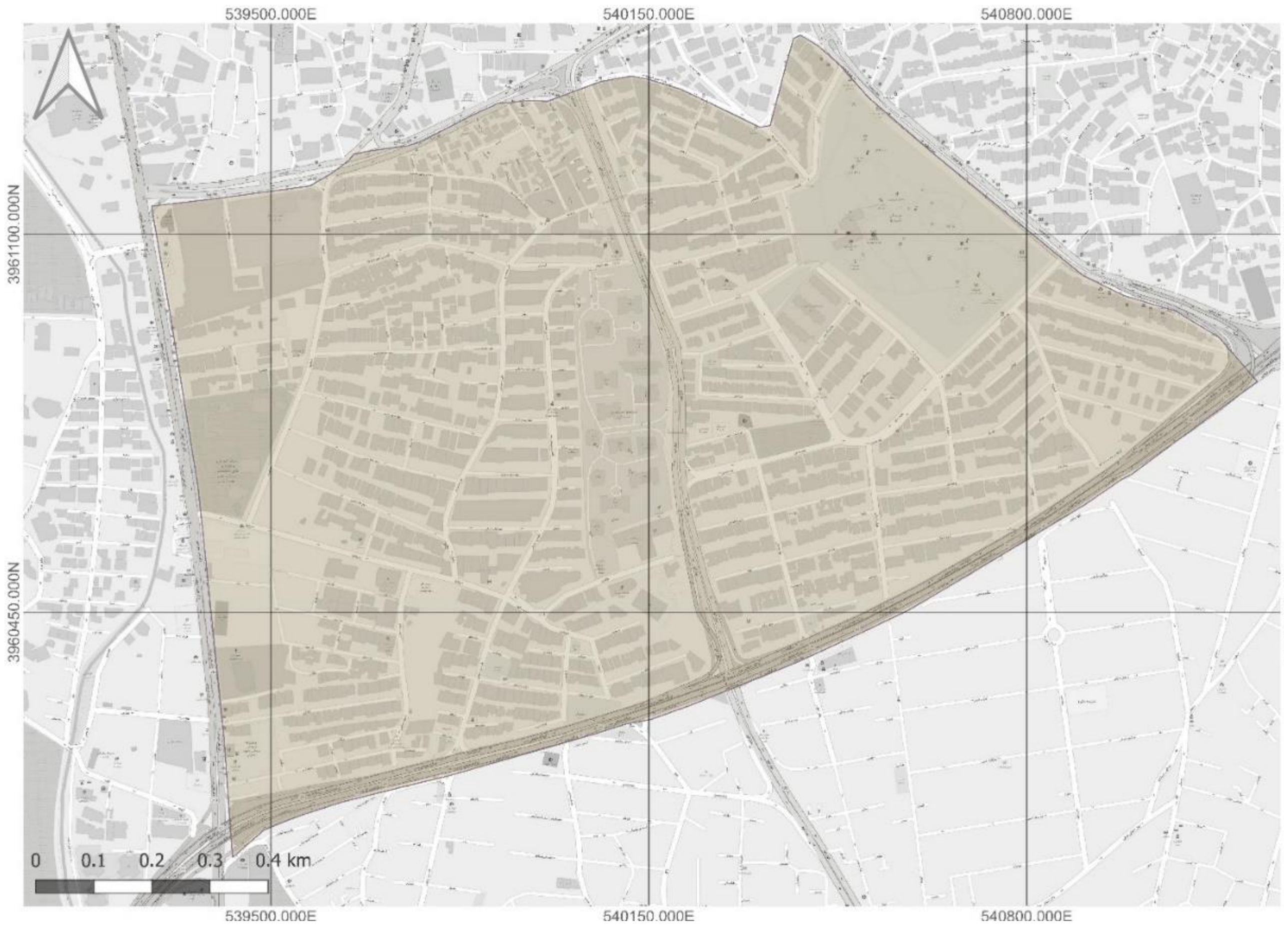


Figure 4.18. The territory of Qeytariyeh Neighborhood (Author, 2022)

In comparison to the past, there has been an increase in the number of building floors, deviating from the relatively small and uniform levels of most residential units that were characteristic of recent housing construction patterns (Hosseini et al., 2023).

One of the primary reasons for the establishment of this neighborhood was the presence of qanats. Some of these qanats are still in active use today to irrigate the green areas of the neighborhood (Ayazi, 2013).

Figure 4.19. The organic-grid street network and the qanat routes in Qeytariyeh (Author, 2022)

A key factor influencing construction in this neighborhood is the natural characteristics of the land and its topography, particularly due to the presence of hills during the city's development after the 1960s. To facilitate construction, certain areas of the hills were leveled, but the natural slopes of the land have been largely preserved, resulting in buildings being constructed at different elevations to accommodate the slope. The steepest slope in this neighborhood can be observed in the original core of the area known as Qeytariyeh Hill. The impact of the topography on the construction of this neighborhood is primarily reflected in the expansion of buildings in an east-west and north-south direction, following the slope patterns. As one moves away from Qeytariyeh Hill towards the south, the slopes gradually decrease in intensity (Ayazi, 2013). Due to the topography, there are numerous steps on the pavements of this neighborhood, and the streets themselves often exhibit slopes.

Figure 4.20. The topography of the neighborhood (Alikhani, 2020)

Figure 4.21. Site plan of a center in the Qeytariyeh Neighborhood

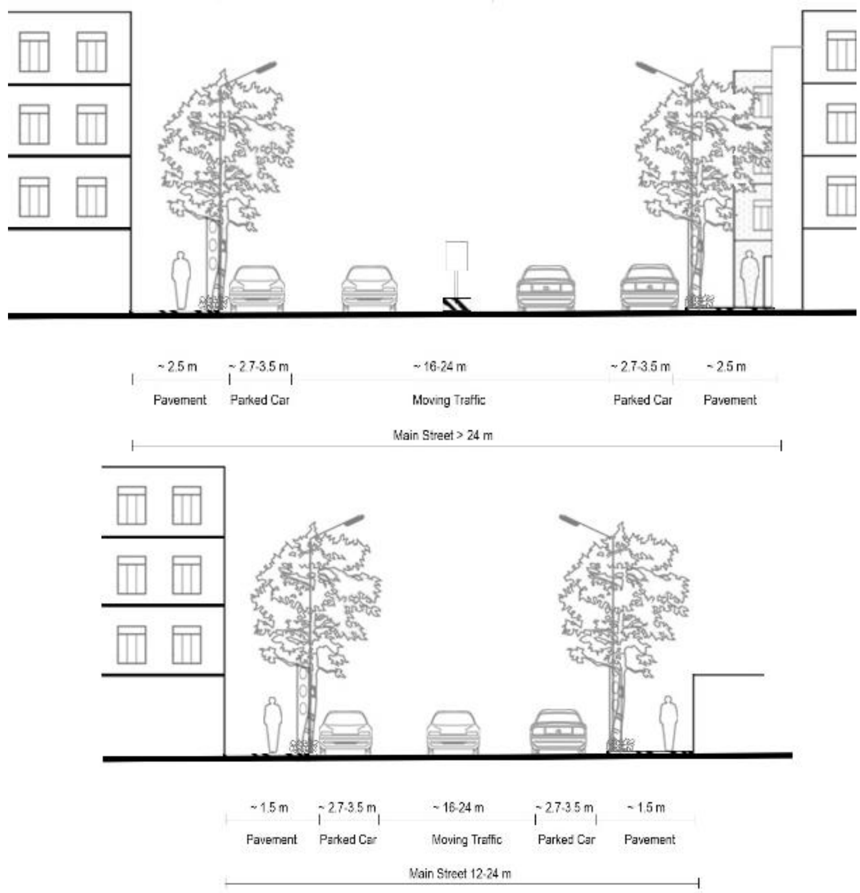


Figure 4.22. Section 1-1 (above) and section 2-2 (below) from two main streets in the organic part and the grid part of the neighborhood

Figure 4.23. Section 3-3 (left) and section 4-4 (right) from a secondary and a dead-end street in Qeytariyeh Neighborhood

Urban studies indicate the prevalence of irregular blocks with varying orientations (organic texture) in this neighborhood compared to later developments characterized by grid textures and regular orientations. Due to the influence of the local topography, the majority of blocks in this area do not have regular shapes, resulting in winding and shorter streets with various twists. Moving towards the south, the blocks acquire more regular geometric shapes, predominantly in an east-west direction. The streets in these areas are more frequent and intersect at right angles (grid texture). The main streets run north-south, while the side streets run east-west. The overall grain size of this neighborhood is primarily medium.

Figure 4.24. The density of buildings in the Qeytariyeh Neighborhood (Author, 2023)

4.1.4. Dr. Hooshyar Neighborhood (Integrated Organic – Tributary)

Dr. Hooshyar's neighborhood is located in District 9 of Tehran municipality, adjacent to Azadi Square. Similar to many neighborhoods in Tehran, it was once comprised of farms surrounding the city. These farms were transformed into a residential area in 1956 when streets were constructed. The neighborhood covers an area of 104 hectares².

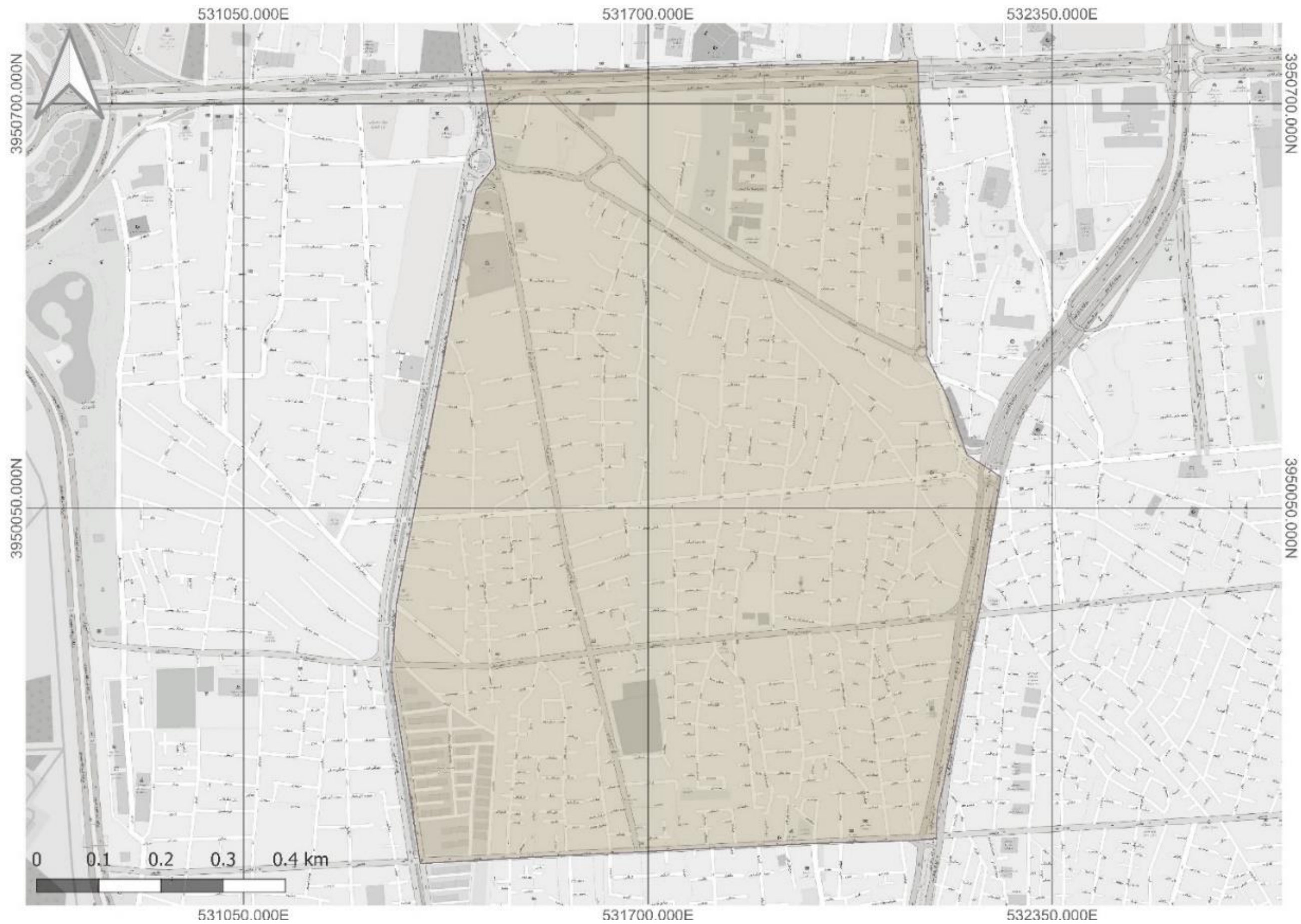


Figure 4.25. The territory of the Dr. Hooshyar Neighborhood (Author, 2022)

The presence of affordable, fine-grained properties, its proximity to the city center, and access to urban terminals have attracted immigrants from the northern and western cities of the country. Since 1976, there has been a decrease in agricultural land in the area. Due to its peripheral nature, the initial construction of this neighborhood lacked a comprehensive plan. Most parts of the neighborhood exhibit a dense and compact texture characterized by narrow and long alleys. As this neighborhood is situated on flat plains, there are no noticeable slopes, and the streets are also level. The buildings, for the most part, are worn out and are included in the renovation plans of the Tehran Municipality (Strategic-Structural Plan for Development and Urbanization of Tehran, 2007).

Figure 4.26. The street network and the location of qanat routes in the Dr. Hooshyar Neighborhood (Author, 2022)

Most of the buildings in this neighborhood, both old and new, are characterized by their low-rise structures, typically ranging from two to four floors in height. As one moves closer to the neighborhood's inner edges, these buildings undergo a transition, becoming notably smaller in scale and featuring fewer floors. This gradual diminishment in size and height is particularly evident along the neighborhood's periphery. It represents a stark contrast to the more densely constructed central area, where taller structures are prevalent.

Figure 4.27. Site plan of a center in the Dr. Hooshyar Neighborhood

Figure 4.28. Street Section 1-1 (left) and section 2-2 (right) from main and secondary streets in Dr. Hooshyar Neighborhood

Figure 4.29. Street sections 3-3 (above left), 4-4 (above right), and 5-5 (below) from secondary and dead-end streets in the Dr. Hooshyar Neighborhood

The absence of architectural coordination within the neighborhood leads to a fragmented visual landscape. Additionally, the majority of the buildings suffer from subpar quality, further exacerbating the neighborhood's overall aesthetic and structural challenges. This architectural inconsistency not only impacts the neighborhood's appearance but also contributes to a sense of disarray and disorder in its layout.

Figure 4.30. The construction quality in Dr. Hooshyar Neighborhood (Author, 2022)

In comparison to the other neighborhoods being studied (except Sanglaj), this area stands out for its marked deficiency in green spaces and the absence of mature trees, resulting in challenges for visual orientation and navigation. The ability to see from within the neighborhood to its surroundings is limited to specific streets that run in a north-south direction, largely attributed to the high-density construction that prevails throughout the area.

Figure 4.31. The density of buildings in Dr. Hooshyar Neighborhood

4.1.5. Darrous Neighborhood (Integrated Organic – Grid - Tributary)

Darrous, located in District 3 of Tehran Municipality, is yet another of the city's historic neighborhoods. In its early days, an Armenian village occupied the northeast region of the neighborhood, engaging in agriculture and animal husbandry in the surrounding lands. The heart of the community was centered around the Armenian Castle, situated near the church. This neighborhood spans an area of 198 hectares[2].

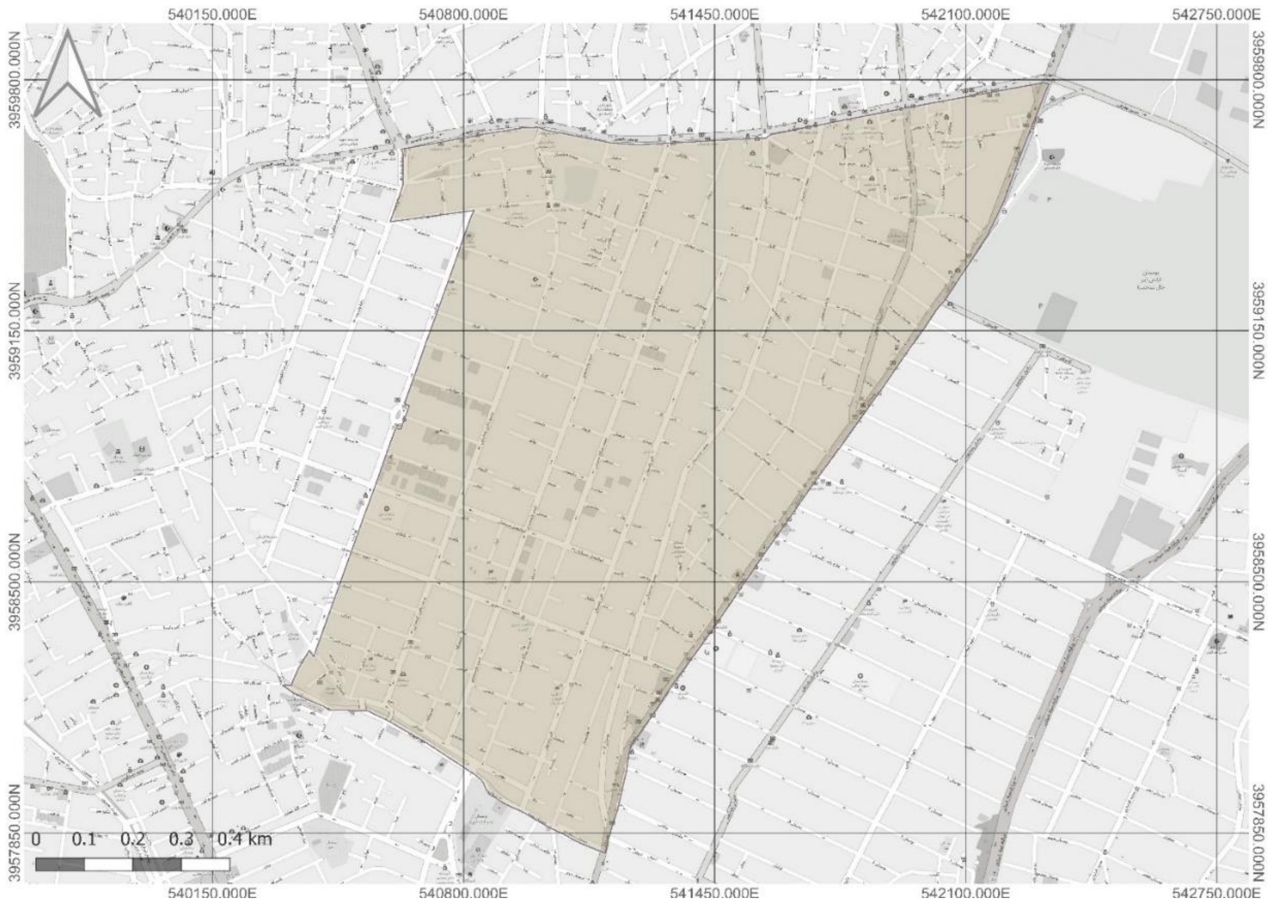


Figure 4.32. The territory of Darrous Neighborhood (Author, 2022)

The settlement of this area can be attributed to a significant historical factor: the presence of two qanat routes, the Nosrat Qanat and the Sheibani Qanat. These qanats have played a crucial role in the neighborhood's development by providing essential sources of both drinking and agricultural water. Even today, these ancient water channels continue to nourish the neighborhood's verdant green spaces, serving as a reminder of its agricultural heritage and the importance of sustainable water sources. Moreover, an eye-catching open water channel gracefully winds its way through the heart of the neighborhood, complemented by the majestic presence of old-growth trees. This iconic landscape serves as a living testament to the neighborhood's rich history and authenticity, creating a sense of connection to the past that enriches the community's character and identity.

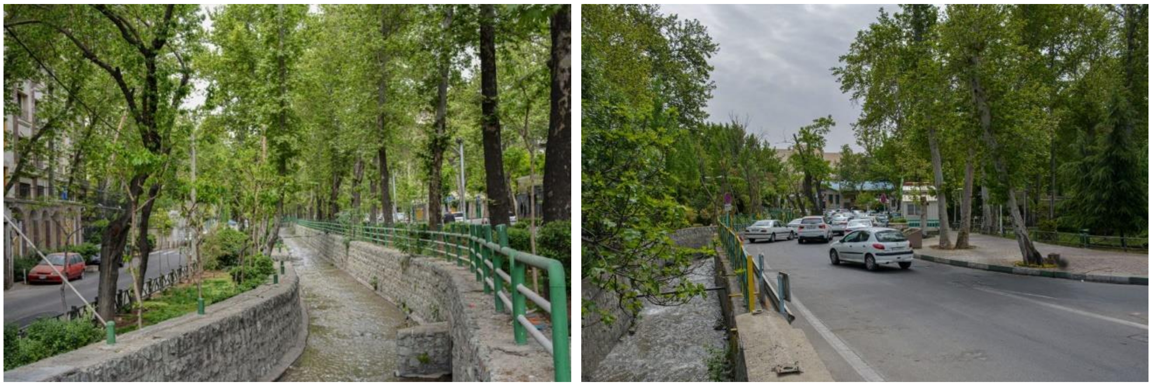


Figure 4.33. The open channel in the south part of Darrous Neighborhood (Zare, 2021a)

Darrous neighborhood bears intriguing traces of its history in its street layouts. The original core of this neighborhood, stemming from its rural origins, still retains the organic street arrangements that reflect its past. However, a significant transformation has occurred since 1991, with extensive construction efforts leading to the introduction of a predominantly grid-like pattern in most side streets. This shift towards a more organized grid system is indicative of the neighborhood's evolution as a residential and urban area. Interestingly, the neighborhood's natural topography and land features have played a role in shaping its street network. These geographical elements have resulted in some sections of the grid system remaining unfinished, creating an interesting blend of organized grids interspersed with the impression of a tributary system. This coexistence of different street layouts showcases the neighborhood's dynamic history and adaptation to changing urban needs.

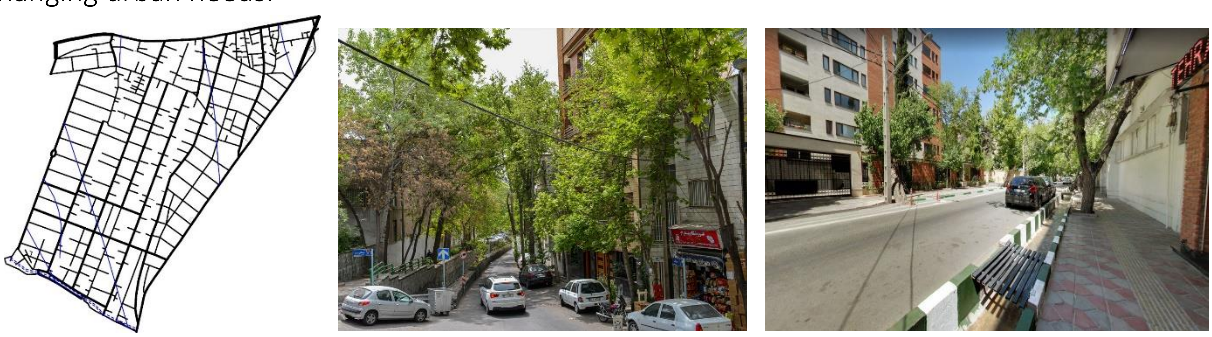


Figure 4.34. The street network, the location of qanat routes, and the open water canal (in southern) in Darrous (Author, 2022)

The sidewalks in the side streets of the Darrous neighborhood present a notable challenge due to their generally narrow width, often measuring as little as 50 cm. These narrow walkways, flanked by open spaces densely populated with trees, make pedestrian navigation a cumbersome task, prompting many residents and pedestrians to choose the roadway instead, exacerbating safety concerns. Moreover, certain side streets within this neighborhood feature steep slopes, which have necessitated the installation of stairs to facilitate street access. Unfortunately, this stairway addition further diminishes the already limited available sidewalk space, intensifying the difficulties faced by pedestrians navigating these streets.

Figure 4.35. The pavement in the secondary streets in the Darrous Neighborhood (Author, 2022)

Figure 4.36. Site plan of a center in the Darrous Neighborhood

Figure 4.37. Street section 1-1 (left) and section 2-2 (right) from main and secondary streets in the Darrous Neighborhood

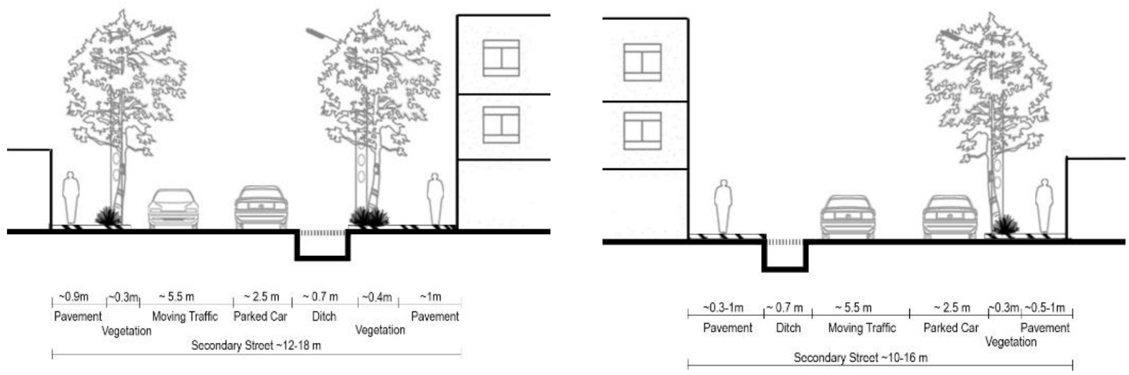


Figure 4.38. Street section 3-3 (left) and section 4-4 (right) from secondary streets in the Darrous Neighborhood

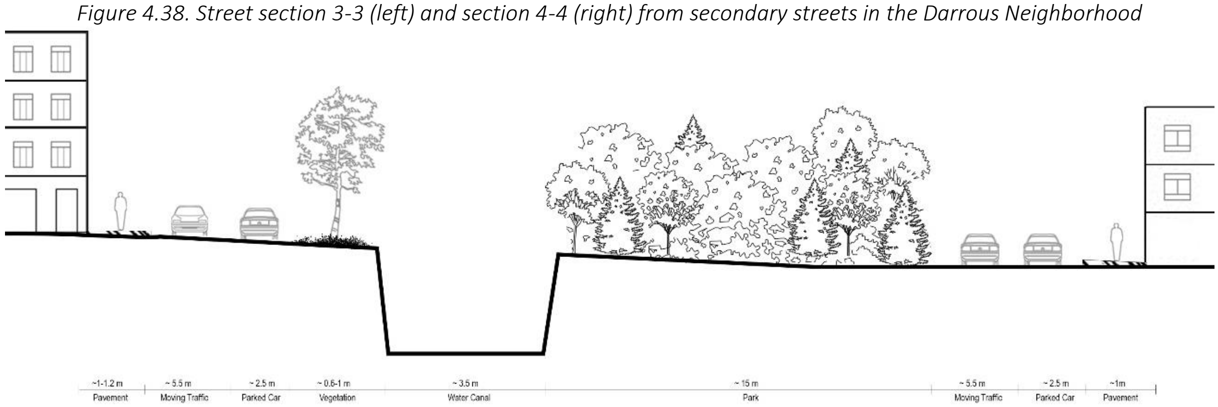


Figure 4.39. Street section 5-5 from the main street with the water canal in the Darrous Neighborhood

Over time, Darrous has undergone a significant transformation in its building density, shifting from a neighborhood adorned with numerous gardens predominantly owned by embassies and affluent individuals to one marked by the presence of towering high-rise structures. Several factors have contributed to this evolution. Firstly, the neighborhood's favorable climate, characterized by mild weather and pleasant surroundings, has made it an increasingly appealing destination for urban development. Its prime location within Tehran has further fueled this growth, attracting both residents and developers. Additionally, the presence of abundant green spaces, while some were sacrificed for new constructions, has provided a unique blend of urban living and natural beauty, making it an attractive prospect for modern living spaces that still offer a connection to nature. Lastly, the historical water canal coursing through Darrous has played a role in this transformation, adding to the neighborhood's charm and contributing to a sense of serenity amidst the bustling city.

Figure 4.40. The density of buildings in the Darrous Neighborhood (Zare, 2021a)

4.1.6. Shahrak-e Qarb Neighborhood (Imitated Organic)

Shahrak-e Qarb, situated in the northwestern region of Tehran within District Two, has a unique and intriguing history. Back in 1961, this area was home to the Christian village of Khovardin, celebrated for its delightful climate. During this period, American engineers embarked on a transformative mission to convert Khovardin into a burgeoning small town. The goal was to shape a modern Tehran, and this newly developed zone bore a striking resemblance to urban planning patterns observed in the United States. As a testament to its origins, remnants of the Khovardin village still linger, notably in the form of the lush tree-lined Khovardin Boulevard and the presence of the village's historic qanat. This distinctive neighborhood spans an impressive expanse, covering approximately 440 hectares^2 of land.

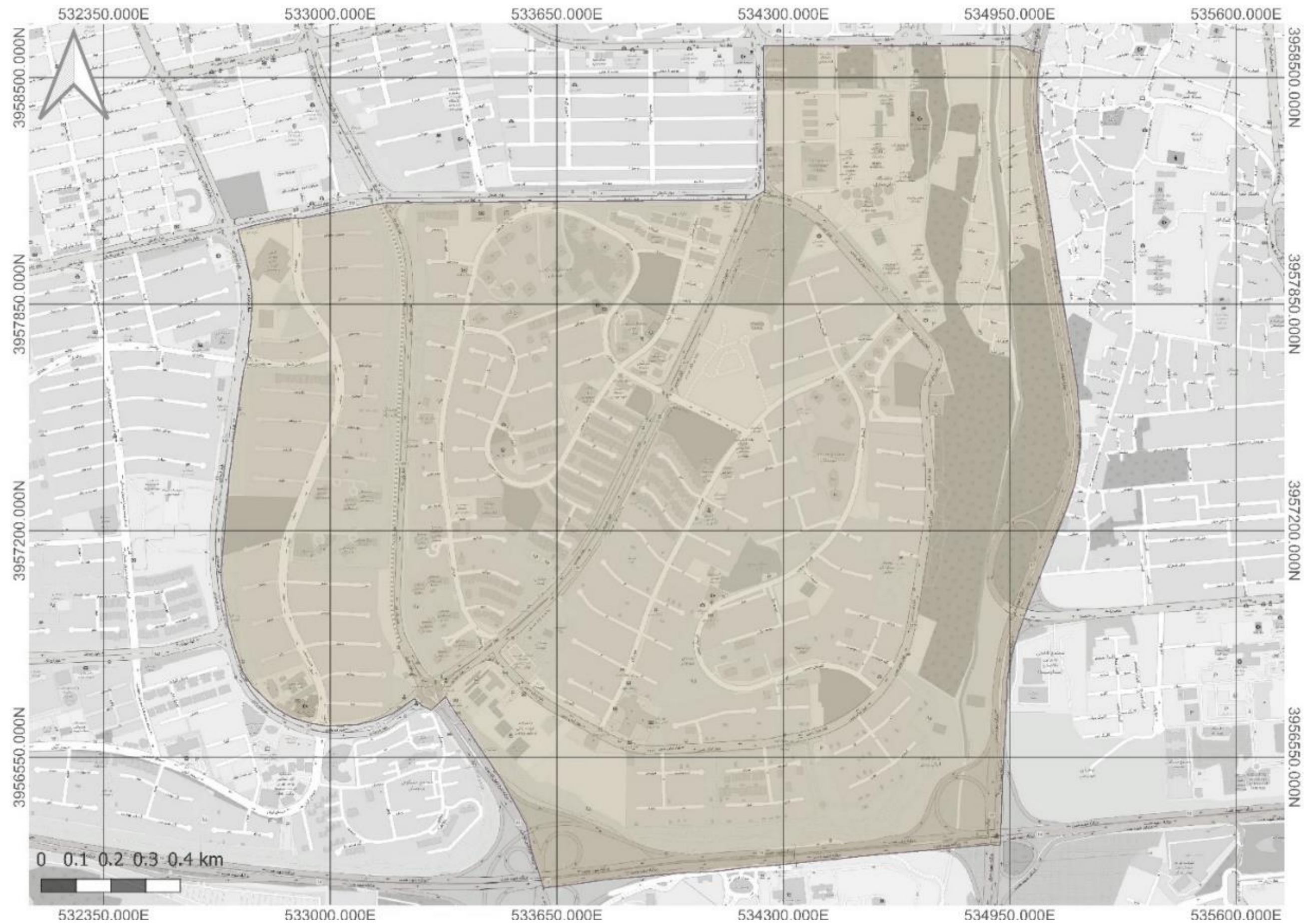


Figure 4.41. The territory of the Shahrak-e Qarb Neighborhood (Author, 2022)

In Shahrak-e Qarb, a neighborhood thoughtfully planned to prioritize the security and serenity of its residents, one can find a plethora of cul-de-sacs strategically positioned throughout. These cul-de-sacs have been designed with the residents' well-being in mind. At the entrance of each cul-de-sac stands a barricade and a guard room, ensuring a heightened sense of security for those within. What sets these spaces apart is the circular open area situated at the cul-de-sac's terminus, a deliberate design choice aimed at creating a car-free oasis within the neighborhood. Pedestrian sidewalks seamlessly connect to adjacent green spaces or the main street's sidewalk, often fortified with metal doors or additional guard rooms. This layout, featuring a guard room at the entrance and an inviting open space at the cul-de-sac's end, serves the dual purpose of safeguarding residents and fostering a strong sense of community within these specific enclaves of Shahrak-e Qarb.

Figure 4.42. A guard room at the beginning and an open space at the end of one cul-de-sac in the Shahrak-e Qarb Neighborhood (Author, 2022)

This neighborhood boasts three prominent, wide boulevards designed in the American urbanism style. The neighborhood's existing boundaries are often shaped by natural features, which play a pivotal role in defining territorial limits. The robustness and continuity of these natural edges enhance their effectiveness in physically separating various areas. The streets and sidewalks in the neighborhood are constructed to exacting standards. Collector streets span widths of 12, 18, and 24 meters, while main streets measure 35 and 45 meters across. Furthermore, encircling the neighborhood is a ring street with a generous width of 76 meters. To establish well-defined boundaries and provide residents with a sense of privacy, the neighborhood's urban planning incorporates a green belt into its design.

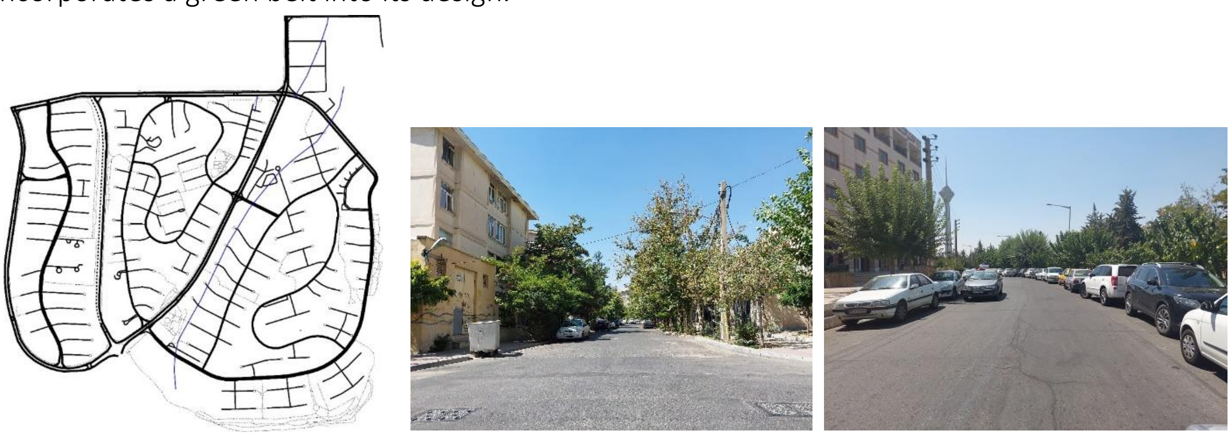


Figure 4.43. The street network and the location of qanat routes in Shahrak-e Qarb (Author, 2022)

Shahrak-e Qarb, a notable neighborhood in Tehran, Iran, has experienced a notable architectural transformation influenced by market demands, environmental considerations, and shifting social dynamics. The original development plan for this neighborhood included a strategic allocation of land, with 20 percent designated for the construction of towering buildings exceeding ten floors, 40 percent reserved for low-rise structures typically limited to four floors, and the remaining 40 percent designated for the construction of two-level villas (Strategic-Structural Plan for Development and Urbanization of Tehran, 2007).

Figure 4.44. Site plan of a center in the Shahrak-e Qarb Neighborhood

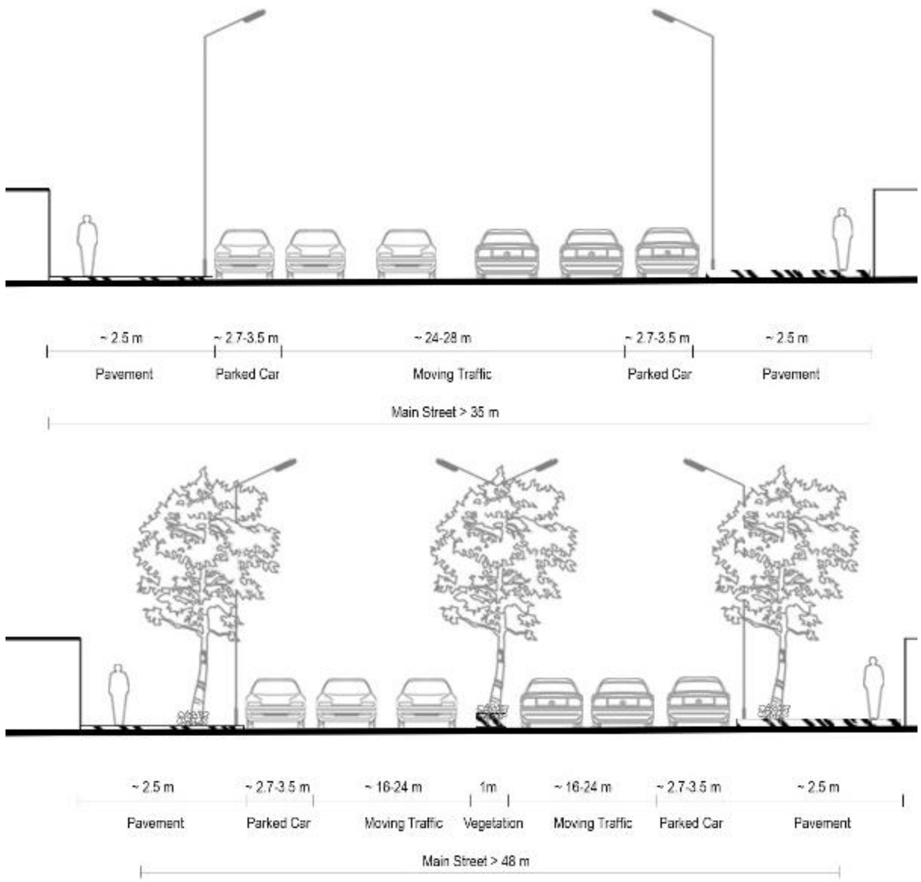


Figure 4.45. Street sections 1-1 (above) and 2-2 (below) from main streets in the Shahrak-e Qarb Neighborhood

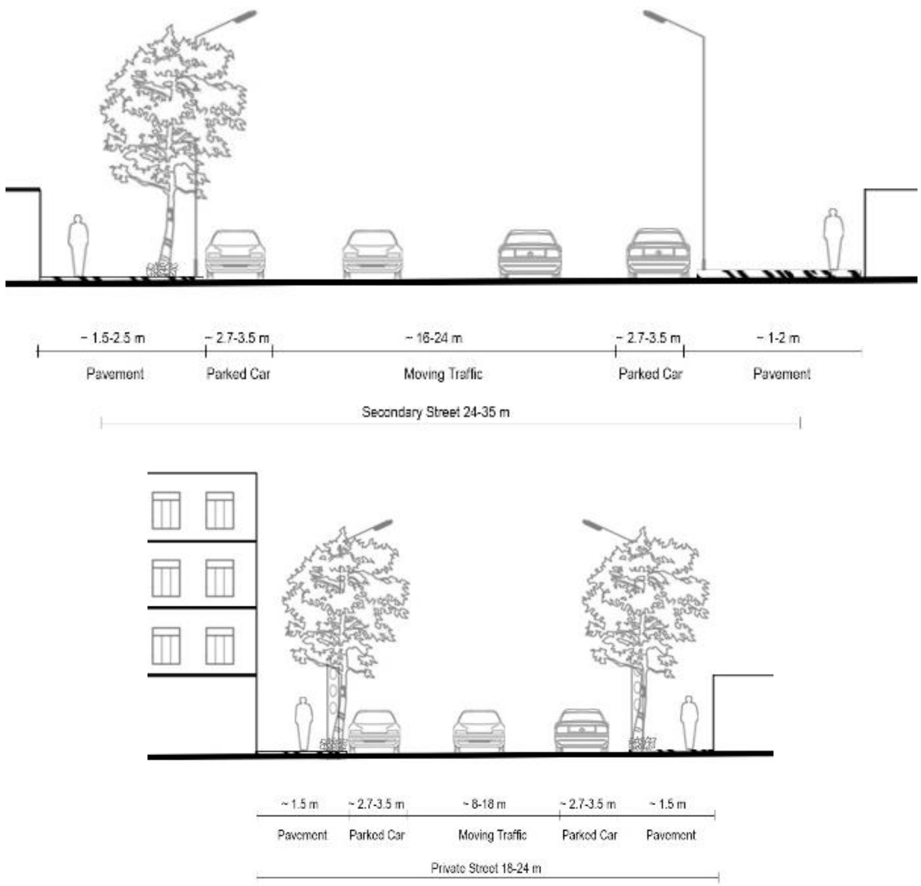


Figure 4.46. Street section 3-3 (above) and section 4-4 (below) from secondary and private streets in the Shahrak-e Qarb Neighborhood

However, Shahrak-e Qarb's favorable climate, strategic location, and the affluent social status of its residents have driven up land values significantly. Consequently, there has been a notable surge in the construction of high-rise buildings, reshaping the neighborhood's overall density profile. Despite the proliferation of these tall structures, the majority of Shahrak-e Qarb's built environment still features low-rise buildings. This coexistence of low and high-density areas within the neighborhood contributes to its unique urban fabric. The main thoroughfares, serving as prominent arteries, prominently feature high-rise buildings, lending a distinctive visual character to the neighborhood. These tall structures often house a mix of commercial and residential spaces, catering to the needs of affluent residents and attracting businesses seeking visibility and accessibility.

Figure 4.47. The density of buildings and the neighborhood's central square in the Shahrak-e Qarb Neighborhood (Zare, 2021b)

Shahrak-e Qarb features urban blocks primarily oriented in the southwest direction, aligning with the qibla, at angles ranging from 15 to 30 degrees. The neighborhood's architectural landscape is characterized by a diverse range of construction materials, with cement and brick being the predominant choices, while stone has made more recent appearances. When evaluating the overall quality of the neighborhood's buildings, it is generally deemed satisfactory, taking into account factors such as their age and adherence to construction standards. This mix of materials and orientations contributes to the visual and structural diversity of Shahrak-e Qarb, enhancing its architectural character. The neighborhood's design choices reflect its dynamic evolution and adaptability to changing urban needs and preferences.

Figure 4.48. The quality of the buildings in the Shahrak-e Qarb Neighborhood (Zare, 2021b)

4.2. Walkability Assessment in Selected Neighborhoods Based on the Form of the Street Networks

This section of the study presents the results obtained from three distinct research methods employed in the investigation. The study areas have been categorized according to specific research factors, facilitating a comparative analysis and comprehensive discussion of the findings. Expert opinions were solicited through interviews to comprehensively evaluate walkability in each neighborhood, utilizing site photos as references. The information gathered from each interview was meticulously extracted, coded, and organized based on their respective frequencies. Furthermore, these codes were further classified following the evaluation factors outlined in the research framework [refer to Appendix D]. To summarize the collective responses, the following table illustrates each neighborhood's experts' positive and negative ratings, highlighting their perspectives on walkability.

Table 4.2. The neighborhoods' ratings based on interviews

Overall	positive (%)	negative (%)	Gesamt (%)
Darrous	34 (82.9%)	7 (17.1%)	41 (18.3%)
Chizar	35 (68.6%)	16 (31.4%)	51 (22.8%)
Sanglaj	24 (58.5%)	17 (41.5%)	41 (18.3%)
Qeytariyeh	16 (57.1%)	12 (42.9%)	28 (12.5%)
Shahrak-e Qarb	13 (46.4%)	15 (53.6%)	28 (12.5%)
Dr. Hooshyar	13 (37.1%)	22 (62.9%)	35 (15.6%)
Gesamt	135 (60.3%)	89 (39.7%)	224 (100%)

$Chi^2(5)=20.501$, $p=.001$, Cramers $V=.303$

The overall positive ratings across all neighborhoods amounted to 135 responses, accounting for 60.3%. Conversely, there were 89 negative ratings, representing 39.7%. In summary, the neighborhoods varied regarding their positive and negative ratings, with Darrous having the highest positive ratings (82.9%) among the experts, while Dr. Hooshyar had the highest negative ratings (62.9%). Chizar had the most total responses (51), while Qeytariyeh and Shahrak-e Qarb had the lowest (28 each).

The interviews primarily focused on aspects related to beauty and attractiveness, including building style, nature, and historical identity. A Fisher-Test analysis revealed significance for these factors ($p= .003$ for beauty and attractiveness, $p= .01854$ for building style, and $p<.001$ for nature and historic identity).

It is essential to consider the significance level (p-value) of 0.05 for all statistical tests conducted using the questionnaire data. Highly significant results are indicated by $p < 0.01$, while values between 0.05 and 0.1 suggest weak significance. If a p-value exceeds 0.05, the result is considered non-significant (Eckey, 2006).

Notably, the statistical analysis conducted on the data did not yield significant results in most cases, with p-values greater than 0.05. This lack of significance can be attributed to the limited number of interviews conducted and the low frequency of specific keywords used in each interview. Therefore, the results may not be fully representative. In summary, while Darrous and Chizar neighborhoods received relatively higher positive ratings, the overall statistical analysis emphasizes caution due to the limited sample size and the low frequency of specific keywords used in the interviews.

Based on the information gathered from the questionnaires, a cross-classified table has been presented to illustrate the combination of two categorical variables. The table also provides descriptive evaluations and an overview of the distribution of participants based on their gender and age, allowing for a comparison between different age groups and the representation of men and women in each category.

Table 4.3. The gender-age cross-table based on questionnaires

			Age					
			Less than 21	21-35	36-45	46-50	more than 61	Sum
Gender	Woman	Quantity	5	22	5	9	3	44
		% of Gender	11.4%	50.0%	11.4%	20.5%	6.8%	100.0%
	Man	Quantity	4	10	17	4	2	37
		% of Gender	10.8%	27.0%	45.9%	10.8%	5.4%	100.0%
Sum		Quantity	9	32	22	13	5	81
		% of Gender	11.1%	39.5%	27.2%	16.0%	6.2%	100.0%

The results show that half of the female participants were in the 21-35-year-old age group, while over 45% of the male participants were in the 36-45-year-old category. As a result, the majority of responses came from these two age groups. It is important to note that all respondents were capable of walking and had no physical or mental disabilities. The following cross-classified table illustrates the distribution of participants in each neighborhood based on whether they owned at least one private vehicle.

Table 4.4. The Mahale-Private Car ownership cross-table based on questionnaires

			Does your family have a private vehicle? yes	no	Sum
Mahale	Chizar	Quantity	8	4	12
		% of Mahale	66.7%	33.3%	100.0%
	Darrous	Quantity	13	3	16
		% of Mahale	81.3%	18.8%	100.0%
	Dr. Hooshyar	Quantity	2	6	8
		% of Mahale	25.0%	75.0%	100.0%
	Qeytariyeh	Quantity	15	2	17
		% of Mahale	88.2%	11.8%	100.0%
	Sanglaj	Quantity	3	6	9
		% of Mahale	33.3%	66.7%	100.0%
	Shahrak-e Qarb	Quantity	17	2	19
		% of Mahale	89.5%	10.5%	100.0%
Sum		Quantity	58	23	81
		% of Mahale	71.6%	28.4%	100.0%

The interpretation of the data reveals significant differences in the ownership of private vehicles across different neighborhoods. Generally, the affluent neighborhoods in north Tehran have a higher percentage of private vehicle ownership compared to the historic and central areas. This suggests that residents in wealthier neighborhoods have better access to resources and are more likely to own a private vehicle. On the other hand, Dr. Hooshyar and Sanglaj neighborhoods have the lowest ownership rates of private vehicles. Lower ownership in Dr. Hooshyar may be due to various factors, such as residents' preference for alternative modes of transportation or the availability of public transportation options. In Sanglaj, the higher ownership rate can be explained by the commercial function of the neighborhood, where owning transport vehicles is more common among businesses. In Chizar, some respondents mentioned difficulties with parking and maneuvering their cars in certain parts of the neighborhood, possibly leading to a higher preference for walking or seeking assistance from neighbors in emergencies, resulting in a relatively lower ownership rate of private vehicles. In contrast, Shahrak-e Qarb has the highest percentage of ownership among the neighborhoods. This can be attributed to the absence of other transportation options in the secondary streets of the neighborhood, which are secured by security guards and restrict public transportation entry. As a result, residents heavily rely on private vehicles for their transportation needs.

Overall, the data suggest that factors such as socio-economic status, geographical location, availability of public transportation, and specific neighborhood characteristics influence the ownership of private vehicles in Tehran. The table below illustrates the frequency at which residents in each neighborhood walk within their respective neighborhoods weekly.

Table 4.5. The number of weekly walking times in each neighborhood

			On average, how many times a week do you go walking or walk to your destination? (number of times)							
			2	2 to 3 times	3	3 to 4 times	5	more than 5 times	more than 10 times	Sum
Mahale	Chizar	Quantity	1	0	5	3	1	1	1	12
		% of Mahale	8.3%	0.0%	41.7%	25.0%	8.3%	8.3%	8.3%	100.0%
	Darrous	Quantity	0	0	0	11	0	3	2	16
		% of Mahale	0.0%	0.0%	0.0%	68.8%	0.0%	18.8%	12.5%	100.0%
	Dr. Hooshyar	Quantity	0	1	0	2	0	0	5	8
		% of Mahale	0.0%	12.5%	0.0%	25.0%	0.0%	0.0%	62.5%	100.0%
	Qeytariyeh	Quantity	0	0	0	14	0	1	2	17
		% of Mahale	0.0%	0.0%	0.0%	82.4%	0.0%	5.9%	11.8%	100.0%
	Sanglaj	Quantity	0	0	0	3	0	1	5	9
		% of Mahale	0.0%	0.0%	0.0%	33.3%	0.0%	11.1%	55.6%	100.0%
	Shahrak-e Qarb	Quantity	0	4	0	13	0	1	1	19
		% of Mahale	0.0%	21.1%	0.0%	68.4%	0.0%	5.3%	5.3%	100.0%
Sum		Anzahl	1	5	5	46	1	7	16	81
		% of Mahale	1.2%	6.2%	6.2%	56.8%	1.2%	8.6%	19.8%	100.0%

The data reveals that residents of Dr. Hooshyar and Sanglaj neighborhoods engage in more frequent walking activities within their respective neighborhoods compared to others. In Chizar, walking is a common mode of transportation and leisure, with an average frequency of about three times per week. When considering the duration of daily walks, the majority of residents in all neighborhoods report walking for approximately one to two hours daily. These findings suggest that walking is a prevalent and regular activity among residents in these neighborhoods, contributing to their overall walkability.

Table 4.6. The number of daily walking hours in each neighborhood

			On average, how many hours a day are you a pedestrian in this neighborhood? (in hours)						
			less than 30 minutes	1 hour	1and half hours	1 to 2 hours a day	2 hours	2 to 3 hours a day	Sum
Mahale	Chizar	Quantity	2	4	4	1	1	0	12
		% of Mahale	16.7%	33.3%	33.3%	8.3%	8.3%	0.0%	100.0%
	Darrous	Quantity	3	8	1	0	2	2	16
		% of Mahale	18.8%	50.0%	6.3%	0.0%	12.5%	12.5%	100.0%
	Dr. Hooshyar	Quantity	2	1	0	0	2	3	8
		% of Mahale	25.0%	12.5%	0.0%	0.0%	25.0%	37.5%	100.0%
	Qeytariyeh	Quantity	1	13	0	0	2	1	17
		% of Mahale	5.9%	76.5%	0.0%	0.0%	11.8%	5.9%	100.0%
	Sanglaj	Quantity	1	4	0	0	2	2	9
		% of Mahale	11.1%	44.4%	0.0%	0.0%	22.2%	22.2%	100.0%
	Shahrak-e Qarb	Quantity	8	7	4	0	0	0	19
		% of Mahale	42.1%	36.8%	21.1%	0.0%	0.0%	0.0%	100.0%
Sum		Quantity	17	37	9	1	9	8	81
		% of Mahale	21%	45.7%	11.1%	1.2%	11.1%	9.9%	100.0%

To interpret the findings, it is valuable to consider both of the previously mentioned crossed tables in conjunction. The second table provides further insights into the duration of daily walking activities in each neighborhood. In Chizar, Darrous, Qeytariyeh, and Sanglaj, the majority of individuals reported spending approximately one hour walking daily. Notably, residents of Darrous and Qeytariyeh primarily walk 3 to 4 times per week, while most people in Sanglaj reported walking around ten times per week. This indicates a higher frequency of walking compared to the other two neighborhoods. Dr. Hooshyar's neighborhood stands out, with a majority of residents walking for 2 to 3 hours daily. Additionally, many reported walking more than ten times per week, indicating a high level of physical activity. On the other hand, Shahrak-e Qarb ranks the lowest in walking duration, with most people spending less than 30 minutes walking daily.

4.2.1. Safety

When it comes to pedestrian safety, particularly in relation to moving traffic, two key elements related to the physical characteristics of the street network are of paramount concern. Firstly, it is essential to consider the width of the streets and the feasibility of walking without encountering conflicts with vehicular traffic. According to Iranian urban planning regulations, streets should have a minimum width of 6 meters (as per the Deputy Minister of Transportation, Ministry of Road and Urban Development, 2020a). Secondly, the implementation of traffic calming measures is imperative in areas identified as posing hazards to pedestrians.

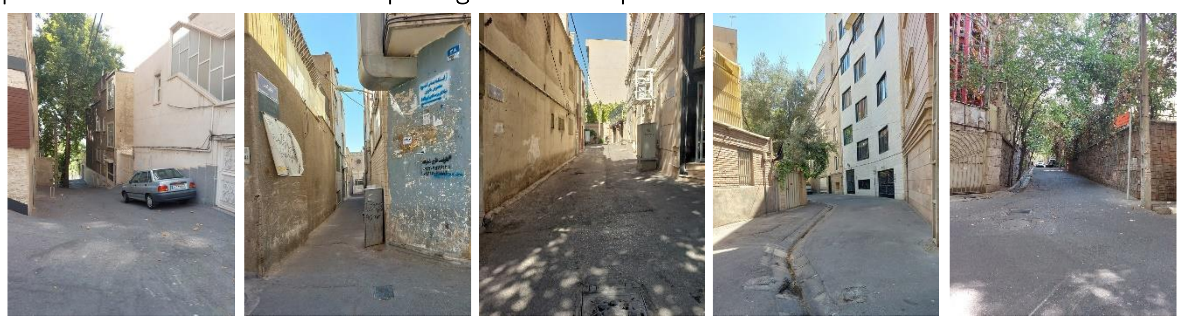
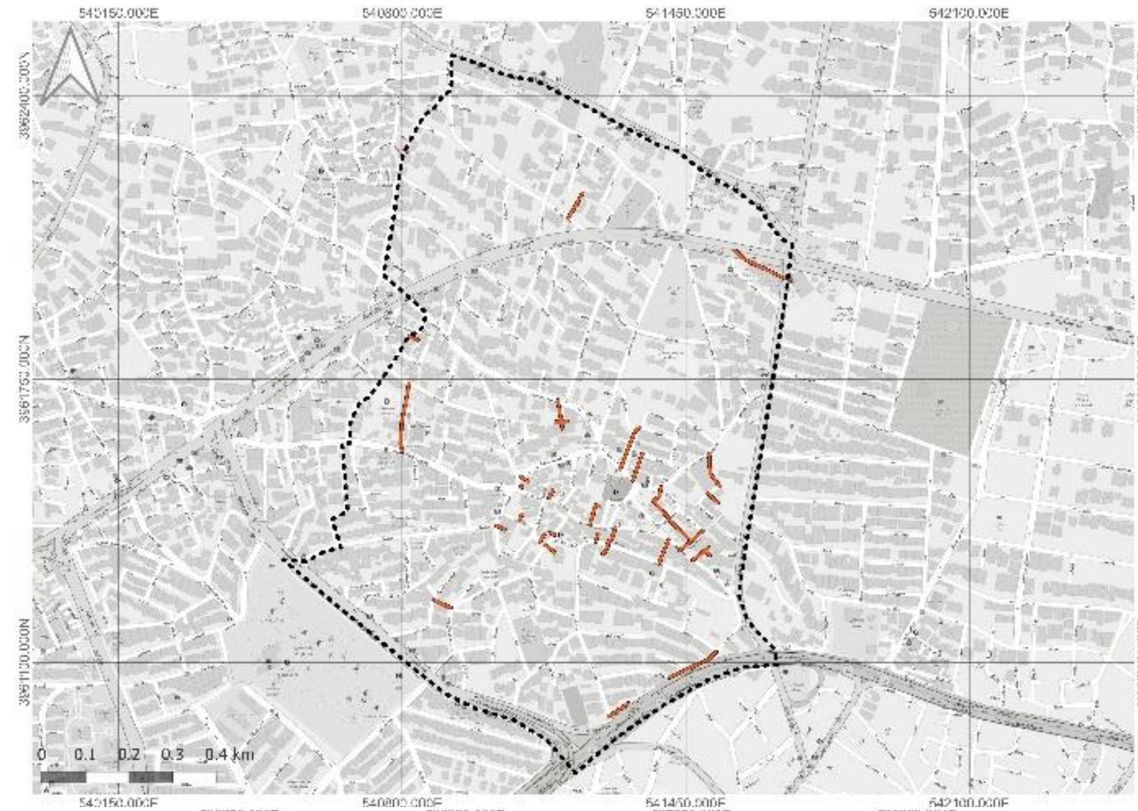


Figure 4.49. The examples of narrow streets (less than six meters) in studied neighborhoods (from left: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, and Darrous. No permission to take photos from the narrow streets in Shahrak-e Qarb, as they are private) (Author, 2022)

In general, the maximum allowable speed on main streets is set at 60 km/h, while it is 50 km/h on side streets, and further reduced to 30 km/h on local roads and squares across all the neighborhoods under examination. It is noteworthy that Sanglaj is an exception, falling outside the scope of Tehran's traffic control and air pollution control plan. This exemption restricts car traffic without prior permission on Saturdays through Wednesdays from 6:30 to 17:00 and on Thursdays from 6:30 to 13:00. However, in Sanglaj, due to its proximity to the Grand Bazaar, cargo vehicles are observed on side streets and even local roads more frequently than in other neighborhoods being studied. The subsequent maps illustrate the location and number of streets narrower than 6 meters in each neighborhood.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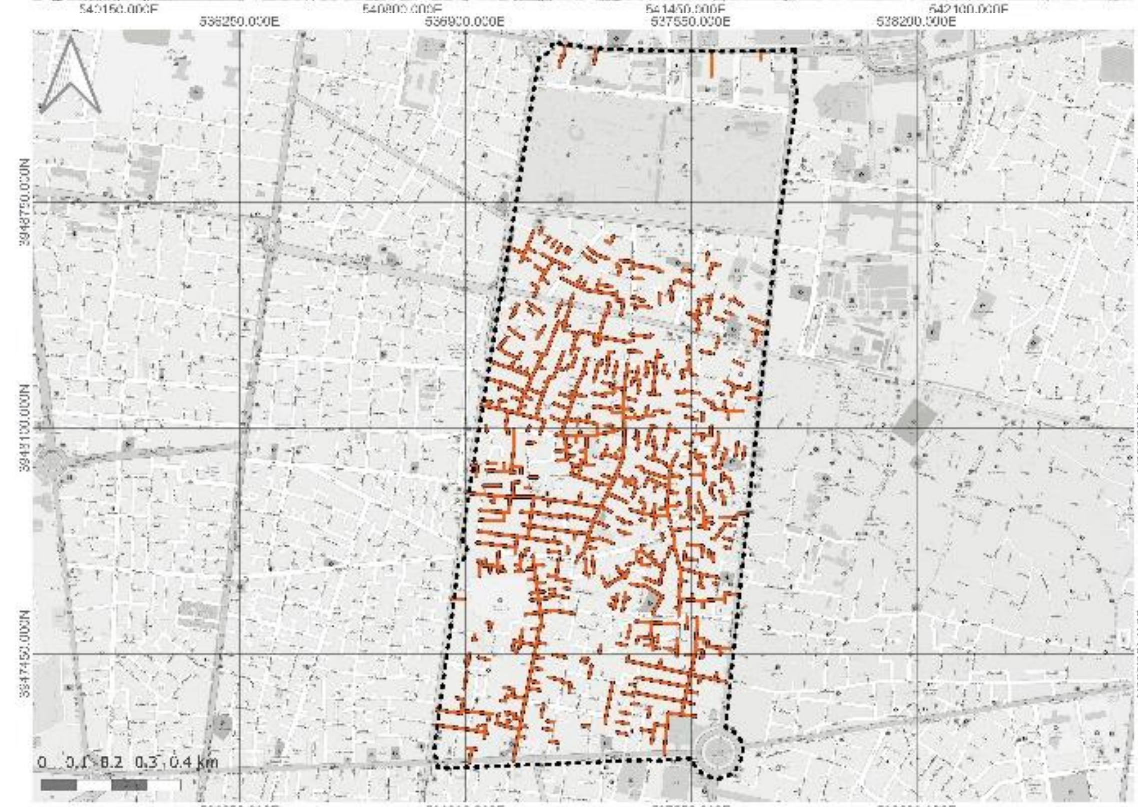
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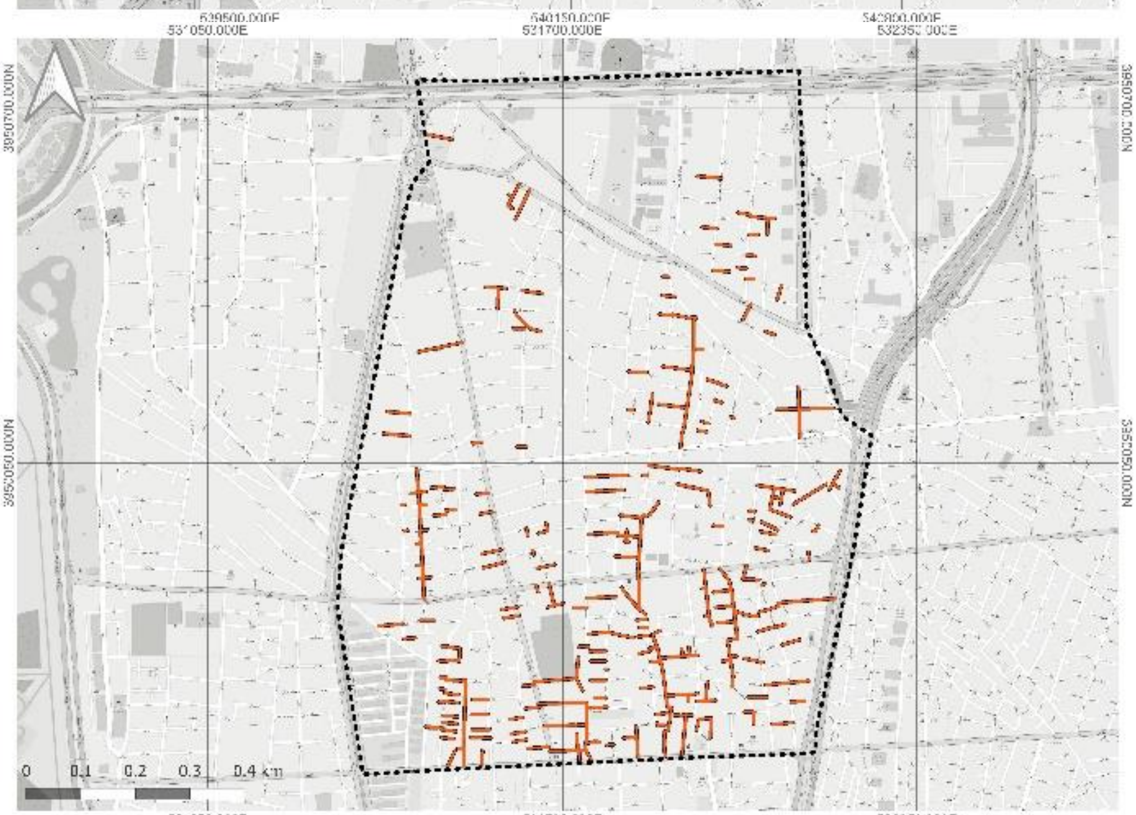
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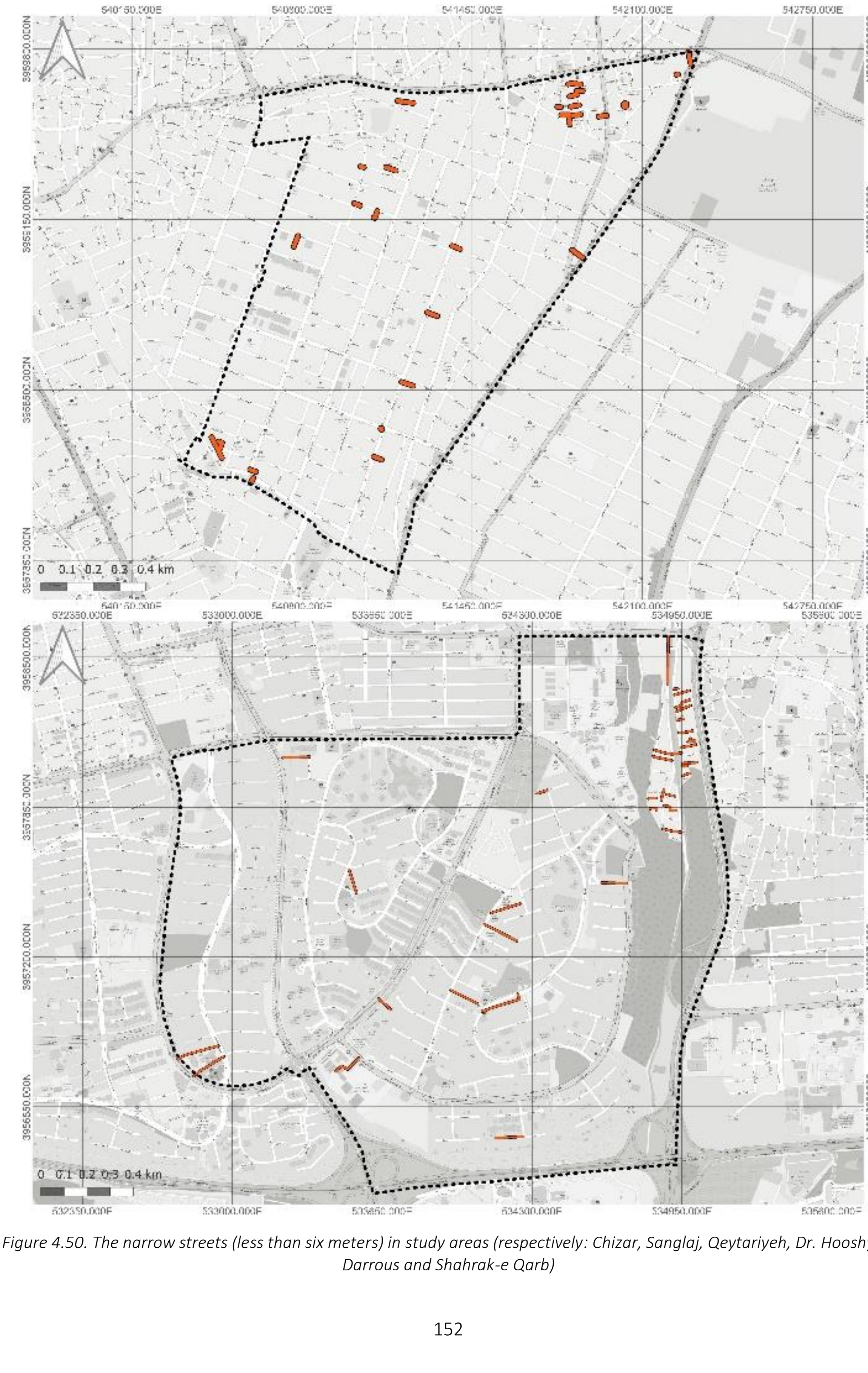


Figure 4.50. The narrow streets (less than six meters) in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous and Shahrak-e Qarb)

For a more meaningful comparison, the length of narrow streets in each neighborhood has been calculated and then divided by the total length of all narrow streets, taking into account the size of each neighborhood. In this calculation, higher values are indicative of a less favorable evaluation in terms of road safety. The table below displays the intermediate ranking of hazardous routes based on the extent of the street network in each neighborhood. Chizar exhibits the highest number of dangerous routes, followed by Shahrak-e Qarb, Sanglaj, Qeytariyeh, Dr. Hooshyar, and Darrous.

Table 4.7. The middle rank of dangerous routes based on the size of the street network

Mahale	Number of dangerous routes	middle rank
Chizar	30	413.4
Shahrak-e Qarb	34	408.09
Sanglaj	424	401.22
Qeytariyeh	38	361.92
Dr. Hooshyar	202	343.96
Darrous	30	267.8

H(5)=18.844, p=0.002

A significant difference in the number of dangerous routes is evident among the neighborhoods (p=0.002). The table is sorted by size, with Chizar having the highest values. The statistical analysis highlights differences between various pairs of neighborhoods in terms of the quantity of hazardous routes.

Streets narrower than 6 meters within Tehran neighborhoods with organic street networks present distinct challenges related to pedestrian infrastructure and safety. The limited width of these streets often leads to the absence of dedicated pedestrian sidewalks. In cases where sidewalks exist, they are typically too narrow to serve their intended purpose effectively. Consequently, pedestrians are compelled to share the road space with vehicles, resulting in potential conflicts and compromising pedestrian safety.

While the restricted width of these streets naturally promotes slower vehicle speeds, instances of reckless driving can still jeopardize pedestrian safety. Furthermore, neighborhoods like Chizar, Qeytariyeh, and Darrous feature notable rows of trees along their streets. Initially, these trees were located within the designated pedestrian-oriented organic network. However, with the intrusion of motor vehicles into these areas, the original planning and allocation of space have been disrupted. Consequently, the narrow streets in Tehran neighborhoods pose significant challenges to pedestrian movement, safety, and the preservation of intended urban design features. The following figure illustrates typical sections of streets narrower than 6 meters in Tehran.

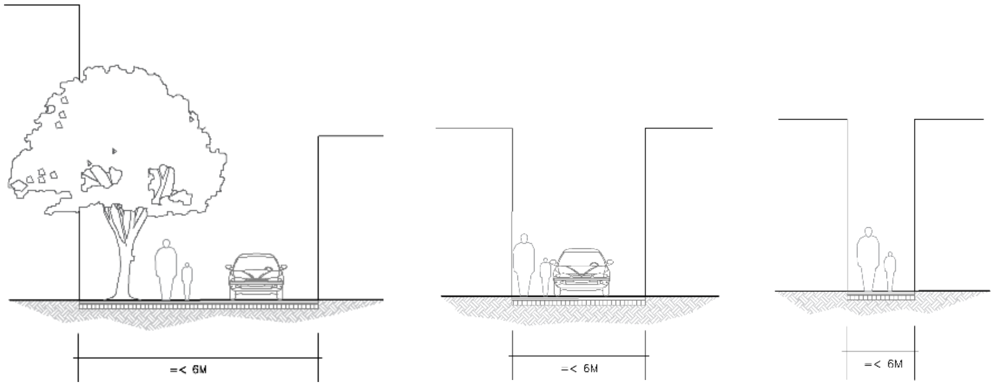


Figure 4.51. Typical street sections from streets narrower than 6 meters in Tehran

The table below offers pairwise comparisons of narrow streets across various neighborhoods. It employs statistical measures to evaluate the significance and direction of neighborhood disparities. Notably, comparisons such as Darrous-Sanglaj, Darrous-Shahrak-e Qarb, Darrous-Chizar, and Dr. Hooshyar-Sanglaj exhibit noteworthy differences ($p<0.05$).

Table 4.8. The pairwise comparison of narrow streets based on the neighborhoods

Paarweise Vergleiche von Viertel

Mahale1-Mahale2	Teststatistik	Std.-Fehler	Standardteststatistik	Sig.	p-Wert
Darrous-Dr. Hooshyar	-76.160	42.842	-1.778	.075	1.000
Darrous-Qeytariyeh	-94.121	53.477	-1.760	.078	1.000
Darrous-Sanglaj	-133.419	41.367	-3.225	.001	.019
Darrous-Shahrak-e Qarb	-140.288	54.847	-2.558	.011	.158
Darrous-Chizar	145.600	56.535	2.575	.010	.150
Dr. Hooshyar-Qeytariyeh	-17.961	38.717	-.464	.643	1.000
Dr. Hooshyar-Sanglaj	-57.259	18.719	-3.059	.002	.033
Dr. Hooshyar-Shahrak-e Qarb	-64.128	40.589	-1.580	.114	1.000
Dr. Hooshyar-Chizar	69.440	42.842	1.621	.105	1.000
Qeytariyeh-Sanglaj	-39.298	37.078	-1.060	.289	1.000
Qeytariyeh-Shahrak-e Qarb	-46.167	51.689	-.893	.372	1.000
Qeytariyeh-Chizar	51.479	53.477	.963	.336	1.000
Sanglaj-Shahrak-e Qarb	-6.869	39.028	-.176	.860	1.000
Sanglaj-Chizar	12.181	41.367	.294	.768	1.000
Shahrak-e Qarb-Chizar	5.312	54.847	.097	.923	1.000

The presented table offers valuable insights through pairwise comparisons of narrow streets across different neighborhoods. These comparisons are accompanied by statistical measures that reveal the significance and direction of neighborhood differences. Here is a detailed interpretation of the findings:

1. Darrous-Dr. Hooshyar: Although Darrous appears to have more narrow streets than Dr. Hooshyar based on a test statistic of -76.160, the p-value of 1.000 indicates that this difference is not statistically significant at the chosen significance level of 0.075.

2. Darrous-Qeytariyeh: Similar to the previous comparison, Darrous seems to have more narrow streets than Qeytariyeh, with a test statistic of -94.121. However, the p-value of 1.000 suggests no statistically significant difference between the two neighborhoods.

3. Darrous-Sanglaj: A substantial negative difference (-133.419) indicates that Darrous has significantly more narrow streets than Sanglaj. The low p-value of 0.019 suggests this difference is statistically significant at the chosen significance level of 0.05 or lower.

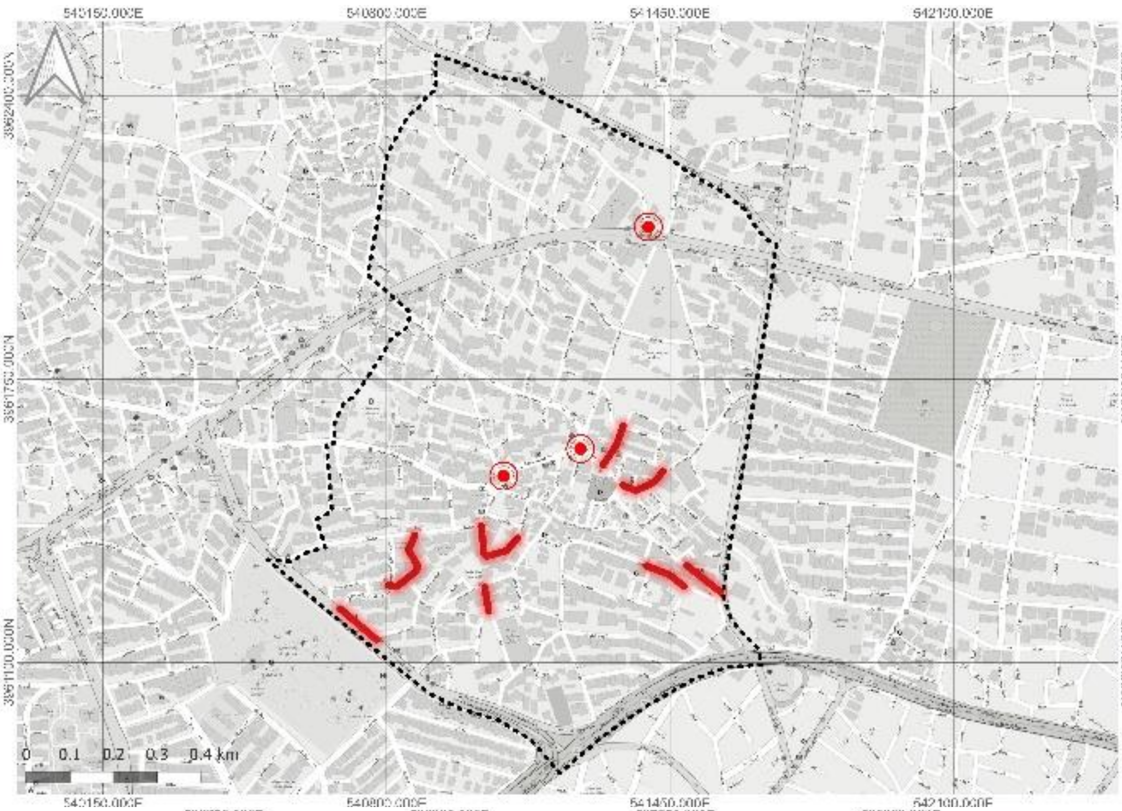
4. Darrous-Shahrak-e Qarb: While Darrous appears to have more narrow streets than Shahrak-e Qarb based on a test statistic of -140.288, the p-value of 0.158 is above the chosen significance level. This suggests that the observed difference may not be statistically significant.

5. Darrous-Chizar: In contrast to previous comparisons, Chizar has a positive difference compared to Darrous, implying that Chizar has a higher number of narrow streets. However, the p-value of 0.150 is above the significance level, indicating no statistically significant difference between the two neighborhoods.

Similar interpretation patterns apply to other pairwise neighborhood comparisons. The test statistics reveal the direction and magnitude of differences, while the p-values determine whether these differences are statistically significant. In summary, the findings highlight a significant difference in the number of narrow streets between Darrous and Sanglaj, with Darrous having more narrow streets. However, other neighborhood comparisons do not show statistically significant differences in the number of narrow streets. It is important to consider additional factors such as historical, cultural, and developmental aspects to fully comprehend the neighborhoods' characteristics and street networks.

Based on the GIS analysis, Chizar and Darrous have the fewest narrow streets, while Shahrak-e Qarb, Qeytariyeh, Dr. Hooshyar, and Sanglaj have more such streets. Less-developed neighborhoods tend to have more narrow streets, with Sanglaj and Dr. Hooshyar standing out due to their commercial and storage functions. Wealthier neighborhoods in northern Tehran with higher private vehicle ownership have more resources for street reconstruction and maintenance. Constraints related to historical and cultural significance, as well as high land values, limit the widening of narrow streets in certain areas.

Ultimately, the identified hazardous spots and routes in each neighborhood underscore the importance of implementing effective traffic calming measures to enhance pedestrian safety.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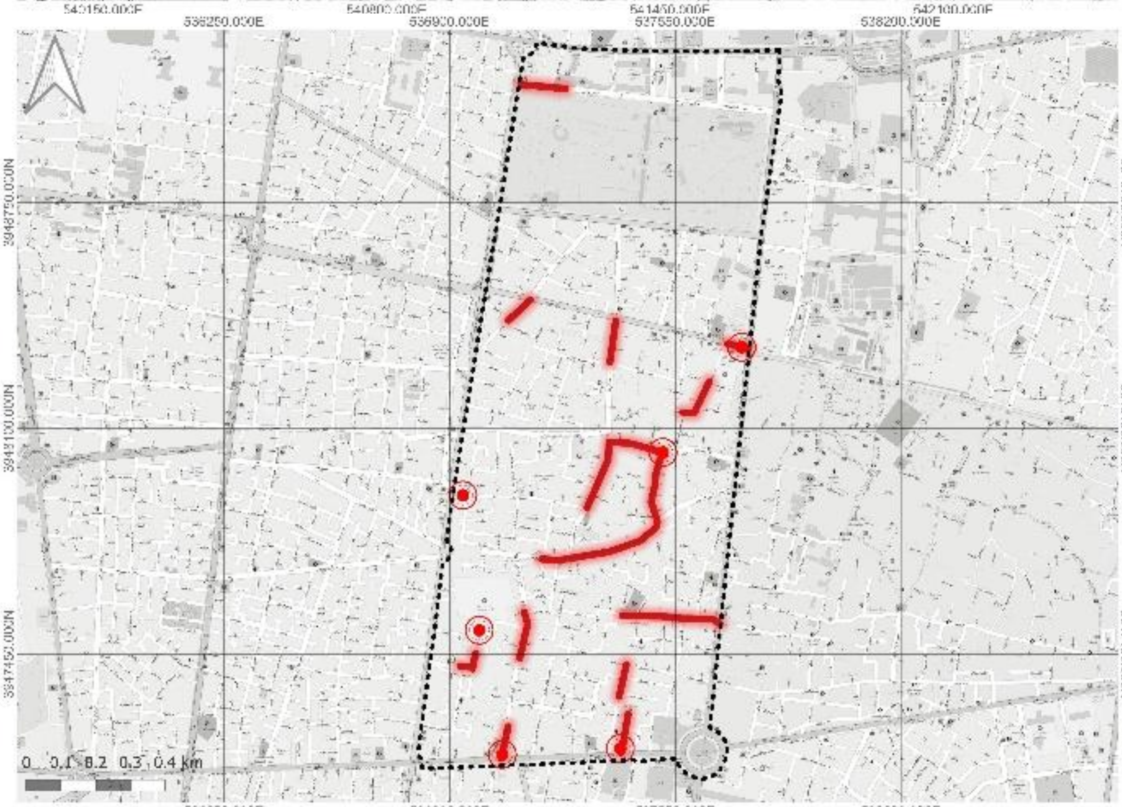
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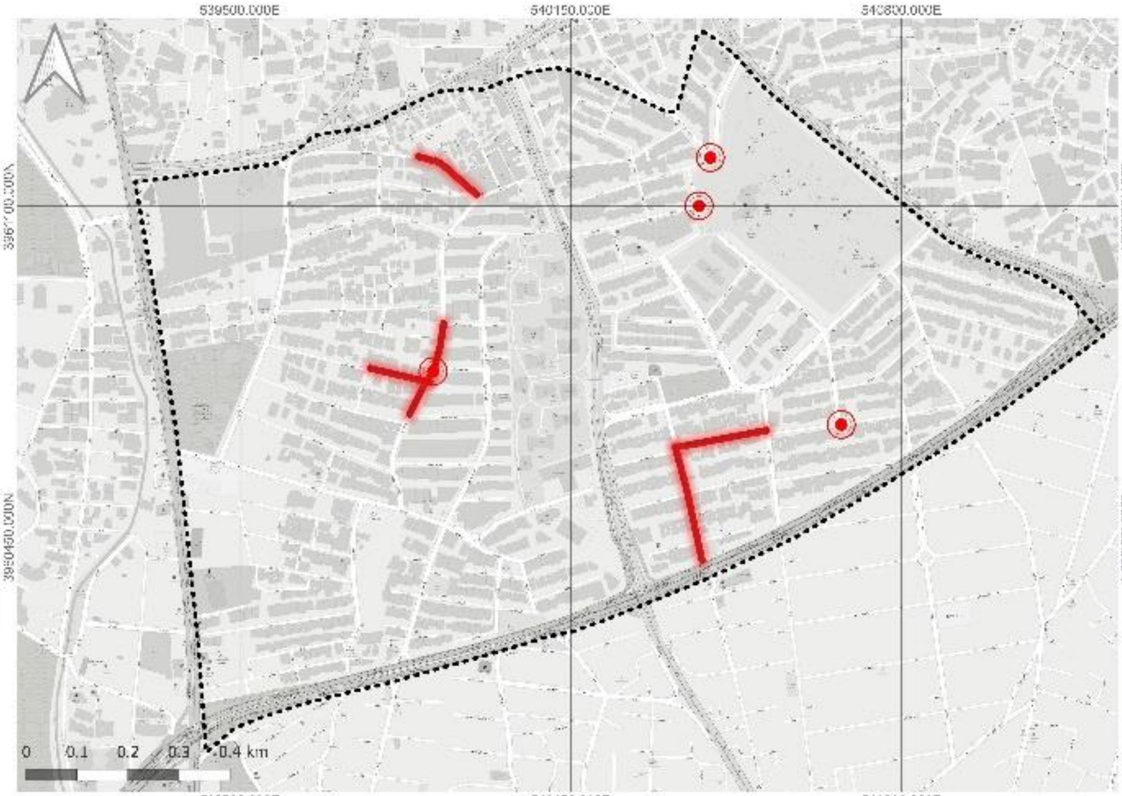
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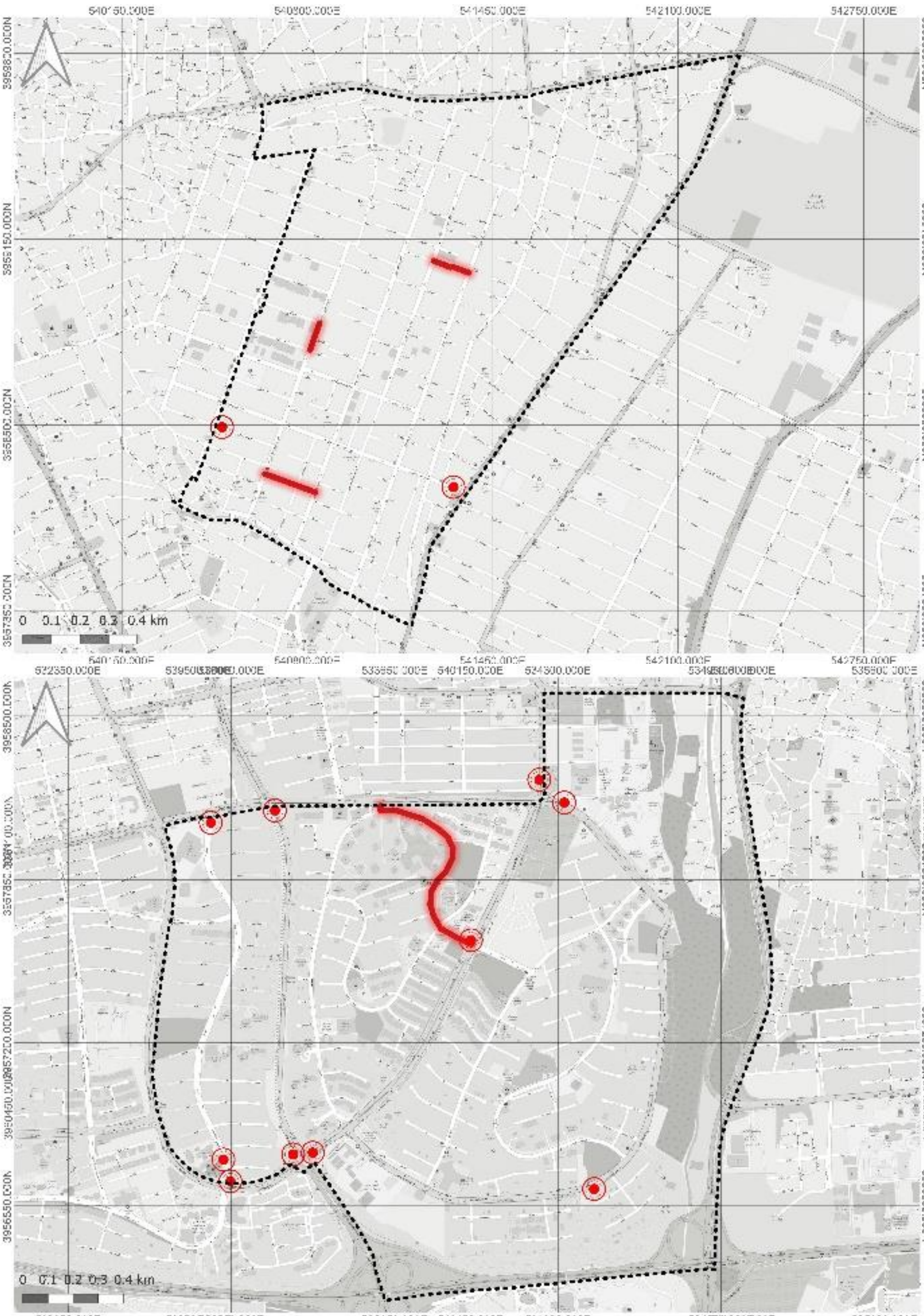

Figure 4.52. The map of dangerous spots and routes against automobile traffic in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb)

The data regarding street lengths have been subjected to a rigorous statistical examination utilizing the Kruskal-Wallis test. This statistical approach is particularly well-suited for assessing group differences, especially when dealing with data that is either ordinal or not distributed in a normal fashion. Importantly, the Kruskal-Wallis test maintains its applicability even in cases where the sample sizes are relatively small, ensuring the robustness of the analysis. This same statistical methodology will be consistently employed in the subsequent phases of the analysis when delving into the geographic information system (GIS) plans to gain further insights into the street networks and urban design characteristics of these neighborhoods.

Table 4.9. The middle rank of dangerous routes based on the size of the street network

Mahale	Number of dangerous routes	middle rank
Shahrak-e Qarb	1	38
Dr. Hooshyar	9	29.89
Qeytariyeh	5	22.6
Sanglaj	12	17.25
Chizar	8	13
Darrous	4	12.25

H(5)=15.085, p=0.010

The outcomes of the Kruskal-Wallis test have unveiled a noteworthy disparity among the various study areas, as evidenced by the obtained p-value of 0.010. This statistical measure underscores the existence of a meaningful divergence in terms of street network characteristics within the neighborhoods under investigation. To further elucidate the significance of these differences, the following table furnishes middle-rank values. The values within the table have been thoughtfully arranged in sequential order, facilitating a clear understanding of how each neighborhood compares concerning the extent of dangerous routes within their respective street networks.

Table 4.10. The pairwise comparison of dangerous routes based on the neighborhoods

Pairwise comparisons by Mahale

Mahale1-Mahale2	Teststatistik	Std.-Fehler	Standardteststatistik	Sig.	p-Wert
Darrous-Chizar	.750	6.982	.107	.914	1.000
Darrous-Sanglaj	-5.000	6.582	-.760	.447	1.000
Darrous-Qeytariyeh	-10.350	7.648	-1.353	.176	1.000
Darrous-Dr. Hooshyar	-17.639	6.851	-2.575	.010	.151
Darrous-Shahrak-e Qarb	-25.750	12.747	-2.020	.043	.651
Chizar-Sanglaj	-4.250	5.204	-.817	.414	1.000
Chizar-Qeytariyeh	-9.600	6.500	-1.477	.140	1.000
Chizar-Dr. Hooshyar	-16.889	5.540	-3.049	.002	.034
Chizar-Shahrak-e Qarb	-25.000	12.093	-2.067	.039	.581
Sanglaj-Qeytariyeh	5.350	6.069	.882	.378	1.000
Sanglaj-Dr. Hooshyar	12.639	5.027	2.514	.012	.179
Sanglaj-Shahrak-e Qarb	-20.750	11.867	-1.749	.080	1.000
Qeytariyeh-Dr. Hooshyar	7.289	6.359	1.146	.252	1.000
Qeytariyeh-Shahrak-e Qarb	-15.400	12.489	-1.233	.218	1.000
Dr. Hooshyar-Shahrak-e Qarb	-8.111	12.018	-.675	.500	1.000

The table serves as an informative resource delineating disparities in dangerous routes across various neighborhoods. It effectively communicates which comparisons hold statistical significance, a determination based on the respective p-values. Negative test statistics within the table imply that the routes within the first-mentioned neighborhood tend to be lengthier or more perilous than those in the second-mentioned neighborhood, with the p-values ultimately elucidating the extent of this significance.

Consequently, we can ascertain a noteworthy distinction between the Chizar and Dr. Hooshyar neighborhoods, with Chizar boasting a smaller p-value, indicating a higher level of significance. Furthermore, Sanglaj and Dr. Hooshyar are distinguished by their prevalence of dangerous spots and routes within their respective neighborhoods. Closely following this trend, Chizar has garnered reports of numerous perilous traffic routes and locations according to user feedback. Qeytariyeh, Shahrak-e Qarb, and Darrous also rank prominently in terms of the frequency of dangerous spots and routes.

Examining Chizar and Sanglaj, it becomes evident that the most hazardous areas are predominantly situated in the central zones of these neighborhoods. These central areas serve as entry and exit points for the neighborhoods, a factor compounded by the presence of narrow streets, amplifying the risk associated with vehicular movement for pedestrians. In the case of Qeytariyeh, increased traffic in the vicinity of Qeytariyeh Park, even from residents of other neighborhoods, has elevated the potential dangers for pedestrians.

Dr. Hooshyar stands out with the highest number of perilous spots among the integrated organic networks, primarily stemming from transporters navigating narrow streets with little regard for pedestrian safety. Given the neighborhood's commercial designation, drivers often overlook residential areas, further exacerbating safety concerns. In contrast, Darrous and Shahrak-e Qarb exhibit fewer dangerous spots within their respective networks. Nevertheless, the process of entering these neighborhoods frequently involves navigating through traffic jams, contributing to pedestrians' feelings of insecurity.

In summation, a compelling revelation regarding safety is that, in most studied neighborhoods, reported dangerous spots and routes align with the pattern of narrow streets. Remarkably, the original organic street network, initially designed with pedestrians in mind, ranks the lowest in safety ratings and is perceived as the least secure concerning traffic and vehicular movement. Conversely, planned imitations of organic networks that consider vehicles as integral street users provide the best safety conditions for pedestrians. Meanwhile, integrated organic street networks and grid-patterned networks offer improved safety by facilitating vehicle movement in high-traffic areas. However, networks integrated with tributaries, characterized by numerous cul-de-sacs and limited options for drivers to access wider streets, exhibit the poorest safety conditions among various integrated organic networks.

Safety reigns supreme as one of the most pivotal factors influencing pedestrians' decisions to choose walking as their preferred mode of transportation within a network. Across all represented neighborhoods, encompassing both men and women, 100% of respondents affirmed that their perception of safety during walking significantly influences their choice to walk or opt for walking as their preferred means of reaching their destinations.

4.2.2. Security

Based on the insights garnered from interviews, the assessment of neighborhood security revolves around three pivotal elements outlined in the form. The first element, the principle of territory, encapsulates concepts like privacy, spatial confinement, and the hierarchical arrangement of spaces and streets. In the context of this element, it is of paramount importance that the neighborhood's street network efficiently guides users from the main streets to their intended destinations. Equally vital is that the street network's design supports the establishment of local gathering points, characterized as semi-public/semi-private spaces.

These spaces are strategically positioned within the network, in proximity to residential areas, or along secondary streets. Semi-public/semi-private spaces within the neighborhoods can manifest in diverse forms, encompassing religious sites, parks, playgrounds, sports facilities, or even open areas. These spaces serve as indispensable focal points for the community, facilitating resident interaction, participation in recreational pursuits, and the cultivation of social bonds. They significantly contribute to the overall livability of the neighborhood and nurture a profound sense of belonging, offering opportunities for relaxation, leisure activities, and community engagement. The preservation and accessibility of these spaces are integral to cultivating a secure and thriving neighborhood environment.

Figure 4.53. Local meeting points in different neighborhoods in Tehran (Author, 2013 (mittle); 2022 (down, left and right); 2023 (above rigt and left))

However, the questionnaire data has brought to light a significant transformation in the role of these spaces, signifying a departure from their once-exclusive utilization by the local community to their more inclusive use by diverse user groups. Such a shift results in diminishing community-oriented spaces, leading to heightened feelings of insecurity among citizens. There is also the potential risk of indigenous residents considering relocation to other districts, while non-local individuals increasingly settle in the neighborhood, potentially further influencing the community's overall perception of safety.

To address these emerging concerns and safeguard the vitality of these spaces, the subsequent maps have been crafted to identify and delineate the semi-public spaces that bear significance for the residents of each neighborhood. The objective is to ensure the preservation of these spaces and uphold their inherent meaning and function for the local community. By doing so, it becomes possible to maintain a sense of place and security that enhances the overall well-being of neighborhood residents.

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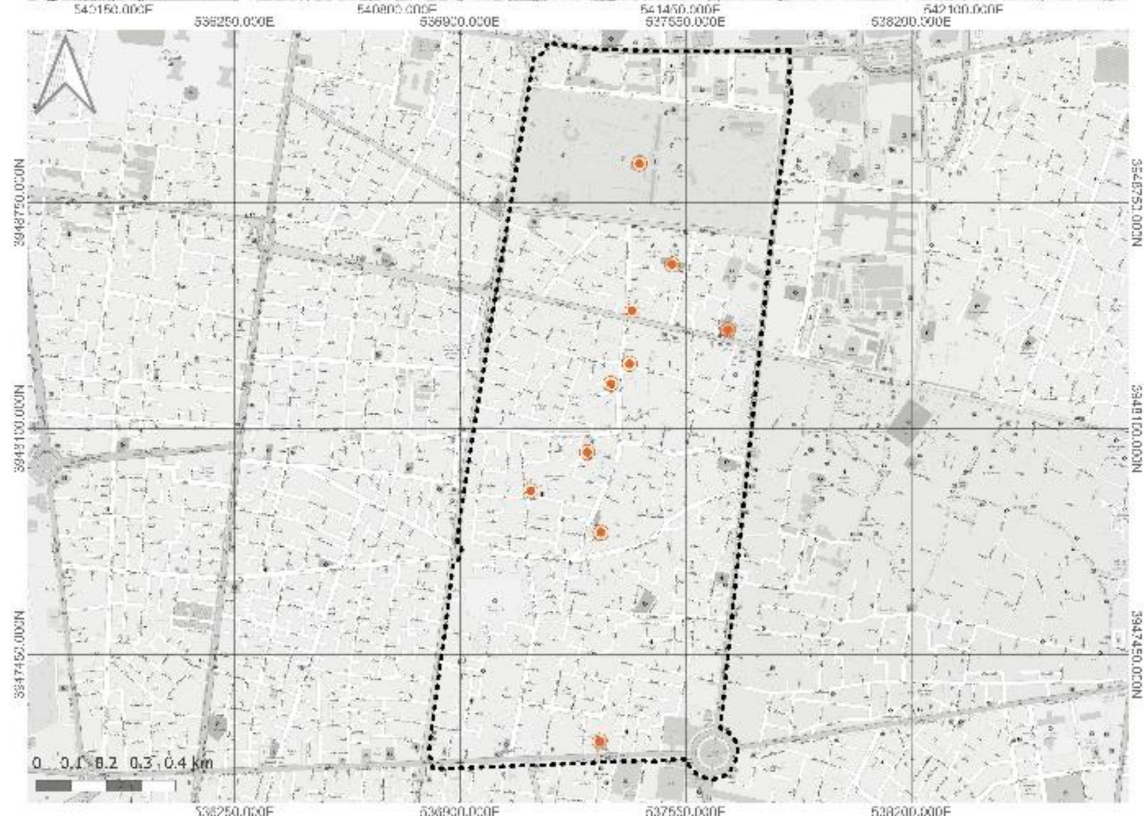

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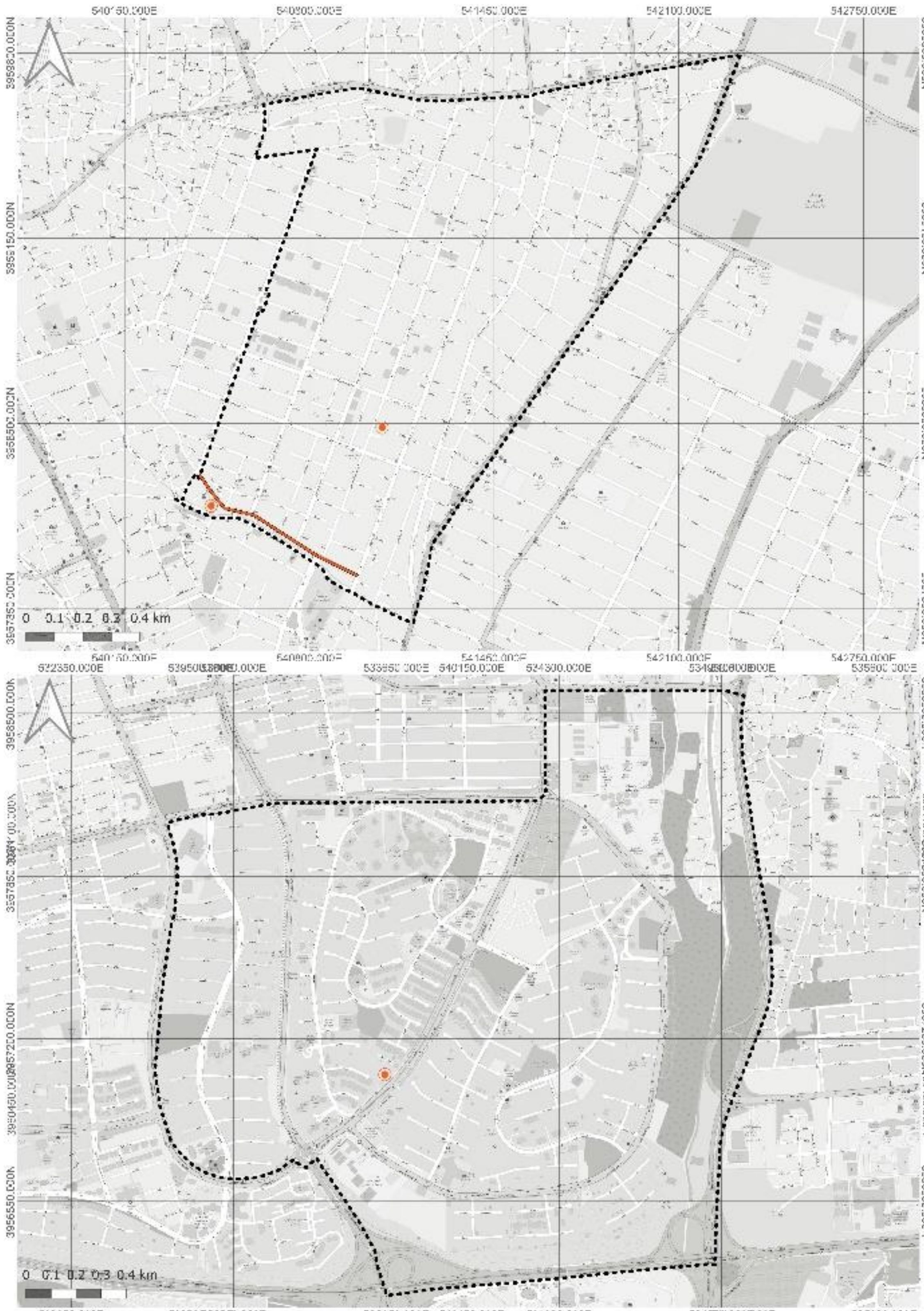


Figure 4.54. The map of semi-public spaces in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous and Shahrak-e Qarb)

Based on the questionnaire analysis, the primary local gathering spots in these neighborhoods are commonly found within shopping malls, parks, and religious places. However, it is worth noting that shopping centers were established many years after the formation of the street networks and were not included in the analysis or the accompanying maps. This suggests that traditional and religious structures in Sanglaj and Chizar have played a significant role in creating local centers within these neighborhoods. In the case of Darrous, the presence of an open water canal has also contributed to creating a pleasant space for residents to walk and socialize with their neighbors.

Conversely, in Qeytariyeh, Dr. Hooshyar, and Shahrak-e Qarb, the identified local meeting points were often located outside of the neighborhood or within establishments such as shopping centers, fitness facilities, cafes, or bookstores. While traditionally, neighborhoods with more local centers were considered safer due to increased foot traffic and "eyes on the street," the questionnaire results indicate that these local centers are increasingly situated inside buildings rather than open spaces. This implies that the presence of open public spaces alone may not be an accurate indicator of neighborhood security.

Moreover, traditional open public spaces that held significance in the past may have lost their meaning as new residents with different beliefs and interests have moved in. In contrast, facilities like sports centers, fitness studios, art centers, and libraries, which are predominantly indoors, have gained popularity among the younger generation and now serve as local gathering spaces in neighborhoods like Chizar, Qeytariyeh, and Darrous. In Shahrak-e Qarb, natural areas such as parks and the canal's edges were identified as local centers.

Notably, respondents from Chizar and Sanglaj were more likely to report religious centers as their local gathering spaces, indicating a higher presence of traditional and religious residents in these neighborhoods. This can also be attributed to the limited changes in the organic street network of these areas, which has preserved their traditional atmosphere.

Another territory-related indicator is the level of accessibility between streets, which can be measured by factors like the number of intersections and the betweenness index, as suggested by Pearce et al. (2021). The following table compares the intersection density in the selected neighborhoods.

Table 4.11. Number of intersections and intersection density in selected neighborhoods

Neighborhood	Chizar	Sanglaj	Qeytariyeh	Dr. Hooshyar	Darrous	Shahrak-e Qarb
Intersection density (number per hectare)	1.870	5.155	1.501	5.063	1.642	0.475

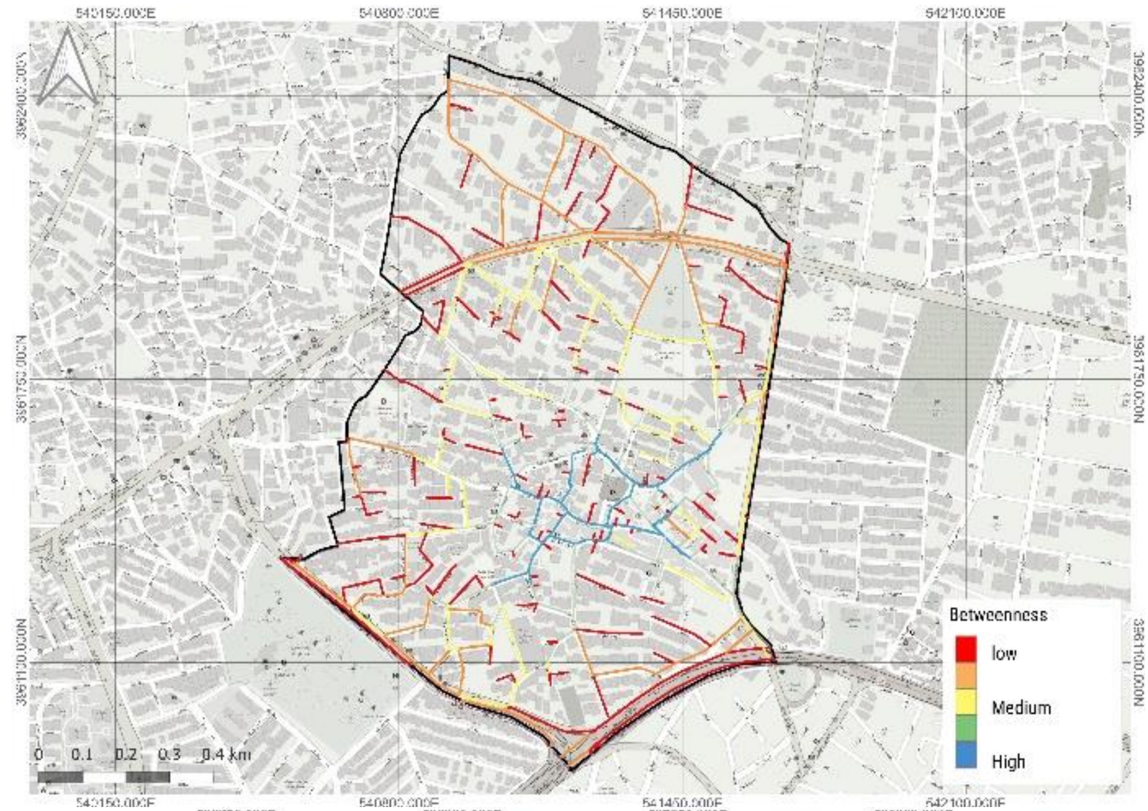
The comparison of the number of intersections and intersection density reveals that Sanglaj and Dr. Hooshyar neighborhoods boast the highest number of intersections. However, when considering intersection density, adjusted for the different sizes of the neighborhoods, Chizar, Qeytariyeh, and Darrous exhibit a similar number of intersections per unit area. This suggests that these three neighborhoods offer a moderate level of street accessibility, with relatively equal distribution.

Conversely, Shahrak-e Qarb neighborhood has the lowest intersection density, approximately 0.5, indicating less street accessibility from a single street. It is important to note that Shahrak-e Qarb was intentionally designed with limited accessibility for external users, aligning with the principles of territories and street hierarchy in organic street networks. These principles aim to restrict the presence of outsiders within the network to enhance residents' security.

Another method for assessing an area's security level is using the **betweenness index**, which relies on the functionality of the street network. For this research, the destination points selected to calculate the betweenness index within an organic street network are the centers of the streets. This choice enables the measurement of the shortest paths that can be established within a 400-meter radius, representing a desired walking distance.

The goal is to determine how well streets are interconnected by assessing how many shortest paths can be formed to link streets together within the specified radius. Longer streets with fewer intersections tend to have lower betweenness values, indicating reduced street connectivity and potentially higher security. Conversely, shorter streets with more intersections result in increased betweenness values, highlighting a more extensive and interconnected street network.

To better visualize the betweenness index and its implications for street connectivity and neighborhood security, the following maps depict the distribution of the betweenness index values. These maps provide a clearer understanding of how the betweenness index is used to evaluate security levels and the degree of street connectivity in the analyzed neighborhoods.



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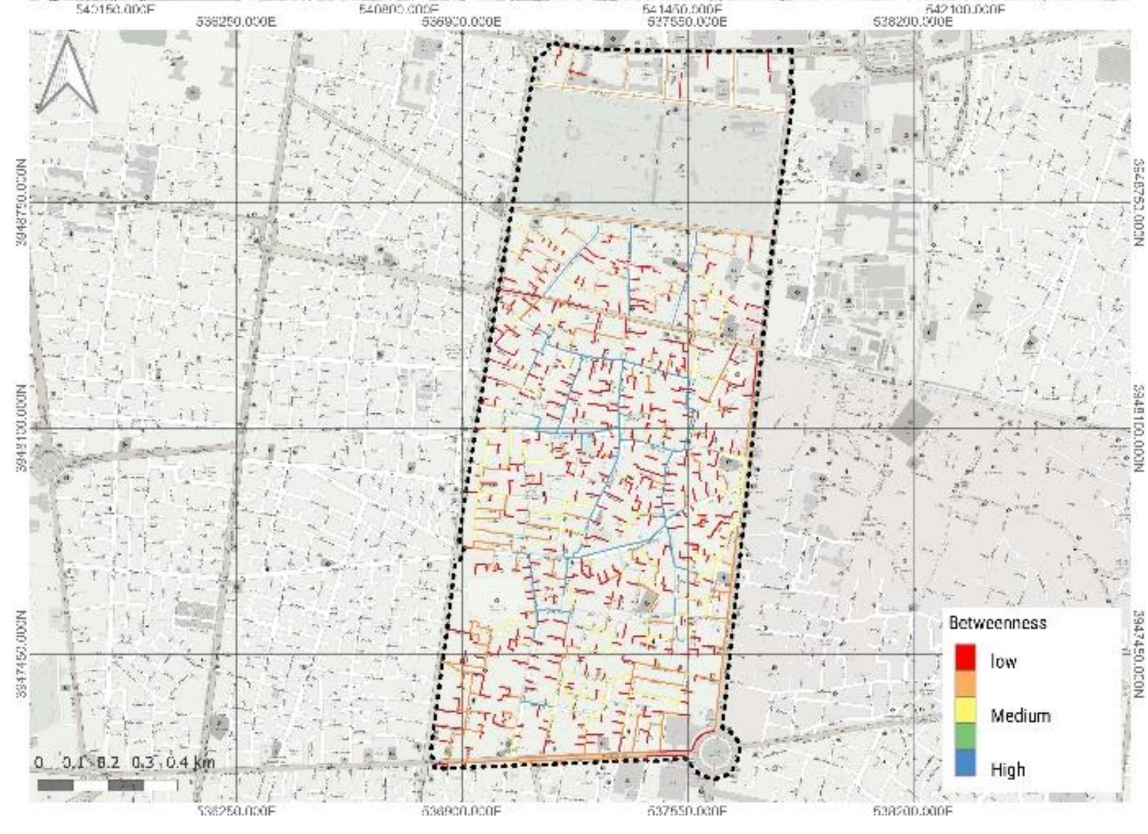

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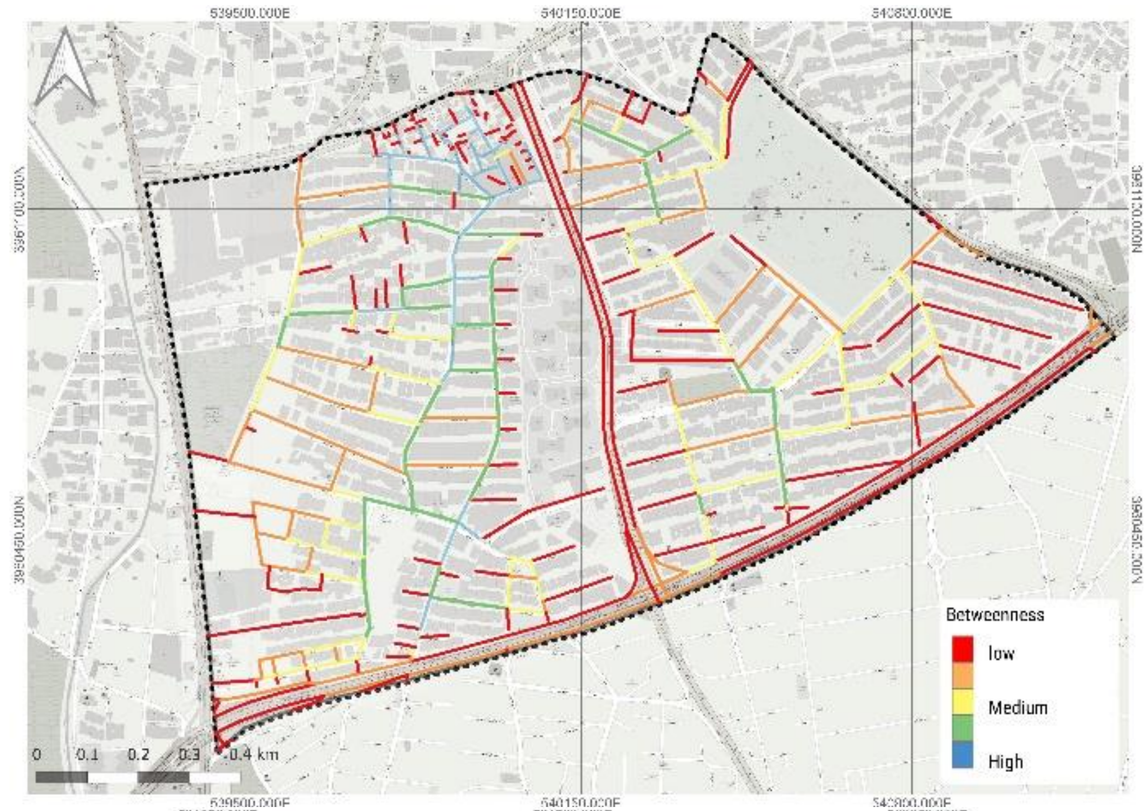
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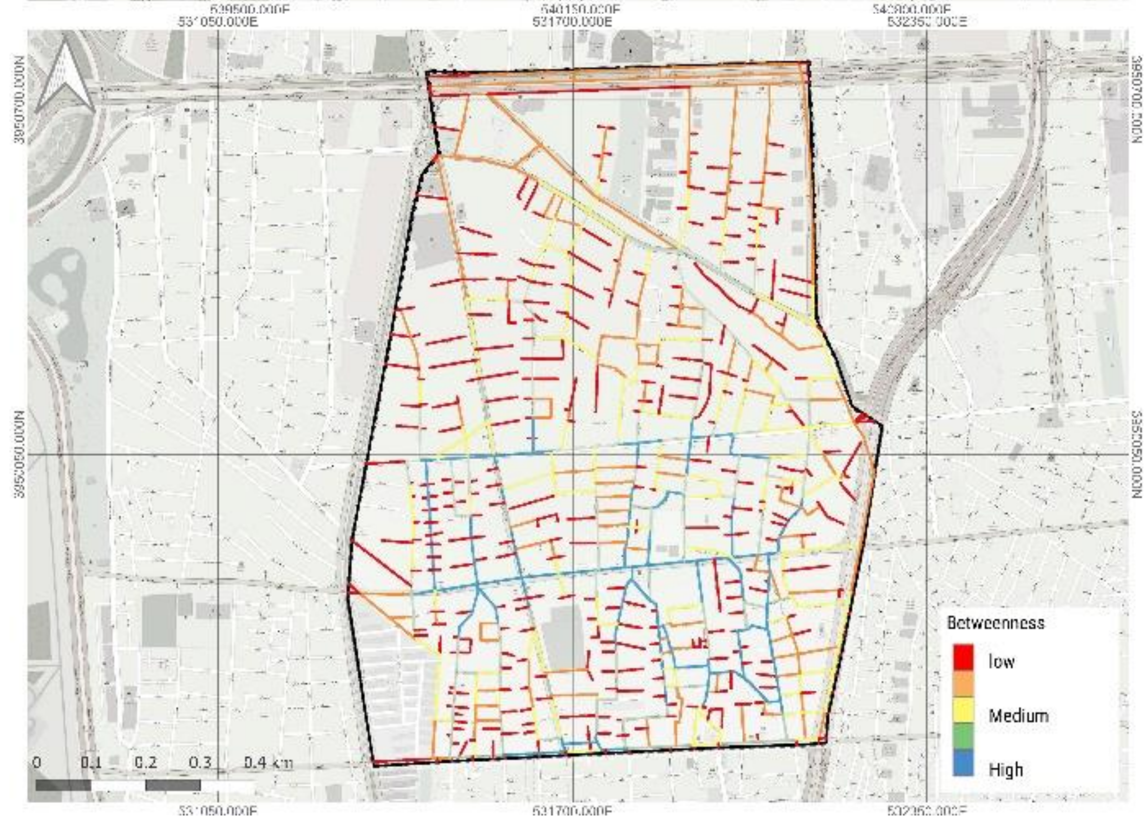
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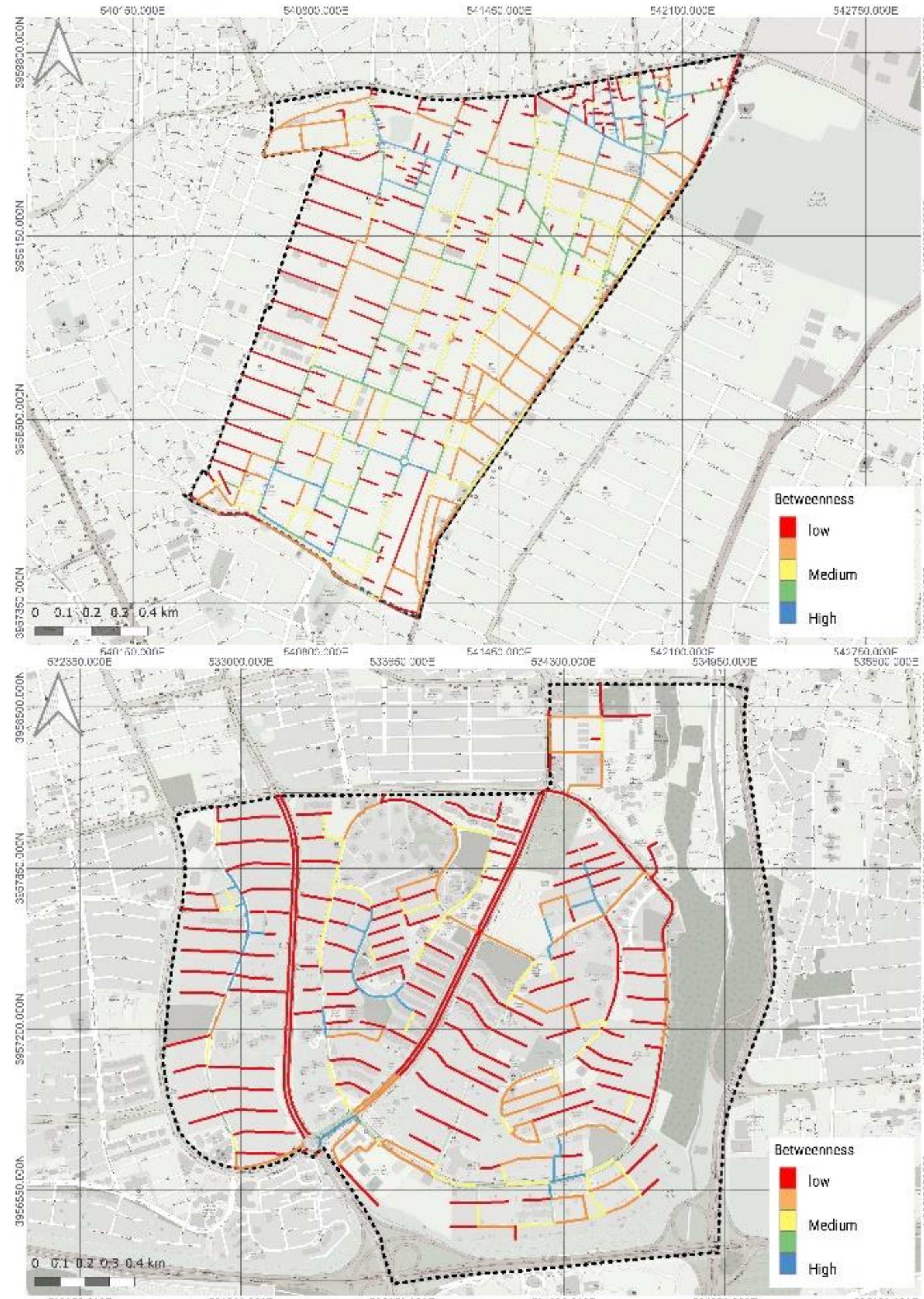


Figure 4.55. The map of betweenness in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb)

Among the studied neighborhoods, Shahrak-e Qarb boasts the lowest betweenness index, averaging 28. Following that, Darrous, Qeytariyeh, and Chizar have moderate betweenness values of 228, 241, and 384, respectively. Lastly, Sanglaj and Dr. Hooshyar have the highest betweenness values among the cases, with values of 1444 and 1604, respectively.

The betweenness index reflects the potential number of pedestrians passing through the center of the streets within the networks. Streets with more options for pedestrians to navigate between surrounding destinations tend to have higher betweenness values. In all the study areas, pedestrians can choose alternate routes within the 400-meter radius, meaning they are not restricted to reaching the center of a street without the option to change their path. However, an issue arises when considering a high-traffic center, such as Qeytariyeh Park, as a destination. In such cases, it becomes crucial to determine whether pedestrians pass through the centers to reach another significant destination. Providing access to an important destination and considering the function of the place provides a different context for the pedestrian's route. Therefore, considering the high betweenness of the center of the street as an accurate measurement accounts for this additional context for pedestrians.

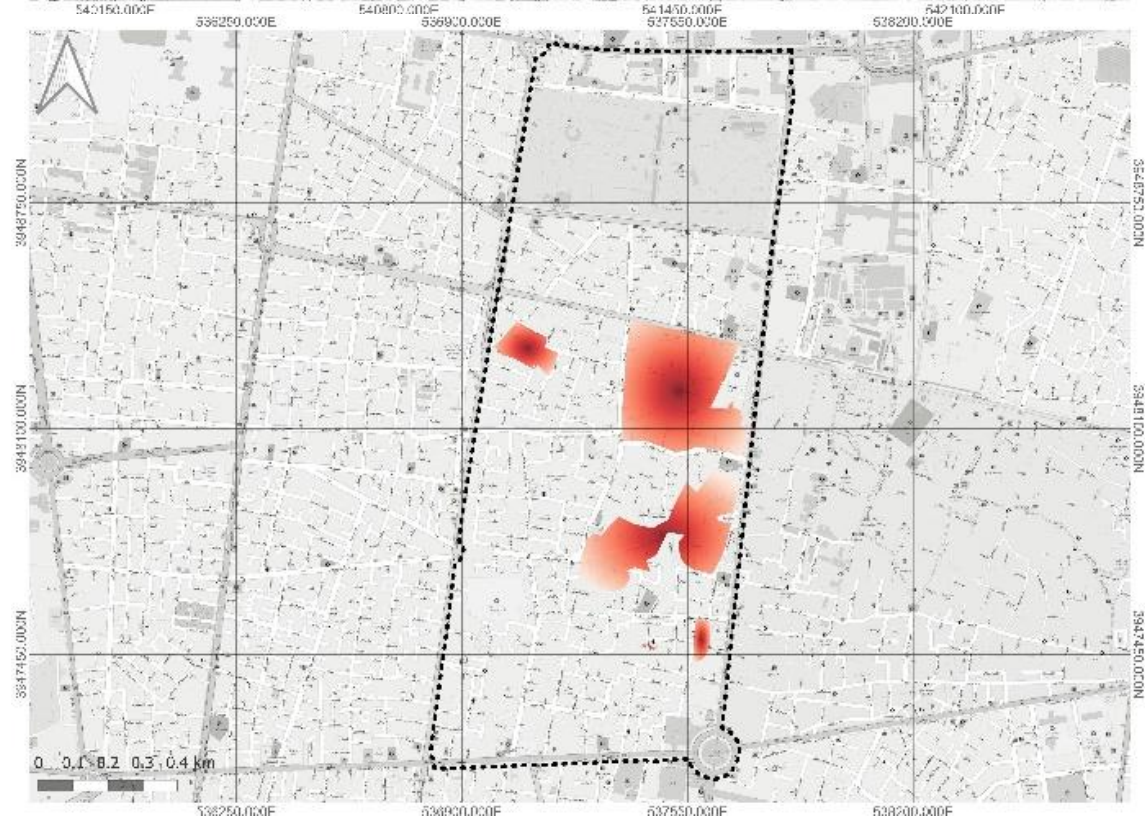
In Chizar, the center of the neighborhood has the highest betweenness, offering multiple shortest paths for pedestrians to navigate and reach different parts of the neighborhood. Sanglaj exhibits a similar situation with two central areas of high betweenness. The northern part of the area comprises a large park, resulting in nearby streets having high betweenness. However, the centers in the southern region also exhibit higher betweenness, indicating greater accessibility.

In most cases, narrow streets have higher betweenness, emphasizing their significance and making changes in these areas (such as widening the streets) challenging. In Qeytariyeh, the organic part of the neighborhood provides more shortest paths compared to the grid pattern side. This may be attributed to the historic center of the neighborhood and its relatively easier accessibility. The grid side includes Qeytariyeh Park, elevating the surrounding streets' betweenness. Similarly, the organic part of Dr. Hooshyar exhibits higher betweenness compared to the tributary side. As expected, cul-de-sac streets offer fewer passing options and lower betweenness. In the Darrous neighborhood, the organic and tributary parts have higher betweenness than the grid part. This can be attributed to the original center of the neighborhood having an organic pattern, integrating it strongly with other parts of the neighborhood. In contrast, the tributary pattern terminates at the edges of the water canal and surrounding green areas, which enhances the betweenness of the surrounding streets.

As previously discussed, due to the security ideology of Shahrak-e Qarb, the neighborhood has lower betweenness values for its streets. This is because most streets are designed to reach very few destinations, and consequently, streets themselves are also passed through less frequently as destinations, as there are limited options for reaching various destinations through each street.

The second security element in this study is the concept of **"Eyes on the Street"**. It refers to spaces within the street networks that are not easily visible to other users. These spaces lack openings, pass-by routes, and adequate lighting. Since these spaces cannot be identified from the maps, individuals were surveyed to identify areas where they feel insecure due to the perception that nobody can see them if trouble arises. The following maps illustrate their responses.


540150.000E
540800.000E
541450.000E
542100.000E
3962400.000N
3961750.000N
3961100.000N
0 0.1 0.2 0.3 0.4 km


536250.000E
536900.000E
537550.000E
538200.000E
3948750.000N
3948100.000N
3947450.000N
0 0.1 0.2 0.3 0.4 km

539500.000E
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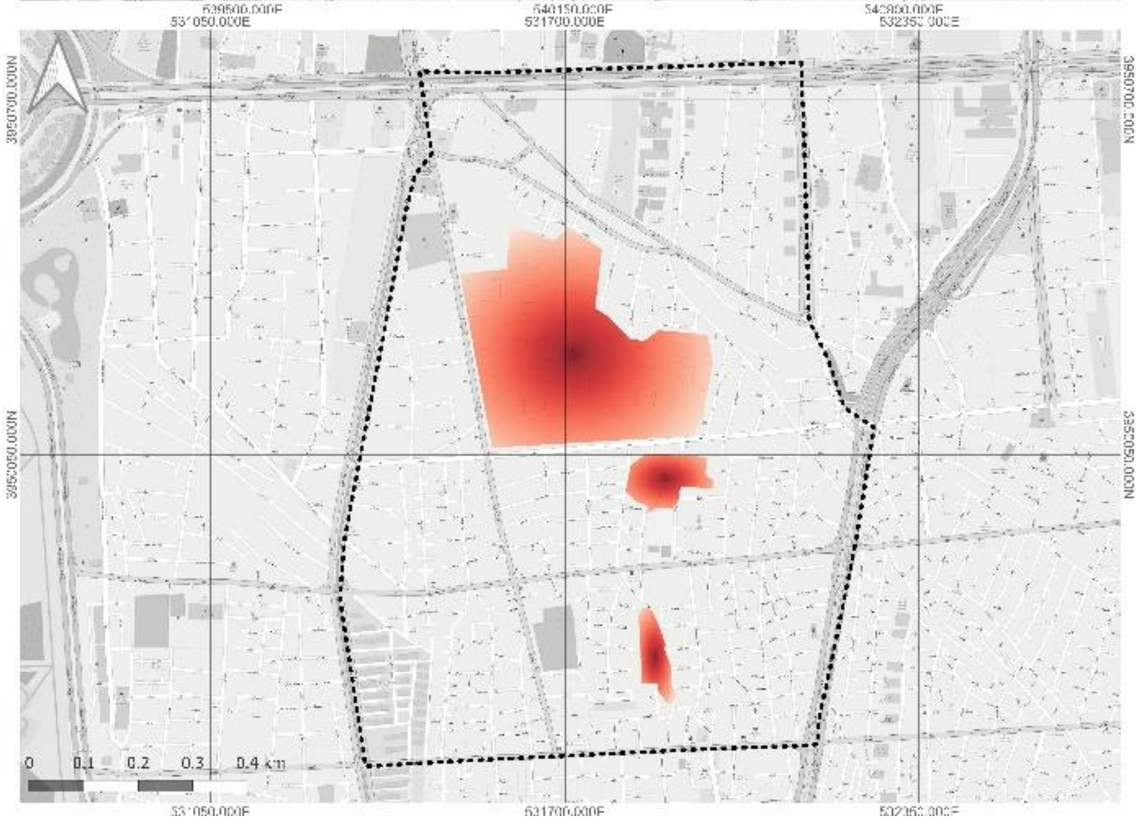

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531700.000E
3950700.000N
3950050.000N
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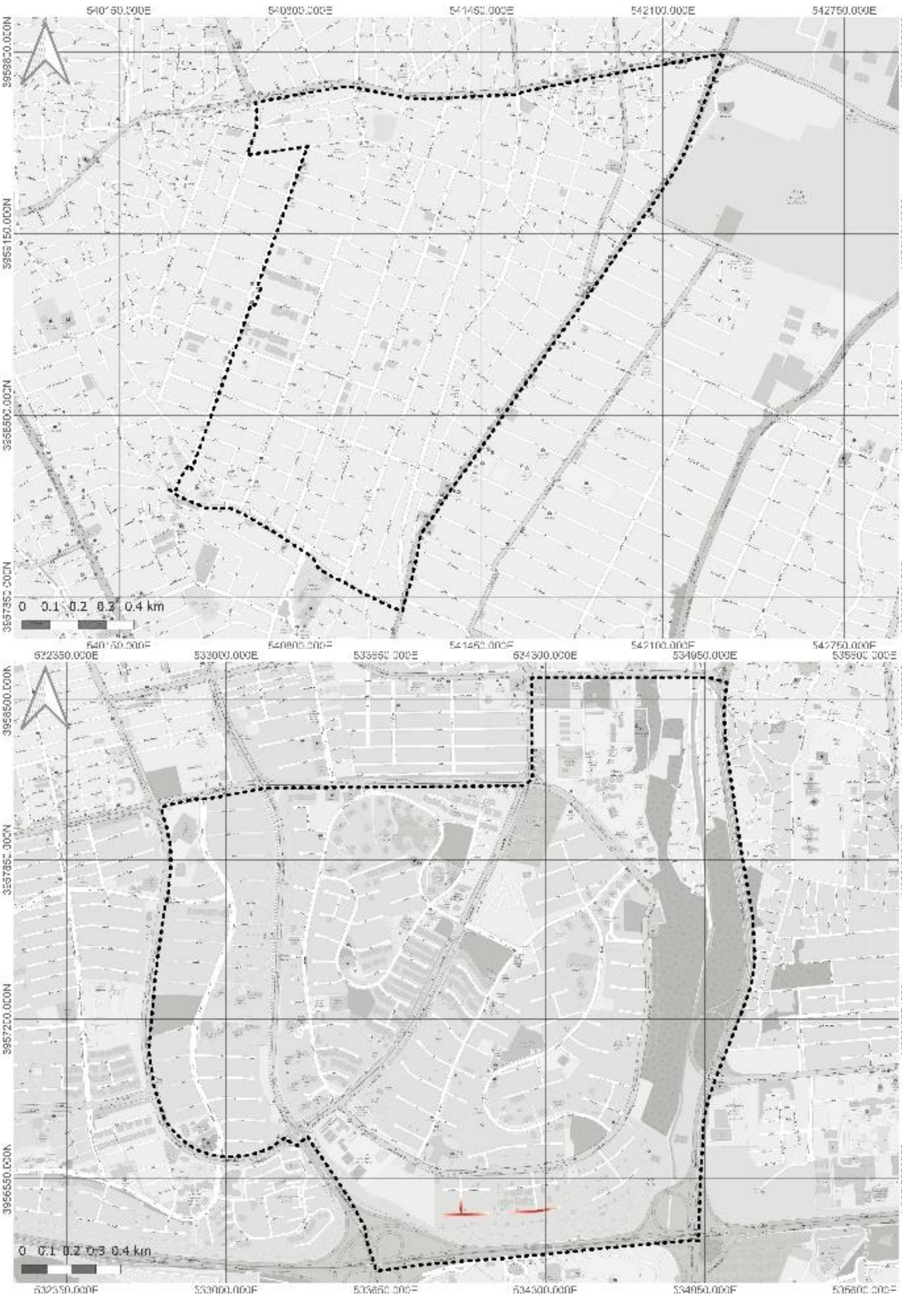


Figure 4.56. The map of feeling-insecure spaces in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb)

According to the maps, individuals mainly report feeling insecure in Sanglaj and Dr. Hooshyar neighborhoods. This sense of insecurity is attributed to the commercial nature of these areas, the presence of non-local individuals, and the lack of activity during nighttime. In Chizar and Qeytariyeh, residents express a partial sense of insecurity as they perceive certain spaces to be overly localized. However, it is important to note that the feeling of security in the Darrous and Shahrak-e Qarb areas is inconclusive. This is because respondents in these areas frequently use private vehicles and do not experience insecurity as pedestrians. Additionally, Darrous hosts many foreign embassies in Tehran, which are guarded for security purposes, while Shahrak-e Qarb has implemented security measures such as security guards and video surveillance systems in many streets.

Furthermore, residents of Chizar and Qeytariyeh appreciate the community structure of certain parts of their neighborhoods. However, non-local citizens who have not resided in the neighborhood for an extended period may feel unwelcome in these areas, leading to insecurity. It is important to note that one of the primary objectives of the organic street network was to limit the entry of non-local individuals, fostering stronger relationships among neighbors and reducing the sense of insecurity. However, as Tehran attracts more immigrants, residents often relocate to other areas in search of better living conditions. Consequently, without local citizens in each neighborhood, the community-structured networks may not function as intended. In the case of Chizar and Qeytariyeh, non-local residents perceive the community-structured areas as insecure for themselves.

Finally, it should be emphasized that the reasons for feeling insecure in Sanglaj and Dr. Hooshyar are not directly related to the form of the streets or the street network. Therefore, these results may not be considered reliable indicators for evaluating security based on the "eyes on the street" concept.

The final aspect of security in this study is **lighting**. Although lighting is not directly related to the form of the street network, it was consistently mentioned as an important factor by the experts interviewed. The organic street network in Tehran is not linear, and many streets remain narrow due to new high-rise constructions. Therefore, proper lighting is crucial to ensure pedestrian safety. Due to limited access to data on the location of street lights in Tehran, residents of the neighborhoods were surveyed about their satisfaction with street lighting after dark.

According to the respondents' opinions, Shahrak-e Qarb has the best lighting, followed by Darrous, Qeytariyeh, and Chizar neighborhoods, which have proper lighting in both the main and side streets. Dr. Hooshyar Neighborhood, on the other hand, received a lower average level of satisfaction from its residents. Comments indicated that while main streets in this neighborhood have adequate lighting, secondary streets, and cul-de-sacs lack sufficient lighting, leading to insecurity among pedestrians. Sanglaj neighborhood received the lowest resident satisfaction with lighting conditions on both main and secondary streets after dark. The results demonstrate that there is currently no correlation between the street pattern and proper lighting. Proper lighting is considered an urban facility issue that can be addressed through appropriate urban planning. In wealthier neighborhoods, buildings often provide sufficient lighting for street users, while poorer areas lack supplemental lighting from building owners, resulting in inadequate lighting, especially in secondary streets.

Additionally, all respondents agreed that proper lighting significantly impacts their sense of security while walking. The table provided illustrates the questionnaire results, showing the percentages of respondents indicating the presence of adequate lighting in main and secondary streets for each neighborhood.

Table 4.12. Existing of the proper lighting in main and secondary streets in selected neighborhoods (in percent)

Neighborhood	Chizar		Sanglaj		Qeytariyeh		Dr. Hooshyar		Darrous		Shahrak-e Qarb	
	W[7]	M[8]	W	M	W	M	W	M	W	M	W	M
Proper lighting in main streets	85.7	100	50	100	100	100	66.6	100	100	100	100	100
Proper lighting in secondary streets	14.3	80	0	0	55.5	100	0	0	50	100	63.6	100

Significantly, there are noticeable differences between the opinions of women and men, particularly regarding secondary streets in Chizar, Qeytariyeh, Darrous, and Shahrak-e Qarb. These differences could be attributed to the limited number of respondents and the varying perceptions of security between women and men.

In conclusion, the findings concerning the security aspect highlight that pedestrians' sense of security can be influenced by various factors. However, when considering the characteristics of organic street patterns, including the hierarchy of streets, principles of territories, higher betweenness index, and a greater number of intersections, it becomes evident that the original organic street pattern in the old and historic core of Tehran provides a higher level of pedestrian security. Following this, the integrated organic pattern with a grid system, and then the grid and tributary networks, offer increased levels of security. In contrast, the imitated organic street network and the integrated network with a tributary system rank lowest in terms of security.

These findings underscore the intricate relationship between urban planning, street network design, and pedestrian security. Understanding these dynamics is crucial for creating safer and more livable urban environments.

[7] women
[8] men

4.2.3. Accessibility

Accessibility encompasses the ability to access a location and navigate the available routes to various destinations. While factors like function and density are closely related to accessibility, this research primarily delves into the significance of urban form. As such, this section centers on neighborhood entrances and the **number of nodes**, which includes intersections and cul-de-sacs. Previous research has indicated that a greater number of nodes enhances neighborhood access and, subsequently, improves walkability in terms of accessibility. The following table provides data on the number of nodes in each neighborhood.

Table 4.13. Number of intersections and the intersection density in selected neighborhoods

Neighborhood	Chizar	Sanglaj	Qeytariyeh	Dr. Hooshyar	Darrous	Shahrak-e Qarb
The number of nodes	342	961	352	855	464	349
Node density (number per hectare)	2.85	9.33	2.27	8.22	2.34	0.79

The results reveal that Sanglaj and Dr. Hooshyar have a higher number of nodes, signifying increased accessibility. It is important to consider that private residences also serve as significant destinations for residents within the neighborhood. Therefore, higher accessibility implies improved access to urban services, amenities, and residential areas. Conversely, Shahrak-e Qarb exhibits the lowest number of nodes due to its deliberate design ideology, aiming to maximize control and surveillance. The deliberate inclusion of numerous cul-de-sacs restricts access in this neighborhood. Other neighborhoods generally have a similar number of nodes, resulting in comparable levels of neighborhood accessibility.

Existing literature suggests that the form of the organic street network can influence the distribution of essential services and the integration of public transportation within the network. However, addressing this matter solely through the number of services and stations does not provide a comprehensive view, which is why it hasn't been extensively discussed in this section. In the historic core of Tehran, the original organic street network offers the highest level of accessibility to the site. As the foundational roots of the city's development, the streets and pathways in this area are more conducive to pedestrian movement compared to the northern parts of the city, which were gradually integrated into the urban structure from rural regions. Consequently, the street layout and intersection density in the northern areas are not as extensive as in the central regions of Tehran. Similarly, the integrated organic street network with tributaries provides numerous access options to the city center due to its abundance of small streets and cul-de-sacs. The least favorable situation is observed in the imitated organic street network, where limited accessibility is employed to segregate the area from the rest of the city.

4.2.4. Connectivity

Connectivity within a street network encompasses both physical and visual aspects. **Physical connectivity** pertains to the effective linking of streets, which contributes to improved walkability, aids in orientation, and encourages pedestrian activity. When assessing physical connectivity based on the street network's form, two key indicators are crucial: the link-to-node ratio (often referred to as the beta index) and the average length of links (referred to as the Eta index). The table below presents these indicators for the studied neighborhoods.

Table 4.14. Beta and Eta indexes in selected neighborhoods

Neighborhood	Chizar	Sanglaj	Qeytariyeh	Dr. Hooshyar	Darrous	Shahrak-e Qarb
Beta index	1.21	1.09	1.18	1.19	1.30	1.19
Eta index	61.16	31.26	71.86	33.33	63.84	139.55

The beta index is directly linked to a neighborhood's walkability rate, with a higher beta index indicating a higher walkability rate. In this context, Sanglaj has the lowest beta index, while Darrous has the highest. This is likely due to Sanglaj having a high number of cul-de-sacs and Darrous having a high number of intersections. The other neighborhoods show similar beta index rates.

Conversely, the eta index demonstrates an inverse relationship with the walkability rate. A higher eta index indicates a lower walkability rate. Shahrak-e Qarb has the highest eta index, indicating a lower walkability rate, while Sanglaj and Dr. Hooshyar have the lowest eta index, indicating a higher walkability rate. The other neighborhoods exhibit similar walkability rates and eta indexes based on this indicator.

Based on the results, Sanglaj has the lowest walkability rate based on the beta index and the highest walkability rate based on the eta index. However, since the beta indicator in the selected neighborhoods does not exhibit significant differences (0.21), it is recommended to use intersection density as a connectivity index, as suggested by Dobesova and Krivka (2012). Intersection density has been previously mentioned in the security section, and based on this index, the eta index provides a more representative measure of connectivity rates.

Regarding physical connectivity, Sanglaj and Dr. Hooshyar have the highest levels, while Shahrak-e Qarb has the lowest. According to the calculations, Chizar, Darrous, and Qeytariyeh neighborhoods have more or less the same level of medium physical connectivity. To compare these results with the responses from the residents, they were surveyed about their knowledge of alternative routes to reach their destinations and whether they actively tried different routes. The table below presents their reports.

Table 4.15. Reports from the questionnaires about the alternative routes to the destinations in each neighborhood

			To reach a destination of this neighborhood, do you have only one alternative route in mind or do you try different routes?			
			I have only one alternative path and I always follow the same one.	There are other paths, but I always follow only one path.	There are more routes and I sometimes try new routes.	Sum
Mahale	Chizar	Quantity	1	7	4	12
		% of Mahale	8.3%	58.3%	33.3%	100.0%
	Darrous	Quantity	0	8	7	15
		% of Mahale	0.0%	53.3%	46.7%	100.0%
	Dr. Hooshyar	Quantity	7	1	0	8
		% of Mahale	87.5%	12.5%	0.0%	100.0%
	Qeytariyeh	Quantity	2	12	3	17
		% of Mahale	11.8%	70.6%	17.6%	100.0%
	Sanglaj	Quantity	1	7	1	9
		% of Mahale	11.1%	77.8%	11.1%	100.0%
	Shahrak-e Qarb	Quantity	15	4	0	19
		% of Mahale	78.9%	21.1%	0.0%	100.0%
Sum		Quantity	26	39	15	80
		% of Mahale	32.5%	48.8%	18.8%	100.0%

In the selected neighborhoods (excluding Dr. Hooshyar and Shahrak-e Qarb), most residents are aware of alternative route options, but they often tend to stick to one path. Interestingly, older individuals, both men and women and those without private vehicles are more open to using new alternative routes. However, it is important to note that these survey results may not precisely align with the calculations, as various factors can influence residents' responses during the evaluation process. Next, a comparison is made between pairs of neighborhoods, taking into consideration the adjusted significant value.

Table 4.16. Reports from the questionnaires about the integrity of the paths

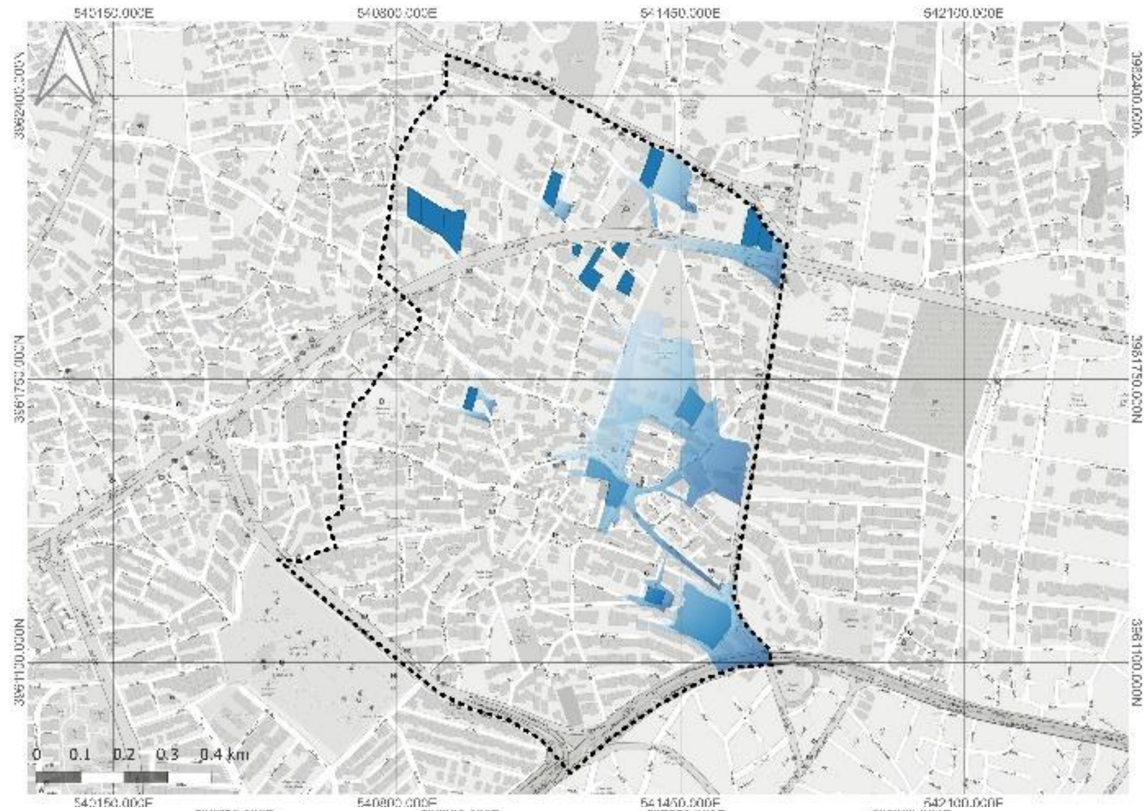
To what extent is the connectivity and integrity of the walking path effective in increasing your willingness to walk?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.[a]
Chizar-Sanglaj	-2.861	9.420	-.304	.761	1.000
Chizar-Qeytariyeh	-28.838	8.054	-3.580	<.001	.005
Chizar-Dr. Hooshyar	-30.937	9.751	-3.173	.002	.023
Chizar-Darrous	-33.312	8.158	-4.083	<.001	.001
Chizar-Shahrak-e Qarb	-41.539	7.877	-5.273	<.001	.000
Sanglaj-Qeytariyeh	25.977	8.806	2.950	.003	.048
Sanglaj-Dr. Hooshyar	28.076	10.380	2.705	.007	.103
Sanglaj-Darrous	30.451	8.901	3.421	<.001	.009
Sanglaj-Shahrak-e Qarb	-38.678	8.644	-4.474	<.001	.000
Qeytariyeh-Dr. Hooshyar	2.099	9.159	.229	.819	1.000
Qeytariyeh-Darrous	4.474	7.441	.601	.548	1.000
Qeytariyeh-Shahrak-e Qarb	-12.701	7.132	-1.781	.075	1.000
Dr. Hooshyar-Darrous	2.375	9.250	.257	.797	1.000
Dr. Hooshyar-Shahrak-e Qarb	-10.602	9.004	-1.178	.239	1.000
Darrous-Shahrak-e Qarb	-8.227	7.249	-1.135	.256	1.000

Each row tests the null hypothesis that the distributions in Mahale 1 and 2 are equal.
Asymptotic significances (2-tailed tests) are shown. The significance level is .050.
a. Significance values are adjusted by Bonferroni's correction for multiple tests.

The results indicate several significant differences in physical connectivity among the neighborhoods. Chizar and Sanglaj neighborhoods exhibit significantly smaller values compared to other cases. On the other hand, it can be concluded that Shahrak-e Qarb has the lowest ranking in terms of physical connectivity, while Sanglaj, Darrous, Qeytariyeh, and Chizar have relatively good physical connectivity. However, the evaluation of physical connectivity in the Dr. Hooshyar neighborhood is inconclusive, as the results are not significant.

To assess **visual connectivity**, specific landmarks in each neighborhood, including the tallest buildings with more than ten floors and famous landmarks like Imamzadeh, have been identified as visible points from various parts of the area. The following maps illustrate the visual connectivity in the case study areas.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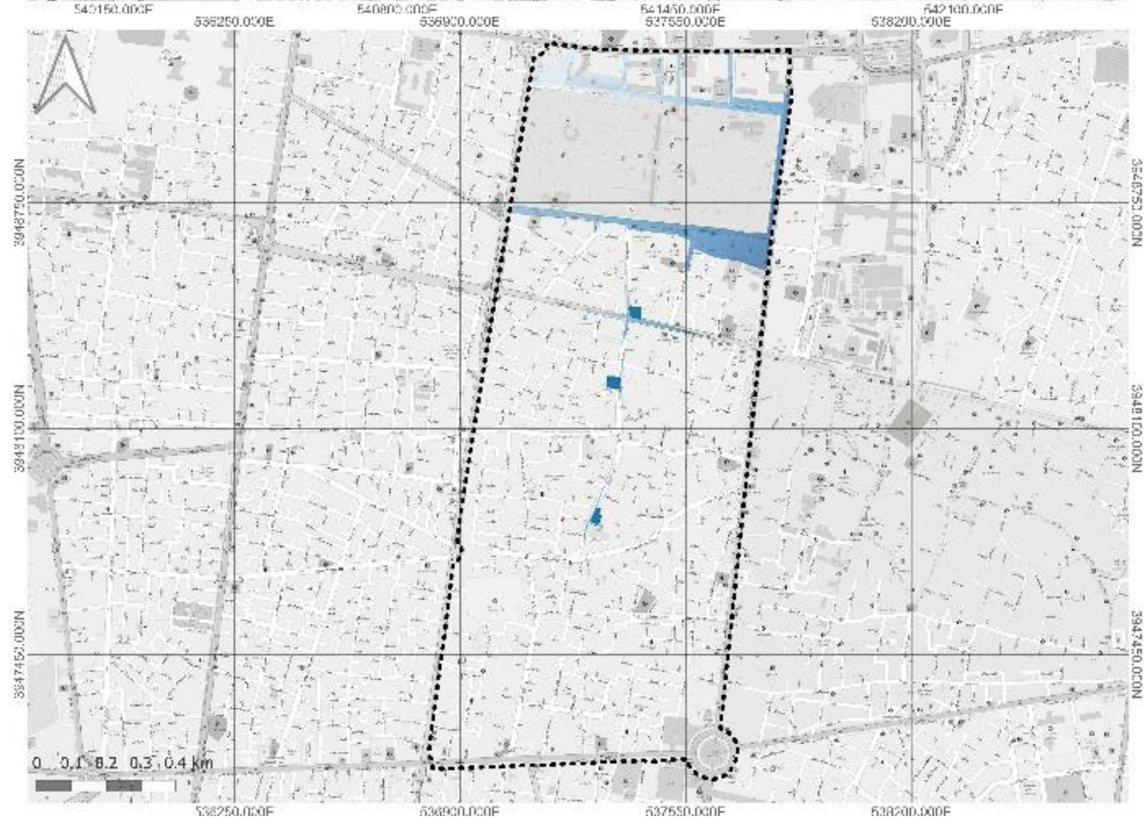
3961750.000N
3961100.000N
0 0.1 0.2 0.3 0.4 km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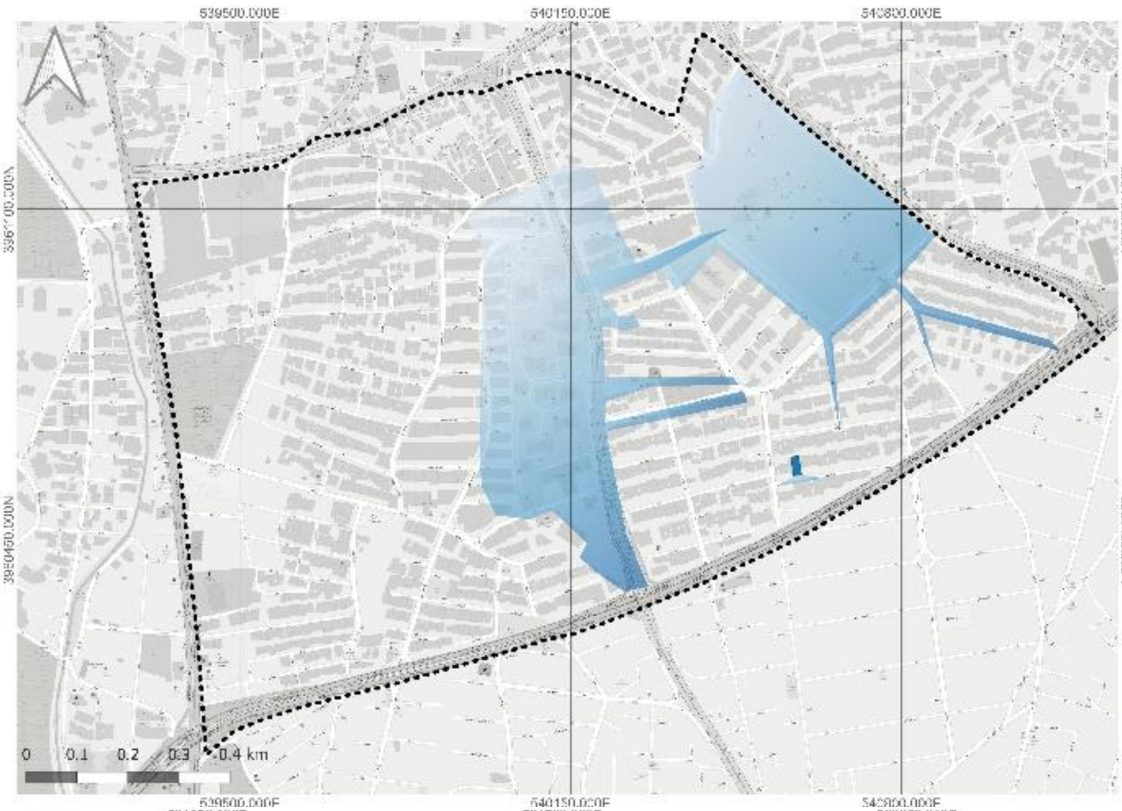
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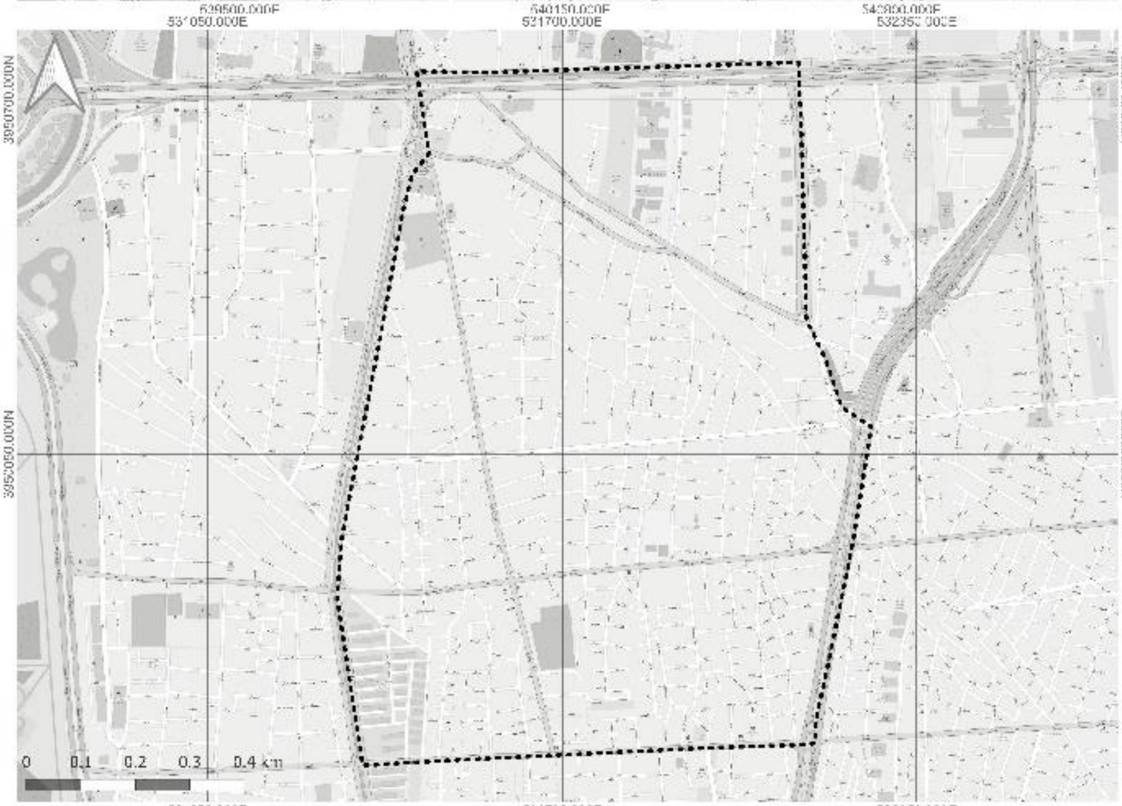
0 0.1 0.2 0.3 0.4 km


531050.000E
531700.000E
3950700.000N
3950050.000N
0 0.1 0.2 0.3 0.4 km

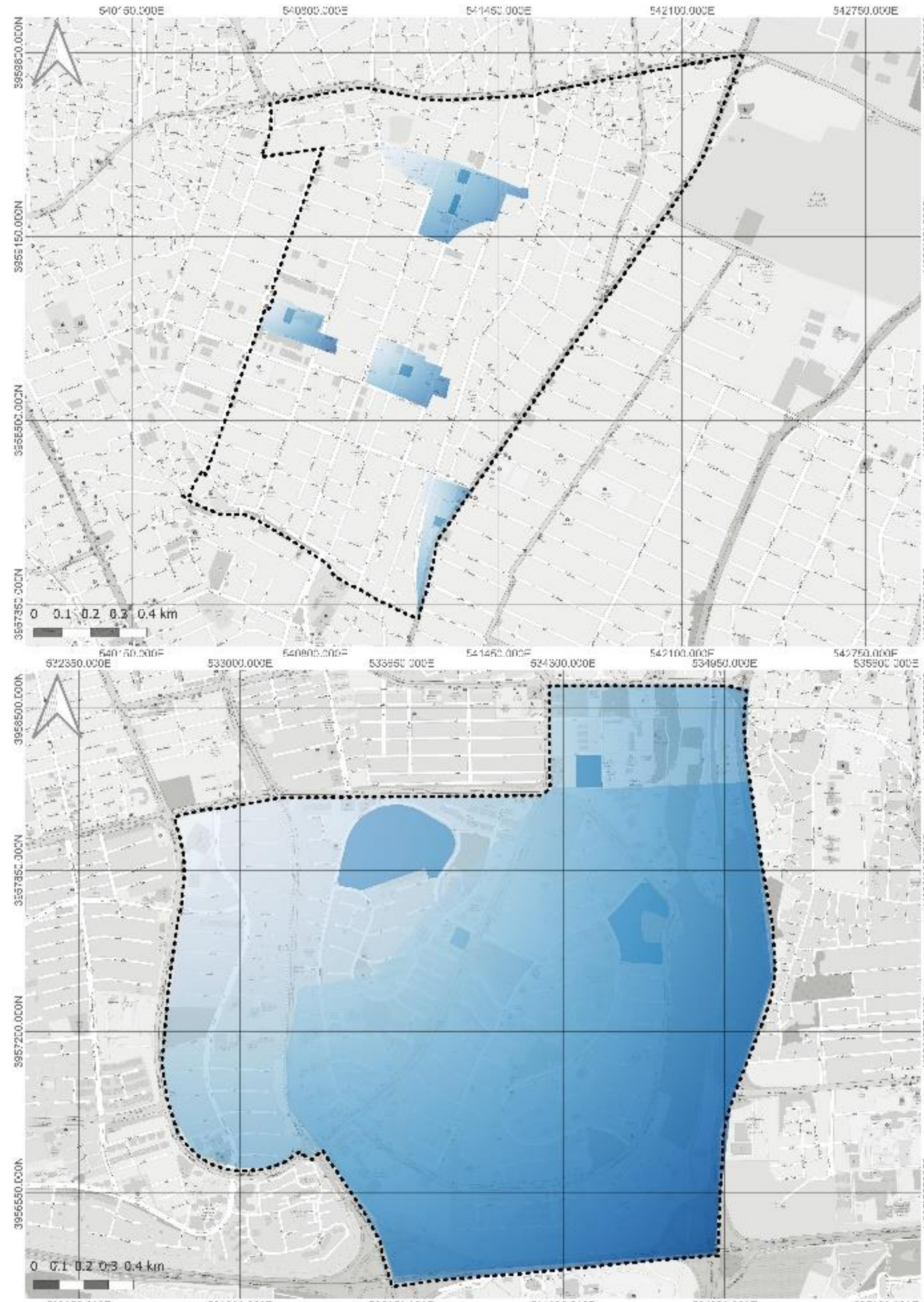


Figure 4.57. The map of visual connectivity in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous and Shahrak-e Qarb)

The topography and the presence of high-rise buildings have a significant influence on the visual connectivity of neighborhoods. In Qeytariyeh, Darrous, and Chizar, certain high buildings are visible from some parts of the neighborhood while remaining hidden from others due to variations in elevation and building height. In flat areas like Dr. Hooshyar and Sanglaj, visual connectivity is limited to nearby streets. However, in Shahrak-e Qarb, the combination of topography and tall multi-floor buildings allows landmarks to be visible throughout the neighborhood, facilitating easy navigation for residents who can rely on these landmarks. On the other hand, restricted access to secondary streets in Shahrak-e Qarb means that only local residents utilize them, although these streets offer similar visual perspectives.

The connectivity analysis reveals that different subcategories of organic street networks demonstrate varying levels of visual connectivity when considering high-rise buildings. However, most respondents reported that the presence of high-rise buildings has minimal impact on their willingness to walk in the neighborhood. Nevertheless, these buildings can serve as valuable landmarks for understanding and navigating the network. It is important to note that this feature of the neighborhoods is not directly related to the street network's form. As a result, the study does not provide a clear basis for comparing the different networks in terms of visual connectivity.

Regarding physical connectivity, denser networks tend to be more connected. While there are variations based on different indexes, it can be concluded that the imitated organic network has the weakest physical connectivity. The integrated network with a grid system (including grid and tributary patterns) exhibits less physical connectivity than the original organic network and the integrated network with a tributary system. Although the tributary pattern is not recognized as a connected network, combining it with the organic network and including long and curved streets results in a more connected network than expected. Among all the networks, the original organic street network in the historic center demonstrates the highest level of physical connectivity. This can be attributed to its long-term formation and development and the need to access multiple functions of the historic core of Tehran.

4.2.5. Climate Comfort

Climatic comfort plays a crucial role in the formation of organic street networks. The twisted and narrow streets intentionally restrict the amount of direct sunlight in Tehran's hot and dry climate, providing pedestrians with shaded areas. Additionally, certain streets feature roofs that protect passersby from wind and precipitation. Based on the responses gathered from questionnaires, neighborhoods were rated on a scale of 1 (very low) to 5 (very high) regarding street comfort for pedestrians, taking into account the street network design. The table below presents the obtained results.

Table 4.17. Climate comfort in selected neighborhoods based on pedestrians responds

Neighborhood	Chizar		Sanglaj		Qeytariyeh		Dr. Hooshyar		Darrous		Shahrak-e Qarb	
	W	M	W	M	W	M	W	M	W	M	W	M
Climate protection because of the street elements such as roof or arch	1.3	1.7	2.5	3	1	-	-	-	1	-	-	-
Providing shadow because of the narrow and twisted streets	2.7	3.6	3.7	4.3	2.3	2.7	1.3	1.5	3	3.3	-	-
Climate protection because of the street trees	4.5	4.7	1.3	1.3	4.7	4.5	1	1.3	5	4.7	2.3	2.7
Topography as a comfort element	2.5	3	5	5	3.5	3.7	5	5	2.3	3.5	4.7	5

The table provided offers a comprehensive comparison and evaluation of pairs of neighborhoods, with a particular focus on assessing how effectively the urban elements within each neighborhood protect individuals against various weather conditions. This aspect of the analysis delves into the critical role of climate comfort, which plays a pivotal role in shaping the organic street networks found within these neighborhoods.

Table 4.18. Reports from the questionnaires about the weather protection in each neighborhood

To what extent do urban elements protect you from weather conditions?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.[a]
Darrous-Chizar	9.750	5.129	1.901	.057	.860
Dr. Hooshyar-Chizar	9.750	6.130	1.590	.112	1.000
Qeytariyeh-Chizar	9.750	5.064	1.925	.054	.813
Shahrak-e Qarb-Chizar	9.750	4.952	1.969	.049	.735
Darrous-Dr. Hooshyar	.000	5.816	.000	1.000	1.000
Darrous-Qeytariyeh	.000	4.678	.000	1.000	1.000
Darrous-Shahrak-e Qarb	.000	4.557	.000	1.000	1.000
Darrous-Sanglaj	-32.000	5.596	-5.718	<.001	.000
Dr. Hooshyar-Qeytariyeh	.000	5.759	.000	1.000	1.000
Dr. Hooshyar-Shahrak-e Qarb	.000	5.661	.000	1.000	1.000
Dr. Hooshyar-Sanglaj	-32.000	6.526	-4.903	<.001	.000
Qeytariyeh-Shahrak-e Qarb	.000	4.484	.000	1.000	1.000
Qeytariyeh-Sanglaj	-32.000	5.537	-5.780	<.001	.000
Shahrak-e Qarb-Sanglaj	32.000	5.435	5.888	<.001	.000
Chizar-Sanglaj	-22.250	5.923	-3.757	<.001	.003

Each row tests the null hypothesis that the distributions in Mahale 1 and 2 are equal.
Asymptotic significances (2-tailed tests) are shown. The significance level is .050.
a. Significance values are adjusted by Bonferroni's correction for multiple tests.

The rightmost column of the table is crucial for interpreting its contents, as it provides the p-values for all pairwise comparisons. When the p-value is less than 0.05, it indicates a significant difference between the two neighborhoods under comparison. In this context, the leftmost column consistently highlights the neighborhood with superior weather protection, which, in this case, corresponds to the Sanglaj neighborhood. This consistent pattern arises from the presence of covered streets exclusively found in Sanglaj. While Chizar has a few similar urban elements, they are relatively scarce and are primarily acknowledged by older residents.

Table 4.19. Reports from the questionnaires about the street comfort in each neighborhood

To what extent do the features of the street provide comfort (e.g. Shadow)?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Shahrak-e Qarb-Sanglaj	1.711	9.021	.190	.850	1.000
Shahrak-e Qarb-Dr. Hooshyar	12.148	9.396	1.293	.196	1.000
Shahrak-e Qarb-Qeytariyeh	38.122	7.442	5.122	<.001	.000
Shahrak-e Qarb-Darrous	38.492	7.564	5.089	<.001	.000
Shahrak-e Qarb-Chizar	38.586	8.220	4.694	<.001	.000
Sanglaj-Dr. Hooshyar	10.438	10.832	.964	.335	1.000
Sanglaj-Qeytariyeh	36.412	9.190	3.962	<.001	.001
Sanglaj-Darrous	36.781	9.289	3.960	<.001	.001
Sanglaj-Chizar	36.875	9.830	3.751	<.001	.003
Dr. Hooshyar-Qeytariyeh	-25.974	9.558	-2.718	.007	.099
Dr. Hooshyar-Darrous	26.344	9.653	2.729	.006	.095
Dr. Hooshyar-Chizar	26.438	10.175	2.598	.009	.141
Qeytariyeh-Darrous	.369	7.765	.048	.962	1.000
Qeytariyeh-Chizar	.463	8.405	.055	.956	1.000
Darrous-Chizar	.094	8.513	.011	.991	1.000

The table presents the results of pairwise comparisons assessing the extent to which street features provide comfort, specifically in terms of shadow. Test statistics, standard errors, standard test statistics, significance levels, and adjusted significance levels are provided for each comparison. When comparisons are made between Sanglaj and the other neighborhoods, no significant differences in street comfort between Sanglaj and Dr. Hooshyar are observed. However, significant differences are noted when Sanglaj is compared with Qeytariyeh, Darrous, and Chizar, with Sanglaj being rated lower in terms of comfort provided by street features than in these neighborhoods. Significant differences are also observed when comparing Dr. Hooshyar with Qeytariyeh, Darrous, and Chizar, with Dr. Hooshyar being rated lower regarding street comfort than Qeytariyeh and Darrous. It is thus indicated that Dr. Hooshyar is perceived as less comfortable than Qeytariyeh and Darrous in terms of street comfort, whereas no significant differences in street comfort are shown for Chizar compared to other neighborhoods.

Table 4.20. Reports from the questionnaires about the comfort of trees in each neighborhood

To what extent do the street trees provide comfort for walking?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Dr. Hooshyar-Sanglaj	-1.889	11.022	-.171	.864	1.000
Dr. Hooshyar-Shahrak-e Qarb	-7.000	9.560	-.732	.464	1.000
Dr. Hooshyar-Qeytariyeh	-36.618	9.725	-3.765	<.001	.002
Dr. Hooshyar-Chizar	40.125	10.353	3.876	<.001	.002
Dr. Hooshyar-Darrous	55.781	9.822	5.679	<.001	.000
Sanglaj-Shahrak-e Qarb	-5.111	9.178	-.557	.578	1.000
Sanglaj-Qeytariyeh	34.729	9.350	3.714	<.001	.003
Sanglaj-Chizar	38.236	10.002	3.823	<.001	.002
Sanglaj-Darrous	53.892	9.451	5.702	<.001	.000
Shahrak-e Qarb-Qeytariyeh	29.618	7.572	3.911	<.001	.001
Shahrak-e Qarb-Chizar	33.125	8.364	3.961	<.001	.001
Shahrak-e Qarb-Darrous	48.781	7.696	6.338	<.001	.000
Qeytariyeh-Chizar	3.507	8.552	.410	.682	1.000
Qeytariyeh-Darrous	19.164	7.901	2.426	.015	.229
Chizar-Darrous	-15.656	8.662	-1.807	.071	1.000

Comfort provided by street trees was compared among different neighborhoods using the data presented in the table. Each pairwise comparison in the table includes test statistics, standard errors, standard test statistics, significance levels, and adjusted significance levels. Significant differences emerge when Dr. Hooshyar is compared with Qeytariyeh, Chizar, and Darrous, with Dr. Hooshyar being perceived as providing a lower level of comfort by street trees than these neighborhoods. Likewise, significant differences are noted when Shahrak-e Qarb is compared with Qeytariyeh and Darrous, with Shahrak-e Qarb being rated lower in terms of comfort provided by street trees compared to these neighborhoods. However, no significant differences are found when comparing Qeytariyeh with Chizar or Darrous, indicating similar levels of comfort provided by street trees in these neighborhoods.

Furthermore, a marginally significant difference is observed between Chizar and Darrous, with Chizar receiving slightly lower ratings in terms of comfort provided by street trees compared to the Darrous neighborhood, although the significance level is relatively high. In summary, the results suggest that Dr. Hooshyar and Shahrak-e Qarb offer higher levels of comfort provided by street trees compared to Qeytariyeh, Chizar, and Darrous. Sanglaj exhibits a similar level of comfort in comparison to the other neighborhoods regarding street trees.

Table 4.21. Reports from the questionnaires about the topography comfort in each neighborhood

To what extent is the topography of the streets comfortable for walking

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Darrous-Chizar	1.240	8.693	.143	.887	1.000
Darrous-Qeytariyeh	-9.825	7.929	-1.239	.215	1.000
Darrous-Shahrak-e Qarb	-35.426	7.724	-4.586	<.001	.000
Darrous-Dr. Hooshyar	-47.531	9.857	-4.822	<.001	.000
Darrous-Sanglaj	-47.531	9.485	-5.011	<.001	.000
Chizar-Qeytariyeh	-8.586	8.583	-1.000	.317	1.000
Chizar-Shahrak-e Qarb	-34.186	8.394	-4.073	<.001	.001
Chizar-Dr. Hooshyar	-46.292	10.391	-4.455	<.001	.000
Chizar-Sanglaj	-46.292	10.038	-4.612	<.001	.000
Qeytariyeh-Shahrak-e Qarb	-25.601	7.600	-3.369	<.001	.011
Qeytariyeh-Dr. Hooshyar	37.706	9.760	3.863	<.001	.002
Qeytariyeh-Sanglaj	-37.706	9.384	-4.018	<.001	.001
Shahrak-e Qarb-Dr. Hooshyar	12.105	9.594	1.262	.207	1.000
Shahrak-e Qarb-Sanglaj	12.105	9.212	1.314	.189	1.000
Dr. Hooshyar-Sanglaj	.000	11.062	.000	1.000	1.000

The provided information includes a comparison of the comfort level for walking on streets in different neighborhoods, focusing on street topography. The table presents test statistics, standard errors, standard test statistics, significance levels, and adjusted significance levels for each pairwise comparison. Notably, no significant differences are observed when comparing Darrous with Chizar, Qeytariyeh, Shahrak-e Qarb, Dr. Hooshyar, and Sanglaj. This suggests that the topography of streets in Darrous provides a similar level of comfort for walking as in these neighborhoods.

However, significant differences emerge when comparing Qeytariyeh with Dr. Hooshyar and Sanglaj, with Qeytariyeh being rated lower in terms of comfort provided by the topography of the streets compared to these neighborhoods. Similarly, when comparing Qeytariyeh with Shahrak-e Qarb, there is a significant difference, with Qeytariyeh rated lower in terms of comfort provided by the topography of the streets. In contrast, the comparison between Dr. Hooshyar and Sanglaj shows no significant difference, suggesting that the topography of the streets in both neighborhoods provides a similar level of comfort for walking.

In summary, the results indicate that Darrous has a lower level of comfort provided by the topography of the streets compared to Shahrak-e Qarb, Dr. Hooshyar, and Sanglaj. Additionally, Qeytariyeh is perceived to have a lower level of comfort in terms of street topography compared to Dr. Hooshyar and Sanglaj. The groups with significant differences and higher values are highlighted in color. Notably, Darrous, Chizar, and Qeytariyeh consistently exhibit significantly lower values for street topography concerning walking comfort.

Another important aspect to consider in evaluating climate comfort is the orientation of the streets. To leverage pleasant cool breezes during hot, dry summer days and maximize sunlight exposure during both hot summers and cold winters, the optimal street orientation in Tehran is northeast-southwest (Akbari and Ebrahimi, 2020). Researchers Seth Kadish (2014) and Geoff Boeing (2019) have developed a method to analyze city orientations, dividing the space into 360° and categorizing road segments into specific orientation ranges. This approach generates orientation maps that offer valuable insights into the street patterns of each city. Furthermore, developer Vladimir Agafonkin (2018) has expanded this methodology to cover regions worldwide through an interactive map. The following maps depict street orientations in the studied neighborhoods of Tehran, providing visual representations of the prevailing street directions in each area.

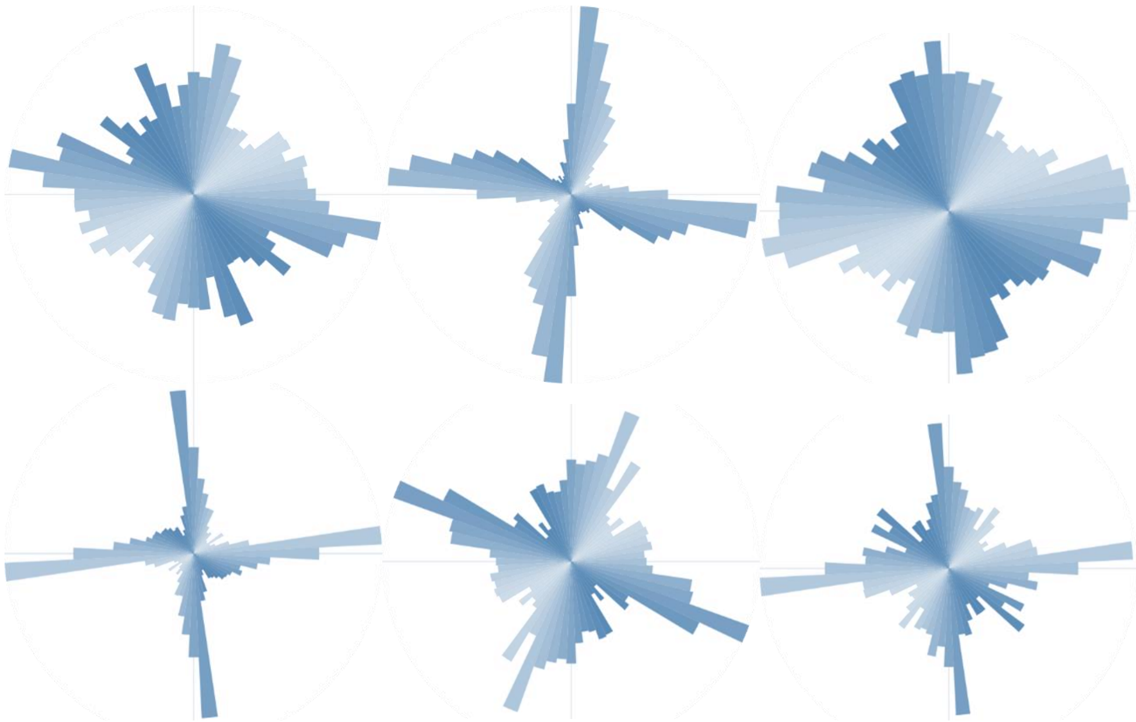


Figure 4.58. The map of street orientation in study areas (from above-left: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb)

The maps provide valuable insights into the prevailing street orientations in the studied neighborhoods of Tehran, with a focus on ensuring climate comfort in the urban environment. Notably, Sanglaj, Darrous, and Chizar exhibit the most favorable street orientations, aligning with the northeast-southwest direction optimal for climate comfort. While Qeytariyeh and Chizar demonstrate more diverse development patterns in various directions, their primary orientation remains discernible. Conversely, Sanglaj, Dr. Hooshyar, and Shahrak-e Qarb display limited growth in different directions, emphasizing their original orientations. However, Qeytariyeh, Dr. Hooshyar, and Shahrak-e Qarb adopt an opposite orientation, running northwest-southeast, aimed at providing comfort to street users. In summary, when considering street orientation, Darrous, Sanglaj, and Chizar emerge as the neighborhoods with the most optimal climate comfort due to the predominant orientation of their main and secondary streets.

Based on the findings, it can be concluded that the neighborhoods lack sufficient street elements to adequately protect pedestrians from adverse weather conditions during walking. While respondents in Sanglaj mentioned the presence of roofs and Sabats, these structures were reportedly damaged and deteriorated, posing potential dangers for pedestrians. Consequently, people often choose alternative routes to avoid such risks. The results also highlight that women pay more attention to the quality of urban structures while walking. Regarding shading, respondents noted that shadows are primarily provided by newly constructed high-rise buildings rather than the size and form of the streets. However, trees were identified as essential elements by a majority of respondents.

Concerning topography, residents held varying opinions. Some individuals viewed topography as a positive feature, enabling them to integrate physical activities into their daily lives. Conversely, others perceived it as a challenge that hindered quick and easy access to their destinations, leading them to rely more on private cars. This perspective was particularly prominent among the older generation. Additionally, respondents mentioned a preference for using the ride-side of the streets whenever possible to avoid steps. In terms of topographical comfort, residents of Shahrak-e Qarb, Sanglaj, and Dr. Hooshyar expressed satisfaction with their neighborhood's topographical features. Differences observed in the responses between women and men can largely be attributed to the age groups of the respondents.

4.2.6. The Quality of Built Environment

The quality of the built environment encompasses various elements and indicators, with a particular focus on street form in this section. Several elements related to street form have been studied, including human scale, proper enclosure, permeability, readability, control, choice, linkage, relative depth, and the principles of stasis and dynamism.

Information regarding the width and height of the streets was not accessible, preventing the calculation of ratios that could provide a better understanding of the human scale in the case study areas. Consequently, residents were questioned about their **sense of confinement** on a scale ranging from 1 (very low) to 5 (very high) when walking through their neighborhoods. The average ratings provided by the respondents are documented in the table below.

Table 4.22. Sense of confinement and human scale in selected neighborhoods based on pedestrians' responses

Neighborhood	Chizar		Sanglaj		Qeytariyeh		Dr. Hooshyar		Darrous		Shahrak-e Qarb	
	W	M	W	M	W	M	W	M	W	M	W	M
The sense of confinement	2.2	2.1	1.3	1.0	2.3	2.1	2.7	2.2	3.5	3.3	3.8	3.5
The average width of the streets in a neighborhood (m)	9.91		4.11		10.06		6.33		8.94		16.24	
The highest height in the neighborhood (m)	67		28		32		28		52		82	
The ratio between the width and height of the streets	6.7		6.8		3.2		4.4		5.8		5.0	

The results reveal that in Sanglaj, residents perceive the neighborhood's design to align with a human scale. They do not consider the narrow width of the streets as a factor that makes them feel enclosed by the built environment. In contrast, residents of Shahrak-e Qarb and Darrous rank the streets as less accommodating to human scale, reporting a greater sense of confinement. Chizar, Qeytariyeh, and Dr. Hooshyar received relatively similar medium rankings in this aspect. The following table presents the adjusted significance values for each pair of neighborhoods, based on the questionnaire responses.

Table 4.23. Reports from the questionnaires about the confinement of the street space in each neighborhood

To what extent do you feel confined as a pedestrian in this neighborhood?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.[a]
Sanglaj-Chizar	6.889	10.052	.685	.493	1.000
Sanglaj-Qeytariyeh	21.085	9.397	2.244	.025	.373
Sanglaj-Dr. Hooshyar	33.243	11.077	3.001	.003	.040
Sanglaj-Darrous	44.806	9.498	4.717	<.001	.000
Sanglaj-Shahrak-e Qarb	-48.924	9.224	-5.304	<.001	.000
Chizar-Qeytariyeh	-14.196	8.595	-1.652	.099	1.000
Chizar-Dr. Hooshyar	-26.354	10.405	-2.533	.011	.170
Chizar-Darrous	-37.917	8.705	-4.356	<.001	.000
Chizar-Shahrak-e Qarb	-42.035	8.405	-5.001	<.001	.000
Qeytariyeh-Dr. Hooshyar	12.158	9.773	1.244	.214	1.000
Qeytariyeh-Darrous	23.721	7.940	2.988	.003	.042
Qeytariyeh-Shahrak-e Qarb	-27.839	7.610	-3.658	<.001	.004
Dr. Hooshyar-Darrous	11.563	9.871	1.171	.241	1.000
Dr. Hooshyar-Shahrak-e Qarb	-15.681	9.607	-1.632	.103	1.000
Darrous-Shahrak-e Qarb	-4.118	7.735	-.532	.594	1.000

Each row tests the null hypothesis that the distributions in Mahale 1 and 2 are equal.
Asymptotic significances (2-tailed tests) are shown. The significance level is .050.
a. Significance values are adjusted by Bonferroni's correction for multiple tests.

The results reveal no significant differences between the responses of women and men regarding the sense of confinement in the neighborhoods. However, disparities exist between the results obtained from GIS calculations and the questionnaire responses. Although respondents ranked Darrous and Shahrak-e Qarb as having a more pronounced sense of confinement, the GIS calculations indicate that Qeytariyeh and Dr. Hooshyar have the lowest ratio between the width and height of the streets, which theoretically should result in a greater sense of confinement for pedestrians. It is crucial to consider that topography plays a role in shaping perceptions of the streets, and the presence of tall buildings does not necessarily imply a heightened sense of confinement for pedestrians.

To assess **permeability**, three indicators were employed. The first indicator is the number of cul-de-sacs, while the second and third indicators are the frequency of intersections and the average distance between intersections in a street network. While permeability primarily contributes to the walkability and connectivity of a neighborhood, it is not directly linked to the concept of human scale. Nevertheless, higher permeability levels can enhance the perception of a human scale by providing more accessible and connected streetscapes for pedestrians. The following table provides relevant information on permeability based on GIS analysis.

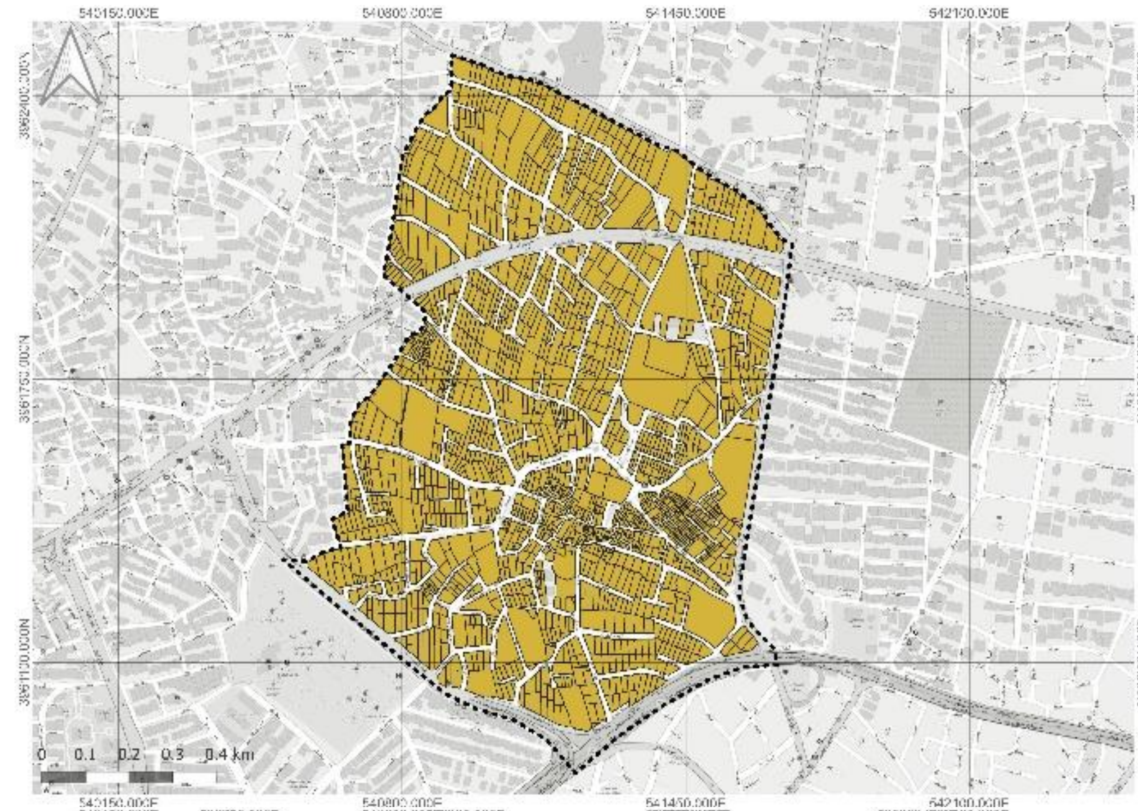
Table 4.24. Permeability analysis in selected neighborhoods

Neighborhood	Chizar	Sanglaj	Qeytariyeh	Dr. Hooshyar	Darrous	Shahrak-e Qarb
The number of cul-de-sacs	116	428	119	327	138	140
The number of intersections	226	533	233	528	326	209
The average distance between intersections (m)	82.5	36.4	101.7	48.7	103.2	127.5

The data shows that Shahrak-e Qarb has the highest average distance between intersections, followed by Qeytariyeh and Darrous. Chizar, on the other hand, exhibits an average number of cul-de-sacs and an intermediate distance between intersections. Dr. Hooshyar and Sanglaj neighborhoods have the lowest distances and the highest number of cul-de-sacs. A network with a greater number of cul-de-sacs restricts access to the center of the network, resulting in reduced permeability and walkability. Conversely, the number of intersections and the average distance between them reflect the size of the network's blocks, with smaller blocks contributing to higher permeability and walkability.

The findings reveal that the original organic street network in the historic center of Tehran and the integrated organic network with tributaries have the highest number of cul-de-sacs and intersections. In the historic center, the abundance of cul-de-sacs was originally designed to facilitate access to houses. Despite the prevalence of cul-de-sacs, the distance between intersections remains small, indicating high permeability in the historic center. In contrast, the original organic network in old Tehran has fewer cul-de-sacs and intersections compared to the historic core neighborhoods. However, the distance between intersections is still significantly smaller than in the integrated and imitated organic street networks. The block sizes in the original organic networks tend to be small, contributing to their permeability.

The integrated organic street network with grid and grid-tributary patterns exhibits a moderate number of intersections and distances between them, as well as a moderate number of cul-de-sacs. Conversely, the imitated organic street network features more cul-de-sacs, fewer intersections, and a much larger distance between intersections, making it less permeable. The following illustrations depict the block sizes in the studied neighborhoods.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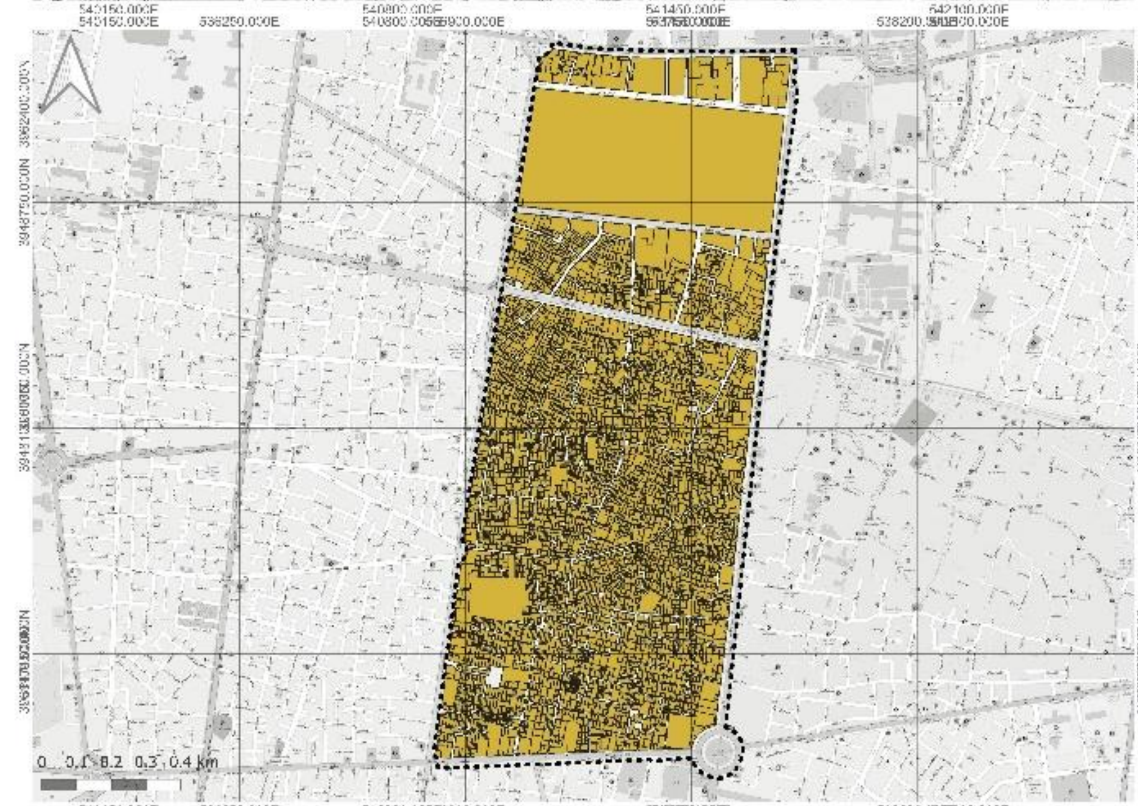
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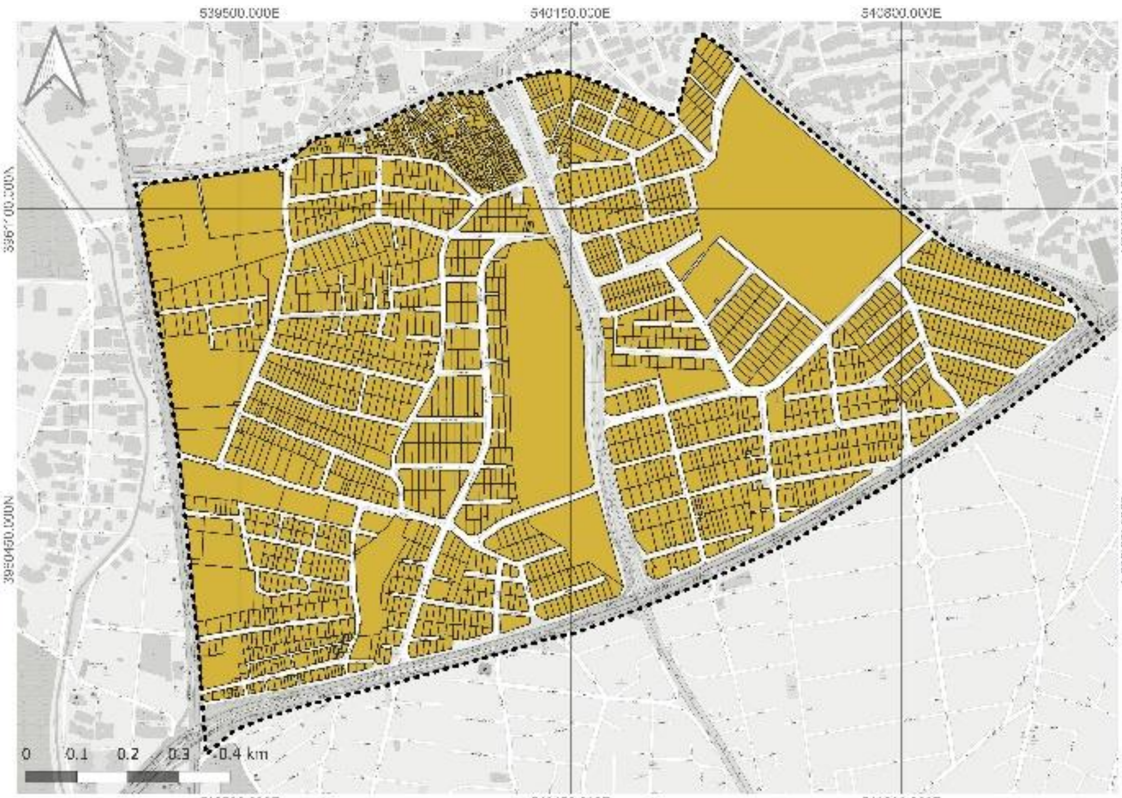
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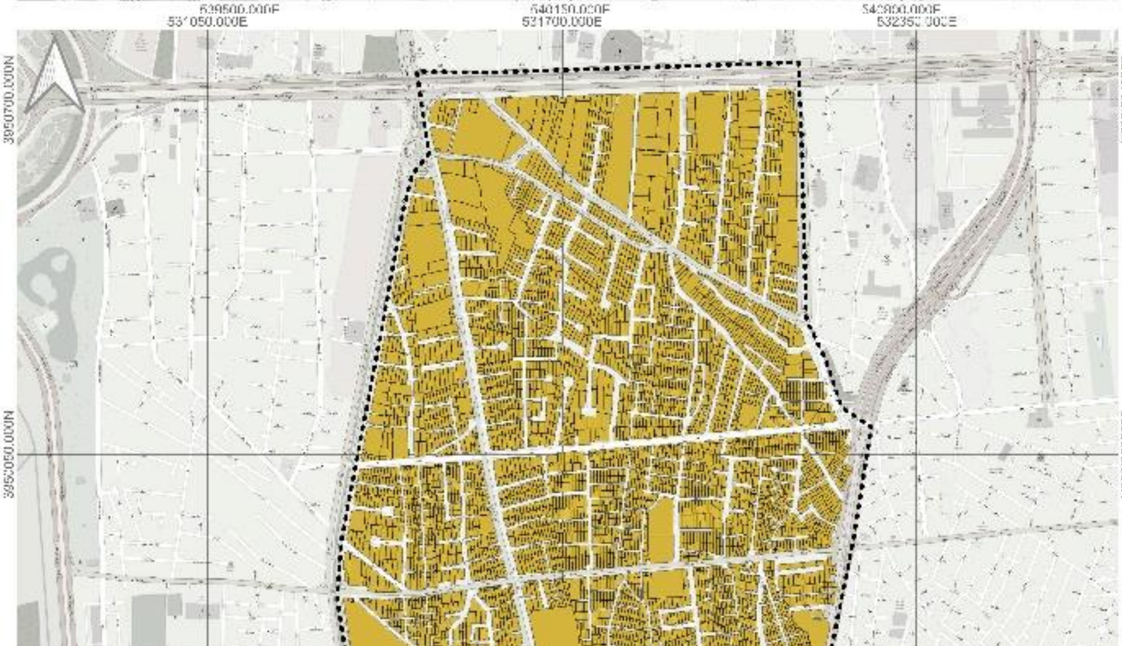
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0.4 km

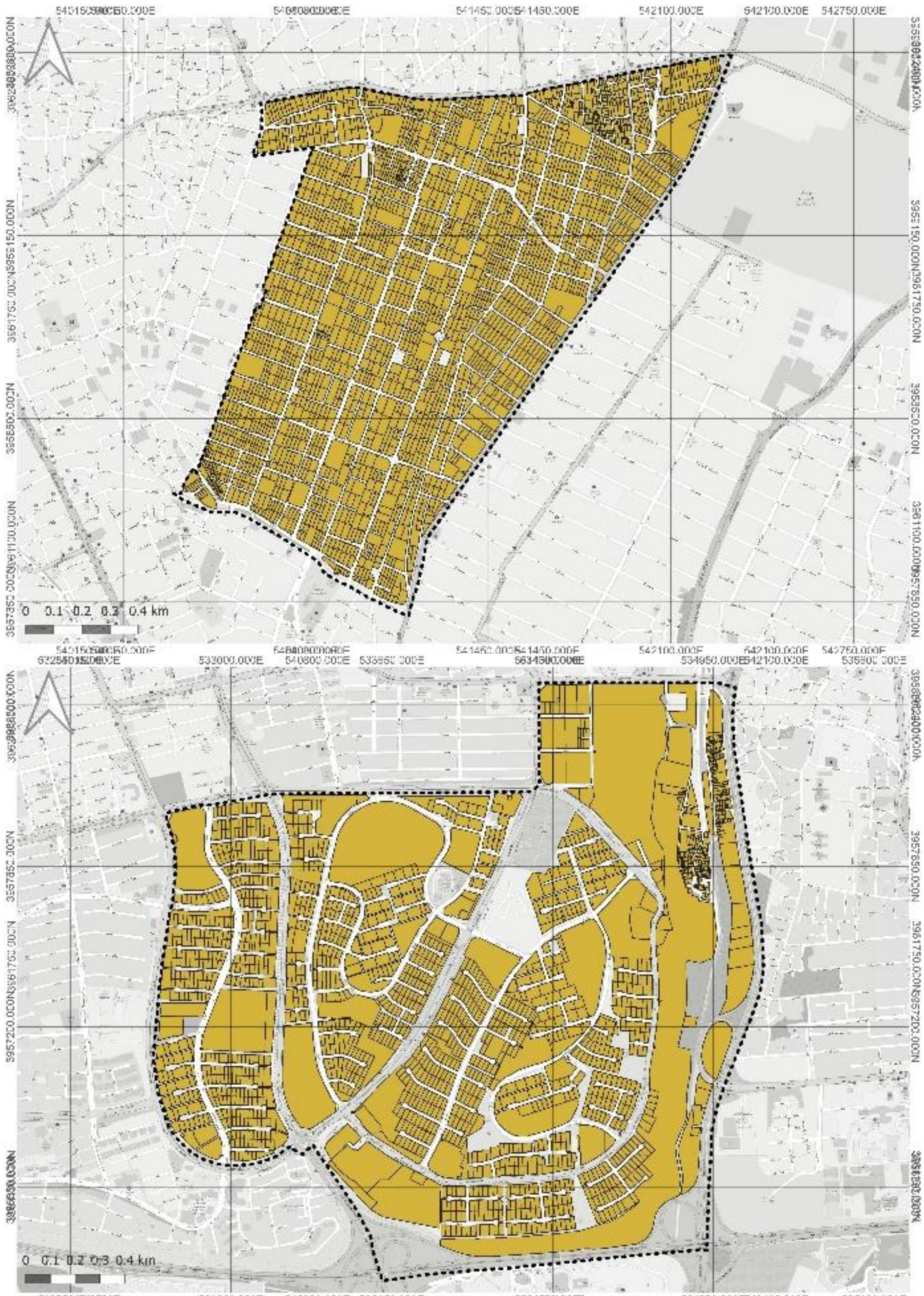


Figure 4.59. The map of block size in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous and Shahrak-e Qarb)

The relationship between the size of blocks and permeability in urban street networks is a critical factor in determining the walkability and accessibility of a neighborhood. Block size refers to the dimensions and extent of the city blocks formed by the network of streets. Permeability, on the other hand, relates to how easily pedestrians can navigate through these blocks and access various parts of the neighborhood.

Smaller blocks in Sanglaj, Chizar, Dr. Hooshyar, and Darrous neighborhoods contribute to higher permeability. This is because smaller blocks create a denser network of streets, resulting in more intersections and shorter distances between them. With more intersections, pedestrians have multiple routes and choices to reach their destinations, which enhances walkability. Additionally, shorter distances between intersections reduce the time and effort required to travel within the neighborhood, making it more accessible and convenient for pedestrians.

Conversely, larger blocks like in Shahrak-e Qarb Neighborhood, tend to have lower permeability. In neighborhoods with larger blocks, there are fewer intersections, and the distances between them are greater. This can lead to longer walking distances to access essential amenities or reach specific destinations, potentially discouraging pedestrian activity. Larger blocks can also limit the number of direct routes available to pedestrians, making it less flexible for individuals to choose their paths.

The table displays the residents' assessments of neighborhood **readability** based on a scale ranging from 1 (very low) to 5 (very high). In the context of an urban street network, readability refers to the ease with which individuals can understand and navigate the layout of the streets and pathways. Readability encompasses several factors, including the logical organization of streets, the presence of recognizable landmarks, and the overall legibility of the urban environment. A highly readable street network is one where users can intuitively grasp the spatial arrangement, identify key destinations, and follow a route without unnecessary confusion or detours. However, the definition of a readable street network differs among residents and non-local users.

Table 4.25. Readability analysis in selected neighborhoods

Neighborhood	Chizar		Sanglaj		Qeytariyeh		Dr. Hooshyar		Darrous		Shahrak-e Qarb	
	W	M	W	M	W	M	W	M	W	M	W	M
Readability	3.7	3.3	4.0	3.9	2.9	2.4	1.7	2.0	3.5	3.8	1.3	1.7

Among the studied neighborhoods, Chizar stands out as having the highest perceived readability, with residents rating it the highest. Sanglaj follows closely behind Chizar, receiving the second-highest rating. Meanwhile, Qeytariyeh and Darrous are evaluated with similar medium-level ratings, suggesting moderate readability in these neighborhoods. Shahrak-e Qarb and Dr. Hooshyar received the lowest ratings for readability among the studied neighborhoods, indicating that residents perceive these areas as having lower readability. These neighborhoods also have fewer landmarks and a greater number of tall buildings, especially in the case of Shahrak-e Qarb, in addition to having a flat topography. The lower ratings provided by women in these neighborhoods could be attributed to the higher proportion of men who work in the neighborhoods and walk there daily, making them more familiar with the neighborhood's layout.

On the other hand, Sanglaj, Chizar, and Qeytariyeh receive higher ratings for readability. This may be due to more housewives and women working in their neighborhoods or having home-office jobs. In Chizar, landmarks such as Imamazadeh Ali Akbar and Ismael help people orient themselves, while in Darrous, the water canal serves a similar purpose. It is important to note that these ratings are based on the residents' perception, and it may differ if a visitor or someone unfamiliar with the neighborhood enters and tries to find their way. Overall, the neighborhoods with more landmarks and distinct urban elements tend to have higher ratings for readability, as they provide unique reference points for navigation.

4.2.7. Attractiveness and Beauty

The final factor addressed in this research pertains to the attractiveness and beauty of the spaces within the organic street networks concerning their form. While some elements may not be directly linked to the form, they are intricately intertwined with the network's characteristics. The results obtained from the interviews indicate that beauty and attractiveness hold significant value when experts evaluate a neighborhood. The following table presents the frequency of keywords associated with beauty and attractiveness that were utilized during the interviews.

Table 4.26. Mentioning beauty and attractiveness (positively or negatively) in selected neighborhoods based on interviews

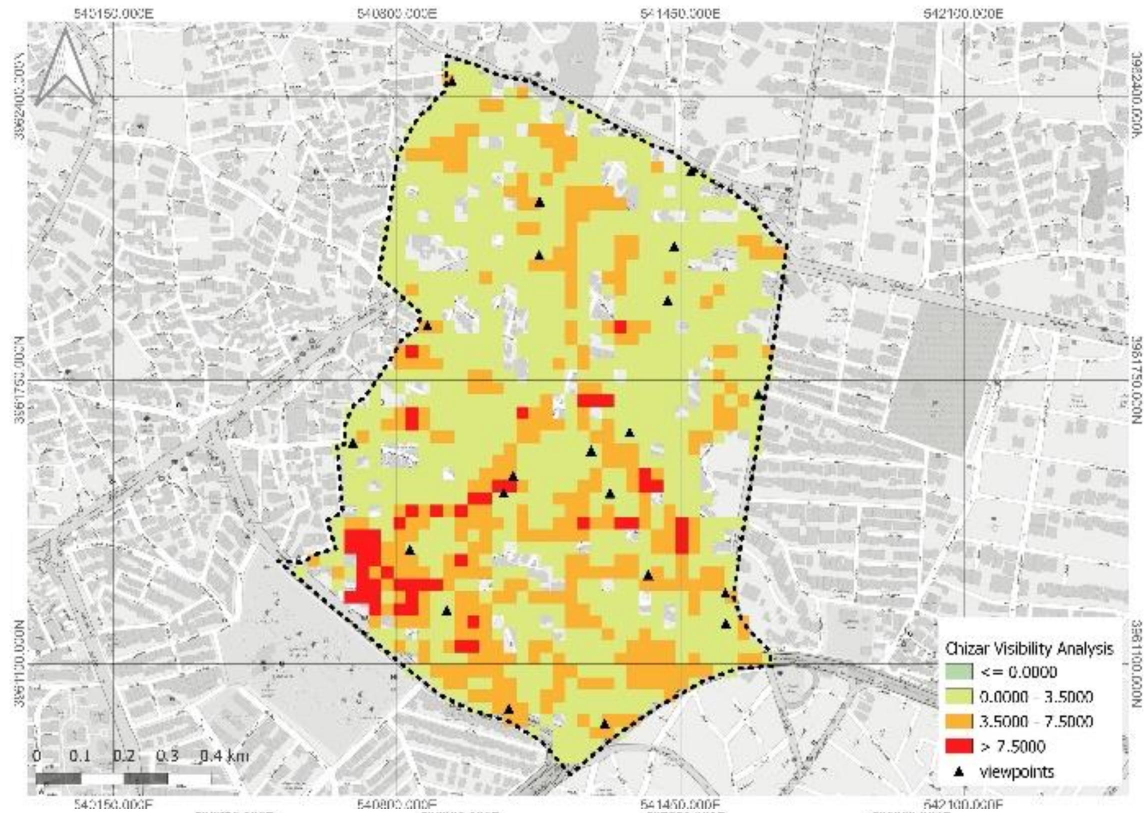
Beautiful and attractive	positive	negative	Gesamt
Chizar	7 (77.8%)	2 (22.2%)	9 (4%)
Sanglaj	7 (87.5%)	1 (12.5%)	8 (3.6%)
Qeytariyeh	4 (100%)	0 (0%)	4 (1.8%)
Dr. Hooshyar	4 (44.4%)	5 (55.6%)	9 (4%)
Darrous	6 (100%)	0 (0%)	6 (2.7%)
Shahrak-e Qarb	0 (0%)	4 (100%)	4 (1.8%)
Gesamt	28 (70%)	12 (30%)	40 (17.9%)

Fisher-Test: p= .003

The data presented in the table provides insights into the perception of beauty and attractiveness in selected neighborhoods based on interviews. The table shows the number and percentage of positive and negative mentions of beauty and attractiveness in each neighborhood. Out of the total responses analyzed, 70% were positive, and 30% were negative regarding beauty and attractiveness. The Fisher-Test indicated a statistically significant relationship between the neighborhoods and the perceptions of beauty and attractiveness (p = 0.003).

These findings highlight the varying levels of beauty and attractiveness perceived by residents in different neighborhoods. Chizar and Sanglaj received more positive mentions, while Dr. Hooshyar had a more balanced opinion. Darrous was unanimously seen as beautiful and attractive, while Shahrak-e Qarb had entirely negative perceptions. These results emphasize the subjective nature of beauty and attractiveness, which can vary based on individual experiences and preferences.

As the interview results may not represent all the elements, the findings of the field analysis are presented below. The first aspect examined is the view of the skyline and nature of the organic street networks. As previously mentioned, the organic network has demonstrated a respect for nature in various ways. Providing a view that takes into account the topography was considered important by residents in the past, as they sought routes that offered a better view to appreciate during their journeys. Consequently, the organic structure adapted itself to these chosen paths. It is important to note that this element differs from the concept discussed in the previous section on visual connectivity, which primarily refers to urban or natural elements aiding pedestrians in orienting themselves in a space. However, views as an element of attractiveness do not necessarily serve as orientation landmarks. The maps below illustrate the visibility of the skyline and nature in each neighborhood based on topography and building heights. The observer's height is set at 1.6 meters. In an analysis of visibility, the focus lies on the visual perspective available to an observer from a specific position. This assessment involves considering key terrain, observation posts, and other relevant locations to evaluate the observer's capabilities in terms of what can be seen and the vulnerabilities arising from what cannot be seen.


Chizar Visibility Analysis
<= 0.0000
0.0000 - 3.5000
3.5000 - 7.5000
> 7.5000
viewpoints
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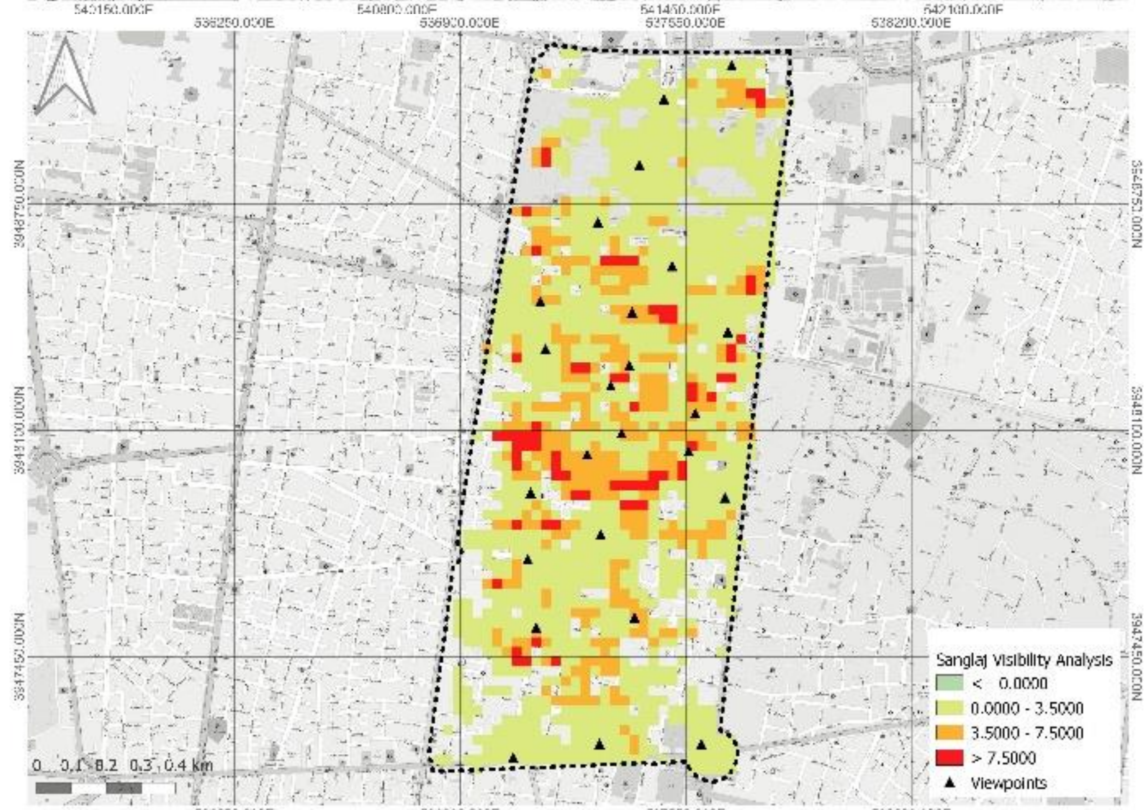
Sanglaj Visibility Analysis
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3.5000 - 7.5000
> 7.5000
Viewpoints
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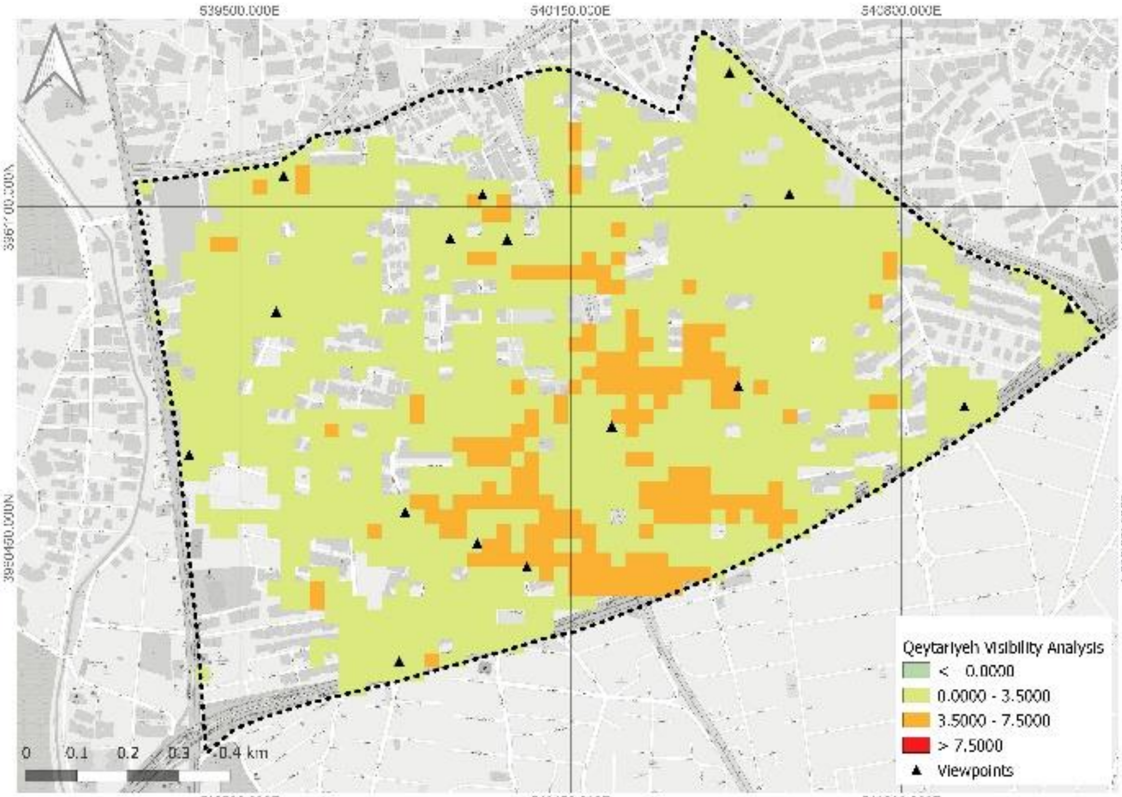
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Qeytariyeh Visibility Analysis
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3.5000 - 7.5000
> 7.5000
Viewpoints
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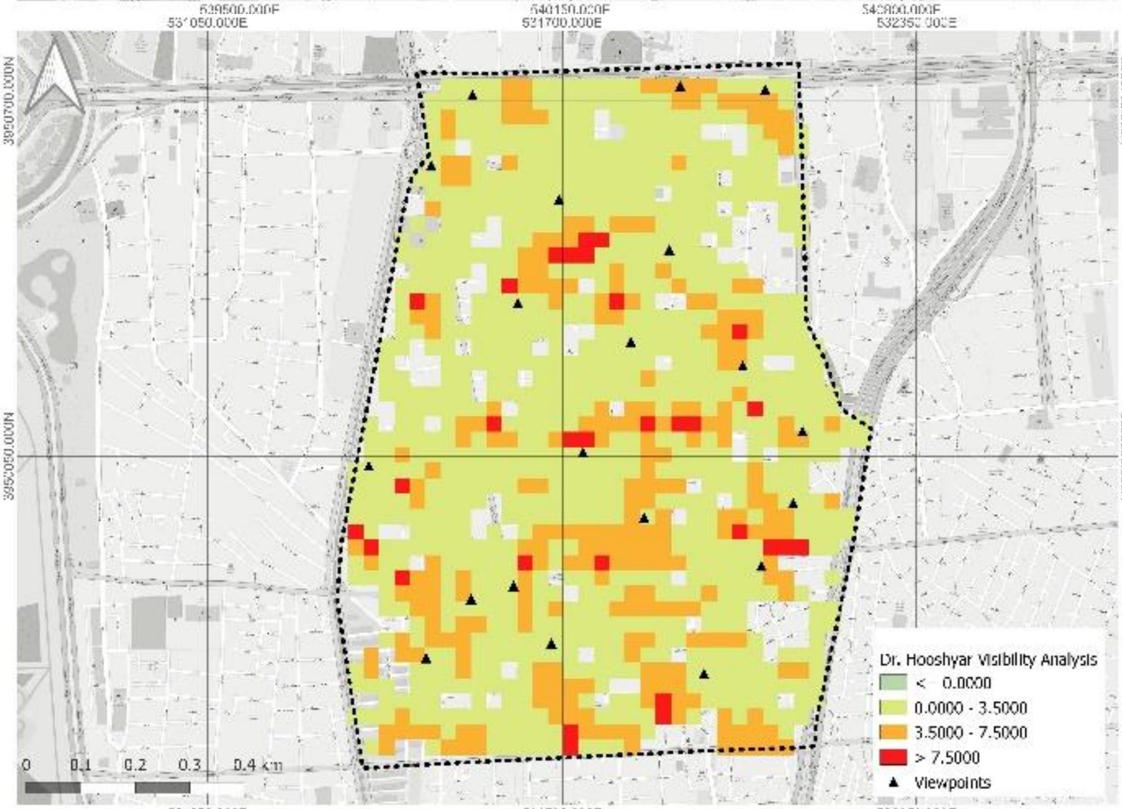
531700.000E
Dr. Hooshyar Visibility Analysis
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0.0000 - 3.5000
3.5000 - 7.5000
> 7.5000
Viewpoints
0 0.1 0.2 0.3 0.4 km

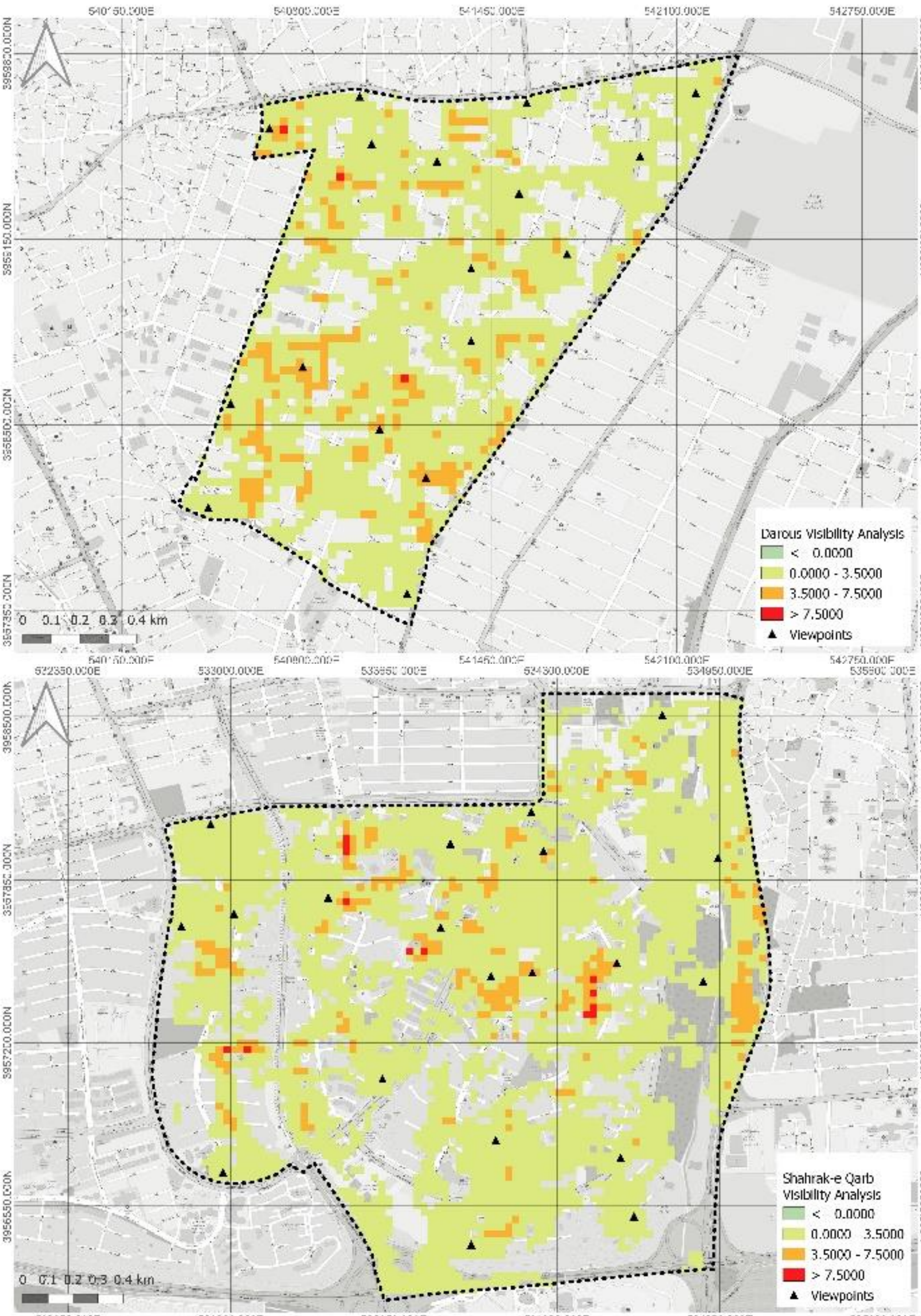


Figure 4.60. Visibility analysis in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb)

The visibility analysis considers the height of objects that are visible from the perspective of pedestrians at various locations. The yellow areas indicate objects that are up to 3.5 meters in height and visible to pedestrians from their viewpoints. These areas represent the range within which pedestrians can observe objects or points of interest at a relatively close distance. The orange areas represent objects with heights visible between 3.5 and 7.5 meters to pedestrians from a slightly greater distance. Pedestrians can observe objects of this height range at a moderate viewing distance. Lastly, the red areas indicate objects that are visible with heights exceeding 7.5 meters and can be seen by pedestrians from a considerable distance. These areas represent points where pedestrians have an extended visibility range, allowing them to perceive taller objects even from a significant distance.

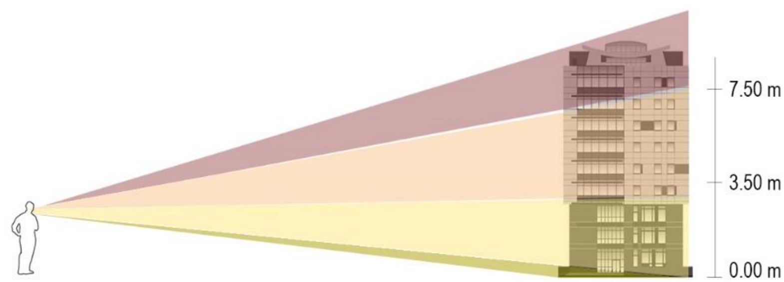


Figure 4.61. Visibility analysis color range

The visibility analysis reveals that Chizar provides good visibility around its main square and the core of the neighborhood, as well as in the southwest part, which serves as one of the entrances to the study area. Sanglaj and Dr. Hooshyar also offer good visibility to the horizon, primarily because they have many low-rise buildings. Visibility is less restricted in the centers of these neighborhoods, where there are numerous storage facilities, commercial spaces, and vacant houses. However, in Qeytariyeh and Darrous, visibility for pedestrians is severely limited due to the presence of many high-rise buildings and the area's topographical features. Shahrak-e Qarb offers good visibility on the main streets, but the secondary streets have a limited view due to tall buildings. The following table presents the adjusted significance values between each pair of neighborhoods based on data extracted from the questionnaires.

Table 4.27. Reports from the questionnaires about the presence of high-buildings in the path in each pair neighborhood

Are the presence of high-rise buildings effective in increasing your desire to walk?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.[a]
Chizar-Dr. Hooshyar	.000	7.262	.000	1.000	1.000
Chizar-Sanglaj	.000	7.016	.000	1.000	1.000
Chizar-Qeytariyeh	-9.265	5.999	-1.544	.122	1.000
Chizar-Shahrak-e Qarb	-11.053	5.867	-1.884	.060	.893
Chizar-Darrous	-15.000	6.076	-2.469	.014	.203
Dr. Hooshyar-Darrous	15.000	6.889	2.177	.029	.442
Sanglaj-Darrous	15.000	6.629	2.263	.024	.355
Dr. Hooshyar-Sanglaj	.000	7.731	.000	1.000	1.000
Dr. Hooshyar-Qeytariyeh	-9.265	6.821	-1.358	.174	1.000
Dr. Hooshyar-Shahrak-e Qarb	-11.053	6.705	-1.648	.099	1.000
Sanglaj-Qeytariyeh	9.265	6.559	1.413	.158	1.000
Sanglaj-Shahrak-e Qarb	-11.053	6.438	-1.717	.086	1.000
Qeytariyeh-Shahrak-e Qarb	-1.788	5.312	-.337	.736	1.000
Qeytariyeh-Darrous	5.735	5.542	1.035	.301	1.000
Shahrak-e Qarb-Darrous	3.947	5.398	.731	.465	1.000

Each row tests the null hypothesis that the distributions in Mahale 1 and 2 are equal.
Asymptotic significances (2-tailed tests) are shown. The significance level is .050.
a. Significance values are adjusted by Bonferroni's correction for multiple tests.

The data presented here shows the results of a statistical analysis conducted to examine the effect of high-rise buildings on individuals' desire to walk in different neighborhoods. The table includes various statistical measures such as the test statistic, standard error, standard test statistic, significance level, and adjusted significance level for each pair of neighborhoods.

The results indicate that in some pairs of neighborhoods, the presence of high-rise buildings does not significantly increase the desire to walk. This is evident from the test statistic values close to zero and the high p-values (above the conventional significance level of 0.05) in pairs such as Chizar-Dr. Hooshyar, Chizar-Sanglaj, and Dr. Hooshyar-Sanglaj.

However, there are pairs of neighborhoods where the presence of high-rise buildings does have a significant effect on individuals' desire to walk. For example, in the pair, Chizar-Darrous, the negative test statistic value of -15.000 suggests that the presence of high-rise buildings in Darrous significantly decreases the desire to walk compared to Chizar. Conversely, the positive test statistic value of 15.000 in the pair Dr. Hooshyar-Darrous indicates that the presence of high-rise buildings in Darrous significantly increases the desire to walk compared to Dr. Hooshyar.

It is worth noting that for some pairs of neighborhoods, there might be a trend suggesting an effect, but the significance levels are relatively high (above 0.05), indicating that the observed differences may not be statistically significant. This suggests that the impact of high-rise buildings on the desire to walk varies across different pairs of neighborhoods and is not a straightforward relationship. Factors such as neighborhood characteristics, individual preferences, and other environmental factors may also significantly influence individuals' walking behavior.

Table 4.28. Mentioning elements of nature (positively or negatively) in selected neighborhoods based on interviews

nature	positive	negative	Gesamt
Chizar	7 (100%)	0 (0%)	7 (3.1%)
Sanglaj	0 (0%)	3 (100%)	3 (1.3%)
Qeytariyeh	5 (100%)	0 (0%)	5 (2.2%)
Dr. Hooshyar	1 (50%)	1 (50%)	2 (0.9%)
Darrous	16 (100%)	0 (0%)	16 (7.1%)
Shahrak-e Qarb	3 (100%)	0 (0%)	3 (1.3%)
Gesamt	32 (88.9%)	4 (11.1%)	36 (16.1%)

Fisher-Test: p<.001

The provided data presents the results of interviews conducted to assess the presence of natural elements in selected neighborhoods and the perception of residents towards them. The table includes information on each neighborhood's positive and negative mentions of nature and the overall results. The Fisher Test, with a p-value of less than 0.001, suggests a statistically significant association between the presence of natural elements and residents' positive or negative perceptions.

The data shows that most respondents across all neighborhoods (88.9%) positively mentioned the presence of natural elements, while a smaller proportion (11.1%) had negative mentions. This indicates a generally favorable perception of the natural environment in these neighborhoods. These findings highlight the importance of natural elements in shaping the perception and overall quality of selected neighborhoods, with positive mentions indicating the positive impact of nature on residents' experiences and the overall desirability of the neighborhood.

On the other hand, to analyze the presence and impact of these elements on pedestrians, the users were questioned about their perception of the natural elements in their neighborhoods. The following table presents their responses regarding the positive impacts, rated on a scale from very low (1) to very high (5).

Table 4.29. Understanding the impacts of natural elements on pedestrians in selected neighborhoods based on pedestrians’ responses

Neighborhood	Chizar		Sanglaj		Qeytariyeh		Dr. Hooshyar		Darrous		Shahrak-e Qarb	
	W	M	W	M	W	M	W	M	W	M	W	M
Greenery	4.7	4.3	1.3	1.3	4.1	3.8	1.0	1.5	4.8	4.5	3.6	3.2
Water resources as an urban element	3.5	4.0	1.0	2.3	2.5	1.3	-	-	5.0	4.8	-	-
Nature sounds	4.0	2.1	1.0	1.0	3.4	1.3	1.0	1.0	3.8	3.2	1.0	1.0
Nature smells	2.3	1.5	1.0	1.0	3.4	2.3	1.0	1.0	3.8	3.2	1.3	1.0
Street walls	3.7	3.5	1.0	1.0	3.8	3.5	2.1	1.5	4.8	3.5	3.5	3.5

The data provides insights into pedestrians' understanding of the impacts of natural elements in the selected neighborhoods. It indicates variations in perception across different neighborhoods and between men and women within the same neighborhood.

Regarding greenery, Chizar, Qeytariyeh, and Darrous stand out as neighborhoods where both men and women perceive it to have a significant positive impact. However, in Sanglaj, Dr. Hooshyar, and Shahrak-e Qarb, both men and women do not consider greenery to have a substantial influence.

When it comes to water resources as an urban element, Chizar and Darrous show a positive perception from both men and women. However, incomplete data for Dr. Hooshyar and Shahrak-e Qarb limits conclusive interpretations.

Regarding nature sounds, Chizar, Qeytariyeh, and Darrous exhibit a positive understanding among both men and women. In contrast, Sanglaj, Dr. Hooshyar, and Shahrak-e Qarb do not perceive nature sounds to have a significant impact.

The perception of nature smells is positive in Qeytariyeh and Darrous for both men and women. However, in Sanglaj, Dr. Hooshyar, and Shahrak-e Qarb, nature smells are not considered influential.

Regarding street walls, Chizar, Qeytariyeh, Darrous, and Shahrak-e Qarb show a positive perception among men and women. Dr. Hooshyar and Sanglaj perceive street walls to have a lesser impact than other neighborhoods. In general, women tend to give slightly higher ratings than men for greenery, water resources, and street walls.

In conclusion, the analysis reveals variations in pedestrians' understanding of natural elements' impacts across neighborhoods. Factors such as greenery, water resources, nature sound, nature smells, and street walls are perceived differently by both men and women. The following table presents the adjusted significance values, comparing the responses from each pair of neighborhoods to questions related to the beauty and attractiveness of the street networks.

Table 4.30. Reports from the questionnaires about the greenery in each pair of neighborhood

How do you rate the greenery of your neighborhood?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.[a]
Sanglaj-Dr. Hooshyar	.278	11.015	.025	.980	1.000
Sanglaj-Shahrak-e Qarb	-23.699	9.173	-2.584	.010	.147
Sanglaj-Qeytariyeh	43.219	9.345	4.625	<.001	.000
Sanglaj-Chizar	46.444	9.996	4.646	<.001	.000
Sanglaj-Darrous	51.840	9.445	5.488	<.001	.000
Dr. Hooshyar-Shahrak-e Qarb	-23.421	9.554	-2.451	.014	.213
Dr. Hooshyar-Qeytariyeh	-42.941	9.719	-4.418	<.001	.000
Dr. Hooshyar-Chizar	46.167	10.347	4.462	<.001	.000
Dr. Hooshyar-Darrous	51.563	9.816	5.253	<.001	.000
Shahrak-e Qarb-Qeytariyeh	19.520	7.568	2.579	.010	.148
Shahrak-e Qarb-Chizar	22.746	8.359	2.721	.007	.098
Shahrak-e Qarb-Darrous	28.141	7.692	3.659	<.001	.004
Qeytariyeh-Chizar	3.225	8.547	.377	.706	1.000
Qeytariyeh-Darrous	8.621	7.896	1.092	.275	1.000
Chizar-Darrous	-5.396	8.657	-.623	.533	1.000

Each row tests the null hypothesis that the distributions in Mahale 1 and 2 are equal.

Asymptotic significances (2-tailed tests) are shown. The significance level is .050.

a. Significance values are adjusted by Bonferroni's correction for multiple tests.

The data presents the ratings of greenery in various neighborhoods through pairwise comparisons. Significant differences in greenery ratings were identified between several pairs of neighborhoods. Specifically:

Sanglaj received significantly lower ratings for greenery compared to Shahrak-e Qarb, Qeytariyeh, Chizar, and Darrous.

Dr. Hooshyar received significantly lower ratings for greenery compared to Shahrak-e Qarb, Qeytariyeh, Chizar, and Darrous.

Shahrak-e Qarb received significantly lower ratings for greenery compared to Qeytariyeh and Chizar.

No significant differences in greenery ratings were observed between the remaining pairs of neighborhoods. These findings indicate variations in the perception of greenery among residents in different neighborhoods, with some neighborhoods being more positively evaluated for their greenery than others.

Table 4.31. Reports from the questionnaires about the water resources in each pair of neighborhood

How do you rate the water resources as a symbol of attractiveness in your neighborhood?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Sanglaj-Qeytariyeh	1.736	6.263	.277	.782	1.000
Sanglaj-Chizar	16.028	6.628	2.418	.016	.094
Sanglaj-Darrous	31.330	6.263	5.002	<.001	.000
Qeytariyeh-Chizar	14.292	5.740	2.490	.013	.077
Qeytariyeh-Darrous	29.594	5.315	5.568	<.001	.000
Chizar-Darrous	-15.302	5.740	-2.666	.008	.046

The data reveals the ratings of water resources as a symbol of attractiveness in various neighborhoods through pairwise comparisons. Significantly different ratings were observed in several pairs of neighborhoods:

Sanglaj received significantly lower ratings for water resources compared to Chizar and Darrous.

Qeytariyeh received significantly lower ratings for water resources compared to Chizar and Darrous.

Chizar received significantly lower ratings for water resources compared to Darrous.

These findings highlight variations in residents' perceptions of water resources' attractiveness in different neighborhoods, with some neighborhoods being more positively evaluated in this regard than others.

Table 4.32. Reports from the questionnaires about the nature sounds in each pair of neighborhood

How do you rate the nature sounds as a symbol of attractiveness in your neighborhood?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Dr. Hooshyar-Chizar	39.667	9.707	4.087	<.001	.001
Sanglaj-Chizar	39.667	9.377	4.230	<.001	.000
Shahrak-e Qarb-Chizar	39.667	7.841	5.059	<.001	.000
Dr. Hooshyar-Darrous	37.625	9.208	4.086	<.001	.001
Sanglaj-Darrous	37.625	8.861	4.246	<.001	.000
Shahrak-e Qarb-Darrous	37.625	7.216	5.214	<.001	.000
Dr. Hooshyar-Sanglaj	.000	10.333	.000	1.000	1.000
Dr. Hooshyar-Shahrak-e Qarb	.000	8.963	.000	1.000	1.000
Dr. Hooshyar-Qeytariyeh	-22.353	9.118	-2.452	.014	.213
Sanglaj-Qeytariyeh	22.353	8.766	2.550	.011	.162
Shahrak-e Qarb-Qeytariyeh	22.353	7.100	3.148	.002	.025
Sanglaj-Shahrak-e Qarb	.000	8.605	.000	1.000	1.000
Qeytariyeh-Darrous	15.272	7.407	2.062	.039	.588
Qeytariyeh-Chizar	17.314	8.018	2.159	.031	.462
Darrous-Chizar	2.042	8.121	.251	.802	1.000

The data presents the ratings of nature sounds as a symbol of attractiveness in different neighborhoods based on pairwise comparisons. Several significant differences were observed in the ratings between pairs of neighborhoods. The following pairs showed significant differences in their ratings: Dr. Hooshyar-Chizar, Sanglaj-Chizar, Shahrak-e Qarb-Chizar, Dr. Hooshyar-Darrous, Sanglaj-Darrous, Shahrak-e Qarb-Darrous, Dr. Hooshyar-Qeytariyeh, Sanglaj-Qeytariyeh, Shahrak-e Qarb-Qeytariyeh, Qeytariyeh-Darrous, and Qeytariyeh-Chizar. However, there was no significant difference in the ratings between Dr. Hooshyar and Sanglaj or between Dr. Hooshyar and Shahrak-e Qarb.

Table 4.33. Reports from the questionnaires about the nature smells in each pair of neighborhood

How do you rate the smell of nature as a symbol of attractiveness in your neighborhood?					
Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Dr. Hooshyar-Chizar	23.042	9.894	2.329	.020	.298
Sanglaj-Chizar	23.042	9.558	2.411	.016	.239
Dr. Hooshyar-Darrous	42.875	9.386	4.568	<.001	.000
Sanglaj-Darrous	42.875	9.032	4.747	<.001	.000
Dr. Hooshyar-Sanglaj	.000	10.533	.000	1.000	1.000
Dr. Hooshyar-Shahrak-e Qarb	-4.421	9.136	-.484	.628	1.000
Dr. Hooshyar-Qeytariyeh	-33.735	9.294	-3.630	<.001	.004
Sanglaj-Shahrak-e Qarb	-4.421	8.771	-.504	.614	1.000
Sanglaj-Qeytariyeh	33.735	8.936	3.775	<.001	.002
Shahrak-e Qarb-Chizar	18.621	7.993	2.330	.020	.297
Shahrak-e Qarb-Qeytariyeh	29.314	7.237	4.051	<.001	.001
Shahrak-e Qarb-Darrous	38.454	7.355	5.228	<.001	.000
Chizar-Qeytariyeh	-10.694	8.173	-1.308	.191	1.000
Chizar-Darrous	-19.833	8.278	-2.396	.017	.249
Qeytariyeh-Darrous	9.140	7.550	1.211	.226	1.000

The provided data represents the results of a statistical analysis of how participants rated nature smells as an element of attractiveness in their respective neighborhoods. The table displays test statistics, standard errors, standardized test statistics, significance levels, and adjusted significance values.

The comparisons between Dr. Hooshyar and Chizar, as well as Sanglaj and Chizar, reveal a significantly positive rating for nature smells as an attractive element in the Chizar neighborhood. The standardized test statistics are 2.329 and 2.411, respectively, with p-values of 0.020 and 0.016. Similarly, the comparisons between Dr. Hooshyar and Darrous, as well as Sanglaj and Darrous, also indicate a significantly positive rating for nature smells in the Darrous neighborhood. The standardized test statistics are 4.568 and 4.747, with p-values of less than 0.001. Furthermore, the comparisons between Sanglaj and Qeytariyeh, as well as Shahrak-e Qarb and Qeytariyeh, show a significant positive rating for nature smells in the Qeytariyeh neighborhood. The standardized test statistics are 3.775 and 4.051, with p-values of less than 0.001. Lastly, the comparison between Shahrak-e Qarb and Darrous reveals a significant positive rating for nature smells in the Darrous neighborhood, with a standardized test statistic of 5.228 and a p-value of less than 0.001.

It is important to note that the adjusted significance values have been calculated using Bonferroni's correction for multiple tests. This correction adjusts the significance threshold to account for the possibility of chance associations arising from conducting multiple statistical tests. The data suggest that participants consistently rated nature smells as an attractive element in certain neighborhoods, particularly Chizar, Darrous, and Qeytariyeh.

Table 4.34. Reports from the questionnaires about the street walls in each pair of neighborhood

How do you rate the street walls as a symbol of attractiveness in your neighborhood?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.
Sanglaj-Dr. Hooshyar	7.250	10.874	.667	.505	1.000
Sanglaj-Qeytariyeh	33.441	9.225	3.625	<.001	.004
Sanglaj-Shahrak-e Qarb	-37.079	9.055	-4.095	<.001	.001
Sanglaj-Chizar	41.750	9.868	4.231	<.001	.000
Sanglaj-Darrous	55.094	9.324	5.909	<.001	.000
Dr. Hooshyar-Qeytariyeh	-26.191	9.595	-2.730	.006	.095
Dr. Hooshyar-Shahrak-e Qarb	-29.829	9.432	-3.163	.002	.023
Dr. Hooshyar-Chizar	34.500	10.214	3.378	<.001	.011
Dr. Hooshyar-Darrous	47.844	9.690	4.937	<.001	.000
Qeytariyeh-Shahrak-e Qarb	-3.638	7.471	-.487	.626	1.000
Qeytariyeh-Chizar	8.309	8.437	.985	.325	1.000
Qeytariyeh-Darrous	21.653	7.795	2.778	.005	.082
Shahrak-e Qarb-Chizar	4.671	8.252	.566	.571	1.000
Shahrak-e Qarb-Darrous	18.015	7.593	2.372	.018	.265
Chizar-Darrous	-13.344	8.546	-1.561	.118	1.000

The provided data presents a statistical analysis of how participants rated street walls as a symbol of attractiveness in their respective neighborhoods. The table includes test statistics, standard errors, standardized test statistics, significance levels, and adjusted significance values.

The comparisons between Sanglaj and Qeytariyeh, Sanglaj and Shahrak-e Qarb, Sanglaj and Chizar, and Sanglaj and Darrous all show a significant positive rating for street walls as an attractive element in the respective neighborhoods. The standardized test statistics range from 3.625 to 5.909, and all associated p-values are less than 0.001.

Similarly, the comparisons between Dr. Hooshyar and Qeytariyeh, Dr. Hooshyar and Shahrak-e Qarb, Dr. Hooshyar, and Chizar, and Dr. Hooshyar and Darrous also indicate a significant positive rating for street walls in the corresponding neighborhoods. The standardized test statistics range from 3.378 to 4.937, and all associated p-values are less than 0.001. Furthermore, the comparisons between Qeytariyeh and Darrous, as well as Shahrak-e Qarb and Darrous, reveal a significant positive rating for street walls in the Darrous neighborhood. The standardized test statistics are 2.778 and 2.372, respectively, with p-values of 0.005 and 0.018. In summary, the data suggest that participants consistently rated street walls as an attractive element in several neighborhoods, including Qeytariyeh, Shahrak-e Qarb, Chizar, and Darrous.

Significant differences and the neighborhoods with higher ratings are highlighted in color. The survey responses indicate that the Chizar and Darrous neighborhoods have the greatest influence from natural elements. This could be attributed to an open water canal in the Darrous neighborhood and two large gardens in religious centers in Chizar, which are highly popular among residents. In Qeytariyeh, the existence of Qeytariyeh Park leads to positive responses regarding the presence of greenery, natural sounds, and smells. Gender differences in responses primarily stem from women's higher engagement in physical activities of nature in their neighborhoods. While men prefer going to the gym, many women mentioned walking as their favorite activity in the neighborhood. Sanglaj and Dr. Hooshyar received the lowest ratings in terms of the neighborhood's attractiveness based on natural elements.

Regarding street walls, respondents from Sanglaj and Dr. Hooshyar expressed concerns about damaged, dirty, and deteriorated facades. Particularly for women, the presence of ruined walls and buildings is an important topic when walking in their neighborhood. Darrous received the most positive responses regarding street walls, as some parts are connected to natural elements like leaves and flowers, creating a different seasonal view. The same holds true for Qeytariyeh, Chizar, and Shahrak-e Qarb. Generally, beauty and attractiveness are more important for women when walking in an area than for men. Consequently, women tend to have a more detailed and favorable mental image of neighborhood spaces and can provide more comprehensive responses. The following table illustrates the differences between women and men in their responses regarding the beauty and attractiveness of the neighborhoods.

Table 4.35. The differences between men and women based on their responses to the beauty and attractiveness factor

Ranking

	N			Mittlerer Rang		Rangsumme	
	Gender			Gender		Gender	
	Woman	Man	Gesamt	Woman	Man	Woman	Man
How effective is the attractiveness and beauty of the path in increasing your desire to walk?	44	36	80	47.55	31.89	2092.00	1148.00
How do you rate the water resources as a symbol of attractiveness in your neighborhood?	29	24	53	27.41	26.50	795.00	636.00
How do you rate the nature sounds as a symbol of attractiveness in your neighborhood?	44	37	81	48.92	31.58	2152.50	1168.50
How do you rate the smells of nature as a symbol of attractiveness in your neighborhood?	44	37	81	47.80	32.92	2103.00	1218.00
How do you rate the street walls as a symbol of attractiveness in your neighborhood?	44	37	81	48.61	31.95	2139.00	1182.00

The analysis highlights variations in perception between women and men regarding various aspects of neighborhood attractiveness. Overall, women tend to rate the attractiveness of paths, nature sounds, nature smells, and street walls higher than men, suggesting a stronger preference or appreciation for these elements of neighborhood attractiveness.

To further emphasize these findings, the following table presents adjusted significance values, with a p-value of less than 0.05 indicating a significant gender difference. The results consistently demonstrate that, in most cases, women have higher significant values for the mentioned questions, indicating notable distinctions between genders in their perceptions of neighborhood attractiveness. This reinforces the notion that women tend to place greater importance on certain elements when evaluating the beauty and attractiveness of their neighborhoods.

Table 4.36. Responds from the pedestrians to the nature attractiveness questions considering the significant gender differences

test statistics: Group variable: Gender

	U	W	Z	p-value
How do you rate the water resources as a symbol of attractiveness in your neighborhood?	336.000	636.000	-.220	.826
How do you rate the nature sounds as a symbol of attractiveness in your neighborhood?	465.500	1168.500	-3.655	<.001
How do you rate the smells of nature as a symbol of attractiveness in your neighborhood?	515.000	1218.000	-3.077	.002
How do you rate the street walls as a symbol of attractiveness in your neighborhood?	479.000	1182.000	-3.339	<.001
How do you evaluate the relations between neighbors in your neighborhood?	746.000	1736.000	-.694	.487

When assessing the relationships between neighbors in the neighborhood, no significant difference was found between genders. This suggests that both men and women share similar views on this matter, indicating a commonality in how they perceive and value neighborly relations in their neighborhoods. These results provide insights into potential variations in how men and women perceive and value different elements of their neighborhood environments.

Moving on to explore the final element of variety in traditional Iranian urban design, the principle of contrast is examined, with a focus on three indicators. The first indicator analyzes the variety of **street widths** in each neighborhood.

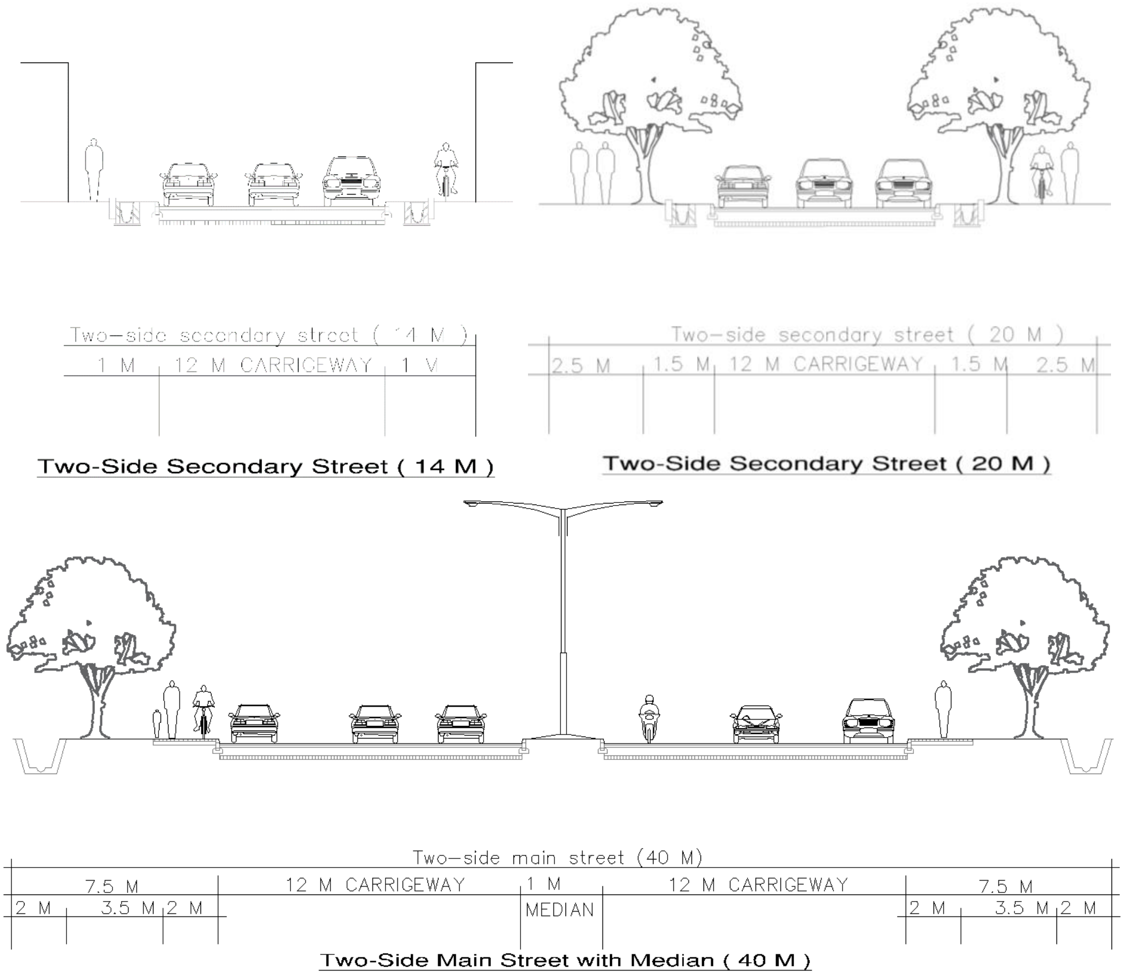
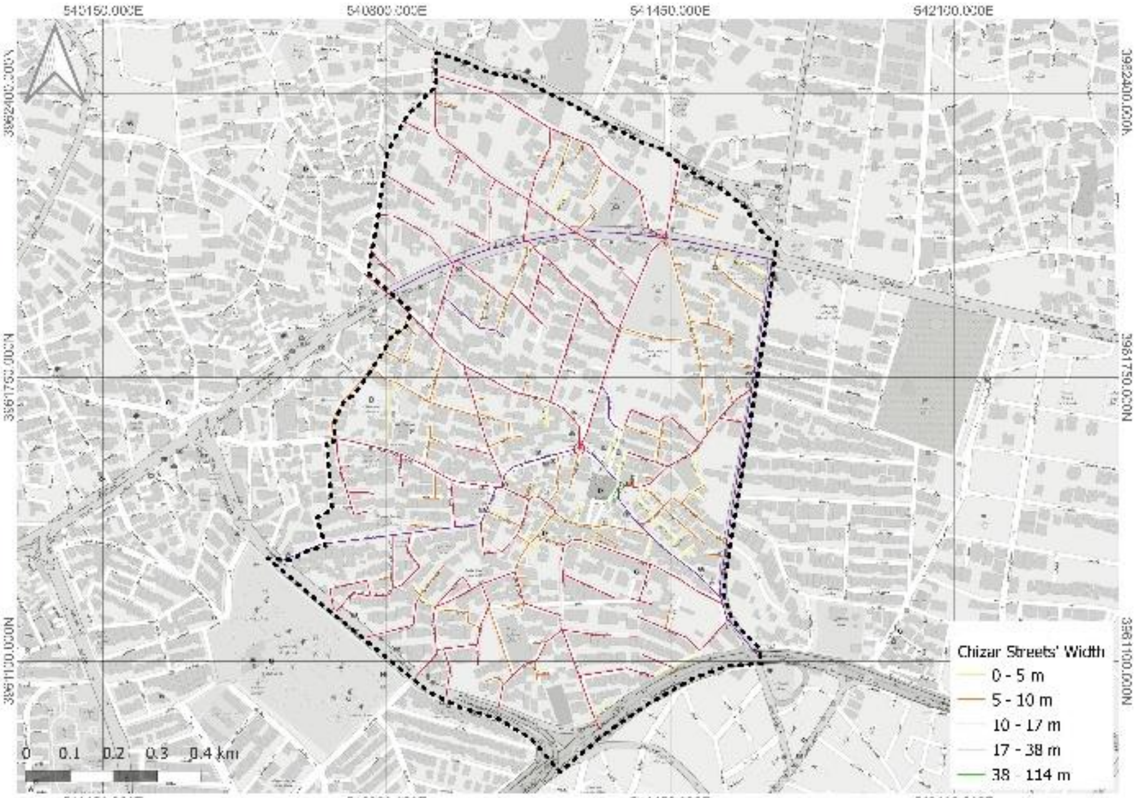
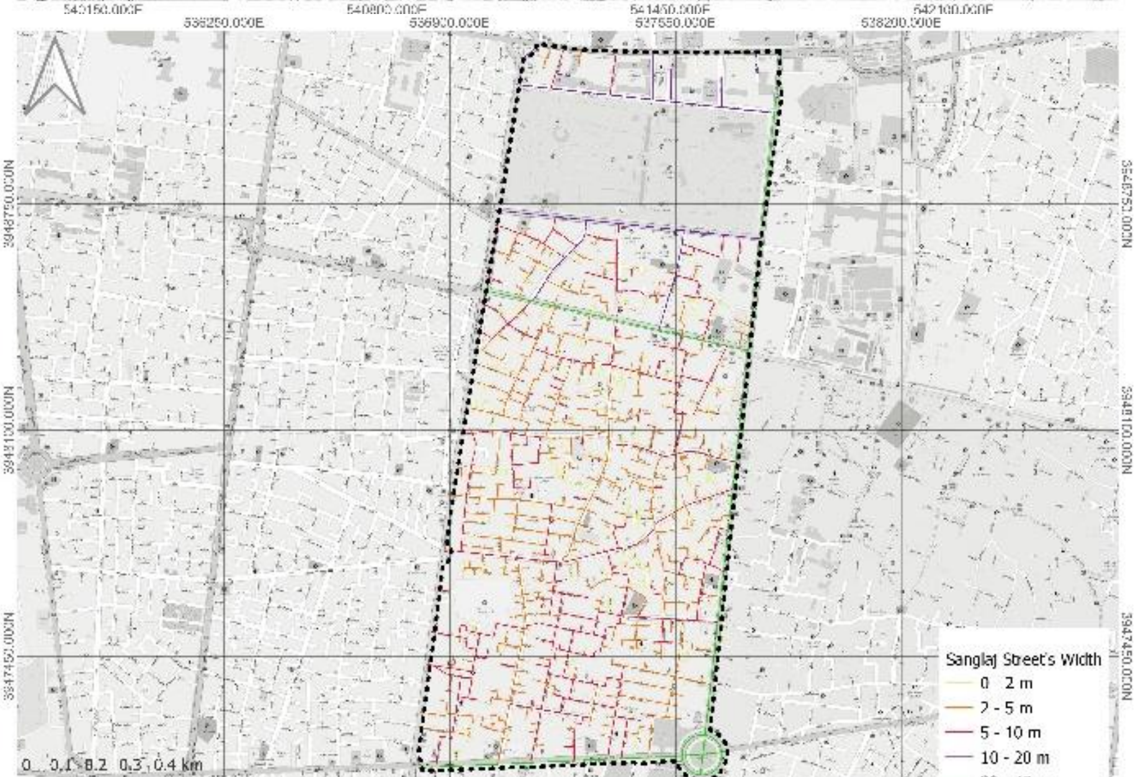
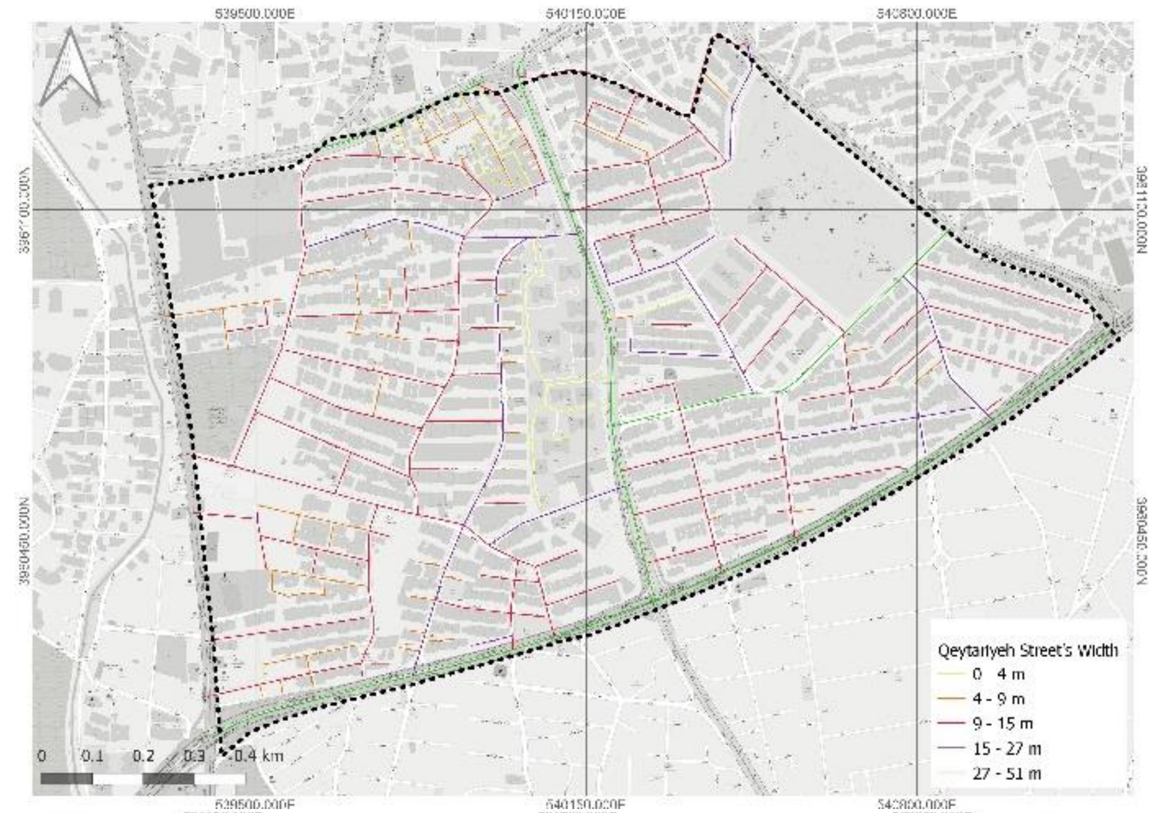


Figure 4.62. Examples of different street width configurations in the Qeytariyeh Neighborhood

The provided maps offer a visual representation of street width distribution in various neighborhoods. Each color on the maps corresponds to a different width category, showcasing the diversity and contrast in street widths across the neighborhoods under study. This visual representation highlights the importance of considering such variety in urban planning and design. Incorporating contrasting elements like street widths can enhance both the aesthetics and functionality of the urban environment, allowing for more harmonious and visually appealing cityscapes.


Chizar Streets' Width
0 - 5 m
5 - 10 m
10 - 17 m
17 - 38 m
38 - 114 m
0 0.1 0.2 0.3 0.4 km


Sanglaj Street's Width
0 - 2 m
2 - 5 m
5 - 10 m
10 - 20 m
20 - 47 m
0 0.1 0.2 0.3 0.4 km



Qeytariyeh Street's Width
0 4 m
4 - 9 m
9 - 15 m
15 - 27 m
27 - 51 m
0 0.1 0.2 0.3 0.4 km

Dr. Hooshyar Street's Width
0 4 m
4 - 7 m
7 - 12 m
12 - 24 m
24 - 62 m
0 0.1 0.2 0.3 0.4 km

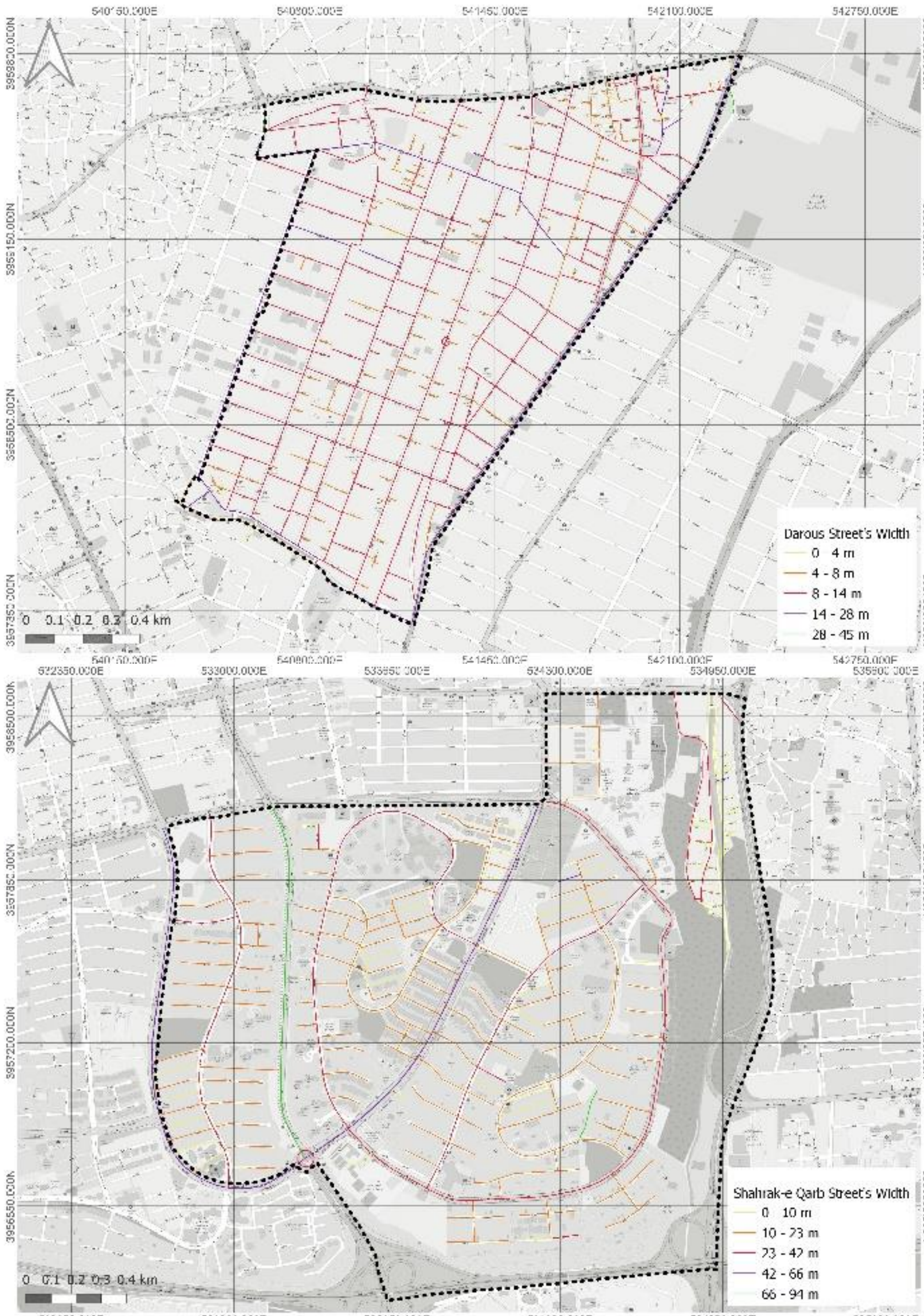


Figure 4.63. The maps of the variety of street widths in study areas (respectively: Chizar, Sanglaj, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb)

The maps demonstrate that neighborhoods such as Chizar, Sanglaj, Dr. Hooshyar, and Shahrak-e Qarb exhibit a noteworthy diversity in street widths. This diversity plays a crucial role in enhancing the overall appeal of these areas, as it allows pedestrians to experience a range of spatial dimensions while walking. The assumption is that a higher degree of variation in street widths contributes to a more favorable evaluation of the neighborhood's attributes. Therefore, the considerable variation in street widths observed in these neighborhoods suggests a positive impact on the urban environment's overall walking experience and aesthetic charm. Statistical analysis further confirms that there are significant differences in terms of street width variety among the neighborhoods ($p < 0.001$), with Chizar showing the highest values in this regard. For more detailed information on the pairwise comparisons, please refer to the provided table.

Table 4.37. The pairwise comparison of the variety of street widths based on the neighborhoods

Paarweise Vergleiche von Viertel

Sample 1-Sample 2	Teststatistik	Std.-Fehler	Standardteststatistik	Sig.	p-Wert
Dr. Hooshyar-Sanglaj	-36.283	33.039	-1.098	.272	1.000
Dr. Hooshyar-Darrous	233.588	40.896	5.712	<.001	<.001
Dr. Hooshyar-Shahrak-e Qarb	-340.743	44.310	-7.690	<.001	<.001
Dr. Hooshyar-Qeytariyeh	-355.864	45.808	-7.769	<.001	<.001
Dr. Hooshyar-Chizar	383.780	48.223	7.958	<.001	<.001
Sanglaj-Darrous	197.305	39.948	4.939	<.001	<.001
Sanglaj-Shahrak-e Qarb	-304.460	43.437	-7.009	<.001	<.001
Sanglaj-Qeytariyeh	319.581	44.964	7.108	<.001	<.001
Sanglaj-Chizar	347.497	47.422	7.328	<.001	<.001
Darrous-Shahrak-e Qarb	-107.155	49.675	-2.157	.031	.465
Darrous-Qeytariyeh	-122.276	51.015	-2.397	.017	.248
Darrous-Chizar	150.192	53.195	2.823	.005	.071
Shahrak-e Qarb-Qeytariyeh	15.121	53.791	.281	.779	1.000
Shahrak-e Qarb-Chizar	43.037	55.863	.770	.441	1.000
Qeytariyeh-Chizar	27.916	57.058	.489	.625	1.000

The table provides a summary of pairwise comparisons of street widths in various neighborhoods, revealing significant differences in street dimensions among specific neighborhoods. Specifically, no significant differences in street widths were found between Dr. Hooshyar and Sanglaj. However, significant variations in street widths were observed between Dr. Hooshyar and Darrous, Shahrak-e Qarb, Qeytariyeh, and Chizar, as well as between Sanglaj and Darrous, Shahrak-e Qarb, Qeytariyeh, and Chizar. Darrous was found to have narrower streets compared to Shahrak-e Qarb, Qeytariyeh, and Chizar. Additionally, Shahrak-e Qarb exhibited significantly wider streets than Sanglaj, Dr. Hooshyar, Darrous, Chizar, and Qeytariyeh. On the other hand, Sanglaj, Dr. Hooshyar, and Darrous had the narrowest streets compared to the other neighborhoods. The second indicator assesses the ratio of **empty and full spaces** in different neighborhoods, and the following table compares this ratio among them.

Table 4.38. The ratio of empty and full spaces in selected neighborhoods

Neighborhood	Chizar	Sanglaj	Qeytariyeh	Dr. Hooshyar	Darrous	Shahrak-e Qarb
The ratio of empty to full spaces in the neighborhood	0.006	0.008	0.006	0.001	0.006	0.01

The calculations reveal that Shahrak-e Qarb has the highest ratio of empty to full spaces. This can be attributed to its wide streets, spacious pavements, numerous green spaces, and a green ring around the neighborhood. The second-highest ratio is observed in Sanglaj, primarily due to the many houses with large yards and numerous narrow and long streets in the neighborhood. Following in the rankings are Darrous, Chizar, and Qeytariyeh, all of which feature significant green spaces and parks. However, Dr. Hooshyar has the lowest ratio of empty to full spaces. The houses have been converted into small apartments with limited or no empty spaces, and the neighborhood has very few green areas.

Another aspect to consider is the symmetry and balance in spaces, which is related to the geometry and layout of the streets. To understand the importance of this aspect for pedestrians and its impact on their willingness to walk in different neighborhoods, citizens were surveyed. The following table presents the respondents' perceptions regarding the influence of street geometry and layout on their willingness to walk in various neighborhoods. Test statistics and significance values are provided for comparing the two neighborhoods.

Table 4.39. The willingness to walk considering the geometry of the streets in different neighborhoods

To what extent is the geometry of the street and its form effective in increasing your willingness to walk?

Mahale1-Mahale2	test statistic	Std.-error	Std. test statistic	Sig.	adjusted. Sig.[a]
Shahrak-e Qarb-Chizar	6.928	7.983	.868	.386	1.000
Shahrak-e Qarb-Dr. Hooshyar	8.053	9.125	.882	.378	1.000
Shahrak-e Qarb-Sanglaj	11.386	8.761	1.300	.194	1.000
Shahrak-e Qarb-Qeytariyeh	18.670	7.228	2.583	.010	.147
Shahrak-e Qarb-Darrous	30.615	7.346	4.167	<.001	.000
Chizar-Dr. Hooshyar	-1.125	9.882	-.114	.909	1.000
Chizar-Sanglaj	-4.458	9.547	-.467	.641	1.000
Chizar-Qeytariyeh	-11.743	8.163	-1.439	.150	1.000
Chizar-Darrous	-23.687	8.268	-2.865	.004	.063
Dr. Hooshyar-Sanglaj	-3.333	10.520	-.317	.751	1.000
Dr. Hooshyar-Qeytariyeh	-10.618	9.283	-1.144	.253	1.000
Dr. Hooshyar-Darrous	22.563	9.375	2.407	.016	.241
Sanglaj-Qeytariyeh	7.284	8.925	.816	.414	1.000
Sanglaj-Darrous	19.229	9.021	2.132	.033	.496
Qeytariyeh-Darrous	11.945	7.541	1.584	.113	1.000

Each row tests the null hypothesis that the distributions in Mahale 1 and 2 are equal.
Asymptotic significances (2-tailed tests) are shown. The significance level is .050.
a. Significance values are adjusted by Bonferroni's correction for multiple tests.

Upon analysis, it is evident that citizens' perceptions vary depending on specific neighborhood comparisons. In some cases, such as Shahrak-e Qarb versus Chizar or Shahrak-e Qarb versus Dr. Hooshyar, the respondents did not find a significant difference in the effect of street geometry on their willingness to walk. However, notable differences in perceptions emerged when comparing Shahrak-e Qarb with other neighborhoods. Comparisons of Shahrak-e Qarb with Qeytariyeh and Darrous revealed a significant positive impact of street geometry on the willingness to walk. Similarly, when comparing Shahrak-e Qarb with Sanglaj and Darrous, the respondents also perceived a significant positive effect. On the other hand, negative perceptions were noted in some comparisons. For instance, respondents perceived a negative impact of street geometry when comparing Chizar and Darrous with Dr. Hooshyar.

As the results confirm, the geometry and layout of the streets hold exceptional value in the Darrous neighborhood. This can be attributed to the scale of the curves and twists in Darrous streets. It is worth noting that Darrous is the only study area where pedestrians can experience these curves at eye level. Additionally, the edges of the water canal in Darrous further emphasize these curves, making them more noticeable and comprehensible to pedestrians.

The last indicator in this section focuses on the **variety of historic and traditional urban street elements**, such as Sagha-Khaneh (a religious drinking fountain), Gozar (alleyway), Kuche-Baq (narrow street), Sabat (street roof), and arches, and examines their role in enhancing the attractiveness of space for users. Experts highlighted two elements that stood out among the others: building styles and the historical identity of the neighborhood. The following table presents the frequency of responses based on different neighborhoods.

Table 4.40. The mentions of building styles (positive or negative) in selected neighborhoods, as determined through interviews

Building Style	positive	negative	Gesamt
Chizar	5 (83.3%)	1 (16.7%)	6 (2.7%)
Sanglaj	7 (53.8%)	6 (46.2%)	13 (5.8%)
Qeytariyeh	1 (20%)	4 (80%)	5 (2.2%)
Dr. Hooshyar	2 (25%)	6 (75%)	8 (3.6%)
Darrous	6 (100%)	0 (0%)	6 (2.7%)
Shahrak-e Qarb	2 (33.3%)	4 (66.7%)	6 (2.7%)
Gesamt	23 (52.3%)	21 (47.7%)	44 (19.6%)

Fisher-Test: p= .01854

Upon analyzing the data, it becomes evident that perceptions of building styles vary across neighborhoods. Chizar, Darrous, and Sanglaj received mostly positive comments regarding their building styles from the majority of respondents. Conversely, negative remarks were notably prevalent, especially for Qeytariyeh, Dr. Hooshyar, and Shahrak-e Qarb. It is important to highlight that Darrous received exclusively positive comments, signifying a pronounced appreciation for its building styles.

Overall, the data strongly indicate that building styles play a significant role in influencing the overall attractiveness of the neighborhoods. The Fisher Test, with a p-value of 0.01854, underscores a statistically significant relationship between the neighborhood and mentions of building styles. These findings underscore the importance of preserving and enhancing historic and traditional urban street elements to create visually appealing and culturally significant spaces for users. Experts also emphasized the perception of historic neighborhoods with distinct identities within the selected neighborhoods. The table below presents the frequency of positive and negative mentions based on interviews.

Table 4.41. Mentioning historic neighborhoods with identity (positively or negatively) in selected neighborhoods based on interviews

Historic with identity	positive	negative	Gesamt
Chizar	6 (100%)	0 (0%)	6 (2.7%)
Sanglaj	8 (100%)	0 (0%)	8 (3.6%)
Qeytariyeh	2 (40%)	3 (60%)	5 (2.2%)
Dr. Hooshyar	2 (66.7%)	1 (33.3%)	3 (1.3%)
Darrous	0 (0%)	3 (100%)	3 (1.3%)
Shahrak-e Qarb	0 (0%)	3 (100%)	3 (1.3%)
Gesamt	18 (64.3%)	10 (35.7%)	28 (12.5%)

Fisher-Test: p<.001

According analyzing the data, it becomes apparent that the perception of historic neighborhoods with identity varies across the selected neighborhoods. Chizar and Sanglaj received exclusively positive mentions for their historic neighborhoods with identity. In contrast, Qeytariyeh, Dr. Hooshyar, Darrous, and Shahrak-e Qarb received a mix of positive and negative comments regarding their historic neighborhoods with identity. The Fisher Test, with a p-value of less than 0.001, strongly indicates a statistically significant relationship between the neighborhood and the perception of historic neighborhoods with identity. The table below presents the responses of pedestrians regarding the role of old street elements in making their walking routes more attractive in selected neighborhoods.

Table 4.42. Understanding the importance of old street elements to pedestrians in selected neighborhoods based on pedestrians' responses

Neighborhood	Chizar		Sanglaj		Qeytariyeh		Dr. Hooshyar		Darrous		Shahrak-e Qarb	
	W	M	W	M	W	M	W	M	W	M	W	M
Old street elements	4.0	3.5	4.1	4.5	1.0	1.9	1.3	1.0	3.8	4.5	1.0	1.0

According to the table, Chizar, Sanglaj, and Darrous received the most positive responses regarding the importance of old street elements for pedestrians. Respondents from these neighborhoods mentioned Sagha-Khaneh and Sabat as the most attractive elements. Some pedestrians even mentioned taking longer routes to pass by these elements. In Sanglaj and Chizar, some people also appreciated the beauty of Kuche-Baq and Gazars but expressed safety concerns, which deterred them from using these spaces for walking. The findings indicate that old street elements significantly enhance the attractiveness of walking routes, particularly in neighborhoods like Chizar, Sanglaj, and Darrous. By promoting a sense of security and maintaining the charm of old street elements, neighborhoods can create more enjoyable walking experiences for pedestrians. However, safety should be addressed in areas where certain elements are appreciated but not utilized due to perceived risks.

In conclusion, the research findings highlight the importance of attractiveness and beauty in evaluating neighborhoods. The subjective nature of beauty is emphasized, as individual experiences and preferences play a significant role. The beauty and attractiveness of organic street networks vary significantly based on different factors.

According to the data, the original organic street network in the old part of Tehran (Chizar) holds the highest ranking in terms of beauty and attractiveness. This can be attributed to its integration of natural features into the street network. The presence of natural elements, such as greenery, water resources, sounds, smells, and street facades, also contributes to the overall attractiveness of neighborhoods. Positive mentions of natural elements are generally high among residents, indicating their favorable perception and the positive impact of nature on the neighborhood's desirability. Integrated organic networks are particularly fascinating when they incorporate natural elements such as old trees and water resources (Darrous).

On the other hand, the imitated organic street network (Shahrak-e Qarb) has the lowest ranking in terms of attractiveness. This is primarily because the green spaces of this network are mainly located along the border, forming a ring-like pattern. People perceive the wide and long streets of the imitated organic network as dull and empty, featuring buildings with uninteresting facades. The historic Tehran area (Sanglaj) has lost much of its greenery and natural aspects, making it less appealing compared to other networks that possess natural attractiveness. Despite this, the historic Tehran area is still captivating to explore due to numerous historical and memorial urban street elements.

The presence of high-rise buildings in neighborhoods has mixed effects on the desire to walk. While some pairs of neighborhoods show a significant impact, others do not exhibit a clear relationship. Other factors, such as neighborhood characteristics, individual preferences, and environmental factors, influence walking behavior. In summary, the research emphasizes the importance of considering attractiveness and natural elements in evaluating neighborhood walkability.

4.3. Summary of the Walkability Assessment in Iranian Organic Street Networks

The analysis of pedestrian safety in the neighborhoods reveals several significant findings. When comparing neighborhoods, there are notable differences in the number of dangerous routes. Chizar emerges as the neighborhood with the highest number of dangerous routes, indicating potentially higher risks for pedestrians. It is followed by Shahrak-e Qarb, Sanglaj, Qeytariyeh, Dr. Hooshyar, and Darrous, suggesting a relatively lower number of hazardous routes in these areas.

The differences in narrow streets between neighborhoods are influenced by historical, cultural, and developmental factors. Some neighborhoods face constraints in widening streets due to their religious, historical, or cultural significance. Additionally, high land values and commercial activities in specific neighborhoods also hinder street-widening efforts. The Kruskal-Wallis test indicates a significant difference in the length of dangerous routes among the neighborhoods. Pairwise comparisons revealed significant differences between Darrous and Dr. Hooshyar and Chizar and Dr. Hooshyar in terms of the number of dangerous routes. However, it is essential to consider other factors and the unique characteristics of each neighborhood to fully understand the implications for pedestrian safety and urban design.

On the other side, Chizar and Sanglaj have more local centers within their neighborhoods, including religious centers, indicating a higher presence of traditional and religious residents. This contributes to a stronger sense of security in these areas due to the preservation of their traditional atmosphere. Darrous benefits from the presence of an open water canal, providing a pleasant space for walking and socializing, which enhances the feeling of security among residents. In contrast, Qeytariyeh, Dr. Hooshyar, and Shahrak-e Qarb report local meeting points outside the neighborhood or in establishments such as shopping centers, fitness centers, cafés, or bookstores. This suggests a less localized sense of community and may contribute to a relatively lower sense of security in these neighborhoods.

The number of intersections and intersection density reveal that Sanglaj and Dr. Hooshyar have the highest number of intersections, providing relatively better accessibility to various streets. Chizar, Qeytariyeh, and Darrous have a similar number of intersections, indicating moderate accessibility. Shahrak-e Qarb has the lowest intersection density, implying less accessibility to other streets from a single street.

The Betweenness index, which measures the importance of streets in terms of their connectivity, varies among neighborhoods. Sanglaj and Dr. Hooshyar have the highest betweenness values, indicating greater accessibility and connectivity. Chizar, Qeytariyeh, and Darrous have moderate betweenness values, while Shahrak-e Qarb has the lowest. Residents express feelings of insecurity in Sanglaj and Dr. Hooshyar neighborhoods due to their commercial nature, the presence of non-local individuals, and the lack of activity during nighttime. Chizar and Qeytariyeh residents have a partial sense of insecurity due to perceived over-localization. Lighting conditions also play a role in residents' security perception. Shahrak-e Qarb has the best lighting, followed by Darrous, Qeytariyeh, and Chizar. Dr. Hooshyar's neighborhood received lower satisfaction, particularly in secondary streets and cul-de-sacs. Sanglaj had the lowest resident satisfaction with lighting conditions on both main and secondary streets after dark. Overall, factors such as neighborhood structure, accessibility, commercial activities, lighting, and community cohesion influence the security perception of residents in these neighborhoods.

The analysis of original organic street networks reveals that while the development of city spaces undergoes numerous changes, the configuration of street networks remains relatively stable. This stability can be attributed to the interconnectedness of streets, the presence of natural elements such as water canals or qanat routes and trees, the strategic placement of historical and religious sites, and the high land value. Over the centuries, organic street networks have integrated with their neighborhood's natural, social, and cultural features. These organic street networks offer better accessibility and straightforwardness than integrated or revised networks, and there is less motivation to change their features. The growth of these original organic networks primarily revolves around key focal points of the neighborhood, such as Imamzadeh (religious shrines), the Bazaar, or water sources. In cases with a single main center, the street network expands in a three-pointed star, typically forming three lines extending in different directions, predominantly north, southwest, and southeast. However, if multiple main centers of a neighborhood are located along a particular street, the growth pattern follows a rectangular form, with the northeast/southwest direction tending to be longer, considering the length of the streets. Overall, the organic nature of these street networks demonstrates a deliberate arrangement that prioritizes accessibility, connection to important landmarks, and the inherent characteristics of the surrounding environment.

Based on various resources such as GIS, interviews, and questionnaires, the research findings suggest the use of a scoring system to facilitate the comparison of walkability evaluations among different neighborhoods. This scoring system involves assigning weights to different factors and calculating an overall score for each neighborhood. Initially, specific evaluation criteria were defined, creating a list of criteria and indicators that can be scored based on the studied factors. Then, relative weights were assigned to each criterion according to their importance in determining walkability, as determined by expert opinions. Subsequently, scores were calculated for each criterion. To achieve this, a scoring scale was established for each criterion, consisting of five stages: poor (1), unsatisfactory (2), satisfactory (3), very satisfactory (4), and outstanding (5). The scoring system was then applied to the data collected from GIS analysis, expert interviews, and pedestrian questionnaires. Each criterion for each neighborhood was evaluated, and corresponding scores were assigned. To obtain the weighted scores for each neighborhood, the scores of each criterion were multiplied by their respective weights. These weighted scores were then summed up to derive the overall walkability score for each neighborhood. The results of the rating system are illustrated in the following table.

Table 4.43. The rating of the walkability scores in each neighborhood based on the evaluation method

Factor	Elements	Score	Chizar	Sanglaj	Qeytariyeh	Dr. Hooshyar	Darrous	Shahrak-e Qarb
Safety	Street width	GIS	1	1	3	3	5	1
		Interview	2	2	3	1	5	1
		Questionnaire	2	2	3	1	5	1
	Calming traffic	GIS	5	3	3	2	5	1
		Interview	3	3	2	2	4	1
		Questionnaire	1	1	3	1	5	3
Security	Semi-public spaces	GIS	5	5	3	1	5	1
		Interview	5	5	3	2	3	1
		Questionnaire	5	5	4	1	4	1
	Level of accessibility	GIS	3	5	3	5	3	1
		Interview	-	-	-	-	-	-
		Questionnaire	5	5	5	3	4	2
	Eyes on the street	GIS	-	-	-	-	-	-
		Interview	5	5	3	1	3	1
		Questionnaire	3	1	3	1	4	4
	Lighting	GIS	-	-	-	-	-	-
		Interview	4	1	5	2	5	5
		Questionnaire	3	1	4	1	4	5
Accessibility	Number of nodes	GIS	3	5	3	5	3	1
		Interview	-	-	-	-	-	-
		Questionnaire	3	3	5	3	4	5
Connectivity	Physical	GIS	3	5	2	5	3	1
		Interview	-	-	-	-	-	-
		Questionnaire	-	-	-	-	-	-
	Visual	GIS	4	2	4	1	3	5
		Interview	-	-	-	-	-	-
		Questionnaire	-	-	-	-	-	-
Climate Comfort	Climate protection and topography	GIS	-	-	-	-	-	-
		Interview	-	-	-	-	-	-
		Questionnaire	5	4	4	2	4	2
	orientation	GIS	5	5	3	1	5	2
		Interview	-	-	-	-	-	-
		Questionnaire	-	-	-	-	-	-
Quality of the built environment	Sense of confinement	GIS	5	5	2	3	4	4
		Interview	-	-	-	-	-	-
		Questionnaire	3	5	3	3	2	2
	Permeability	GIS	4	5	3	5	3	2
		Interview	-	-	-	-	-	-
		Questionnaire	-	-	-	-	-	-
	Readability	GIS	-	-	-	-	-	-
		Interview	-	-	-	-	-	-
		Questionnaire	5	5	3	2	4	1
attractiveness	Nature	GIS						
		Interview	4	1	4	2	5	3
		Questionnaire	4	1	3	1	5	3
	Contrasting	GIS	5	5	3	2	2	1
		Interview	5	5	3	2	1	1
		Questionnaire	5	5	3	2	2	1
Sum			115	106	97	66	114	63

The summary of the table indicates that Chizar, with its original organic street network in the old part of Tehran, has the highest walkability rate when considering the layout of the street network. Darrous follows closely with an integrated grid-tributary-organic street network, with just one point less in the ranking. Next is Sanglaj, with its original organic street network in the historic part of Tehran, and Qeytariyeh, with an integrated grid-organic street network. The last two places are occupied by Dr. Hooshyar, with an integrated tributary-organic street network, and Shahrak-e Qarb Neighborhood, which features an imitated organic street network.

Furthermore, the findings provide insight into the walkability situation in these neighborhoods. However, it should be noted that certain factors unrelated to the street network's layout have influenced the results, particularly in the methods involving interviews and questionnaires. For instance, the feeling of insecurity due to the presence of non-locals of Sanglaj and Dr. Hooshyar Neighborhoods affected the outcomes.

To summarize the whole results of this section, each type of network has been mentioned based on different factors. The original organic street network in the old parts of the city is characterized by several distinct features and qualities that contribute to its unique charm and character. While each neighborhood may have its specific nuances, certain common elements can be observed. Firstly, these old parts of the city tend to have the highest number of hazardous routes. This may be attributed to the historical development of the streets, which often followed irregular paths without modern considerations for safety and traffic flow. However, despite these hazards, the neighborhoods generally maintain a good level of accessibility, as indicated by their high betweenness centrality. This means that there are multiple paths connecting different areas, allowing for convenient movement of and between neighborhoods. One notable aspect of the old street network is the presence of trees along the streets. The abundance of greenery contributes to the aesthetic appeal and provides a refreshing atmosphere. The trees also offer shade and a connection to nature, enhancing the pedestrian experience. Additionally, the positive impact of greenery, combined with water resources and nature sounds, adds to the overall ambiance and creates a pleasant environment for residents and visitors alike. While there may be certain perceptions of over-localization in some areas, the neighborhoods generally exhibit comparable levels of accessibility and walkability rates to each other. This suggests that residents have relatively equal access to amenities and services of their respective neighborhoods.

The streets in the old parts of the city typically have a generally similar number of nodes, indicating a balanced distribution and connectivity. This ensures that various destinations in the neighborhoods are reasonably accessible. Although there may be a significant variety in street widths, with few streets narrower than six meters, the overall street comfort remains consistent and comparable to other neighborhoods. Furthermore, certain high buildings are visible from some parts of the neighborhood, adding to the visual interest and creating a unique skyline. The presence of these structures adds a sense of history and architectural significance to the area. The main square, core, and southwest part of the neighborhood have good visibility, ensuring a sense of openness and security. Adequate lighting conditions also contribute to the overall safety and comfort of pedestrians during nighttime. Old street elements, such as the buildings' architectural styles and the overall layout of the streets, are highly regarded by residents. Positive comments regarding these elements highlight their importance in preserving the historical and cultural identity of the neighborhood. In summary, the original organic street network in the old parts of the city combines elements of historical charm, accessibility, and natural beauty. While there may be certain hazards and a perceived sense of over-localization, the neighborhoods offer good connectivity, walkability, and comparable levels of accessibility. The presence of trees, water resources, and greenery, along with positive architectural styles and old street elements, enhances the overall experience for pedestrians and creates a unique and appealing atmosphere.

The historic parts of the city, characterized by an original organic street network, possess their distinct qualities and characteristics. One notable aspect of these historic areas is that they have the second-highest number of hazardous routes. This implies that the streets may have irregular or challenging configurations that can pose safety concerns for pedestrians and drivers. However, despite these hazards, the street network exhibits a high betweenness centrality, indicating good accessibility. Multiple paths connect different areas of the neighborhood, facilitating convenient movement. Narrow streets can limit the space available for pedestrians and vehicles, potentially leading to congestion and reduced accessibility. The historic areas also have a high concentration of commercial and storage functions. This suggests that these neighborhoods may have been historically designated for commercial activities, resulting in a lively and bustling atmosphere during the day. However, residents may feel insecure due to the commercial nature and a perceived lack of activity during nighttime. This could be attributed to reduced lighting conditions and a potential decrease in pedestrian presence after business hours.

In terms of the street network itself, there are generally more nodes present compared to other types of organic street networks. This higher number of nodes indicates a more complex and interconnected street layout of the neighborhood. As a result, accessibility of the neighborhood is likely higher, allowing residents to easily reach various destinations in their immediate vicinity. Additionally, the historic areas exhibit the highest accessibility of the original organic street network. This indicates that these neighborhoods offer exceptional connectivity to different parts of the city, making them well-connected hubs of the overall urban fabric. The streets and paths in these historic areas are more conducive to pedestrian movement, emphasizing the importance of walkability. The higher physical connectivity of these neighborhoods signifies that there are numerous routes available for pedestrians to traverse, promoting efficient and enjoyable strolls through the area. However, the northern parts of the city, of the historic areas, may have a lower street formation and intersection density compared to the central areas. This implies that the street network in the north is less extensive, potentially resulting in fewer connecting streets and intersections.

The neighborhood exhibits the lowest beta index due to a high number of cul-de-sacs. Cul-de-sacs are dead-end streets that limit through traffic, contributing to a more localized and enclosed atmosphere. The presence of cul-de-sacs can have a limiting effect on the overall connectivity of the neighborhood. Furthermore, the historic areas have the lowest eta index, indicating a higher walkability rate compared to other types of organic street networks. This suggests that the streets in these neighborhoods are well-designed for pedestrian movement, providing a pleasant and easily navigable environment for walkers. While visual connectivity to nearby streets may be limited, the neighborhood offers good visibility to the horizon. This is due to the prevalence of low-rise buildings, allowing residents to have unobstructed views of the distant surroundings. The presence of street trees provides a similar level of comfort compared to other organic street networks. While limited perception of greenery, water resources, nature sounds, and street walls may be reported by residents, the high level of comfort provided by the topography compensates for this absence

The Integrated grid and organic street network in the neighborhoods exhibit a combination of features and characteristics that shape the overall experience of residents and visitors. One notable feature of this street network is the presence of trees along the streets. The inclusion of trees enhances the aesthetic appeal of the neighborhoods and provides a refreshing and natural atmosphere for pedestrians. The positive impact of greenery, water resources, nature sounds, and street walls further contributes to the overall ambiance, creating a pleasant environment for residents to enjoy. The neighborhood exhibits a moderate number of narrow streets. While narrow streets can limit space for pedestrians and vehicles, the overall number remains manageable, maintaining a balance between accessibility and a sense of enclosure. The street network demonstrates a relatively equal number of intersections, ensuring connectivity throughout the neighborhood. This allows for convenient movement and ease of navigation of and between different areas. Although the betweenness centrality suggests a moderate level of accessibility, there may be a partial sense of insecurity due to a perceived over-localization. This feeling may arise from a concentration of certain activities or businesses in the neighborhood, potentially leading to a perception of limited diversity or a lack of vibrancy in certain areas. The neighborhoods generally have adequate lighting conditions, which contribute to the overall safety and comfort of pedestrians during nighttime.

In terms of the street network structure, there is a generally similar number of nodes, indicating a balanced distribution and connectivity of the neighborhoods. This ensures that various destinations in the area are reasonably accessible. The accessibility levels of the neighborhoods are comparable to one another, suggesting a relatively even distribution of amenities and services for residents. The beta index, which measures the level of street connectivity, is similar to that of the Darrous and Chizar neighborhoods. This indicates that the level of connectivity of the street network is consistent among these areas. The walkability rate and eta index in these neighborhoods align with other neighborhoods, implying that they offer a similar pedestrian-friendly environment and ease of movement.

Medium physical connectivity in these neighborhoods is relatively similar to others, suggesting a moderate level of interconnectedness and accessibility. Certain high buildings are visible from some parts of the neighborhood, adding to the visual interest and potentially creating a unique skyline. The presence of these structures contributes to the architectural diversity and character of the area. However, the street comfort in these neighborhoods is rated lower compared to Dr. Hooshyar, potentially indicating some factors that impact the overall pedestrian experience. It is worth noting that the street comfort is similar to the other types of organic street networks, suggesting consistency in the perceived comfort across these areas. The presence of trees contributes to a comparable degree of comfort and ambiance in these neighborhoods.

The ratio between the width and height of streets in these neighborhoods is lower, potentially creating a sense of confinement. This aspect may contribute to a different spatial experience and perception for pedestrians. The visibility for pedestrians may be limited due to the presence of high-rise buildings and topographical features. This can influence the overall sense of openness and visual connectivity of the neighborhood. Perceptions of greenery, water resources, nature sounds, and the smells of nature are generally positive, highlighting the importance of these elements in creating an appealing and pleasant environment. While there may be a significant variety in street widths, potentially contributing to a diverse streetscape, negative comments on building styles indicate varying architectural preferences among residents.

Regarding the importance of old street elements for pedestrians, responses are mixed, reflecting differing perspectives on the significance of historical elements of the neighborhood. In summary, the Integrated grid and organic street network in these neighborhoods showcase a mix of positive and potentially challenging aspects. The presence of trees, greenery, water resources, and nature sounds contributes to the overall ambiance and enhances the pedestrian experience. However, perceived over-localization and lower street comfort compared to other neighborhoods may present certain concerns. The variety in street widths and the impact of high-rise buildings and topographical features can influence the area's spatial perception and pedestrian visibility. The overall importance of old street elements receives mixed responses, reflecting differing opinions among residents.

The Integrated tributary and organic street network in these neighborhoods is characterized by a variety of features and considerations that shape the overall experience of residents and visitors. The presence of trees along the streets adds a touch of natural beauty to the neighborhoods.

These trees contribute to the aesthetic appeal, provide shade, and create a more pleasant walking environment. However, it is worth noting that more narrow streets are concentrated in the historic center. While this adds to the charm and character of the area, it can also pose challenges in terms of space for pedestrians and vehicles.

The commercial nature of these neighborhoods results in more transportation activities. This indicates a higher volume of movement and potentially adds to the vibrancy and liveliness of the area. However, the increased commercial activity may also contribute to a sense of insecurity among residents, particularly due to the presence of non-local individuals. These neighborhoods have a high number of dangerous spots and routes. This suggests that certain areas may present safety concerns for pedestrians and drivers. It is important to address these hazards to ensure the overall well-being and safety of residents and visitors.

Despite the presence of hazards, the street network exhibits a high betweenness, indicating good accessibility. There are multiple routes and connections in the neighborhood, facilitating convenient movement and accessibility to different parts of the area. Residents express lower satisfaction with lighting conditions in secondary streets and cul-de-sacs. This suggests that certain areas of the neighborhoods may lack adequate lighting, potentially impacting the perceived safety and comfort of pedestrians, especially during nighttime.

The higher number of nodes in the street network indicates a more complex and interconnected layout of the neighborhoods. This suggests that various destinations in the area are reasonably accessible, promoting convenient movement in the neighborhood. Accessibility of the neighborhood is likely higher due to the concentration of nodes and connections. This means that residents have relatively easy access to amenities, services, and different parts of the neighborhood, enhancing the overall convenience and quality of life.

The beta index, which measures street connectivity, is similar to other neighborhoods. This indicates a comparable level of interconnectedness and accessibility of the street network. However, the neighborhoods have the lowest eta index, indicating a higher walkability rate compared to other forms of integrated organic street networks. This suggests that the streets are well-designed for pedestrian movement, making it easier and more enjoyable to navigate the neighborhood on foot.

The high physical connectivity of these neighborhoods further emphasizes the ease of movement and accessibility of the area. This interconnectedness ensures that residents have multiple routes available to reach their destinations efficiently. Visual connectivity to nearby streets may be limited of these neighborhoods. This can impact the overall sense of openness and visibility, potentially creating a more enclosed or localized environment.

In terms of street comfort, the neighborhoods are rated lower compared to the other forms of integrated organic street networks. This suggests that there may be certain factors influencing the pedestrian experience that need attention and improvement in these neighborhoods. The level of comfort provided by street trees is higher compared to the other forms of integrated and original organic street networks in the old parts of the city. The presence of street trees adds to the overall comfort and aesthetic appeal, enhancing the walking experience for pedestrians. Similarly, the comfort provided by the topography of the streets is similar to the original organic street networks in the historic parts of the city. The natural contours and features of the streets contribute to the overall comfort and ambiance of the neighborhood. However, the street tree comfort is lower compared to the other forms of integrated and original organic street networks in the old parts of the city. This suggests that while trees are present, they may not provide the same level of comfort as in other areas.

The ratings for readability and presence of landmarks are lower, implying that the streets may be less legible and lack distinctive landmarks, potentially making navigation more challenging for pedestrians. The lower distances in the street network indicate higher accessibility of the neighborhood. This means that destinations are relatively close to each other, allowing for easier and quicker access to amenities and services.

While there is a positive perception of greenery, water resources, and street walls, it is noted that the impact of these elements may be lesser compared to other neighborhoods. This suggests that while they are present, they may not have the same prominence or influence in shaping the overall character and experience of the neighborhood. The neighborhoods offer good visibility to the horizon due to the presence of many low-rise buildings. This allows residents to enjoy open views and a sense of spaciousness in their surroundings. However, there is a limited perception of greenery, water resources, nature sounds, and street walls. This indicates that while these elements may exist, they may not be as prominent or noticeable in the neighborhood.

The neighborhoods have the lowest ratio of empty to full spaces, potentially creating a denser and more built-up environment. This may contribute to a different spatial experience and sense of confinement for pedestrians. Negative comments on building styles suggest that there may be differing architectural preferences among residents. This highlights the subjective nature of the aesthetic preferences of the neighborhood. Mixed responses regarding the importance of old street elements for pedestrians reflect varying perspectives on the significance of historical elements of the neighborhood. This indicates that residents may have differing views on the value and relevance of preserving and incorporating old street elements.

In summary, the Integrated tributary and organic street network in these neighborhoods presents a mixed set of characteristics and considerations. The good accessibility contributes to the overall pedestrian experience. However, challenges such as the commercial nature, higher number of dangerous spots, limited visual connectivity, lower street comfort, and mixed perceptions of old street elements should be addressed to create a safer, more comfortable, and cohesive urban environment.

The Integrated grid-tributary and organic street networks in these neighborhoods exhibit a combination of features that shape the overall experience of residents and visitors. Compared to other networks, there are fewer narrow streets in these neighborhoods. This can contribute to a more open and spacious feel, allowing for smoother traffic flow and potentially more space for pedestrians. The presence of an open water canal provides a pleasant space in the neighborhood. This water feature adds to the overall ambiance, offering a visually appealing element and potentially creating a peaceful atmosphere for residents and visitors to enjoy.

The moderate number of intersections in the street network allows for a balance between accessibility and traffic management. It provides enough connections to facilitate movement without creating an excessive density of intersections that could lead to congestion. The moderate betweenness indicates a moderate level of accessibility of the neighborhoods. While it may not have the highest level of accessibility, it still ensures reasonable connectivity and convenient access to different parts of the area.

The number of nodes in the street network is generally similar, indicating a comparable level of connectivity and access to various destinations in the neighborhood. This promotes convenience and ensures that residents have access to amenities and services at a reasonable distance. The beta index, which measures street connectivity, is the highest among the different networks due to the high number of intersections. This indicates a denser network of streets, allowing for efficient movement and a higher degree of connectivity in the neighborhoods. The walkability rate and eta index, which measure the ease of pedestrian movement, are similar to other neighborhoods. This suggests that these neighborhoods provide a pedestrian-friendly environment, allowing for comfortable and convenient walking experiences.

The physical connectivity of these neighborhoods is medium, indicating a moderate level of connectedness in the street network. This supports efficient movement and accessibility throughout the area. Certain high buildings are visible from some parts of the neighborhood, adding to the visual character of the area. The presence of these tall structures can contribute to a unique skyline and provide landmarks for orientation. However, the level of comfort provided by the topography of the streets is lower compared to the other organic networks. This suggests that the natural contours and features of the streets may not offer the same level of comfort and aesthetic appeal as in other areas.

The positive perception of greenery, water resources, nature sounds, and street walls suggests that these elements have a favorable impact on the overall environment and ambiance of the neighborhoods. They contribute to a pleasant atmosphere, enhancing the pedestrian experience. The limited visibility for pedestrians due to high-rise buildings and topographical features may create a more enclosed or restricted environment in the neighborhoods. This can influence the overall spatial perception and pedestrian comfort.

There is a significant variety in street widths, offering a diverse streetscape that adds visual interest and character to the neighborhoods. This variation can create a more dynamic and engaging environment for pedestrians. Positive comments on building styles indicate that residents appreciate the architectural aesthetics and styles present in these neighborhoods. The buildings contribute to the visual appeal and unique character of the area. The positive responses regarding the importance of old street elements for pedestrians highlight the value placed on preserving and incorporating historical elements of the neighborhood. This reflects an appreciation for the heritage and cultural significance of the old street elements.

In summary, the Integrated grid-tributary and organic street networks in these neighborhoods offer a mix of features that shape the overall experience. The presence of an open water canal, good lighting conditions, a positive perception of greenery, and street walls contribute to a pleasant environment. However, limited visibility, lower topographical comfort, and reliance on private vehicles may affect the pedestrian experience. The neighborhood's character, variety in street widths, and positive feedback on building styles contribute to the overall appeal.

The Imitated Organic street networks in these neighborhoods exhibit a unique set of characteristics and considerations. The presence of trees along the streets adds a natural and aesthetic element to the neighborhoods. The greenery contributes to the overall ambiance and can provide shade and a sense of tranquility for pedestrians. Due to the commercial nature of these neighborhoods, there are more transportation activities. This suggests a bustling and active environment with increased vehicular and pedestrian movement, potentially creating a vibrant atmosphere.

The identification of more natural spots as local centers highlights the integration of natural elements of the neighborhood. These spots can serve as focal points, providing opportunities for relaxation and community interaction. The lowest intersection density indicates less accessibility in these neighborhoods. This implies that there are fewer connections and pathways, which may restrict movement and make it more challenging to navigate the area. The lowest betweenness index suggests less connectivity of the street network. This could result in limited direct routes and a more segmented or disconnected layout, affecting the overall accessibility and cohesiveness of the neighborhoods.

Residents may feel insecure due to a combination of factors, including security ideology, less accessibility, and reliance on private vehicles. This perception of insecurity can impact the sense of safety and comfort for pedestrians. The neighborhoods boast the best lighting conditions, ensuring good visibility and a sense of safety, particularly during nighttime. Well-lit streets enhance the overall pedestrian experience and contribute to a secure environment. With the fewest nodes in the street network, accessibility of the neighborhoods may be comparatively lower. This can result in longer travel distances and a less interconnected street network, potentially affecting the convenience of reaching different destinations.

The limited accessibility of the neighborhood may be intentionally designed to segregate the area from other parts of the city. This deliberate separation can influence the overall character and function of the neighborhoods. The Imitated Organic street networks exhibit the worst situation in terms of accessibility compared to the other networks. This indicates significant challenges in terms of movement and connectivity of these neighborhoods.

The neighborhoods have a similar beta index to other neighborhoods, suggesting a comparable level of street connectivity. However, the highest Eta Index indicates a lower walkability rate, implying that walking may be less favored as a mode of transportation in these neighborhoods. The lowest physical connectivity suggests a less connected street network of the neighborhoods. This can impact the efficiency of movement and the overall accessibility of different destinations. Landmarks visible throughout the neighborhood can serve as reference points and facilitate navigation for pedestrians. The presence of recognizable landmarks contributes to wayfinding and orientation of the neighborhoods.

Rated lower in street comfort compared to integrated organic street networks, the Imitated Organic street networks may have certain characteristics that make walking less comfortable. Factors such as street layout, infrastructure, or design elements may contribute to this perception. The level of comfort provided by street trees is lower compared to integrated organic street networks. This indicates that the presence of trees may not have as significant of an impact on the pedestrian experience of these neighborhoods. However, the higher level of comfort provided by the topography of the streets suggests that the natural features and terrain of the neighborhoods contribute positively to the overall walking experience.

Limited visibility in secondary streets due to tall buildings can create a more enclosed or confined environment in the neighborhoods. This may affect the sense of openness and visual connectivity for pedestrians. The limited perception of greenery, nature sounds, and nature smells suggests that these elements may not be as prominent or noticeable in the neighborhoods. This can influence the overall sensory experience and connection with the natural environment. A positive perception of street walls indicates that these architectural elements contribute positively to the overall character and atmosphere of the neighborhoods. Street walls can provide visual interest and enclosure, defining the urban space. Positive responses regarding the impact of street geometry on walking willingness, when compared to integrated organic street networks, suggest that the layout and design of the streets of the Imitated Organic neighborhoods may be more conducive to pedestrian movement. Negative comments on building styles indicate a less favorable reception of the architectural design of these neighborhoods. The aesthetics and architectural character may not be as well-received or appreciated by residents or visitors.

In summary, the Imitated Organic street networks in these neighborhoods present a mix of characteristics. While there is a presence of trees along the streets and positive responses regarding the impact of street geometry, the neighborhoods face challenges such as limited accessibility, a lower walkability rate, and negative comments on building styles. The neighborhoods' commercial nature, combined with their unique architectural features, can create a distinct ambiance but may also affect pedestrian comfort and security.

5. Conclusion

5.1. Key Insights and Lessons from the Study

At the outset of this research, seven research questions were formulated for investigation and guiding the research process. To present a comprehensive view of the answers, this section delves into key insights and lessons derived from an extensive study on organic street networks' configuration and their profound impact on walkability. These networks, renowned for their evolutionary development and harmonious integration with diverse urban elements, offer a unique canvas for unraveling the complexities of pedestrian-friendly urban environments.

Question 1. How does the configuration and form of organic street networks in Tehran impact walkability?

The research unequivocally demonstrates that organic street network configuration exerts a substantial influence on pedestrian activity in urban areas. This influence arises from the organic networks' gradual evolution, seamlessly integrating with various urban elements such as blocks, buildings, natural features, and architectural styles, to meet the evolving needs of their users. Consequently, a comprehensive evaluation of walkability necessitates a deep dive into street network configuration and form.

Interventions aimed at enhancing walkability, devoid of due consideration for network configuration may inadvertently disrupt the physical, social, and cultural fabric of the network. Essentially, the physical attributes of the street network contribute significantly to a neighborhood's identity and essence. Such transformations may lead to a loss of neighborhood identity and, consequently, a decline in walkability.

Despite contemporary challenges such as urban development and increased automobile usage, organic street networks continue to hold intrinsic value for long-standing neighborhood residents. These networks persist as welcoming environments for locals, particularly when vital factors like security are adequately addressed.

The study sheds light on the divergent perspectives held by residents and visitors regarding organic street networks. While these networks may appear secure and easily navigable to residents, they might present an unfamiliar and less secure environment to outsiders. This underscores the significance of incorporating local and tourist viewpoints into walkability assessments. There are eyes on the streets, but they can be invisible to visitors, or sometimes even these eyes on the streets (which are mostly the residents of the site) make the visitors feel insecure.

This study shows, that within Iranian organic street networks, the paramount determinant of walkability is security. A secure environment, characterized by relatively stable physical network attributes, encourages residents to embrace walking as their preferred mode of transportation for daily routines and leisure activities.

Question 2. What are the key characteristics and principles of Iranian traditional urban design that are observable in organic street networks, and how do these principles contribute to walkability?

The key characteristics and principles of Iranian traditional urban design observable in organic street networks significantly contribute to walkability in Tehran's neighborhoods. These principles are deeply ingrained in the organic network's form and function, enhancing the pedestrian experience. First and foremost, the organic network respects nature and incorporates elements like trees and old trees, emphasizing the connection between the urban environment and the natural surroundings.

Natural elements enjoy profound significance in Iranian organic street networks, given the nation's predominantly warm and arid climate. Historical reverence for water bodies and greenery persists as a crucial facet of urban life. These natural elements not only enhance the aesthetic allure of pedestrian environments but also contribute substantially to environmental comfort and sustainable identity.

Furthermore, Iranian organic street networks frequently feature communal gathering spaces, often located near green areas or significant natural landmarks such as ancient trees or rivers. These spaces serve as focal points for community interaction, fostering an overall sense of security within the neighborhood. Their presence bolsters community cohesion and bolsters the walkability of the area. This harmony with nature not only beautifies the streets but also provides shade, making walking more comfortable in Tehran's hot and dry climate.

Human scale is another crucial principle, ensuring that streets' dimensions and layouts cater to pedestrians' needs, providing them with a sense of space and openness during their walks. Spatial continuity, hierarchy, and connectivity principles foster well-connected neighborhoods, where residents can easily navigate from the center to peripheral areas. Privacy and enclosure principles create a sense of intimacy and safety within neighborhoods, while the principle of contrasting adds variety and visual interest to streetscapes. Moreover, the organic network encourages static and dynamic elements, incorporating pause spots and social gathering areas that invite pedestrians to rest and interact, promoting community engagement during walks. Finally, the principle of scale and proportion ensures that streets are not monotonous, with varying widths, heights, and covered sections to maintain visual interest and comfort. Collectively, these principles make Tehran's organic street networks conducive to walking, offering shade, comfort, sociocultural richness, and a deep sense of place, fostering an environment where residents feel a strong sense of belonging and connectivity within their neighborhoods.

Question 3. What are the distinctions between original, integrated, and imitated organic street networks in Tehran, and how do these distinctions influence walkability factors?

The distinctions between original, integrated, and imitated organic street networks in Tehran significantly influence walkability factors in the city. Each type of network has its unique characteristics and impacts on the pedestrian experience, as illustrated by the research findings. Below, a summary of the strengths and weaknesses of each network type is provided, concerning the walkability of the street network.

Original Organic Street Networks

Strengths:

Historical Significance: The original organic street network represents the historical and cultural heritage of Tehran. These networks have evolved, reflecting the city's deep-rooted history and traditional urban planning principles.

Walkability: Original organic networks are often walkable. They are characterized by winding streets, human-scale dimensions, and natural shade, making them conducive to walking and fostering a strong sense of place.

Community and Culture: These networks promote community interaction and cultural richness due to their connection to historical and religious sites, encouraging residents to walk to these places for various activities.

Resilience: The historical context and natural features that influenced the formation of these networks often lead to more resilient urban structures, particularly in areas near mountains or rivers.

Adaptability: Original organic street networks have evolved to cater to the needs and preferences of their users. This adaptability can be a strength as the network is inherently designed to serve the local community effectively.

Human Scale: Original networks tend to exhibit a human-scaled design, with narrow streets and low height of the street walls.

Weaknesses:

Slow Adaptation Rate: Original organic networks need many years to adapt themselves to new surroundings, which is not compatible with the speed of urban development in many areas.

Safety Concerns: As the organic street networks consider pedestrians as the main users of the street network spaces, and considering that these networks do not have enough time to adapt themselves to include both pedestrian and motorized users as the users of the network spaces, they face with safety issues, such as narrow and winding streets that can pose challenges for vehicular and pedestrian traffic.

Limited Capacity for Change: Adapting original organic networks to modern needs can be a slow and challenging process due to their historical value and existing configurations.

Integrated Organic Street Networks

Strengths:

Improved Connectivity: Integrated organic networks combine the adaptability of organic layouts with a degree of connectivity more typical of grid-like networks. This can enhance overall accessibility and walkability.

Balanced Evolution: These networks strike a balance between preserving traditional elements and introducing modern infrastructure, potentially resulting in improved walkability.

Weaknesses:

Loss of Authenticity: The integration of grid-like elements may dilute the unique character and authenticity of the organic street network, impacting its historical and cultural significance.

Challenges in Implementation: Retrofitting an original street network into an integrated design can be complex and may face resistance from residents who value the traditional layout.

Lack of Integration within the Street Network: As the integrated organic street networks are the result of different development processes during different eras, they present mostly different configurations, sociocultural infrastructure, and urban characteristics. These often result in a lack of neighborhood street network integration.

Imitated Organic Street Networks

Strengths:

Modern Design Features: Imitated organic networks often incorporate modern design principles and infrastructure, making them more conducive to contemporary walkability standards.

Balanced Approach: These networks attempt to mimic the adaptability and character of original organics while introducing elements that enhance walkability.

Addressing the Needs of Both Street Network Users: As the imitated organic street network has a designer, who is aware of both pedestrians and motorized users of the urban spaces, these networks consider enough spaces for both user groups.

Weaknesses:

Lack of Authenticity: Imitated organic networks may lack the historical and cultural authenticity of original networks, potentially leading to a less unique urban identity.

Risk of Overdesign: Striking the right balance between imitating organic elements and incorporating modern features can be challenging, leading to potential overdesign or a loss of functionality. On the other side, these networks may sometimes prioritize motorized users due to the higher prevalence of motorized transportation in modern societies.

Question 4. How do factors such as safety against motorized traffic, security against crime, accessibility, connectivity, climate comfort, quality of the built environment, and attractiveness vary across different types of organic street networks in Tehran?

Factors such as safety against motorized traffic, security against crime, accessibility, connectivity, climate comfort, quality of the built environment, and attractiveness can vary across different types of organic street networks in Tehran due to the unique characteristics and design principles associated with each type. Here is an overview of how these factors may vary:

Safety against Motorized Traffic

Original Organic Street Network: These networks tend to prioritize pedestrian due to their narrow and winding streets. The slower traffic speeds and limited access points contribute to safer conditions for pedestrians. But other issues may cause danger against safety; such as the limited view due to the shape of the streets and the short width of many streets to include pedestrian and motorized users.

Integrated Organic Street Network: Safety against motorized traffic can vary depending on the extent of integration with modern road systems. Areas with grid or tributary integration may have higher traffic volumes and potential safety concerns, while those with radial integration may have better-controlled traffic flow.

Imitated Organic Street Network: The imitated organic street network, designed with modern principles, often prioritizes safety against motorized traffic. Wider streets and well-defined traffic lanes can contribute to safer conditions for both pedestrians and motorists. However, the presence of high-rise buildings in some areas may increase traffic density and impact safety.

Security Against Crime

Original Organic Street Network: There are two different perspectives; For the residents, these networks often have a strong sense of community due to their historical significance. Close-knit neighborhoods can contribute to higher security levels as residents tend to look out for each other. But for the visitors, who are not familiar with the network, the blind corners, the limited view and the shape of the streets are the insecurity signs.

Integrated Organic Street Network: Security can vary depending on factors such as street lighting, visibility, and the presence of public spaces. Integrated networks with modern elements may incorporate better security features for residents and users, specifically women.

Imitated Organic Street Network: The imitated organic street network can benefit from modern monitoring services and security guards. The presence of modern, high-density residential towers may require additional security measures, such as surveillance systems. However, the layout of the streets in the inner parts of the network limits the presence of non-residents, which may increase the feeling of security for the core network's residents.

Accessibility

Original Organic Street Network: These networks are known for their accessibility to important cultural, religious, and historical sites. They provide convenient access to these destinations, enhancing the overall accessibility for residents and visitors. However, due to the principle of hierarchy of the streets, the accessibility to the semi-private and private spaces is limited.

Integrated Organic Street Network: Accessibility can vary depending on the extent of integration. Grid-based integration may improve accessibility to commercial areas, while radial integration may enhance access to transportation hubs. The tributary-organic street network, due to the higher number of cul-de-sacs has decreased accessibility within the network.

Imitated Organic Street Network: Imitated organic street networks are typically designed to provide easy accessibility to commercial areas, services, and amenities. The planned nature of these networks can result in well-connected and accessible urban environments.

Connectivity

Original Organic Street Network: These networks may have limited connectivity to major thoroughfares due to their historical origins. However, they excel in providing local connectivity within neighborhoods.

Integrated Organic Street Network: Connectivity varies based on the type of integration. Grid integration tends to provide better connectivity to the wider city grid, while radial integration may offer improved connectivity to key radial routes. Tributary integration with organic street networks limits the connectivity within the network, due to the higher number of cul-de-sacs.

Imitated Organic Street Network: Connectivity within imitated organic networks can be quite efficient due to their planned design. Streets are often designed to connect seamlessly, enhancing the flow of traffic and pedestrian movement.

Climate Comfort

Original Organic Street Network: These networks often feature natural shade, narrow streets, and greenery, which can provide climate comfort by offering relief from the hot climate.

Integrated Organic Street Network: Climate comfort can depend on the level of integration with modern road systems. Wider streets in integrated networks may have fewer natural cooling features.

Imitated Organic Street Network: The climate comfort in imitated organic street networks can vary depending on the extent to which they incorporate green spaces, shade, and sustainable urban design principles. But generally, the huge scale of the design limits the comfort of the greenery and the provided shade from them.

Quality of the Built Environment

Original Organic Street Network: These networks have a rich and historic built environment with traditional architecture, creating a unique sense of place. Quality can vary depending on preservation efforts.

Integrated Organic Street Network: Quality may vary based on the balance between modern and traditional elements. Efforts to maintain historical character and a balanced integration with modern elements can positively impact the built environment.

Imitated Organic Street Network: These networks aim to replicate the charm and aesthetics of traditional organic networks. The quality of the street walls is typically high, but the absence of historic and traditional elements portrays a newly constructed area devoid of any distinct identity. The lack of attention to detail, the absence of principles related to contrast and proportion, and the vast scale of urban spaces within this type of network collectively diminish the quality of the built environment.

Attractiveness

Original Organic Street Network: Original networks are often considered attractive due to their historical charm, cultural significance, and human-scaled design.

Integrated Organic Street Network: Attractiveness varies depending on how well modern elements are integrated into the network. Well-planned integration can enhance the overall aesthetic appeal. However, in general, many of the integrated organic street networks can preserve their organic structure due to the presence of natural elements within the network, which minimizes changes to the original layout. Consequently, they are primarily attractive based on their natural features.

Imitated Organic Street Network: Imitated organic street networks are often considered attractive due to the incorporation of greenery, wide promenades, and well-designed public spaces. However, the vast scale and the presence of blind street walls harm their aesthetics.

Question 5. Do gender perspectives influence perceptions of the walkability of organic street networks?

The research findings spotlight also the significant role of gender perspectives in shaping perceptions of walkability within organic street networks. The study highlights substantial disparities in how men and women perceive the importance of lighting and its impact on their sense of security in street spaces. Women, in particular, prioritize well-lit areas as a critical factor contributing to their sense of security.

Conversely, women exhibit a heightened appreciation for the quality and aesthetics of urban structures during their walking experiences. They tend to assign slightly higher ratings than men when evaluating elements such as greenery, water features, and the condition of street walls. This heightened attention to the physical environment reflects a deeper connection with the urban landscape and a preference for aesthetically pleasing, well-maintained surroundings.

Question 6. How can a scoring system be effectively developed to compare walkability evaluations among different neighborhoods, and what criteria and indicators should be considered in this system?

To effectively develop a scoring system for comparing walkability evaluations among different neighborhoods, it is crucial to consider specific criteria and indicators. Based on the research findings and methodology, the following criteria and indicators were considered in the scoring system.

<u>Criteria:</u>

- Safety: Street Width, Calming Traffic.

- Security Against Crime: Existing Semi-public Spaces, Level of Accessibility, Eyes on the Street, Lighting.

- Accessibility: Number of Nodes.

- Connectivity: Physical Connectivity, Visual Connectivity.

- Climate Comfort: Climate Protection and Topography, Orientation

- Quality of the Built Environment: Sense of Confinement, Permeability, Readability.

- Attractiveness: Nature, Contrasting Features.

<u>Scoring Methodology:</u>

- Defining Evaluation Criteria: Initially, specific evaluation criteria were defined based on the studied factors.

- Assigning Relative Weights: Relative weights were assigned to each criterion based on their importance in determining walkability. These weights were determined through expert opinions.

- Scoring Scale: A scoring scale was established for each criterion, consisting of five stages: poor (1), unsatisfactory (2), satisfactory (3), very satisfactory (4), and outstanding (5).

- Data Collection and Evaluation: The scoring system was applied to the data collected from various sources, including GIS analysis, expert interviews, and pedestrian questionnaires. Each criterion for each neighborhood was evaluated, and corresponding scores were assigned.

- Calculating Weighted Scores: To obtain the weighted scores for each neighborhood, the scores of each criterion were multiplied by their respective weights.

- Calculating Overall Walkability Score: The weighted scores for all criteria were then summed up to derive the overall walkability score for each neighborhood. The results of the rating system are illustrated in a table to show the walkability scores for different neighborhoods based on the evaluation criteria and indicators.

This scoring system allows for a comprehensive assessment of walkability in different neighborhoods, considering various factors that influence the pedestrian experience. It provides a standardized and objective method for comparing walkability across neighborhoods.

Question 7. What are the implications of the research findings for urban planning and design in other research areas, and how can they inform strategies to improve walkability in the city's organic street networks?

The study highlights the importance of recognizing the diversity of organic street networks within a city. Planners and designers should consider the unique characteristics and historical contexts of different neighborhoods when developing urban planning strategies.

Moreover, the research underscores the significance of gender perspectives in shaping perceptions of walkability. Urban planning and design should be gender-inclusive, considering the specific needs and preferences of both men and women.

The quality of the built environment significantly influences walkability and may differ from the local and visitor's point of view. Planners should consider factors like the sense of confinement, permeability, and readability of streets when designing urban spaces and decide if the residents of the neighborhood or the visitors or both should be considered as the main users of the site.

The presence of old greenery, water resources, and contrasting features enhance the attractiveness of streets, making them more inviting for pedestrians. Urban planners should incorporate these elements into their designs to create more appealing environments while respecting the nature, culture, and history of the neighborhood.

The use of scoring systems, as demonstrated in the research, can be an effective tool for evaluating and comparing walkability across different neighborhoods based on the street network's configuration.

In addition, involving the community in the planning and design process is crucial. Collecting input from residents, especially women, can lead to more inclusive and successful urban development projects.

Nevertheless, the study shows that different neighborhoods may require different strategies for improving walkability. Flexibility and adaptability in urban planning are essential to address the unique challenges and opportunities presented by organic street networks.

These insights emphasize the complex interplay between network configuration, physical characteristics, cultural context, and perceived security in determining walkability in organic street networks. Moreover, they underscore the importance of natural elements in organic street networks, particularly in Iran's climate, and highlight the role of community gathering spaces in enhancing both the social fabric and walkability of these neighborhoods.

Nevertheless, the research findings emphasize the need for holistic and context-specific approaches to urban planning and design. Understanding these dynamics can inform urban planning efforts in Tehran and other similar urban contexts to create walkable environments while respecting local culture and heritage.

5.2. Comparative Analysis with Prior Research

The study's findings shed light on the configuration of street networks and their relationship with walkability, offering valuable insights that contribute to the existing body of research. While there are relatively few studies that have delved into this intersection of street network design and walkability, this research builds upon and enhances the understanding of key factors influencing pedestrian behavior and perceptions.

The findings of the research regarding the semi-public/ semi-private spaces have unveiled a significant transformation in the role of these spaces, signaling a departure from their once-exclusive use by the local community towards a more inclusive utilization by diverse user groups. This observed shift is consistent with the findings of previous research conducted by Hedayati Marzbali and associates (2017) as well as Montgomery (2013). Their studies underscore the notion that the evolution of community-oriented spaces away from their original purposes can contribute to heightened feelings of insecurity among the local populace. Additionally, this transformation carries the potential risk of indigenous residents seeking residence in alternative neighborhoods, while non-local individuals relocate to the area, potentially further influencing the community's perception of safety (Hedayati Marzbali et al., 2017; Montgomery, 2013).

One of the standout findings of this research is the paramount importance of security and the feeling of being secure, irrespective of the type of street network. This aligns with prior studies that have emphasized the significance of perceived security against crime as a critical perceptual quality of the built environment that positively influences walking behavior (Koohsari et al., 2012). The study underscores that neighborhoods with commercial and economic importance or affluent areas may place even greater emphasis on security due to factors like the influx of non-local individuals and a potentially higher risk of theft.

Interestingly, the study reveals that safety against vehicular traffic ranks relatively lower in importance for people when deciding to walk in organic street networks in Tehran. However, this finding contrasts with research conducted in Melbourne, where safety from traffic was associated with increased walking (Koohsari et al., 2012). This discrepancy suggests that the influence of traffic safety on walking behavior may vary across different contexts or populations, highlighting the need for context-specific urban planning interventions.

Another noteworthy discovery from this research pertains to gender-based differences in perceptions of walkability, particularly concerning lighting and the sense of security in street spaces. These findings align with previous studies by Valentine (1990), Loukaitou-Sideris (2005), and Phadke (2007), which have consistently demonstrated that women generally require more lighting in urban spaces to feel secure compared to men.

Furthermore, the study emphasizes the importance of semi-public/semi-private urban spaces within street networks for enhancing the sense of security. This aligns with the findings of Jamei et al. (2021) and underscores the significance of recognizing the variations among different study areas, shaped by societal, cultural, and religious beliefs and norms. In contrast to some earlier studies that highlighted the insecurity of organic urban spaces due to their unreadability and limited access for non-locals, this research suggests that, in the Iranian context, organic street networks are considered readable by locals due to the presence of landmarks and meaningful elements. The limited access for non-locals to semi-public/semi-private spaces is perceived not as a weakness but rather as a strength of the street network, as it enhances the sense of security.

Lastly, this research expands upon the typology of organic street networks by identifying more sub-categories than those previously discussed by Azizi and Azari (2020). This underscores the diversity of organic street network configurations, particularly in Tehran, where certain areas retain original organic structures due to their proximity to the natural features of the land.

5.3. Highlighting the Novelty and Uniqueness of This Study

This study exhibits several aspects of novelty that distinguish it from existing research in the field;

Focus on Organic Street Networks: The study primarily focuses on organic street networks, a topic that has received relatively limited attention in the realm of urban planning and walkability research. Delving into the nuances of these street networks contributes unique insights into an area that has been less explored. On the other side, few researchers considered the configuration of the street networks in their walkability evaluation.

Gender Perspective: The research systematically incorporates a gender perspective into the evaluation of walkability. This adds another dimension to the study, as it uncovers disparities between men and women in terms of their perceptions of walkability, particularly regarding the importance of lighting, aesthetics, and the quality of the built environment. Considering that the lighting standards met the expectations of male users but were deemed insufficient by female users, it is essential to take into account both female and male users of the site when establishing the standards for urban facilities.

Adaptability to Different Contexts: The study recognizes the potential adaptability and relevance of its findings to various geographical, cultural, sociopolitical, and economic contexts. This adaptability is a unique feature, as it highlights the transferability of the research to regions with similar climatic conditions, traditional urban planning principles, sociocultural factors, and even those facing different urban challenges.

The walkability scoring system based on the configuration of the street networks can be adapted in other research. The list of factors, elements, and indicators can be used as the checklist for the evaluation of walkability if the configuration of the street network matters. The elements can be localized based on the climate and sociocultural aspects of the neighborhood users and the indicators should adapt to the law and transportation rules of the study area. Such systems can provide valuable data for urban planners and policymakers to prioritize areas for improvement based on the budget and time of the project.

Expanded Typology: Through the expansion of the typology of organic street networks and the identification of additional sub-categories, the research recognizes the diversity and intricacy inherent in these networks. This refined classification system strengthens the study's contribution to the comprehension of street network configurations and can be applied to other research endeavors related to organic street networks. This typology provides adaptability and can be further customized to suit the unique characteristics of various areas under investigation.

Introducing Imitated Organic Street Network: This research explored a planner-designed street network inspired by the principles of organic street networks. It represents the third category of organic street networks and was included to compare the impacts of street network configuration in both self-developed and planner-designed street networks with similar shapes. The findings of this study underscore the importance of re-evaluating the principles of traditional Iranian urban design for this type of street network, as it demonstrates a lower level of walkability based on its configuration.

In conclusion, the principles, typologies, and insights of this research have the potential to transcend geographical, cultural, and sociopolitical boundaries. However, it is crucial to consider localized adaptation and contextualization when applying these findings to ensure that they align seamlessly with the unique characteristics of each region or city. This research serves as a bridge connecting traditional urban principles with contemporary urban challenges.

5.4. Applying Research in Practical Scenarios

The following guidance offered by the study of organic street networks is to be considered for its practical application in real-world scenarios. To bridge the gap between theoretical research and actionable outcomes, attention should be given to how these research findings can be effectively implemented in urban planning, development, and daily life. Here are some key considerations for the application of research in practical scenarios:

Preservation and Adaptive Reuse

- Preservation and safeguarding of original organic street networks imbued with historical, cultural, and sociocultural significance.

- Encouragement of adaptive reuse and revitalization of historic structures within organic networks, with a focus on preserving their architectural authenticity.

Integration and Collaboration

- In integrated organic street networks, the pursuit of a harmonious equilibrium between preserving traditional elements and introducing modern infrastructure, with a commitment to respecting the neighborhood's historical character.

- Formation of close collaborations with local communities to solicit their input and gain approval for integration projects, fostering a sense of ownership and pride.

Safety and Accessibility

- Implementation of measures aimed at enhancing the safety of pedestrians and motorized users, including optimizing street design to accommodate various user types without compromising safety.

- Investment in well-lit and secure public spaces, especially during the evening and nighttime hours, to encourage residents' participation in community activities. This can be achieved through investment in improved sociocultural infrastructure, such as local meeting points and enhanced lighting.

Inclusivity and Community Engagement

- Recognition of the distinct needs and preferences of different genders when designing urban spaces.

- Engagement with local communities to collect insights and feedback on urban design projects, ensuring their perspectives are valued.

Environmental Integration

- Integration of natural features like greenery, trees, and water elements into urban design whenever possible, enhancing the aesthetic appeal and comfort of public spaces while contributing to environmental sustainability.

- Establishment of green gathering spaces within organic networks to serve as communal focal points, fostering interaction and a sense of belonging.

Community Involvement and Holistic Planning

- Encouragement of community participation in urban planning and development processes through public meetings, workshops, and consultations to gather input and insights from residents.

- Facilitation of initiatives empowering neighborhoods to play an active role in maintaining and improving their organic street networks.

- Adoption of a holistic approach to urban planning, considering not only the physical layout of streets but also their social and cultural significance. Recognizing that walkability encompasses more than just infrastructure; it is also about creating a sense of place and community.

Expert Collaboration and Evaluation

- Collaboration with experts in urban design, anthropology, sociology, and architecture to gain a comprehensive understanding of the neighborhood's dynamics.

- Establishment of monitoring and evaluation mechanisms to track the impact of urban planning interventions on walkability and community well-being.

Adaptability and Responsiveness

- Readiness to adjust strategies as needed based on feedback and changing community needs, ensuring that the urban environment remains responsive to evolving demands.

By embracing these guidelines, vibrant, inclusive, and walkable organic street networks can be collaboratively crafted by urban planners, policymakers, and community stakeholders, catering to the needs of both present and future generations. This forward-looking approach ensures that the city not only values its rich heritage but also embraces innovation and progress.

5.5. Identifying Limitations and Research Gaps for Further Exploration

While addressing the limitations of this study, it is important to recognize that an organic street network, like any street network configuration, cannot be considered in isolation from its socio-cultural and economic aspects. Despite the efforts to minimize their influence, it is crucial to acknowledge the inherent interconnectedness among these factors, which has inevitably impacted the analysis results to some extent.

To provide a more comprehensive understanding of pedestrian behaviors, it would be beneficial to incorporate field research methodologies such as gathering GPS information and conducting pedestrian route analysis. These approaches can help minimize the potential for subjective interpretations from both users and researchers.

Identifying research gaps is essential not only to acknowledge limitations but also to pave the way for future research endeavors. These considerations and potential research avenues contribute to a deeper understanding of this complex subject. In the following, some ideas for conducting further research in this field have been mentioned.

Long-Term Impact of Urban Development

While this study has shed light on the importance of organic street networks and their role in walkability, further research could explore the long-term impact of various urban development strategies on these networks. This could involve studying neighborhoods that have undergone significant changes such as changing the general height of the street walls, cutting the old trees, reconstruction of an old ruined structure, etc. in their street configurations over several decades to assess how these changes have affected walkability and community life.

Gender and Walkability

This research has touched upon gender-related differences in perceptions of walkability. Future studies could delve deeper into this aspect, examining how gender influences not only perceptions but also actual patterns of pedestrian behavior within organic street networks. Such research could inform gender-sensitive urban planning strategies.

Comparative Analysis of Organic Street Networks

Conducting a comparative analysis of organic street networks in different cultural, climatic, and geographical contexts could offer valuable insights. This could involve studying networks in countries with similar organic layouts to Iran, as well as those with different urban planning traditions. Understanding the commonalities and differences could lead to more universally applicable urban design principles.

Comparing the Results of Analysis Based on Virtual Reality Tools Versus Real-World Observations

Organic street networks undergo a gradual and time-consuming process of adaptation to evolving societal needs and changing urban dynamics, which can be inherently dynamic and continually evolving. In this context, virtual reality tools can serve as valuable aids in comprehending the transformations within organic street networks and forecasting their future design and behavior. This predictive capability can contribute to the more efficient and effective design of imitated organic street networks, eliminating the necessity for extended waiting periods required for the self-adaptation of organic street networks.

Technological Advancements and Walkability

Investigate the role of emerging technologies, such as smart city infrastructure and transportation innovations, in enhancing walkability within organic street networks; For example, how technologies such as real-time navigation apps, electric scooters, and autonomous vehicles are impacting pedestrian experiences.

Environmental Sustainability

Organic street networks often lend themselves to sustainable urban design. Future research could explore the environmental benefits of these networks, such as reduced car dependence, improved air quality, or lower carbon emissions. Quantifying these benefits may provide evidence for the environmental case for organic layouts.

Pedestrian with Disabilities Infrastructure and Accessibility

This study shows that there are difficulties regarding the accessibility and movement for individuals with disabilities. Analyzing the existing infrastructure and identifying areas where improvements are needed and how they can be implemented may be another issue to study.

Identifying these research gaps and pursuing further exploration in these areas can contribute to a richer body of knowledge on organic street networks. These avenues of research can also offer practical insights for policymakers and urban planners as they strive to create more livable, sustainable, and walkable cities.

In conclusion, the diverse organic street networks found in different neighborhoods of Tehran exhibit unique characteristics that shape the pedestrian experience. While each network type presents its strengths and challenges, there is a common need to enhance walkability to meet the demands of a modern street network. Integrating traditional elements with modern requirements makes it possible to create walkable environments that cater to the community's diverse needs. Addressing safety, accessibility, connectivity, security, and comfort will contribute to creating cohesive and enjoyable urban environments. The study's findings emphasize the importance of considering cultural and societal norms when defining and assessing walkability in Iranian streets, considering the rich history, cultural beliefs, and natural features that shape these organic street networks. Incorporating design elements that align with the local culture enhances the livability and acceptance of walkable streets.

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7. Appendixe

7.1. Appendix A. Syntax codes for interviews (software R 4.2.2):

```
library(lsr)

# lighting
positive1<-c(0,0,1,0,1,2)
negative1<-c(2,1,0,2,0,0)
aspekt1<-cbind(positive1, negative1)
fisher.test(aspekt1)

# nature
  positive2<-c(7,0,5,1,16,3)
  negative2<-c(0,3,0,1,0,0)
  aspekt2<-cbind(positive2, negative2)
  fisher.test(aspekt2)
  aspekt2

# street wall
positive3<-c(3,0,0,1,0,0)
negative3<-c(2,5,0,6,0,3)
aspekt3<-cbind(positive3, negative3)
fisher.test(aspekt3)

# side walk
positive3<-c(0,0,0,0,1,3)
negative3<-c(3,0,1,0,1,0)
```

```
aspekt3<-cbind(positive3, negative3)
fisher.test(aspekt3)
aspekt3


# Building Style
positive4<-c(5,7,1,2,6,2)
negative4<-c(1,6,4,6,0,4)
aspekt4<-cbind(positive4, negative4)
fisher.test(aspekt4)
aspekt4

# beautifuland attractive
positive5<-c(7,7,4,4,6,0)
negative5<-c(2,1,0,5,0,4)
aspekt5<-cbind(positive5, negative5)
fisher.test(aspekt5)
aspekt5


# eyes on the street
positive6<-c(1,0,0,1,1,0)
negative6<-c(0,1,0,0,0,1)
aspekt6<-cbind(positive6, negative6)
fisher.test(aspekt6)

# safety feeling
positive7<-c(1,0,0,2,2,2)
negative7<-c(5,4,2,3,2,3)
aspekt7<-cbind(positive7, negative7)
fisher.test(aspekt7)

# historic with identity
```

```
positive8<-c(6,8,2,2,0,0)
negative8<-c(0,0,3,1,3,3)
aspekt8<-cbind(positive8, negative8)
fisher.test(aspekt8)
aspekt8

# welcoming
positive9<-c(2,0,0,0,1,0)
negative9<-c(1,1,0,1,0,0)
aspekt9<-cbind(positive9, negative9)
fisher.test(aspekt9)

# sloping
positive10<-c(3,0,3,0,0,1)
negative10<-c(2,0,2,0,0,0)
aspekt10<-cbind(positive10, negative10)
fisher.test(aspekt10)

# shadow
positive11<-c(1,0,0,0,0,0)
negative11<-c(0,0,0,1,0,0)
aspekt11<-cbind(positive11, negative11)
fisher.test(aspekt11)


# scale
positive12<-c(2,2,0,1,0,0)
negative12<-c(0,0,0,2,1,0)
aspekt12<-cbind(positive12, negative12)
fisher.test(aspekt12)

# feeling of discovery
positive13<-c(1,1,0,0,1,0)
```

```
negative13<-c(0,0,0,0,0,0)
aspekt13<-cbind(positive13, negative13)
fisher.test(aspekt13)

# hierarchy of streets
positive14<-c(1,1,1,0,0,1)
negative14<-c(0,0,0,0,0,0)
aspekt14<-cbind(positive14, negative14)
fisher.test(aspekt14)

# skylineand view
positive15<-c(1,1,0,0,0,1)
negative15<-c(0,2,0,1,0,0)
aspekt15<-cbind(positive14, negative15)
fisher.test(aspekt15)

# Feeling of security
positive16<-c(0,5,2,1,1,0)
negative16<-c(0,1,0,2,2,1)
aspekt16<-cbind(positive16, negative16)
fisher.test(aspekt16)

# Pedestrain oriented
positive17<-c(1,3,2,4,3,3)
negative17<-c(0,0,0,2,1,4)
aspekt17<-cbind(positive17, negative17)
fisher.test(aspekt17)

# Readability
positive18<-c(0,0,2,1,1,1)
negative18<-c(0,2,0,0,2,1)
aspekt18<-cbind(positive18, negative18)
fisher.test(aspekt18)
```

```
# Comfort
positive19<-c(0,1,1,0,1,0)
negative19<-c(0,0,0,2,2,1)
aspekt19<-cbind(positive19, negative19)
fisher.test(aspekt19)

positive<- positive1+positive2+positive3+positive4+
  positive5+positive6+positive7+positive8+
  positive9+positive10+positive11+positive12
  positive13+positive14+positive15+positive16+
  positive17+positive18+positive19



  negative<- negative1+negative2+negative3+negative4+
    negative5+negative6+negative7+negative8+
    negative9+negative10+negative11+negative12
  negative13+negative14+negative15+negative16+
    negative17+negative18+negative19

bewertung<-cbind(positive, negative)
rownames(bewertung)<-c("Chizar", "Sanglaj","Qeytariyeh", "Dr. Hooshyar"
                       ,"Darrous", "Shahrak-e Qarb")

bewertung

chisq.test(bewertung)
cramersV((bewertung))
```

7.2. Appendix B. Questionnaire Form

Questionnaire for doctoral thesis

Information about the project

With regards, the above questionnaire has been prepared in line with Niku Khaleghi's doctoral dissertation in urban design, entitled "Evaluation of the Walkability within Organic Street Networks". In this context, six neighborhoods in Tehran, including Chizer, Sanglaj, Qeytariyeh, Darous, Dr. Hooshyar and Shahrak-e Qarb, have been selected as case studies for this research. Considering the political conditions of the country and travel restrictions to Iran, it was decided to distribute the questionnaire among the residents of these areas. If you have a short time for it, you will help my work process a lot.

Thank you for your timeand cooperation in advance.

Participant's gender: 1. Woman 2. Man

Participant's age: 1. Less than 20 years 2. 21 to 35 years 3. 36 to 45 years

4. 46 to 60 years 5. More than 61 years

Does your family own a private motor vehicle? 1. Yes 2. No

Does your neighborhood have proper lighting in main streets especially at night? 1. Yes 2. No

Does your neighborhood have proper lighting in secondary streets, especially at night? 1. Yes 2. No

On average, how many times a week do you go walking or walk to your destination? (number of times) ………………

On average, how many hours a day are you a pedestrian in this neighborhood? (in hours) ……………..………..

To what extent do urban elements protect you from weather conditions?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent do the features of the street provide comfort (ex. Shadow)?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent do the street trees provide comfort for walking?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent is the topography of the streets comforatble for walking?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent is the geometry of the street and its form effective in increasing your willingness to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent is the level of security against crims in the street space effective in increasing your willingness to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent is the level of security against traffic in the street space effective in increasing your willingness to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent is the connectivity and integrity of the walking path effective in increasing your willingness to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

How effective is the attractiveness and beauty of the path in increasing your desire to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent is the level of comfort and climatic comfort in the street space effective in increasing your willingness to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

How effective is proper street lighting in increasing your willingness to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent the possibility of being seen from the buildings around the street effective in increasing your willingness to walk and feeling safe in you?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To what extent do you feel confined as a pedestrian in this neighborhood?

1. Very low 2. Low 3. Middle 4. High 5. Very high

Are the presence of high-rise buildings effective in increasing your desire to walk?

1. Very low 2. Low 3. Middle 4. High 5. Very high

How do you evaluate the relations between neighbors in your neighborhood?

1. Very low 2. Low 3. Middle 4. High 5. Very high

To reach a destination of this neighborhood, do you have only one alternative route in mind or do you try different routes?

1. **I have only one alternative path and I always follow the same one.**
2. **There are other paths, but I always follow only one path.**
3. **There are more routes and I sometimes try new routes.**

□ As the respondent of this questionnaire, I declare my consent to use the information given in the mentioned thesis and the resulting articles anonymously.

7.3. Appendix C. Syntax codes for questionnaires (SPSS Statistics 29.0):

```
* Encoding: UTF-8.

set  locale="en_US.windows-1252".

FILTER OFF.
USE ALL.
EXECUTE.




*****************************************************************************************************************************
** Vorbereitung
*****************************************************************************************************************************



if v_4=  '2' v_4r=1.
if v_4= '2 to 3 times' v_4r=2.
if v_4=  '3'    v_4r=3.
if v_4= '3 to 4 times' v_4r=4.
if v_4= '5' v_4r=5.
if v_4= 'more than 5 times' v_4r=6.
if v_4= 'more than 10 times' v_4r=7.
Execute.

Value Labels v_4r
1 '2'
2 '2 to 3 times'
3 '3'
4 '3 to 4 times'
```

```
5 '5'
6 'more than 5 times'
7 'more than 10 times'.



IF v_5="less than 30 minutes" v_5r=1.
IF v_5="30 minutes" v_5r=2.
IF v_5="1" v_5r=3.
IF v_5="1and half hours" v_5r=4.
IF v_5="1 to 2 hours a day" v_5r=5.
IF v_5="2" v_5r=6.
IF v_5="2 hours" v_5r=6.
IF v_5="2 to 3 hours a day" v_5r=7.
Execute.

Value Labels v_5r
1 'less than 30 minutes '
2 '30 minutes'
3 '1 hour'
4 '1and half hours'
5 '1 to 2 hours a day'
6 '2 hours'
7 '2 to 3 hours a day'.


*************************************************************************************************************************
** Deskription
*************************************************************************************************************************



* Benutzerdefinierte Tabellen.
CTABLES
  /VLABELS VARIABLES=Viertel Gender Age v_1 v_2 v_3 v_4r v_5r
```

```
    DISPLAY=LABEL
  /TABLE Viertel [COUNT F40.0, COLPCT.COUNT PCT40.1] + Gender [COUNT F40.0, COLPCT.COUNT
PCT40.1] +
    Age [COUNT F40.0, COLPCT.COUNT PCT40.1] + v_1 [COUNT F40.0, COLPCT.COUNT PCT40.1] +
v_2 [COUNT
    F40.0, COLPCT.COUNT PCT40.1] + v_3 [COUNT F40.0, COLPCT.COUNT PCT40.1] + v_4r [COUNT
F40.0,
    COLPCT.COUNT PCT40.1] + v_5r [COUNT F40.0, COLPCT.COUNT PCT40.1]
  /CATEGORIES VARIABLES=Viertel Gender Age v_1 v_2 v_3 v_4r v_5r ORDER=A KEY=VALUE
EMPTY=INCLUDE
  /CRITERIA CILEVEL=95.


CROSSTABS
  /TABLES=Gender BY Age
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ  PHI
  /CELLS=COUNT ROW
  /Barchart
  /COUNT ROUND CELL.

CROSSTABS
  /TABLES=Viertel BY v_1 v_2 v_3 v_4r v_5r v_26
  /FORMAT=AVALUE TABLES
  /STATISTICS=CHISQ  PHI
  /CELLS=COUNT ROW
    /Barchart
  /COUNT ROUND CELL.


GRAPH
  /BAR(SIMPLE)=MEAN(v_6) MEAN(v_7) MEAN(v_8) MEAN(v_9) MEAN(v_10) MEAN(v_11) MEAN(v_12)
MEAN(v_13)
    MEAN(v_14)  MEAN(v_15)  MEAN(v_16)  MEAN(v_17)  MEAN(v_18)  MEAN(v_19)  MEAN(v_20)
MEAN(v_21) MEAN(v_22)
    MEAN(v_23) MEAN(v_24) MEAN(v_25)
  /MISSING=LISTWISE.
```

```
GRAPH

  /BAR(SIMPLE)=MEAN(v_6) MEAN(v_7) MEAN(v_8) MEAN(v_9) MEAN(v_10) MEAN(v_11) MEAN(v_12)
MEAN(v_13)

    MEAN(v_14)  MEAN(v_15)  MEAN(v_16)  MEAN(v_17)  MEAN(v_18)  MEAN(v_19)  MEAN(v_20)
MEAN(v_21) MEAN(v_22)

    MEAN(v_23) MEAN(v_24) MEAN(v_25)  BY Viertel

  /MISSING=LISTWISE.
```

```
MEANS TABLES=v_8

v_9

v_10

v_11

v_12

v_13

v_14

v_15

v_16 BY Viertel

  /CELLS=Count MEAN STDDEV MIN Median MAX RANGE.
```

```
MEANS TABLES=

v_17

v_18

v_19

v_20

v_21

v_22

v_23

v_24

v_25 BY Viertel

  /CELLS=Count MEAN STDDEV MIN Median MAX RANGE.
```

```
************************************************************************************************************************
** Untersuchung zu den ordinalen Variablen
************************************************************************************************************************

** Viertel

NPAR TESTS
  /K-W=v_6
v_7
v_8
v_9
v_10
v_11
v_12
v_13
v_14
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
v_24
v_25 BY Viertel(1 20)
  /MISSING ANALYSIS.

NPTESTS
```

```
  /INDEPENDENT TEST (v_6
v_7
v_8
v_9
v_10
v_11
v_12
v_13
v_14
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
v_24
v_25) GROUP (Viertel) KRUSKAL_WALLIS(COMPARE=PAIRWISE)
  /MISSING SCOPE=ANALYSIS USERMISSING=EXCLUDE
  /CRITERIA ALPHA=0.05  CILEVEL=95.


** Geschlecht


NPAR TESTS
  /M-W= v_6
v_7
v_8
v_9
v_10
v_11
v_12
v_13
```

```
v_14
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
v_24
v_25 BY Gender(1 2)
  /MISSING ANALYSIS.

** Alter

NONPAR CORR
  /VARIABLES= v_6
v_7
v_8
v_9
v_10
v_11
v_12
v_13
v_14
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
```

```
v_24
v_25 with  Age
  /PRINT=SPEARMAN TWOTAIL NOSIG
  /MISSING=PAIRWISE.

** Private Vehilcle

NPAR TESTS
  /M-W= v_6
v_7
v_8
v_9
v_10
v_11
v_12
v_13
v_14
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
v_24
v_25 BY v_1(1 2)
  /MISSING ANALYSIS.


** Lighting main street

NPAR TESTS
  /M-W= v_6
```

```
v_7
v_8
v_9
v_10
v_11
v_12
v_13
v_14
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
v_24
v_25 BY v_2(1 2)
  /MISSING ANALYSIS.



** Lighting secondary street

NPAR TESTS
  /M-W= v_6
v_7
v_8
v_9
v_10
v_11
v_12
v_13
v_14
```

```
v_15
v_16
v_17
v_18
v_19
v_20
v_21
v_22
v_23
v_24
v_25 BY v_3(1 2)
  /MISSING ANALYSIS.

File Label Daten.

OUTPUT MODIFY
  /REPORT PRINTREPORT=NO
  /SELECT  NOTES
  /DELETEOBJECT DELETE=YES
  /OBJECTPROPERTIES   VISIBLE=YES.
```

7.4. Appendix D. Interviews Coding Results

The ensuing table showcases the interview results, categorizing them by neighborhoods and respective interviewees.

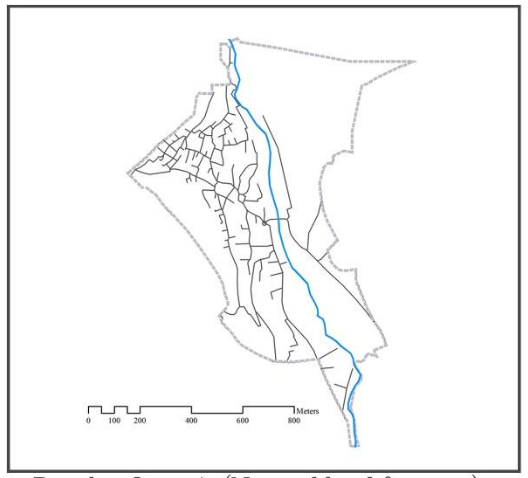
Table 7.1. The extracted codes from interviews and their frequencies

	Chizar	Sanglaj	Qeytariyeh	Dr. hooshyar	Darrous	Shahrak-e Qarb
Expert 1	Not suitable for walking in the evening and nights, greenery, lack of lighting, attractive street walls, warm-colored street walls, no sidewalks, a mixture of modernity and tradition, beautiful, pleasant cul-de-sacs, eyes on the street, trees, lack of safety feeling, historical elements, with identity, narrow streets, welcoming, urban gardens, vehicle-oriented.	Lack of greenery, insecurity feeling, narrow streets, attractive because of historical and unique urban elements, inviting to discovery, unsafe, worn-town fabric, not walkable, lack of color, dirty street wall sand flooring, unsecured cul-de-sacs, roofed streets are attractive, identity, memorable and nostalgic.	Green, vehicle-oriented, sloping, proper lighting, steps, not walkable, narrow sidewalks, many high-rise buildings, traffic, proper width of the streets.	Insecurity feeling, traces of organic structure, not suitable for children, lack of valuable urban structures, narrow streets, low density, vehicle-oriented, lack of visual quality, not inviting, not attractive, lack of lighting, not human-scaled, no tranquility, spatial irregularity, lack of proportion among vertical and horizontal lines, high height, irregular height.	Water, new building, tree cutting, memorial elements, trees, green, narrow sidewalks, good structure, parking one-side, good lighting, smell, sound, attractive, Kuche-baq, insecurity feeling, discovery, urban opening, eyes on the street, high traffic, safety.	Not attractive, no identity, very wide streets, suitable sidewalks, green, not readable, irregularity in buildings heights, proper cul-de-sacs, vehicle-oriented, suitable for walking, not pleasant. Good lighting, proper sloping.
Expert 2	Urban gardens, spatial disturbance, sloping, tangible organic structure, with identity, pleasant slope, welcoming, indecisive neighborhood, not modern and not traditional, feeling of discovery, a mixture of modernity and tradition, attractive, appropriate street walls, because of the slope, many streets are not suitable to pause,	Ruined street views and walls, insecurity, not walkable, with identity, blind corners and edges, not inviting, Excessive wear and tear, narrow streets, not readable cul-de-sacs, historical elements, neighbors community.	Local haunts, liveable, pleasant sloping, feeling of neighborhood with neighbor community, traces of grid, with identity, traces of history, fairly readable, green, the old parts are more readable, trees, urban elements.	Friendly, cozy, warm-colored street walls, various materials, human-scaled, sense of security, readable, identical, trees, local haunts, walkable, space for children, eyes on the street, structural problems of street walls, the unbalanced	High-social class neighborhood, walkable, suitable width of streets, green, sense of beauty and calmness, sense of security, less feeling of identity, readable for citizens and hard to read for visitors, water, modern, tranquility,	It is not a neighborhood, just a passing place, without social function. Hierarchy of streets, calm, but lack of sense of security, no eyes on the street, very big, many parking spaces in the streets, not suitable for all the users.

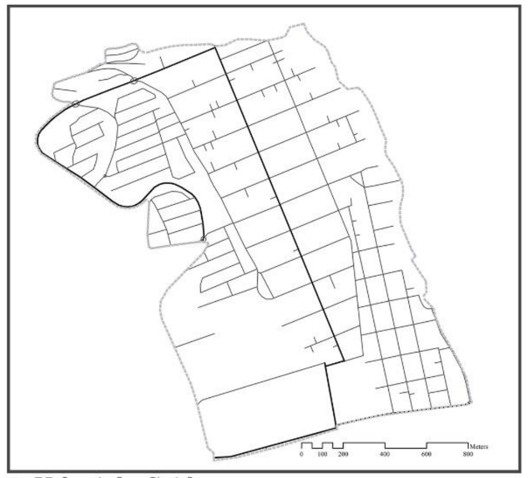
	play, trade or meet. Local haunts.			height of the street walls.	water, traces of grid.	
Expert 3	greenery, hierarchy of streets, blind street walls, contrasting due to the topography, lack of proper sidewalks, skyline, different heights of street walls.	Dirty flooring and street walls, unsafe urban structures like wooden roofs, unique views, jagged edges, historical, attractive, unsuitable new constructions, variety, contrasting, discovering, hierarchy of spaces and streets, crowded main streets, cozy secondary streets, worn-town fabric.	Trees, proper streets, walkable, hierarchy of streets, attractive, steps and sloping, positive topography, contrasting, sense of touch.	Labor accommodation style, traffic, lack of greenery, many corners, cozy, haunts, improper view, lack of landmarks, jagged edges, feeling of uncompleted street plan, mass volume, dirty street walls, uncomfortable, no shadow, unfamiliar, no identity, feeling of insecurity.	Water, sound, greenery, wide streets, urban gardens, attractive, bridges and connections, proper sidewalks, less mass volume, walkable.	Hierarchy of streets, clear sidewalks, readable urban design, low mass density, wide streets, blink street walls, urban opening but no function (passive), good urban view, green, good connections, many empty spaces, not attractive, walkable but vehicle-oriented, uncomfortable, feeling of unsafety in main streets.
Expert 4	Small scale, unplanned, traditional.	An old structure, different scales, historic.	Modern, no traces of history, no historical elements, no identity, faceless structures, expanded.	Chaotic, straight landmarks, modern fabric, attractive.	Organized, not historic, no identity.	Completely new urban area (like suburban), wide spaces, green, out-of-city spaces, new structures, no identity, organized.
Expert 5	Unorganized street spaces, motorized problems, attractive scale of the buildings, unattractive narrow streets, not inviting, closed street walls, no sidewalks, green, shadow, parked cars, attractive and comfortable due to the water, door spaces, old buildings, steps attractive, unsafety feeling, speed of the traffic.	Blind street walls, unreadable, unattractive street walls, limited greenery, drainage, climate comfort, feeling of unsafety, attractive scale, no view, improper lighting, attractive urban structures, feeling of	-	Very narrow and feeling of safety due to the slow speed, attractive secondary streets, blind street walls, no interaction and social control, no eyes on the street, safe cul-de-sacs, lack of lighting, unattractive scale of the buildings.	Green, narrow streets, no pedestrian spaces, parked cars, narrow streets, trees, attractive aspects of nature, water canal, welcoming, unreadable, insecurity feeling, open spaces, attractive scale of the buildings.	Wide streets, high traffic, safe, blind street walls, proper sidewalks, classic division of the spaces, good lighting, not attractive, but safe and walkable.

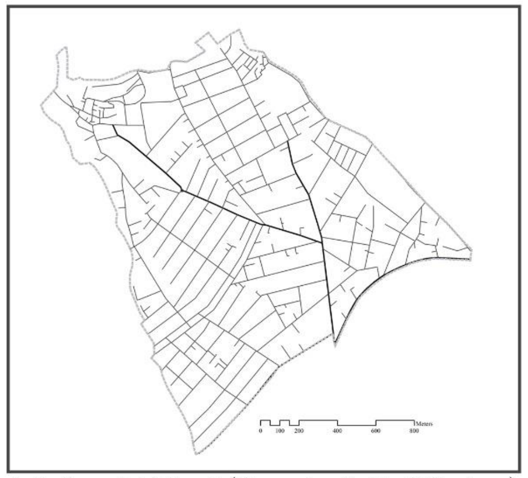
		insecurity, pedestrian-oriented plan.				
Frequency of the Keywords	lighting (-2); nature (+7); street wall (+3,-2); sidewalk (-3); Building style (+5,-1); beautiful and attractive (+7,-2); eyes on the street (+1); safety feeling (-5, +1); historic with identity (+6); narrow streets (-2); welcoming (+2,-1); sloping (+3,-2); shadow (+1); scale (+2); feeling of discovery (+1); hierarchy of streets (+1); skyline and view (+1); Feeling of security; Pedestrian-oriented (+1); readability; Comfort.	lighting (-1); nature (-3); street wall (-5); sidewalk; Building style (+7,-6); beautiful and attractive (+7,-1); eyes on the street (-1); safety feeling (-4); historic with identity (+8); narrow streets (-2); welcoming (-1); sloping; shadow; scale (+2); feeling of discovery (+1); hierarchy of streets (+1); skyline and view (+1,-2); Feeling of security (+5,-1); Pedestrian-oriented (+3); readability (-2); Comfort (+1).	lighting (+1); nature (+5); street wall; sidewalk (-1); Building style (+1,-4); beautiful and attractive (+4); eyes on the street; safety feeling (-2); historic with identity (+2,-3); narrow streets (+1); welcoming; sloping (+3,-2); shadow; scale; feeling of discovery; hierarchy of streets (+1); skyline and view; Feeling of security (+2); Pedestrian-oriented (+2); readability (+2); Comfort (+1).	lighting (-2); nature (+1,-1); street wall (+1,-6); sidewalk; Building style (+2,-6); beautiful and attractive (+4,-5); eyes on the street (+1); safety feeling (-3, +2); historic with identity (+2,-1); narrow streets (-2); welcoming (-1); sloping; shadow (-1); scale (+1,-2); feeling of discovery; hierarchy of streets; skyline and view (-1); Feeling of security (+1,-2); Pedestrian-oriented (+4,-2); readability (+1); Comfort (-2).	lighting (+1); nature (+16); street wall; sidewalk (+1,-1); Building style (+6); beautiful and attractive (+6); eyes on the street (+1); safety feeling (+2, -2); historic with identity (-3); narrow streets (+2,-3); welcoming (+1); sloping; shadow; scale (+1); feeling of discovery (+1); hierarchy of streets; skyline and view; Feeling of security (+1,-2); Pedestrian-oriented (+3,-1); readability (+1,-2); Comfort.	lighting (+2); nature (+3); street wall (-3); sidewalk (+3); Building style (+2,-4); beautiful and attractive (-4); eyes on the street (-1); safety feeling (+2,-3); historic with identity (-3); wide streets (+1,-3); welcoming; sloping (+1); shadow; scale; feeling of discovery; hierarchy of streets (+1); skyline and view (+1); Feeling of security (-1); Pedestrian-oriented (+3,-4); readability (+1,-1); Comfort (-1).

7.5. Appendix E. List of Tehran's street networks based on the neighborhoods

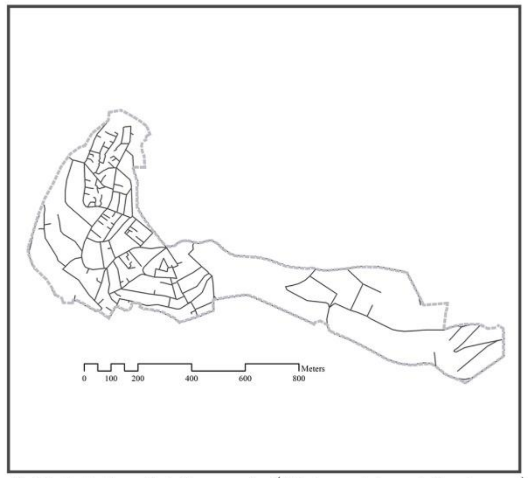

1. Darake: Organic (Natural land features)


2. Ewin: Organic (Natural land features)

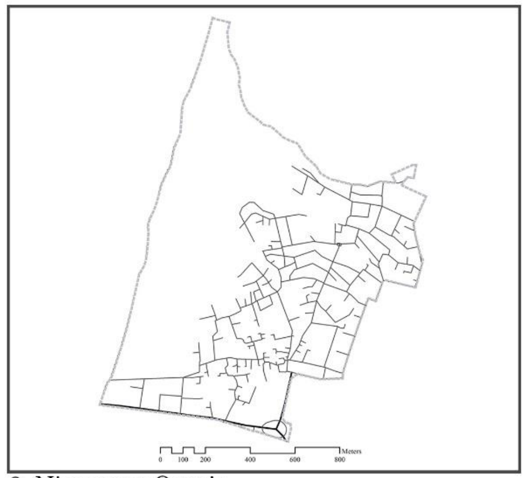

3. Velenjak: Grid


4. Zaferanie: Mixed (Organic- Grid- Tributary)


5. Darband: Organic (Natural land features)


6. Golabdareh: Organic (Natural land features)


7. Jamaran: Organic


8. Niavaran: Orgaic


9. Kashanak: Mixed (Organic- Grid- Tributary)

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7.5. Appendix E.
List of Tehran's street networks
based on the neighborhoods

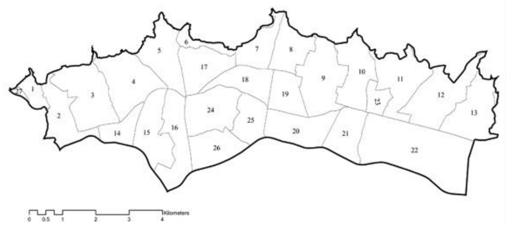
Dissertation: Assessing Walkability within Tehran Organic Street Network Based on the Network's Form
By: Niku Khaleghi
Supervisors: Prof. Dr. Barbara Engel, Prof. Dr. Behnaz AMinzadeh Goharrizi

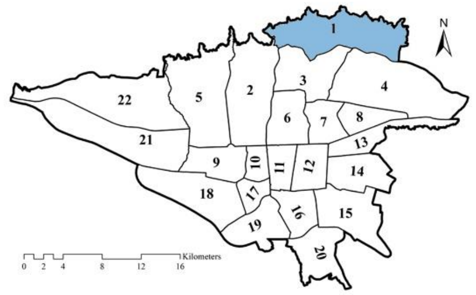
Legend:

Street

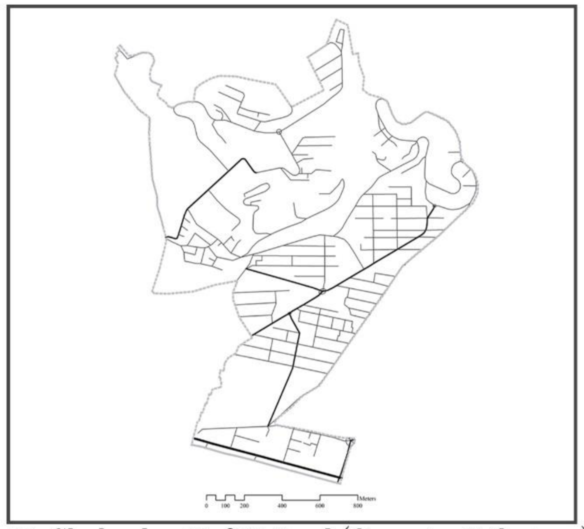
District Boundry

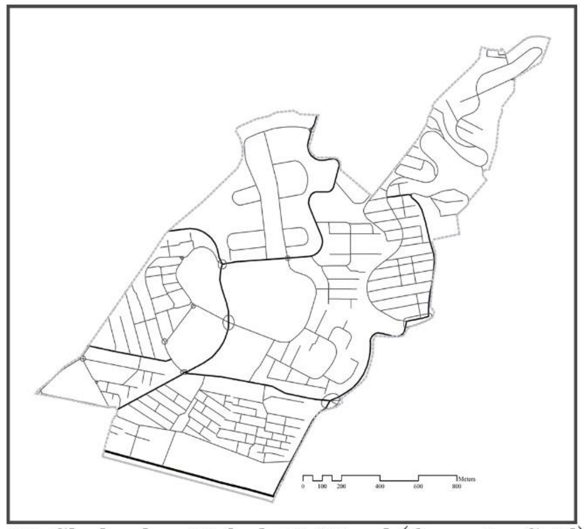
Water Bodies


District 1

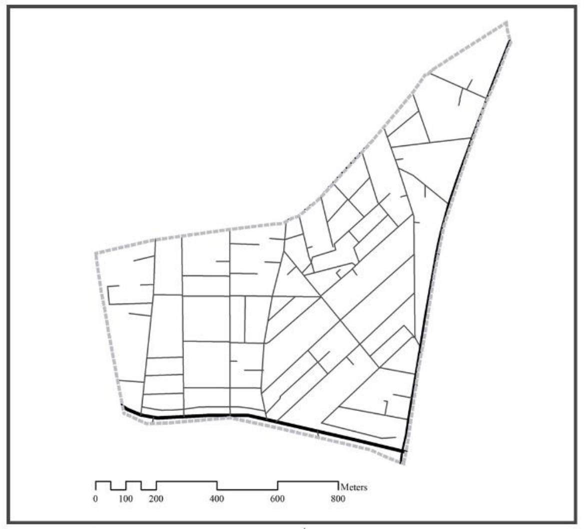



10. Darabad: Organic (Natural land features)

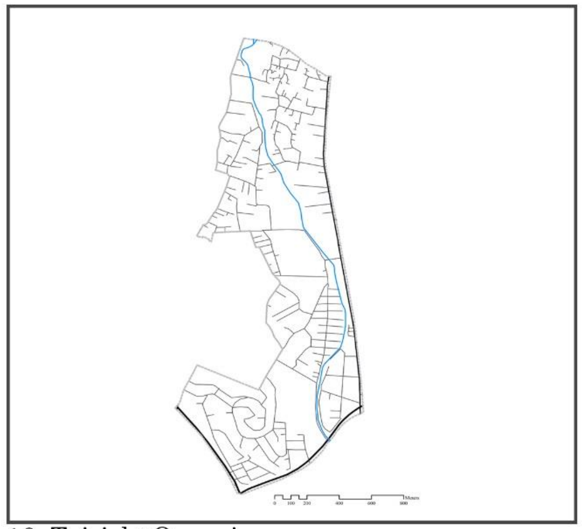

11. Shahrak-e Naft: Mixed (Organic- Tributary)

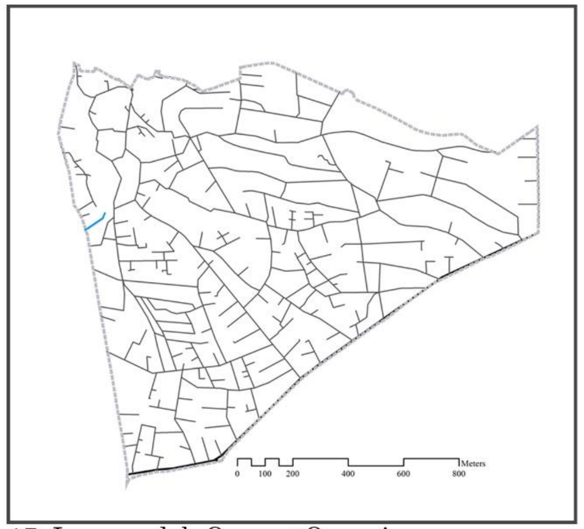

12. Shahrak-e Mahalati: Mixed (Organic- Grid)

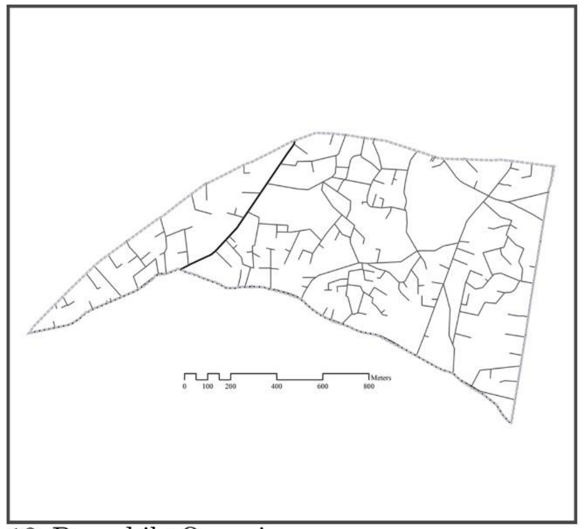

13. Sohanak: Organic


14. Mahmoudie: Mixed (Grid- Tributary- Radial)


15. Baq-e Ferdous: Organic


16. Tajrish: Organic


17. Imamzadeh Qasem: Organic


18. Dezashib: Organic

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7.5. Appendix E.
List of Tehran's street networks based on the neighborhoods

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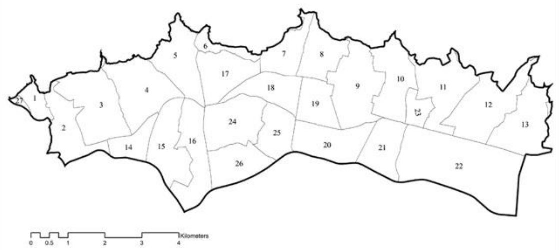
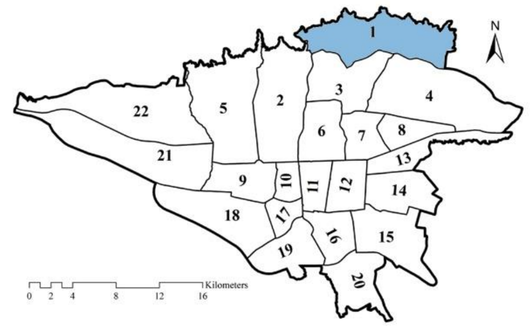
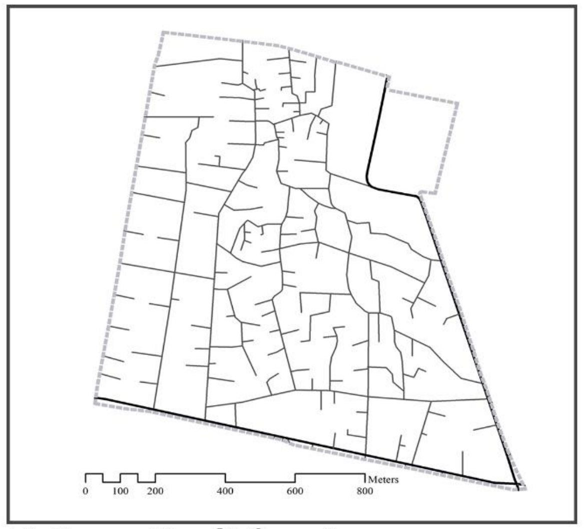
By: Niku Khaleghi
Supervisors: Prof. Dr. Barbara Engel,
Prof. Dr. Behnaz AMinzadeh Goharrizi

Legend:

- Street
- District Boundry
- Water Bodies

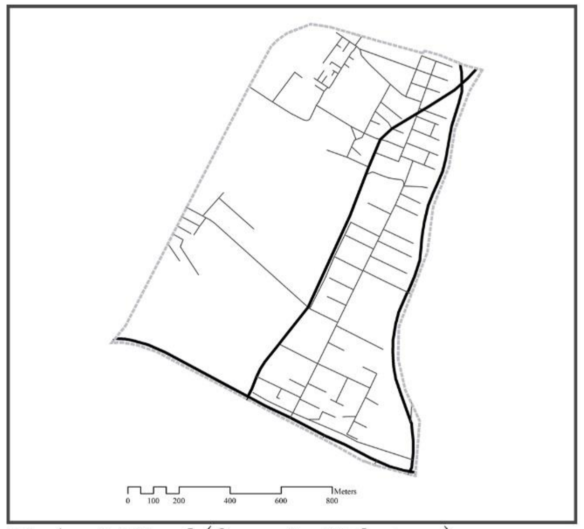

District 1



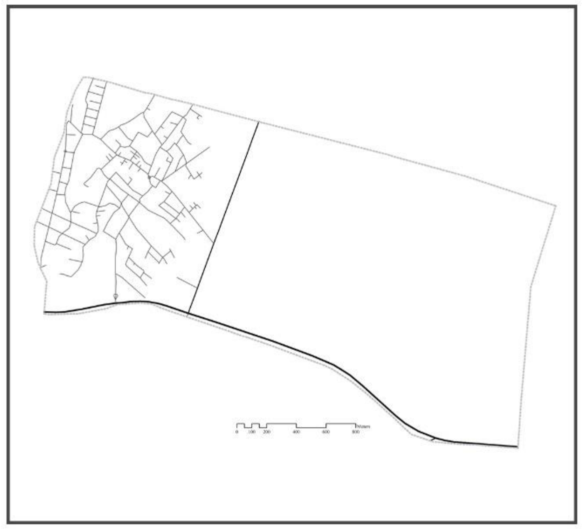


19. Hesar-e Bouali: Organic

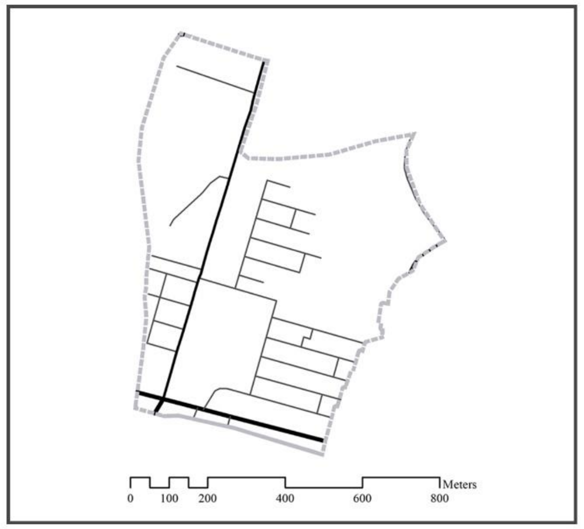
20. Farmanie: Mixed (Organic- Grid)



21. Araj: Mixed (Organic- Tributary)

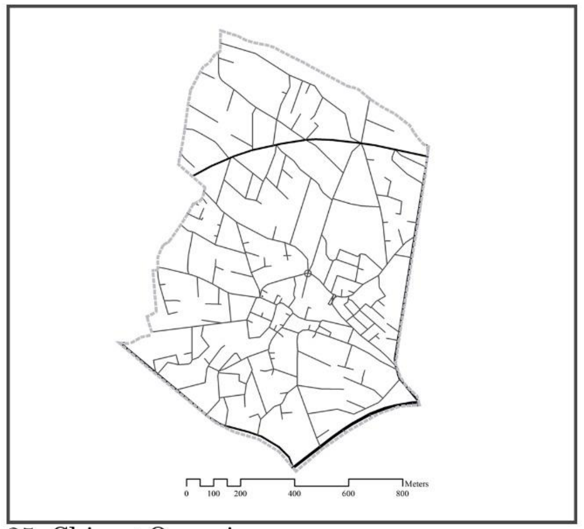


22. Ozgol: Organic

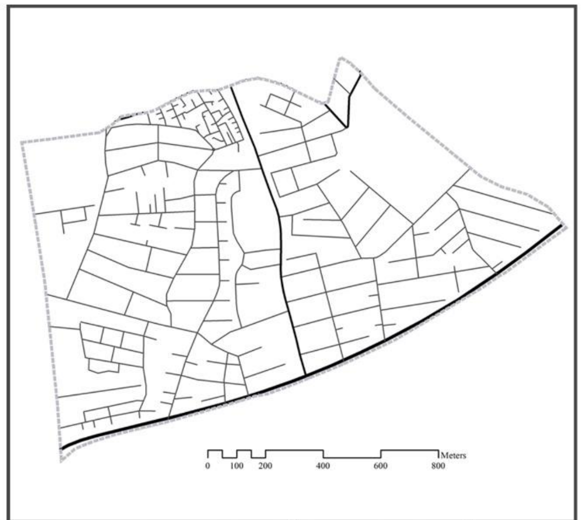


23. Daneshgah-Golha: Grid

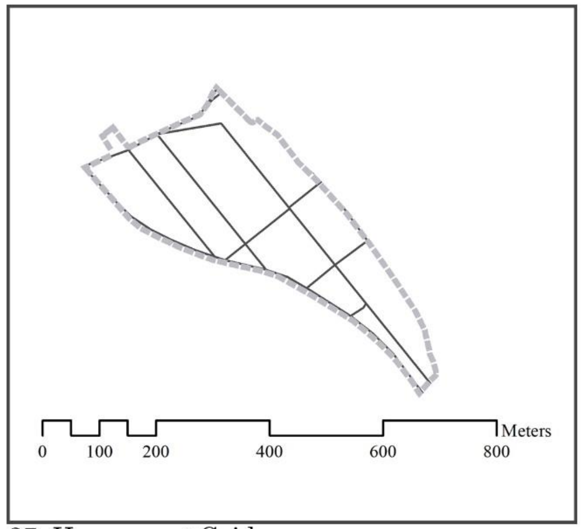
24. Hekmat: Organic



25. Chizar: Organic



26. Qeytariyeh: Mixed (Organic- Grid)



27. Hezarsang: Grid

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7.5. Appendix E.
List of Tehran's street networks based on the neighborhoods

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By: Niku Khaleghi
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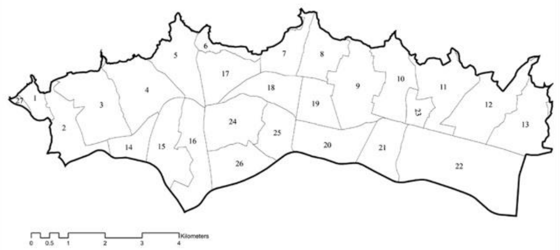
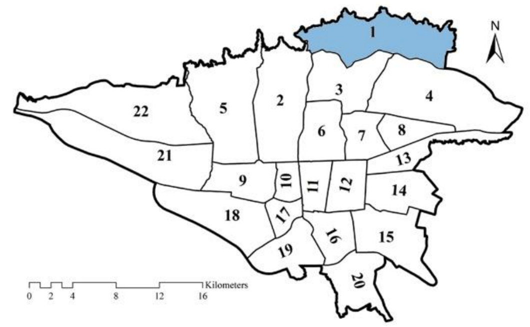
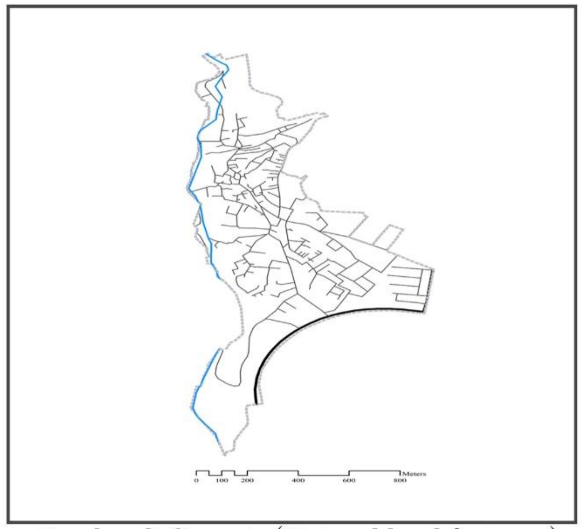
Legend:

Street
District Boundry
Water Bodies

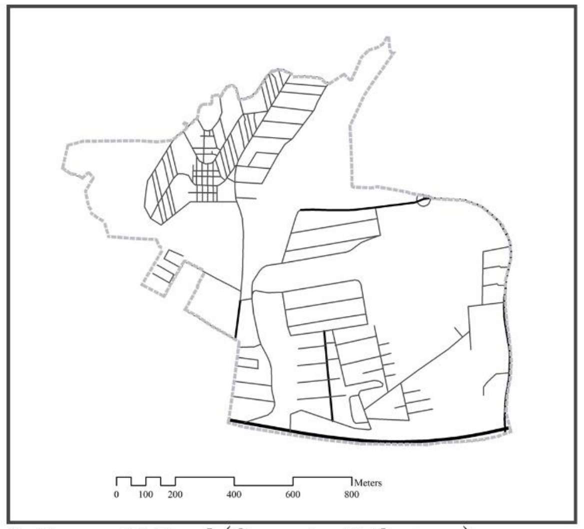


District 1

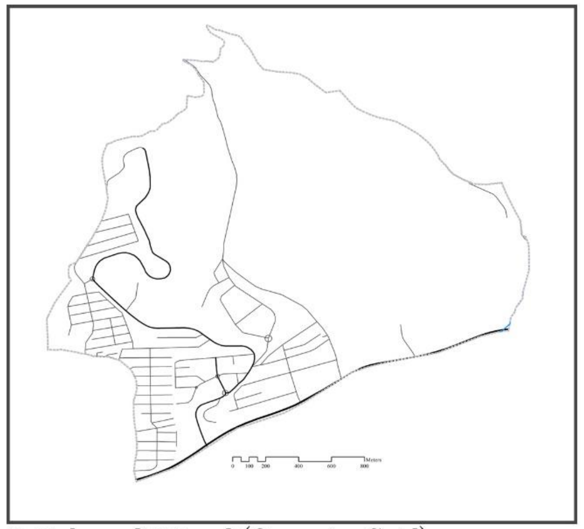




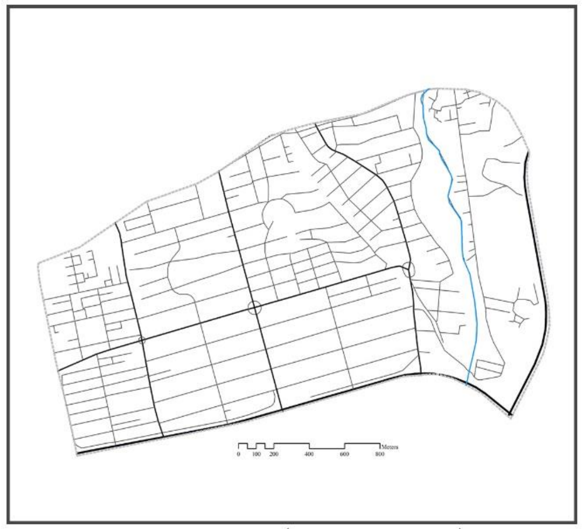
1. Farahzad: Organic (Natural land features)



2. Parvaz: Mixed (Organic- Tributary)

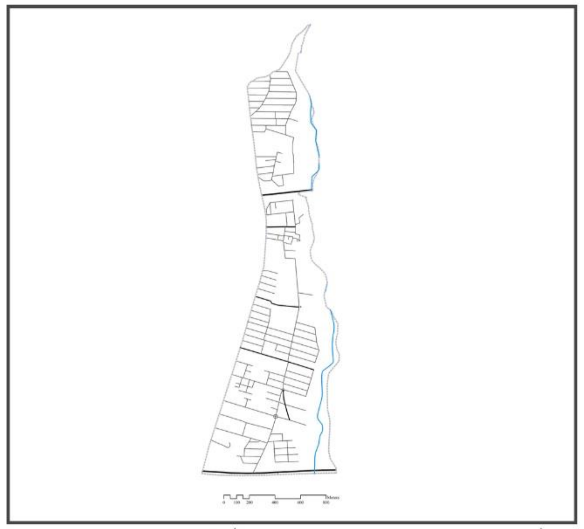


3. Behourd: Mixed (Organic- Grid)

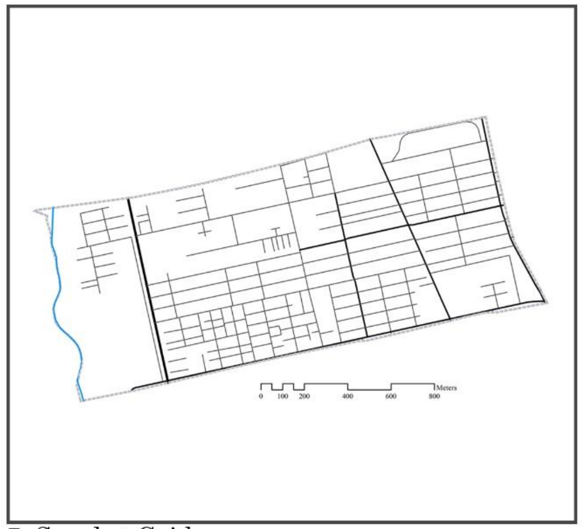


4. Saadatabad: Mixed (Organic- Grid)

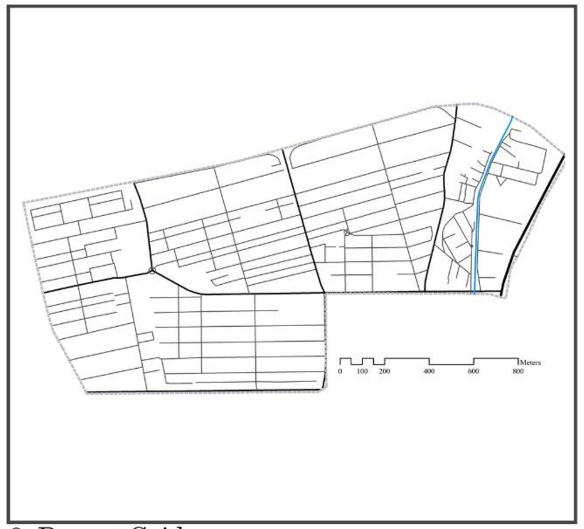
5. Aseman: Mixed (Organic- Grid)



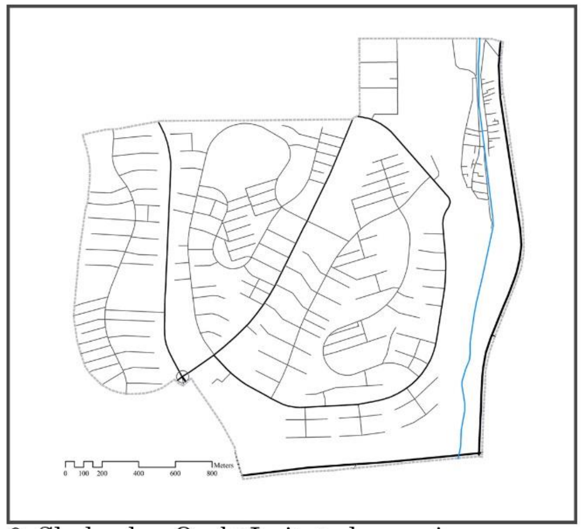
6. Poonak: Mixed (Grid- Tributary- Organic)



7. Sepehr: Grid



8. Darya: Grid



9. Shahrak-e Qarb: Imitated organic

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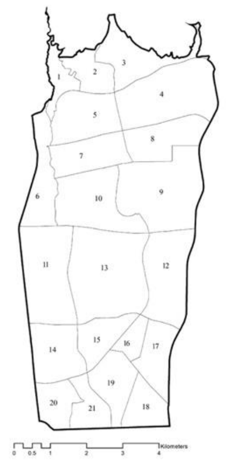
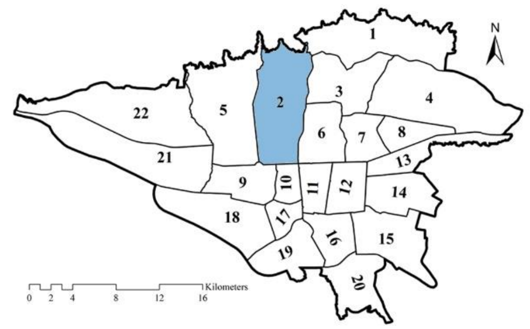
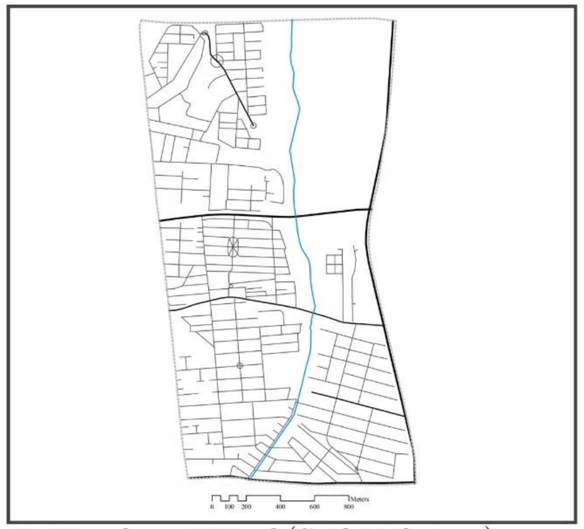


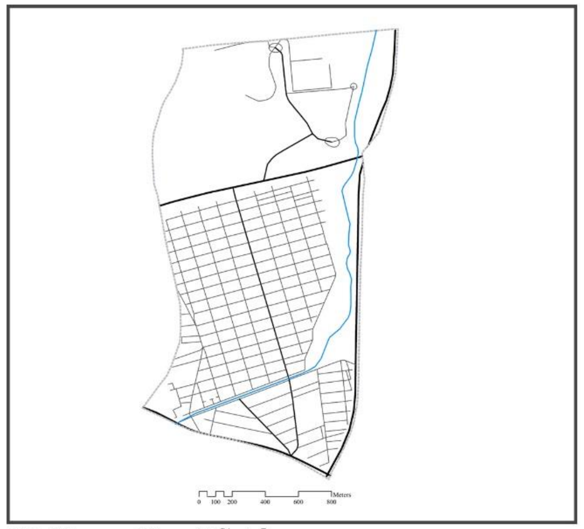
District 2



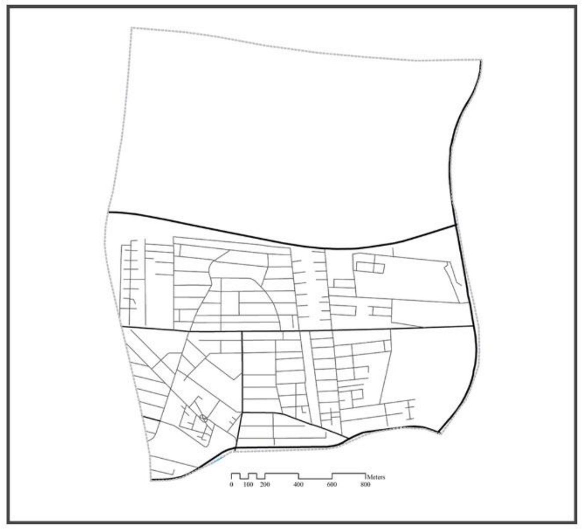
10. Ivanak: Imitated organic



11. Marzdaran: Mixed (Grid- Tributary)



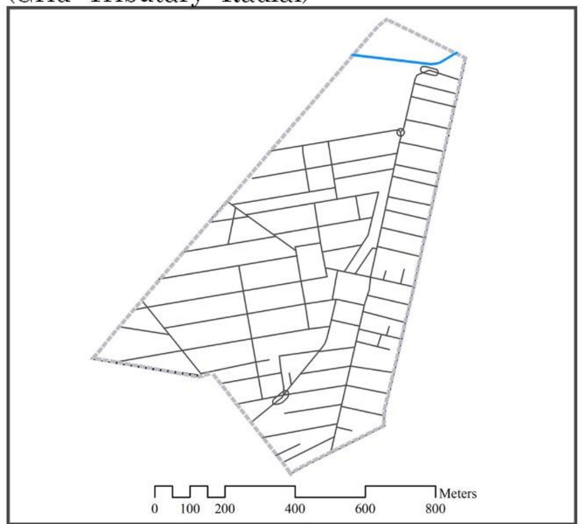
12. Kouye Nasr: Grid



13. Shahrak Azmaesh: Mixed (Grid- Tributary- Radial)

14. Sadeghieh: Mixed (Grid- Tributary)

15. Satarkhan: Tributary



16. Tehran Villa: Mixed (Grid- Radial)

17. Shahrara: Mixed (Grid- Radial)

18. Tohid: Mixed (Grid- Radial- Tributary)

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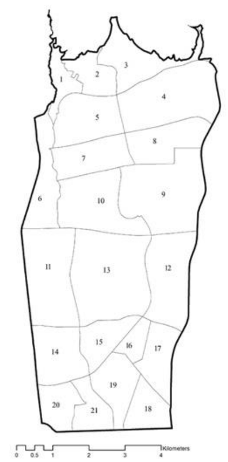
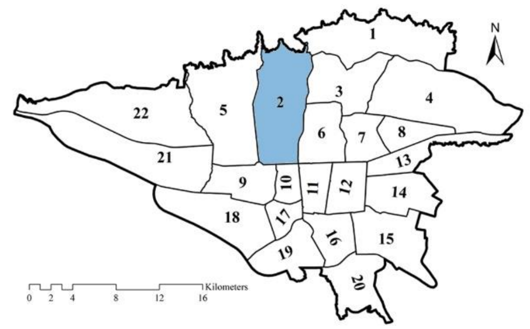
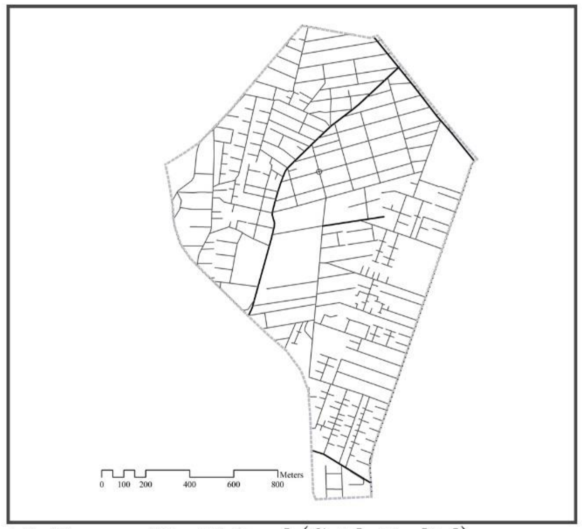


District 2





19. Daryan Nou: Mixed (Grid- Radial)

20. Tarasht: Mixed (Organic- Tributary)

21: Sharif: Mixed (Organic- Radial- Tributary)

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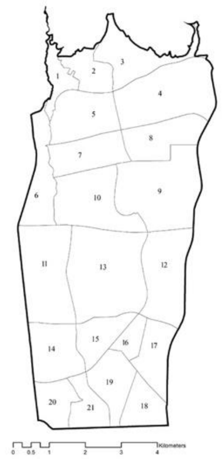
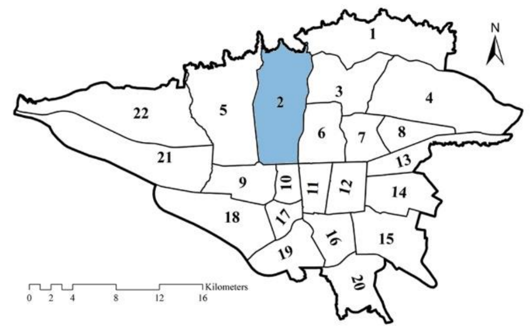
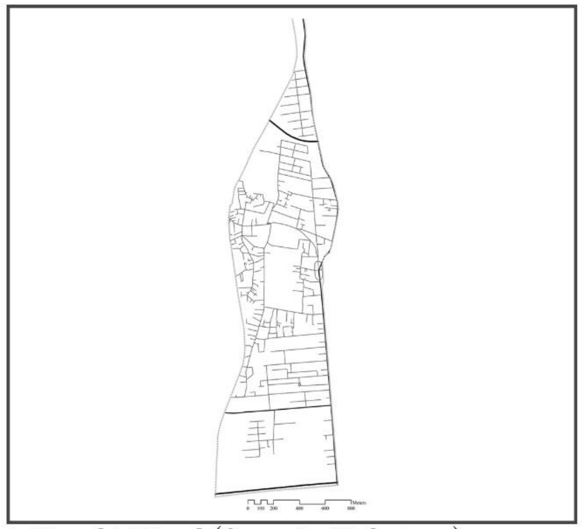
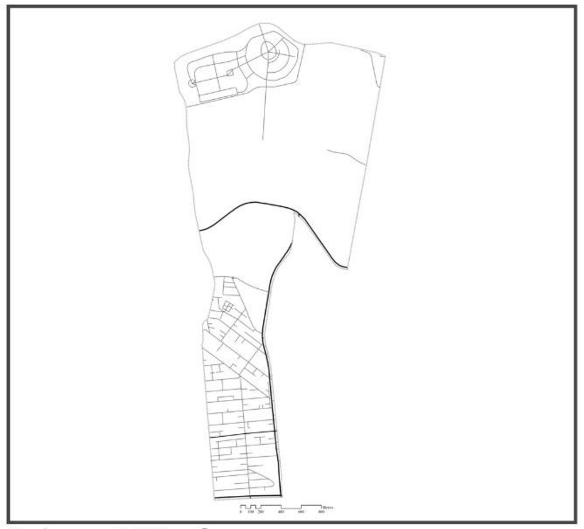


District 2

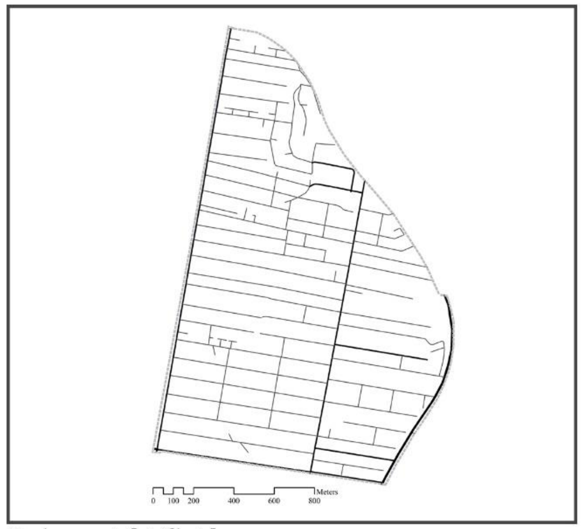




1. Vanak: Mixed (Organic- Tributary)

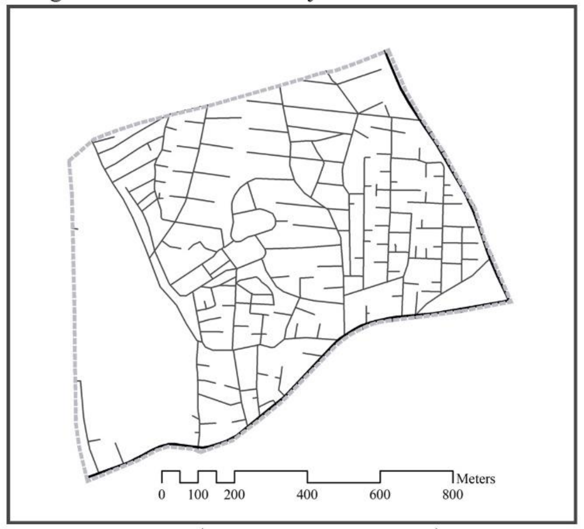


2. Ararat: Mixed
(Organic- Grid- Tributary- Radial)

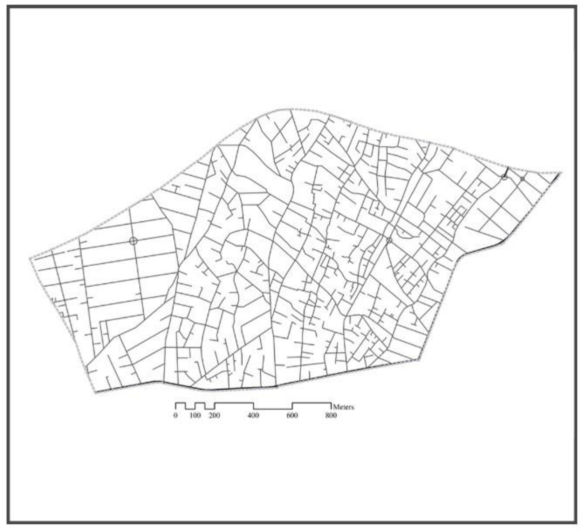


3. Amanieh: Grid

4. Zargande: Organic



5. Sadr: Mixed (Organic- Tributary)



6. Ekhtiarieh: Organic

7. Darous: Mixed (Grid- Tributary- Organic)

8. Golhak: Mixed (Organic- Grid- Radial-Tributary)

9. Kavousieh: Mixed (Grid- Radial)

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Legend:

Street

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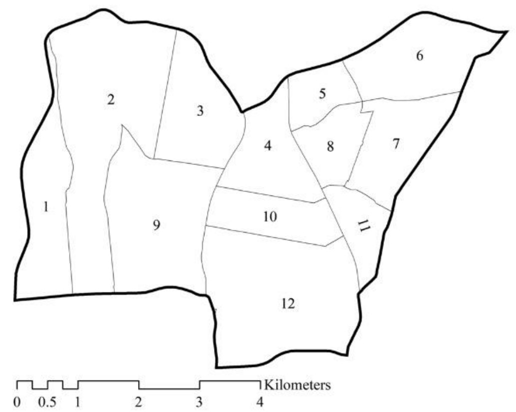
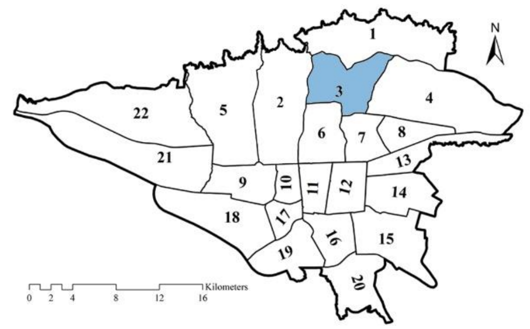
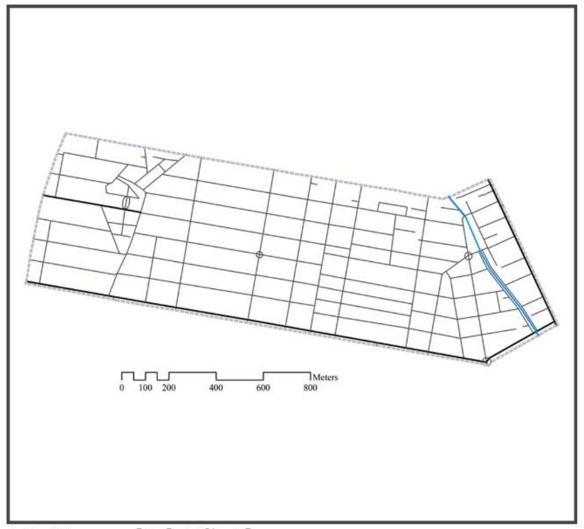
Water Bodies



District 3





10. Davoudieh: Grid

11. Qoba: Mixed (Grid- Tributary- Radial- Organic)

12. Seyed Khandan: Mixed (Radial- Grid- Tributary)

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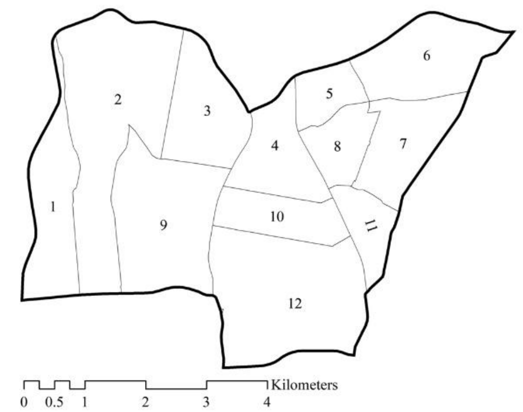
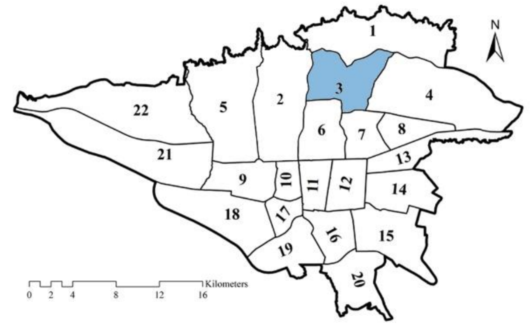
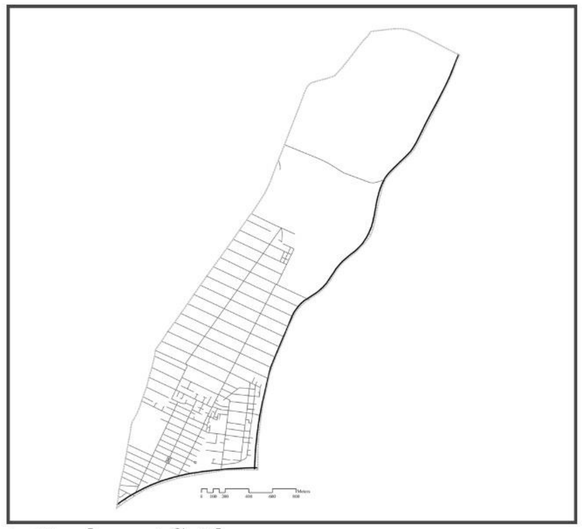


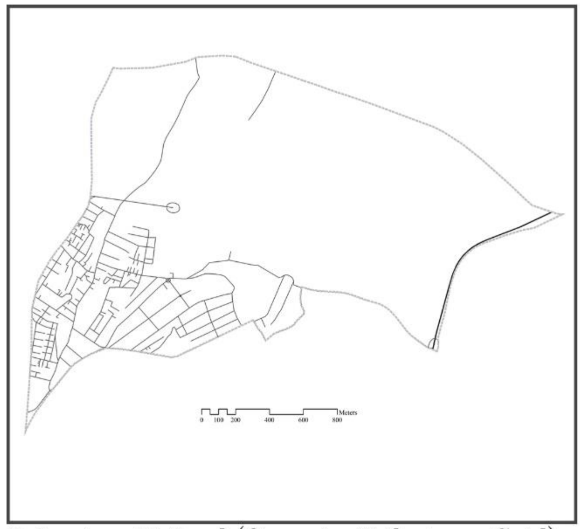
District 3



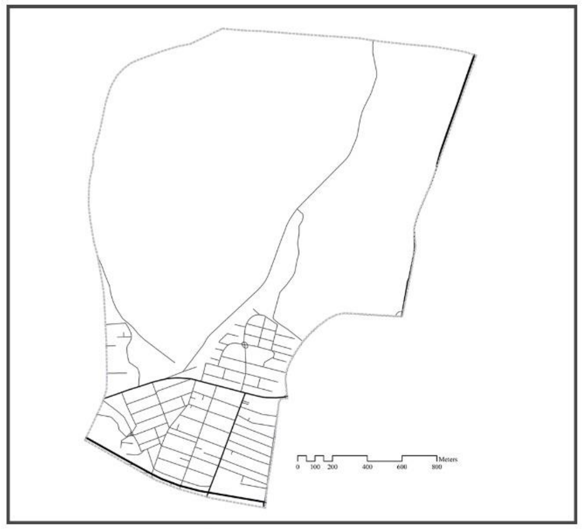


1. Pasdaran: Grid

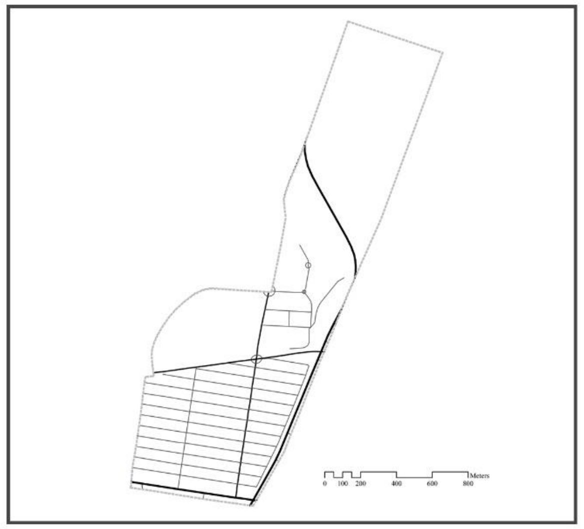
2. Hoseinabad: Mixed (Organic- Grid)



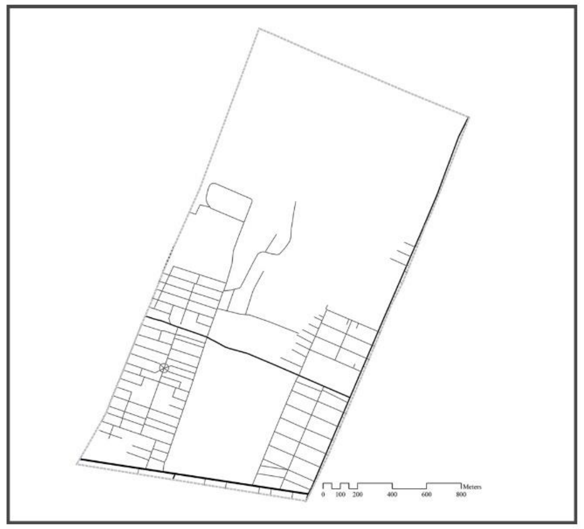
3. Lavizan: Mixed (Organic- Tributary- Grid)



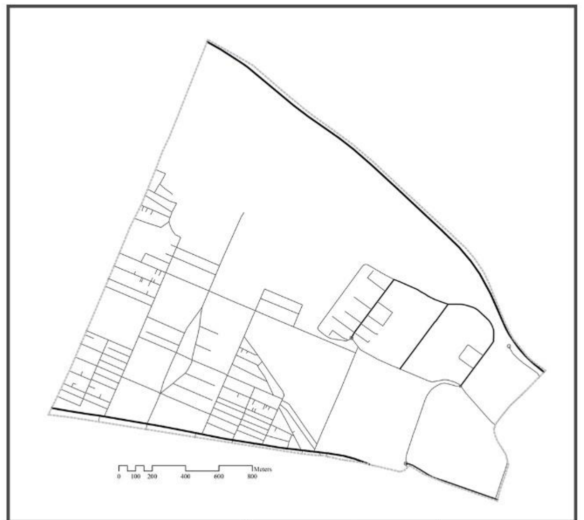
4. Shamsabad: Grid



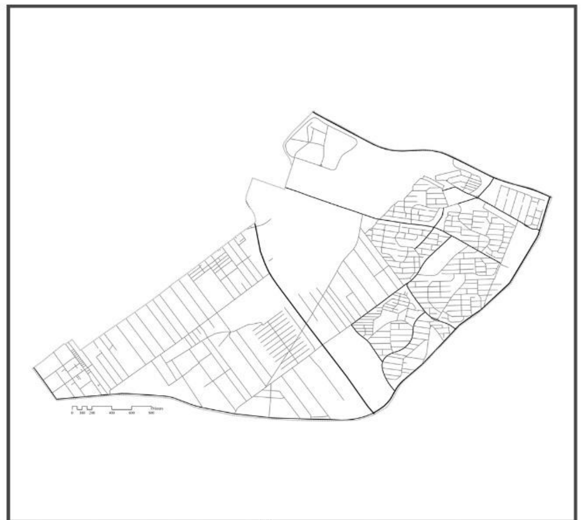
5. Qanat Kosar: Grid



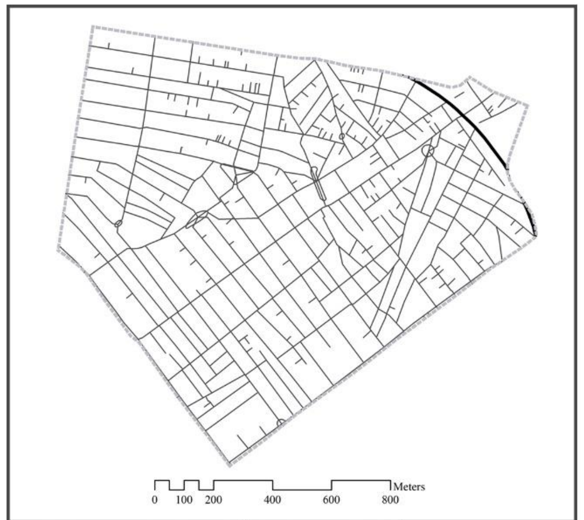
6. Majidabad: Grid



7. Kouhsar: Mixed (Grid- Tributary)



8. Hakimieh: Mixed (Imitated organic- Grid- Tributary- Radial)



9. Golshan: Mixed (Radial- Grid)

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Street
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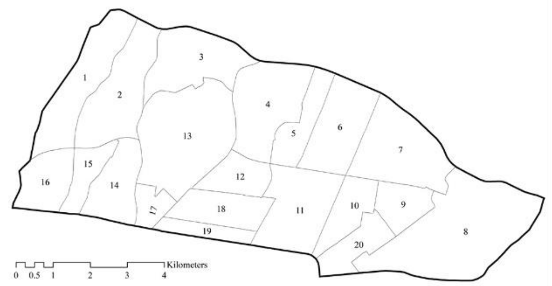
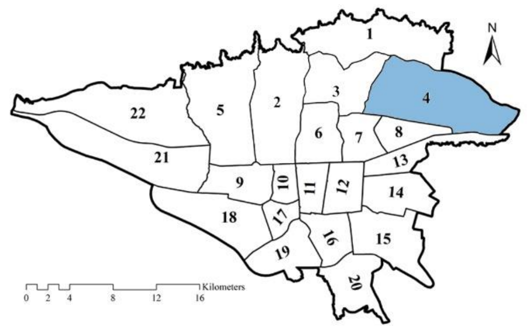
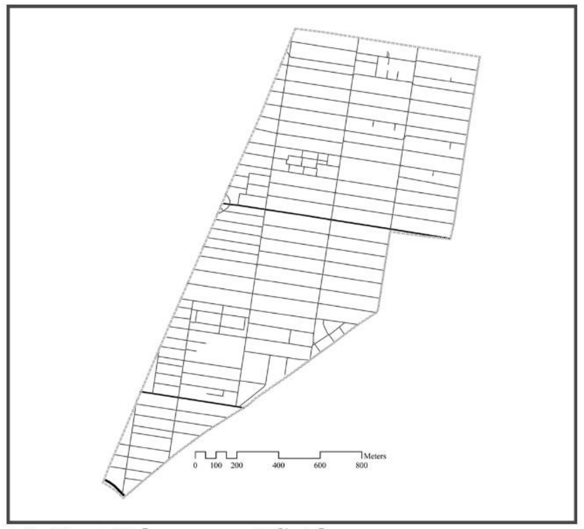
Water Bodies

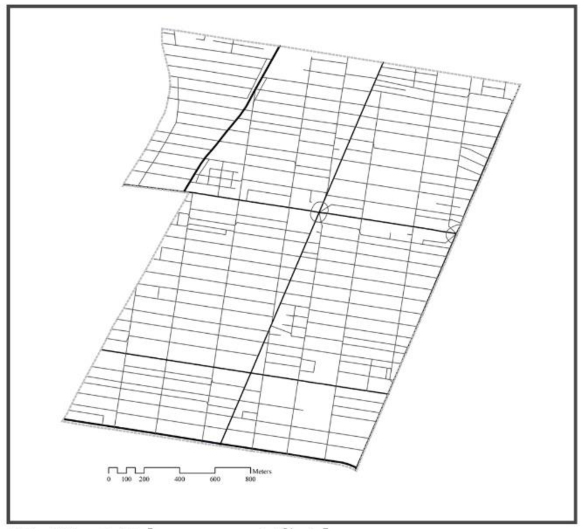


District 4

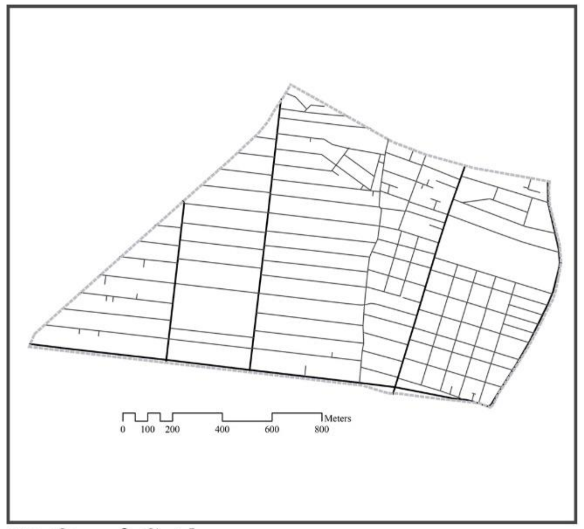




10. East Tehranpars: Grid



11. West Tehranpars: Grid



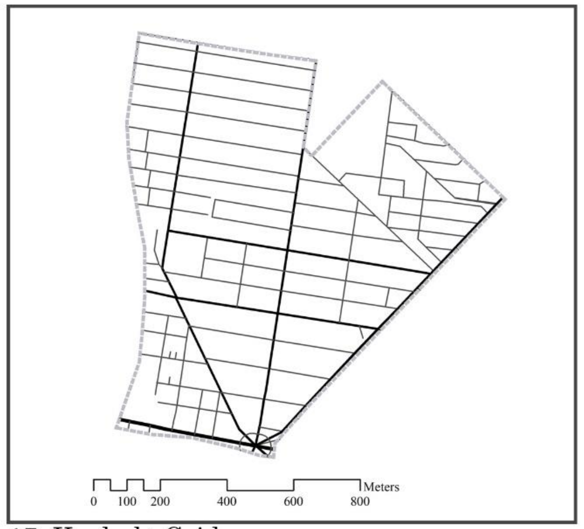
12. Oqaaf: Grid

13. Shemiran nou: Grid

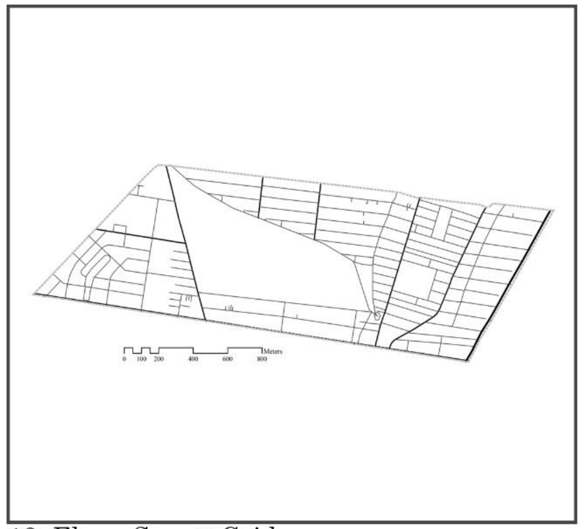
14. Majidieh: Grid

15. Kazemabad: Mixed (Grid- Tributary)

16. Mehran: Mixed (Radial- Grid- Tributary)



17. Kouhak: Grid



18. Elm-o Sanat: Grid

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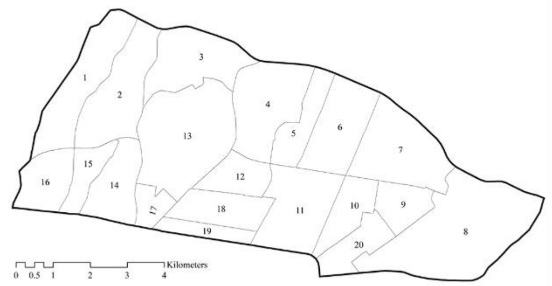
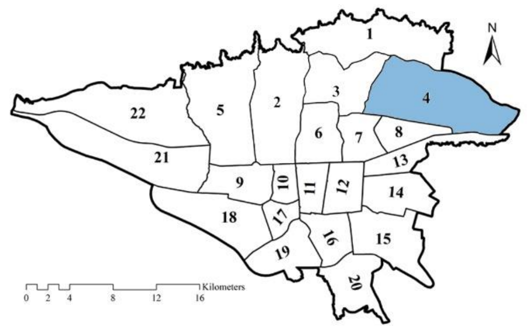
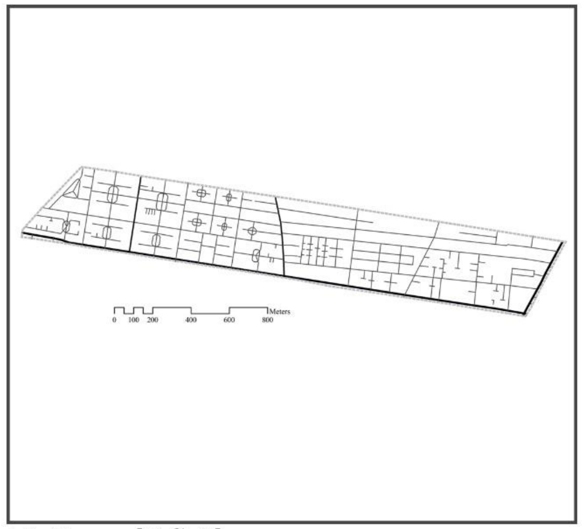
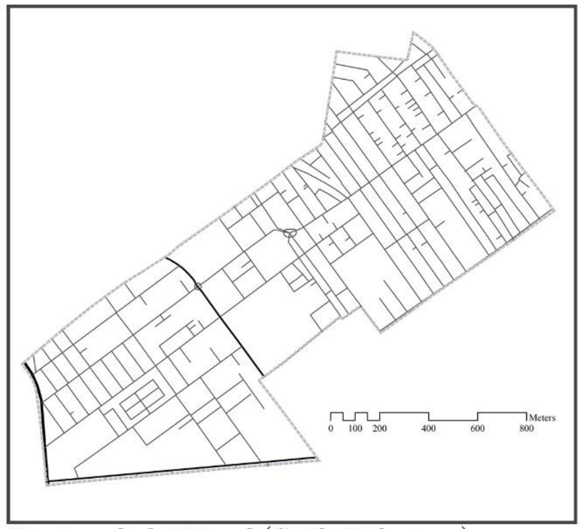


District 4




19. Narmak: Grid


20. Javadieh: Mixed (Grid- Tributary)

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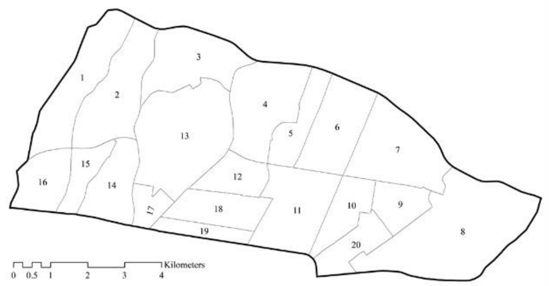
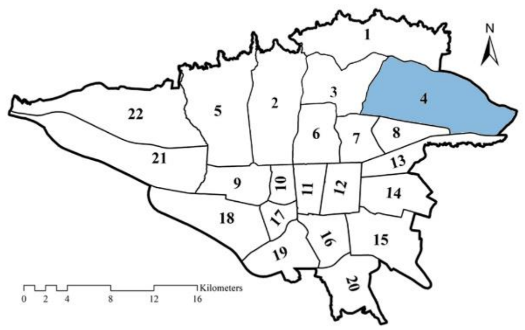
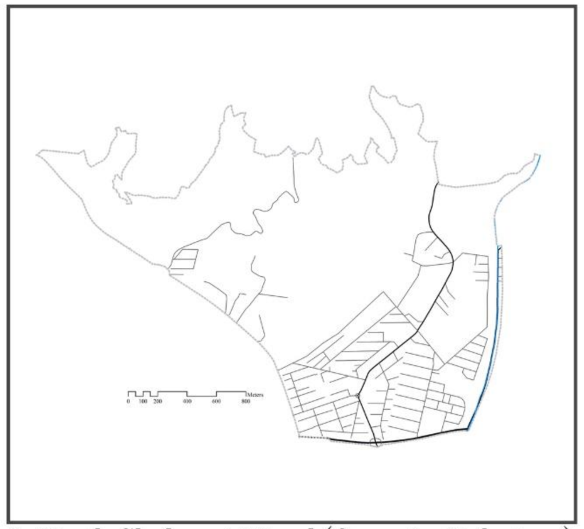
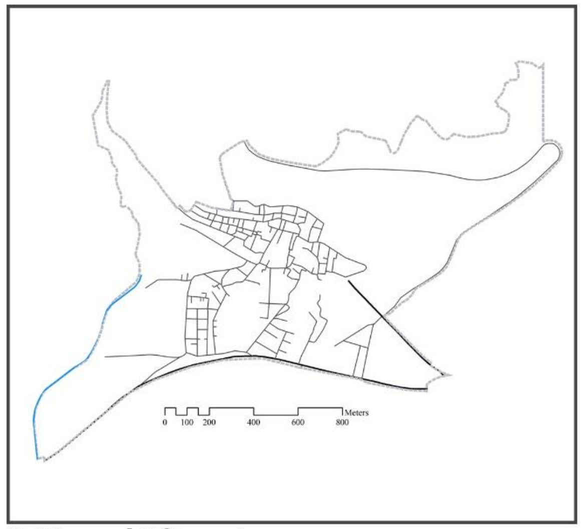

District 4



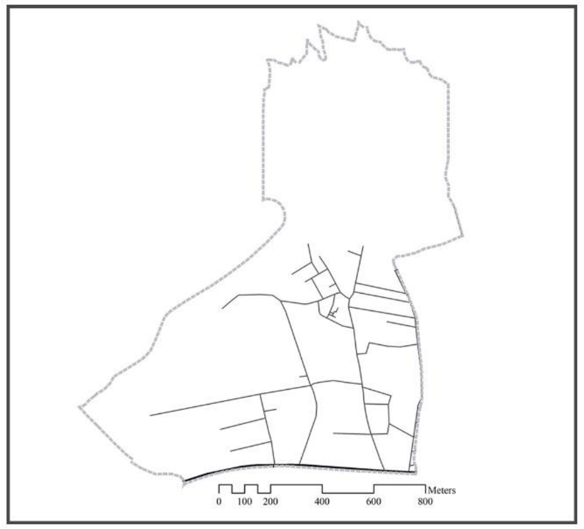
1. Baharan: Mixed (Organic- Grid)



2. North Shahran: Mixed (Organic- Tributary)

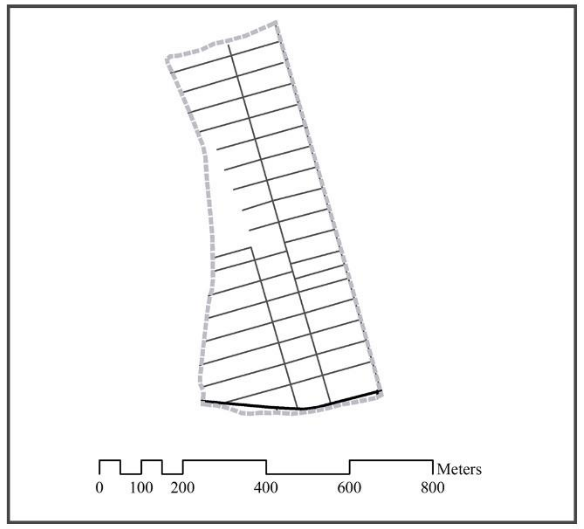


3. Hesarak: Organic



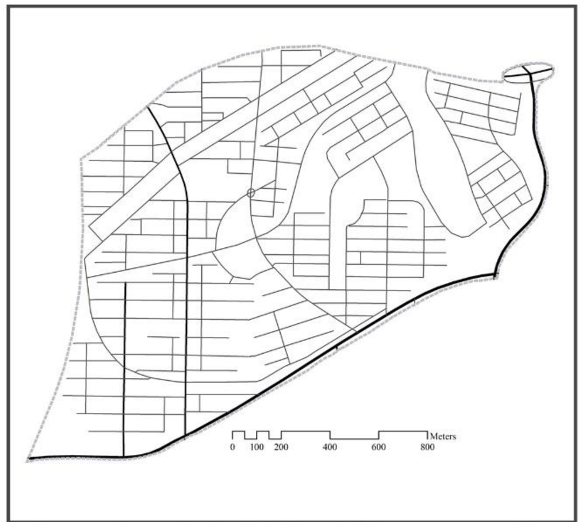
4. Moradabad: Organic

5. Naft: Grid

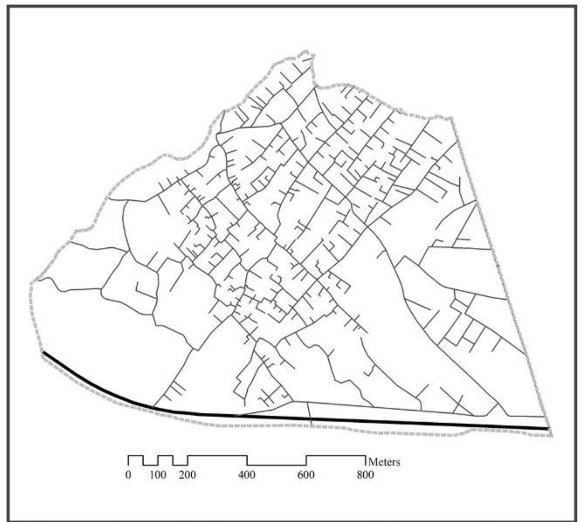


6. Kouhsar: Grid

7. Al-Mahdi: Mixed (Organic- Radial- Grid)



8. North Janadabad: Mixed (Organic- Radial- Grid)



9. Kan: Organic (Natural land features)

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List of Tehran's street networks based on the neighborhoods

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By: Niku Khaleghi
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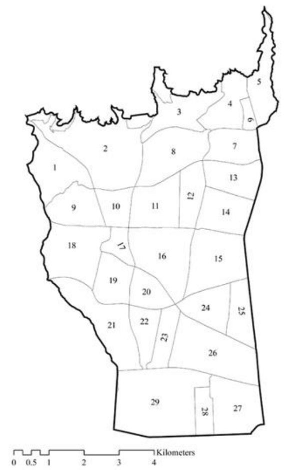
Legend:

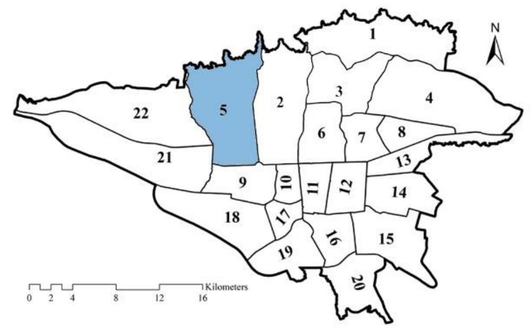
Street

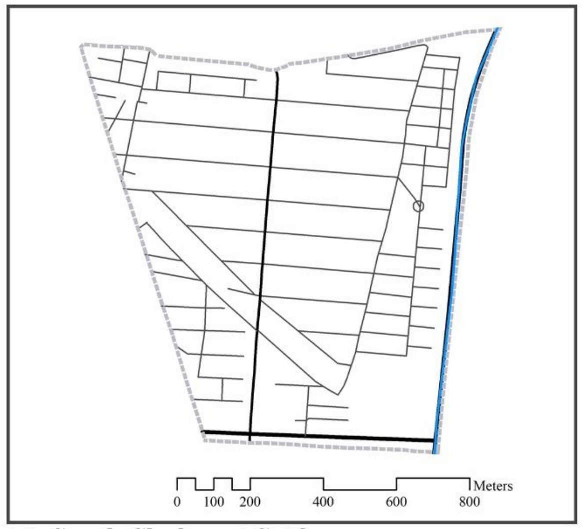
District Boundry

Water Bodies

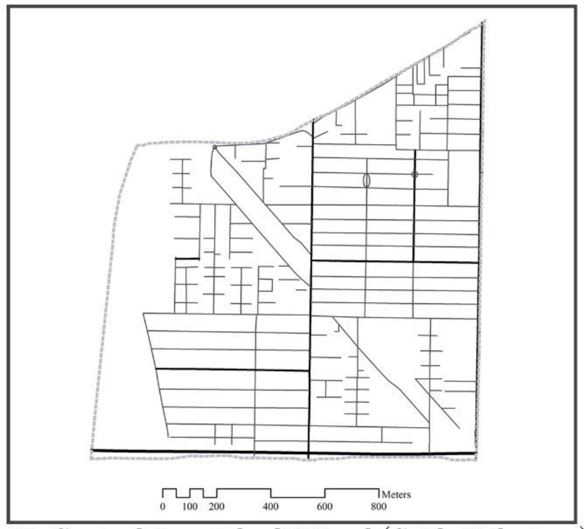


District 5

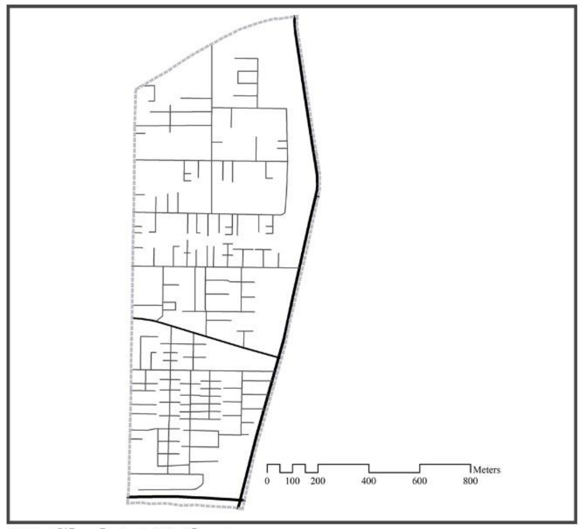




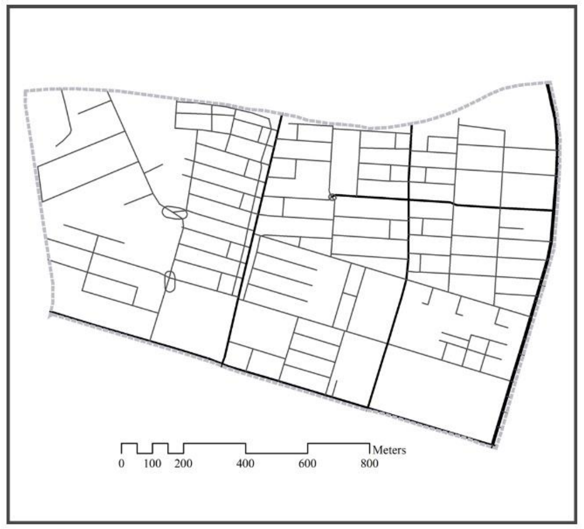
10. South Shahran: Grid



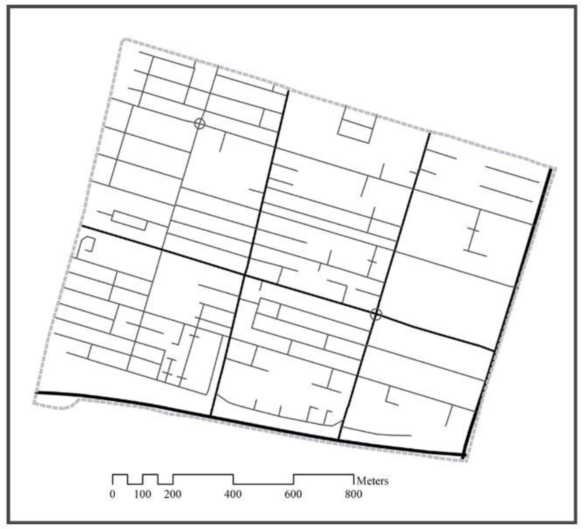
11. Central Janatabad: Mixed (Grid- Tributary)



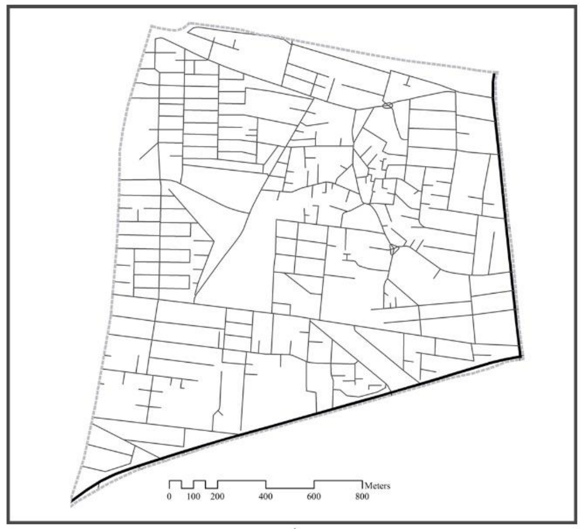
12. Shahin: Tributary



13. North Pounak: Grid

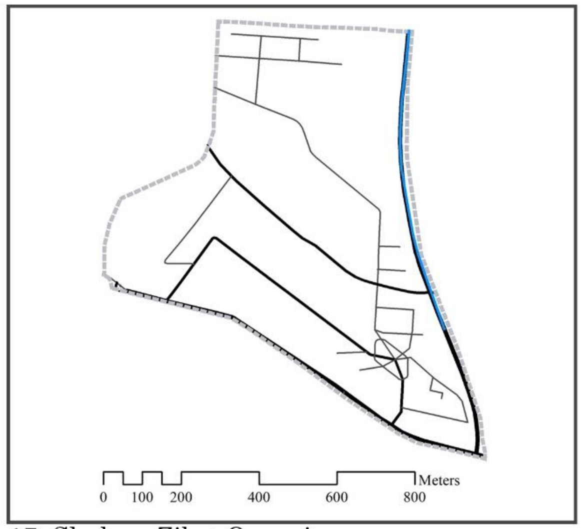


14. South Pounak: Grid



15. Baq-e Feyz: Mixed (Organic- Grid- Tributary)

16. South Janatabad: Grid



17. Shahr-e Ziba: Organic

18. Andisheh: Organic

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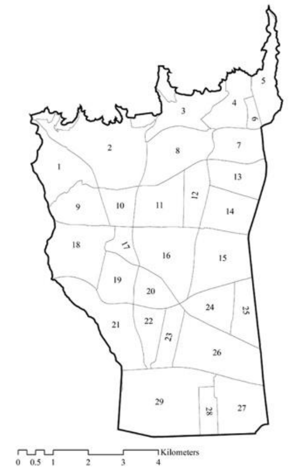
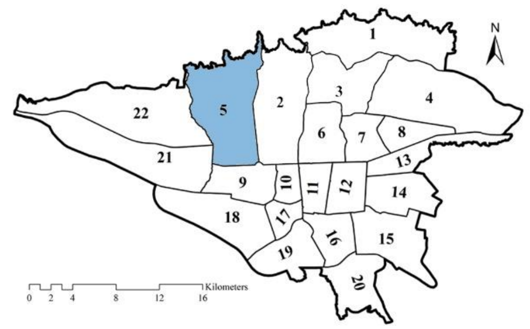
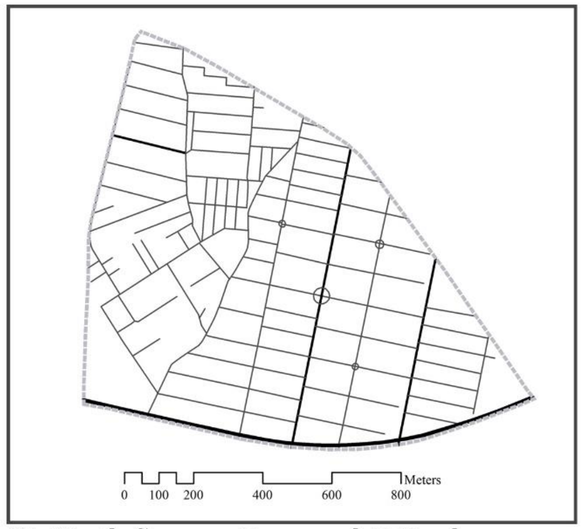


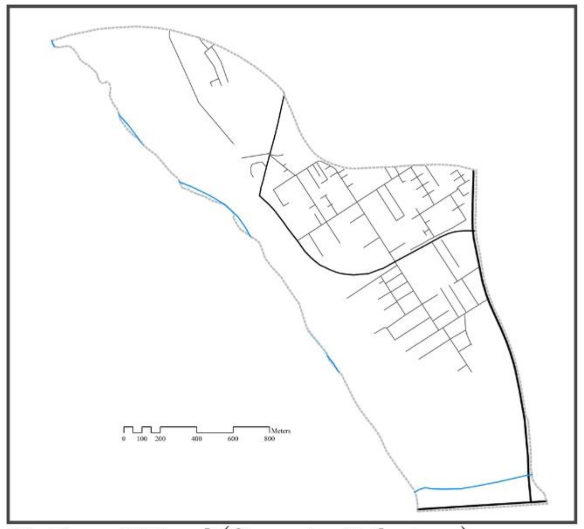
District 5



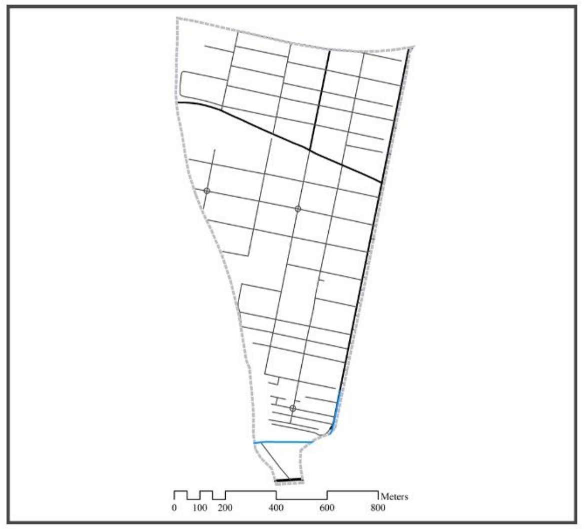
19. Sazman-e Aab: Grid



20. North Sazman Barnameh: Mixed (Grid- Radial)

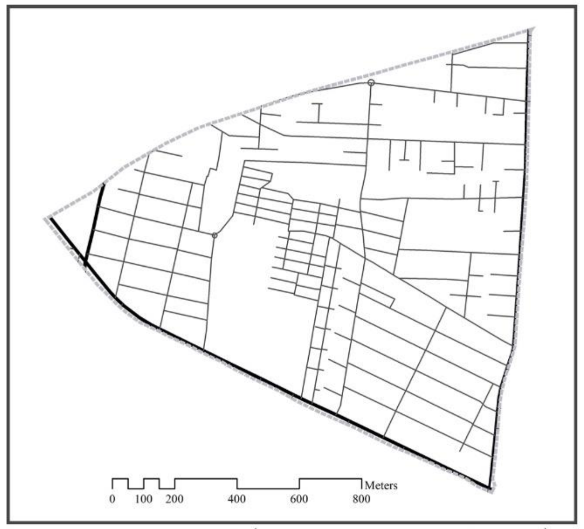


21. Eram: Mixed (Organic- Tributary)



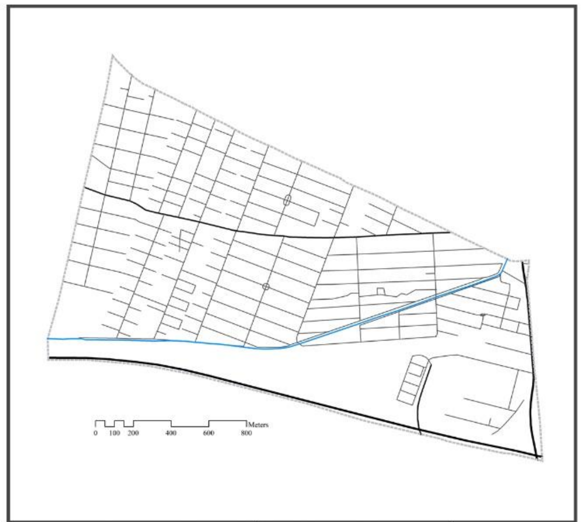
22. South Sazman Barnameh: Grid

23. Parvaz: Grid

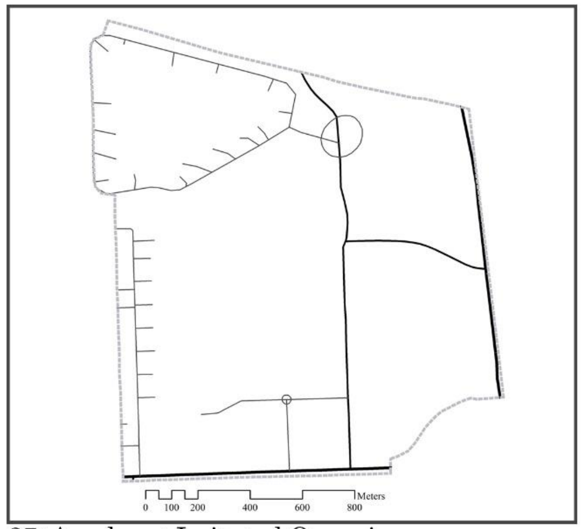


24. Mehran: Mixed (Grid- Tributary- Radial)

25. Abaazar: Mixed (Grid- Tributary)



26. Ferdous: Mixed (Grid- Tributary)



27: Apadana: Imitated Organic

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Street

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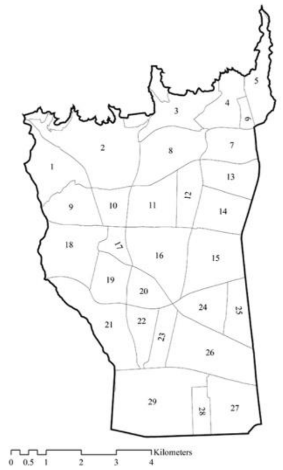
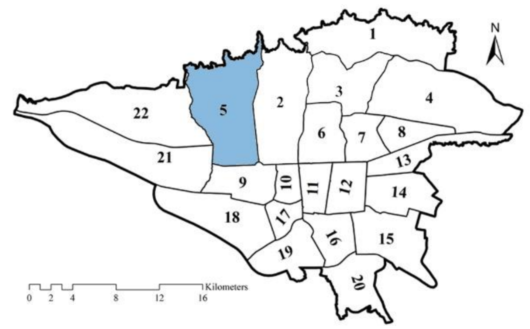
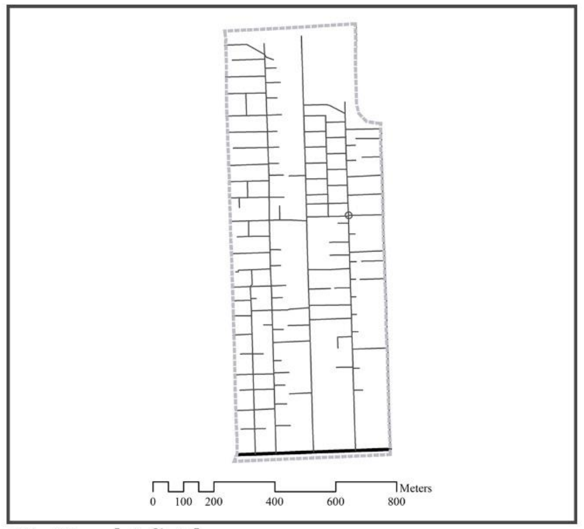
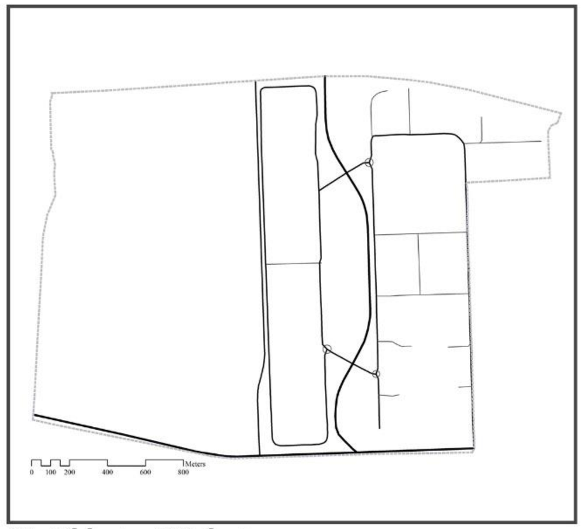


District 5





28. Bimeh: Grid



29. Ekbatan: Tributary

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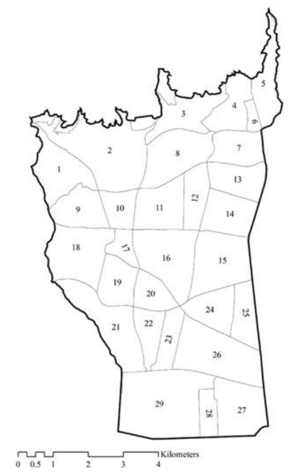
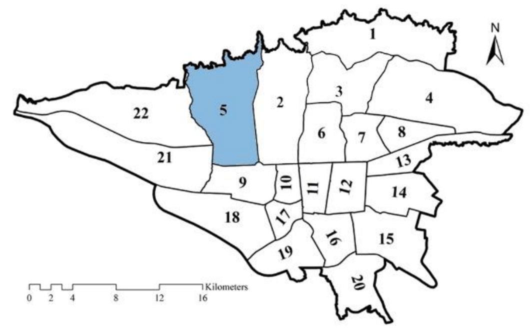
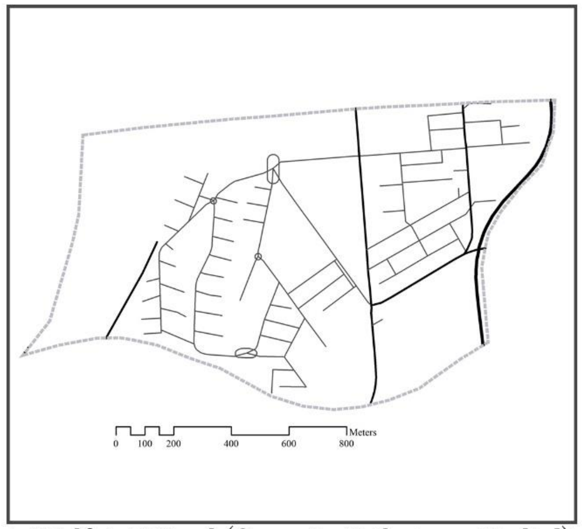
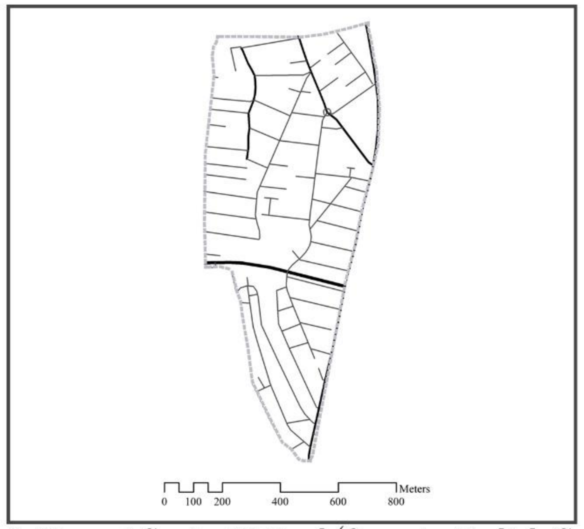


District 5

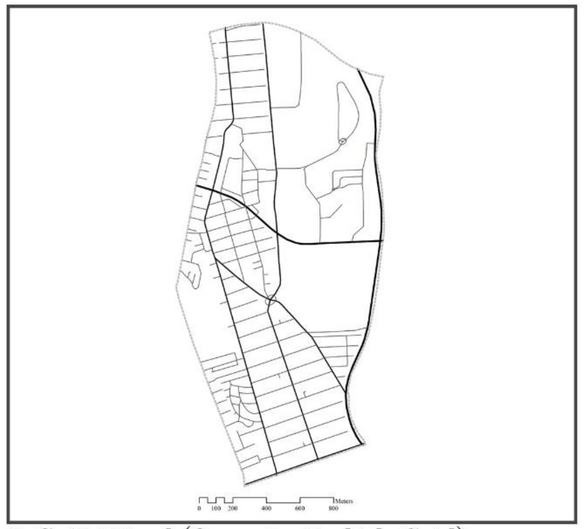




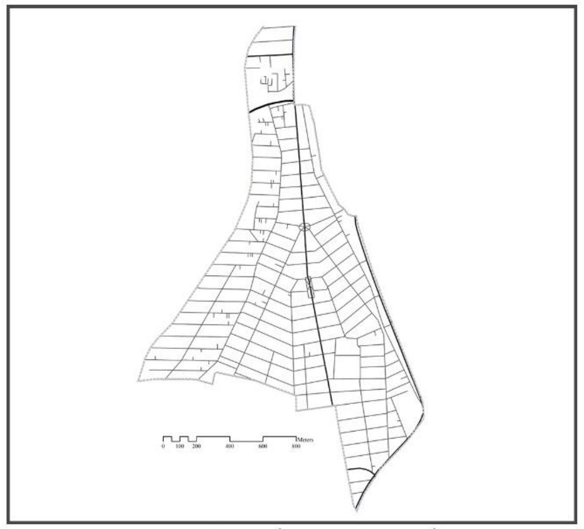
1. Walfajr: Mixed (Organic- Tributary- Radial)



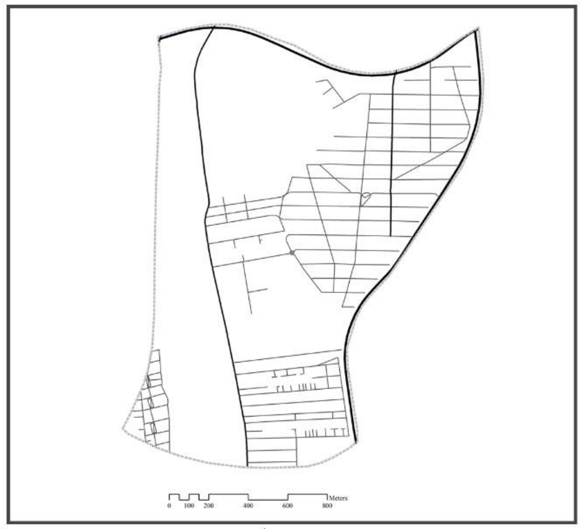
2. Nezami Ganjavi: Mixed (Organic- Radial- Grid)



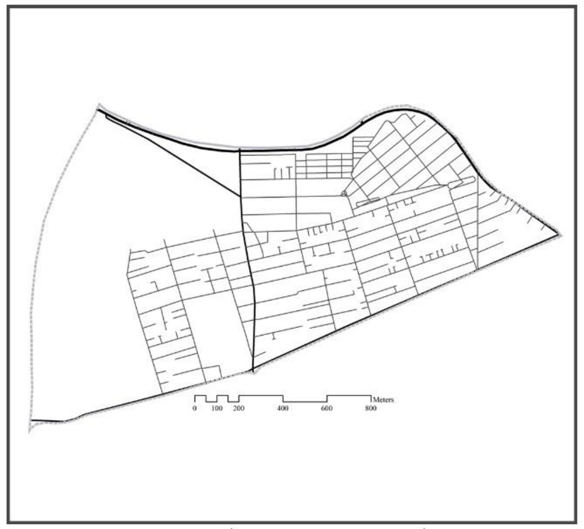
3. Sa'i: Mixed (Organic- Radial- Grid)



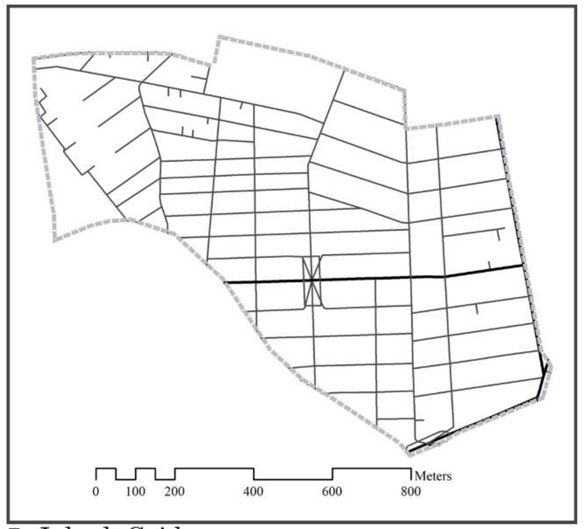
4. Yousefabad: Mixed (Grid- Radial)



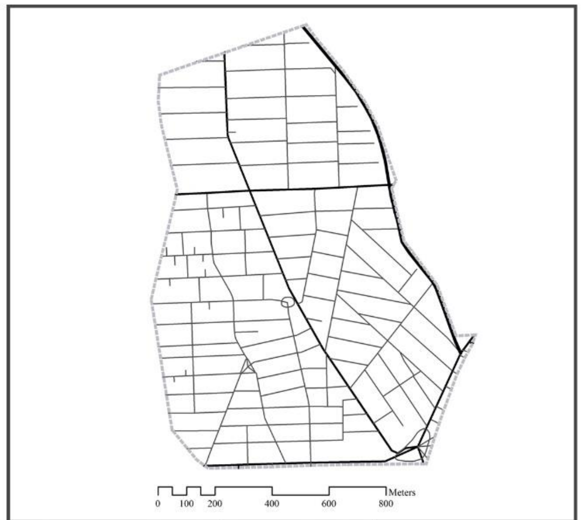
5. Amirabad: Mixed (Organic- Tributary- Radial)



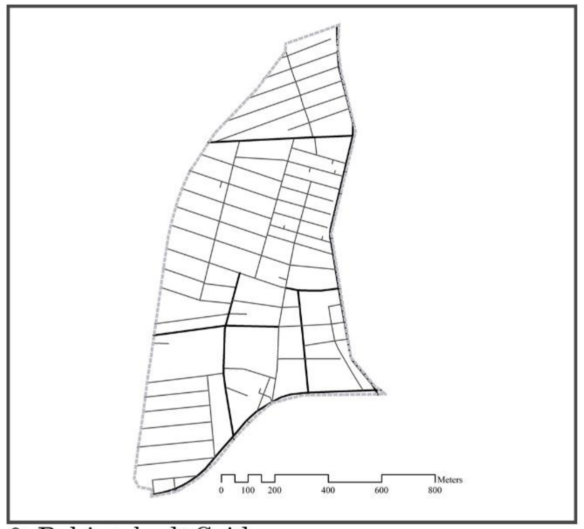
6. Fatemi: Mixed (Grid- Tributary)



7. Jahad: Grid



8. Sana'i: Mixed (Grid- Radial)



9. Behjatabad: Grid

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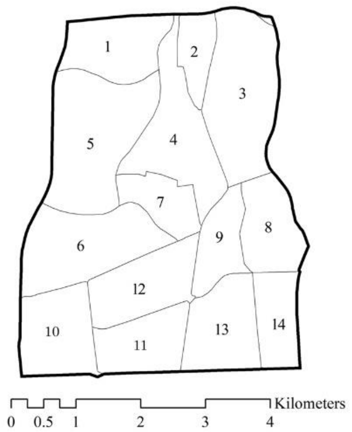
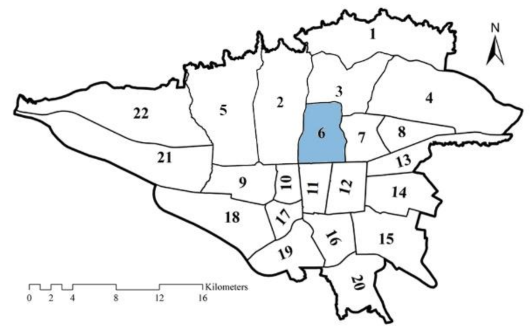
Legend:

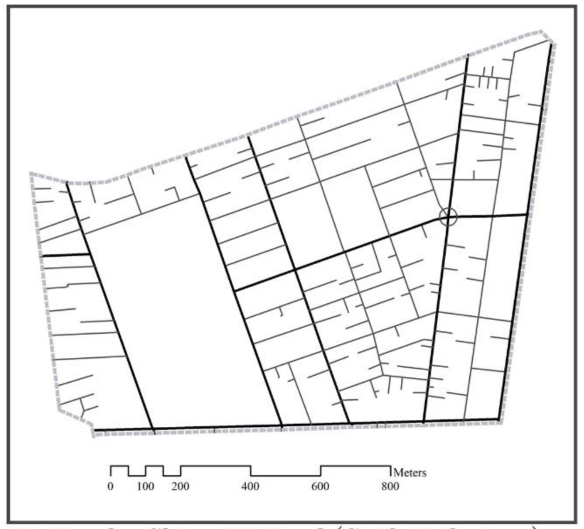
- Street
- District Boundry
- Water Bodies



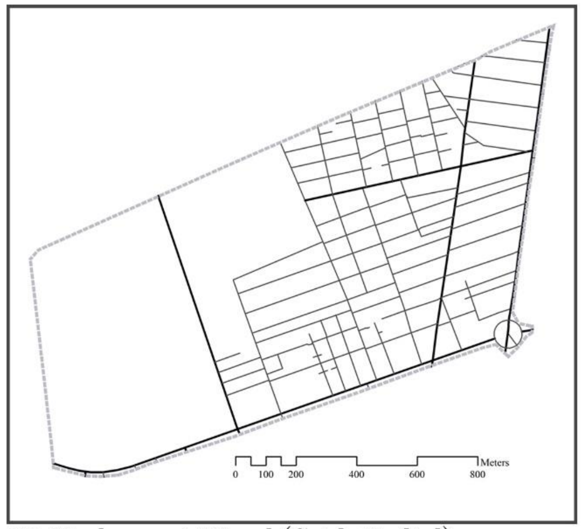
District 6



10. Jamalzadeh: Mixed (Grid- Tributary)



11. Vesal-e Shirazi: Mixed (Grid- Tributary)



12. Keshavarz: Mixed (Grid- Radial)

13. Valiasr: Mixed (Grid- Tributary)

14. Iranshahr: Mixed (Grid- Tributary)

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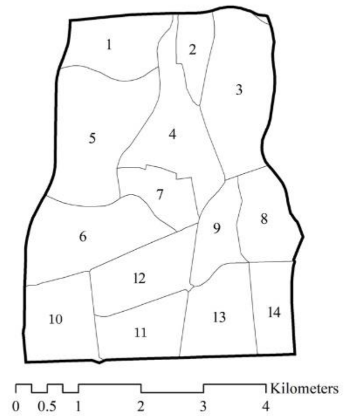
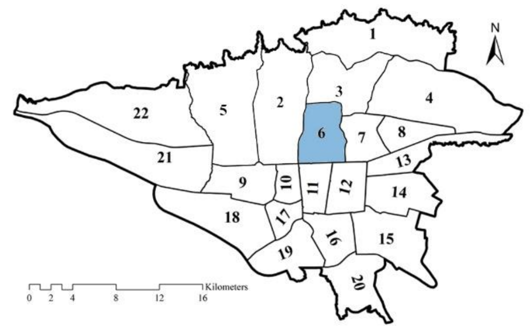
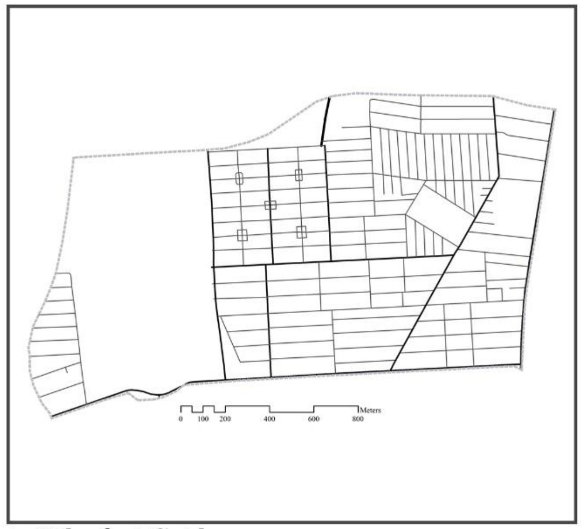
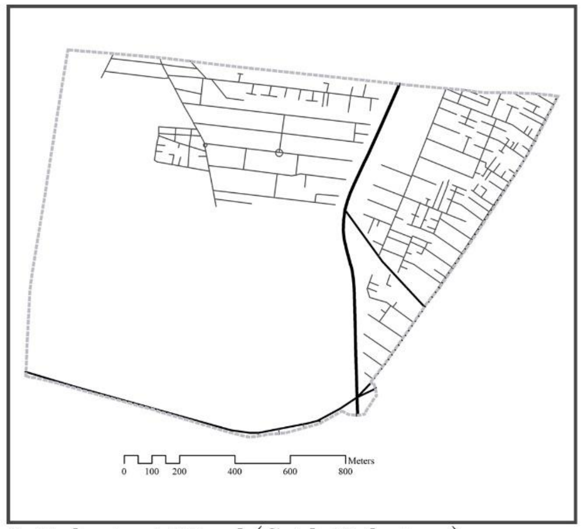


District 6

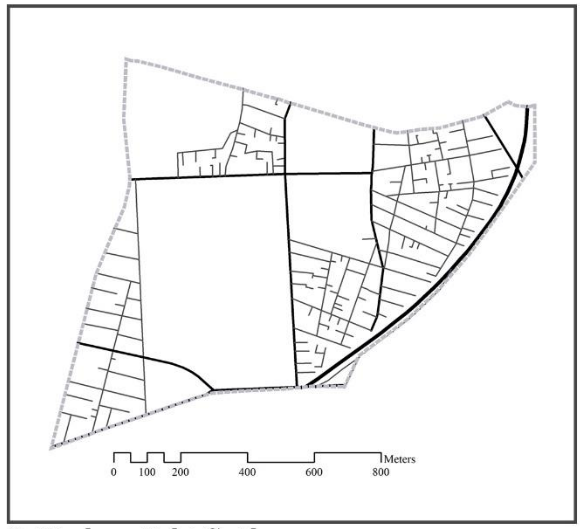




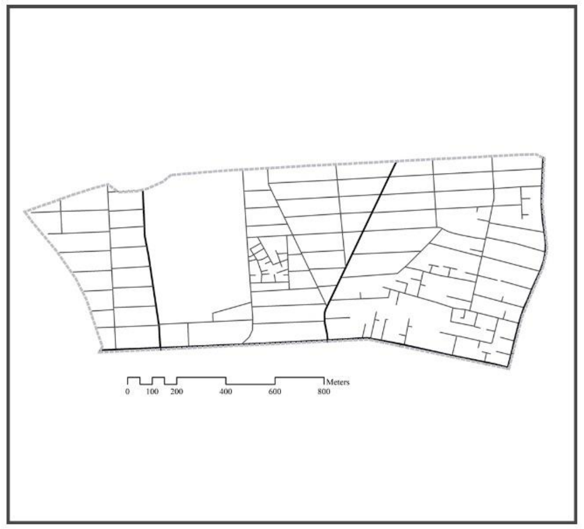
1. Niloofar: Grid



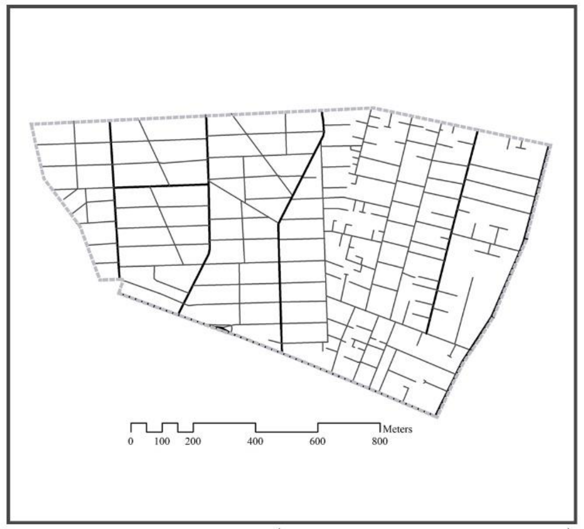
2. Dabestan: Mixed (Grid- Tributary)



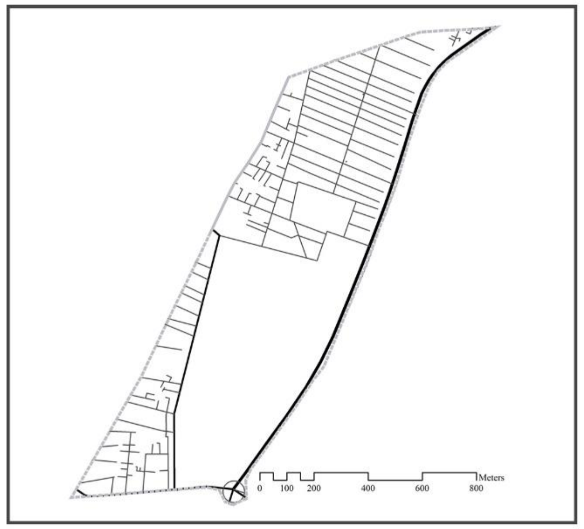
3. Heshmatieh: Grid



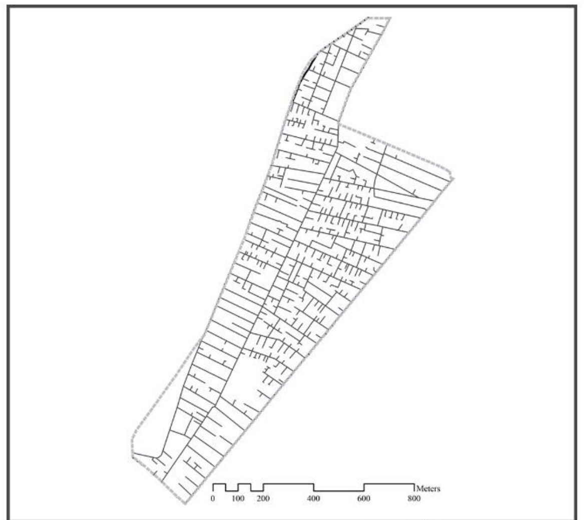
4. Abasabad: Grid



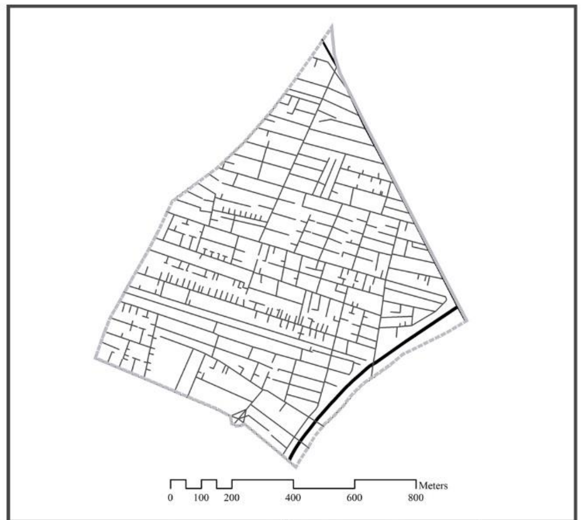
5. Sohrexardi: Mixed (Grid- Tributary- Radial)



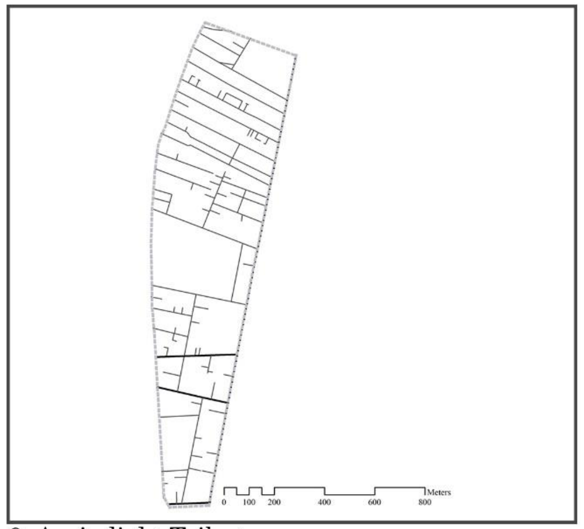
6. Kaj: Grid



7. Khajeh Nezam-ol-molk: Mixed (Grid- Tributary)



8. Araamaneh: Mixed (Grid- Tributary)



9. Amjadieh: Tributary

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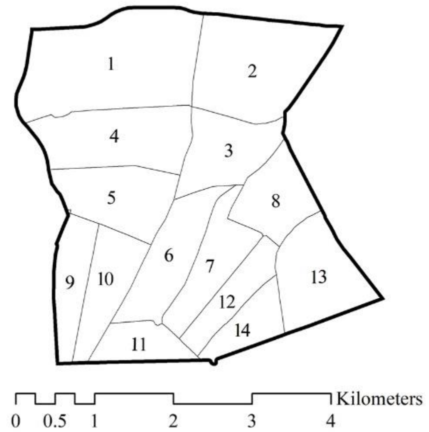
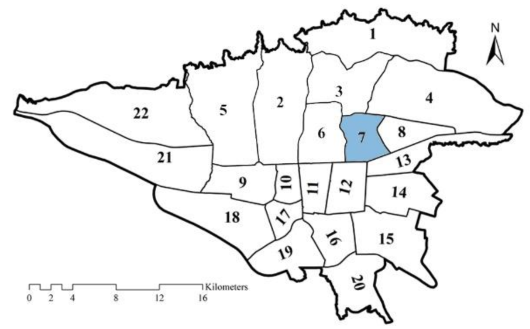
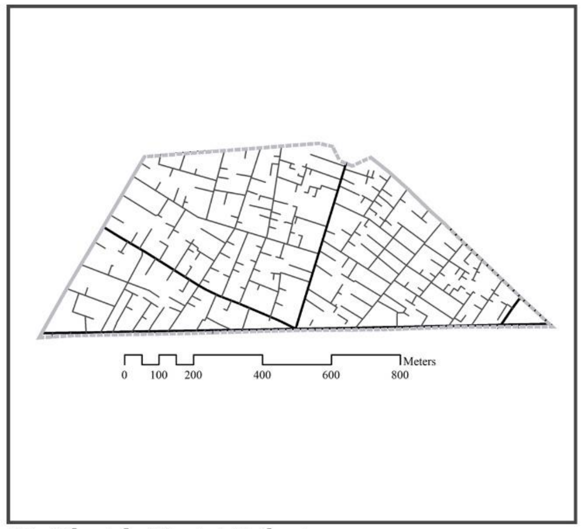


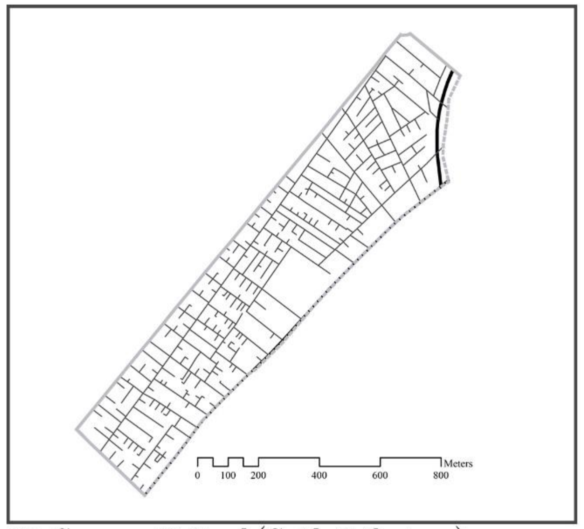
District 7



10. Bahar: Mixed (Grid- Tributary)

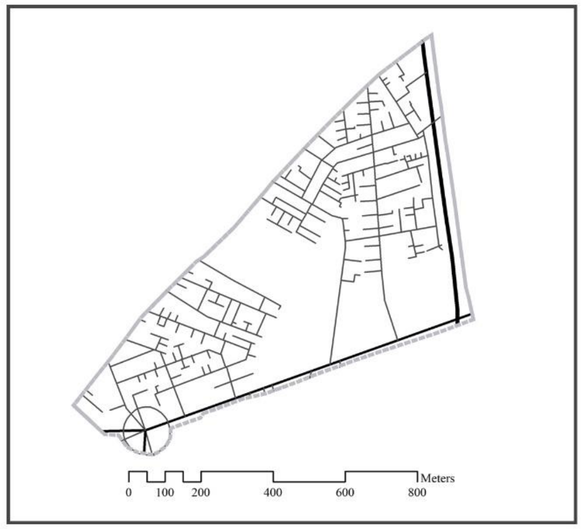


11. Khajeh Nasir: Tributary



12. Gorgaan: Mixed (Grid- Tributary)

13. Shahed: Mixed (Grid- Radial)



14. Nezamabad: Tributary

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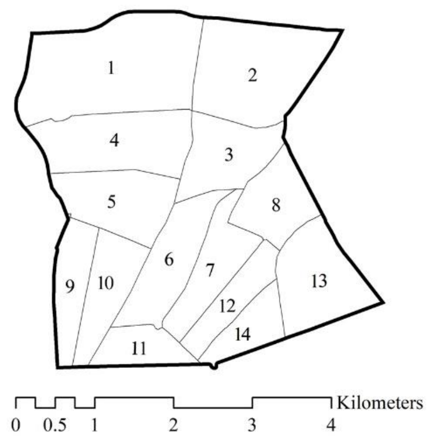
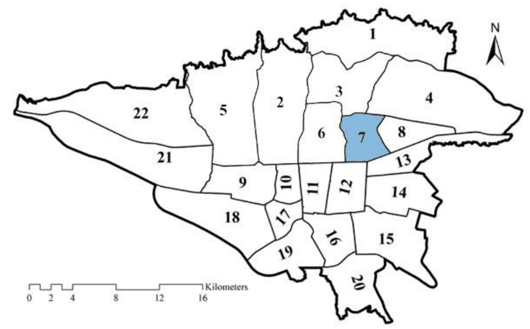


District 7



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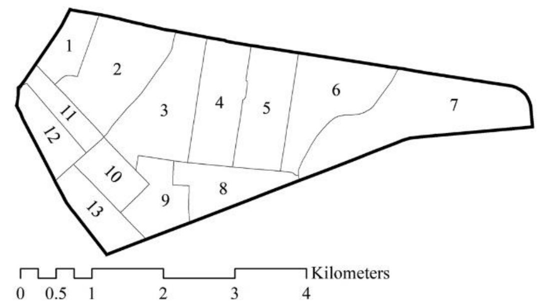
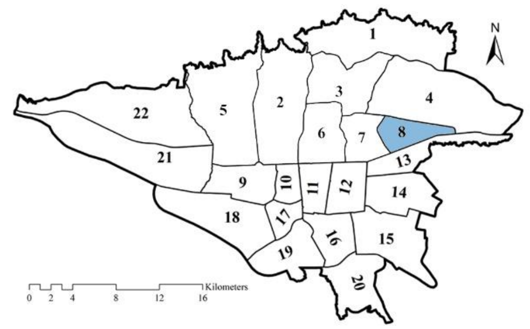
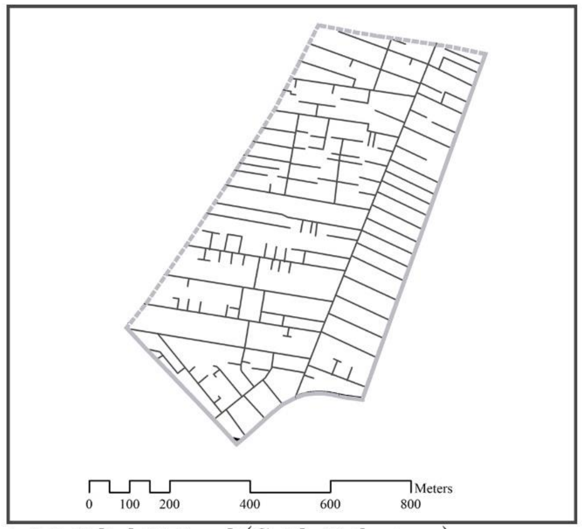
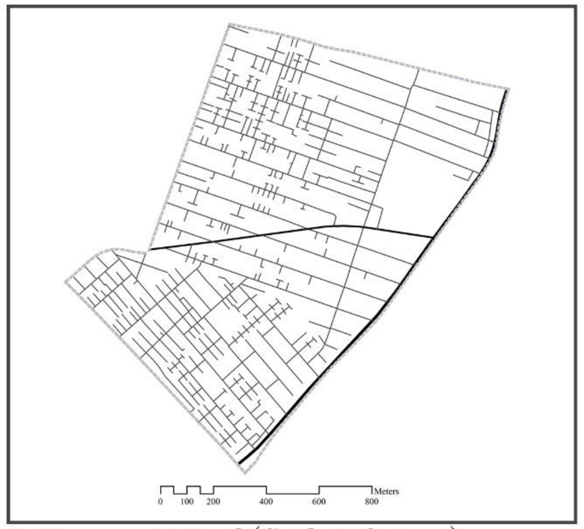


District 8



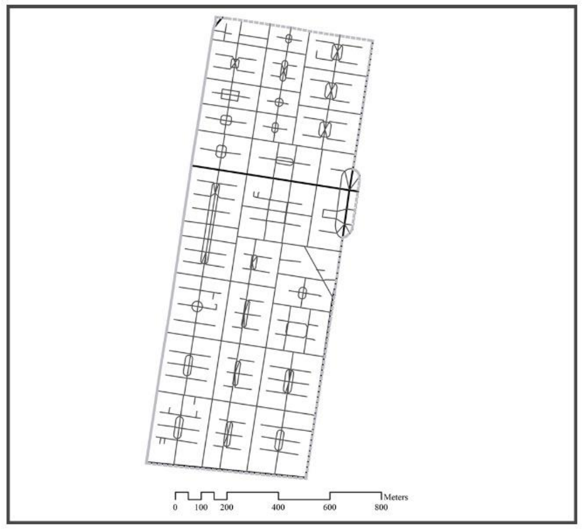


1. Majidieh: Mixed (Grid- Tributary)



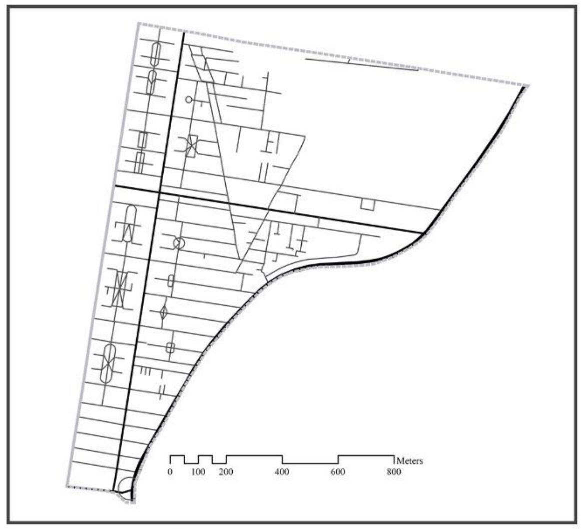
2. Kermaan: Mixed (Grid- Tributary)

3. Fadak: Grid

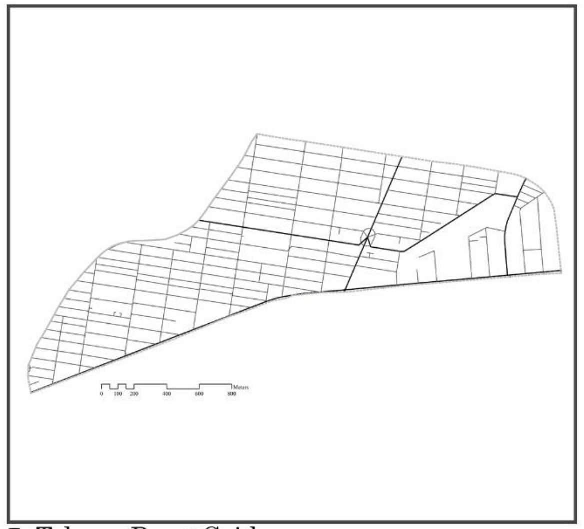


4. Haft Hoz: Grid

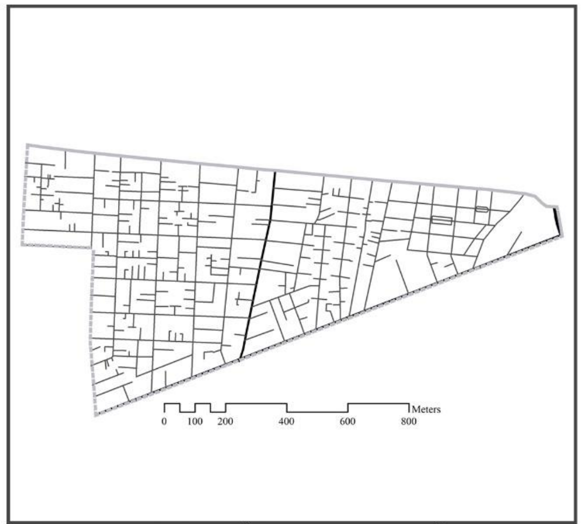
5. Madaen: Grid



6. Dardasht: Grid

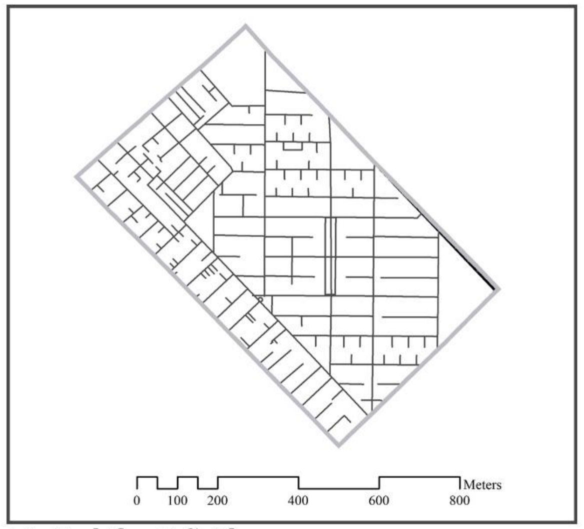


7. Tehran Pars: Grid

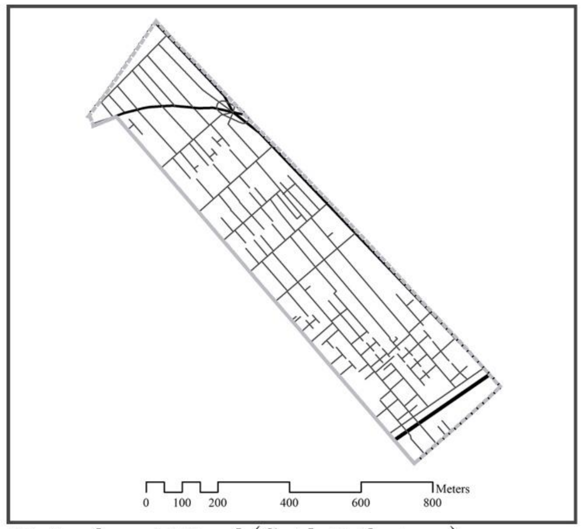


8. Narmak: Mixed (Grid- Tributary)

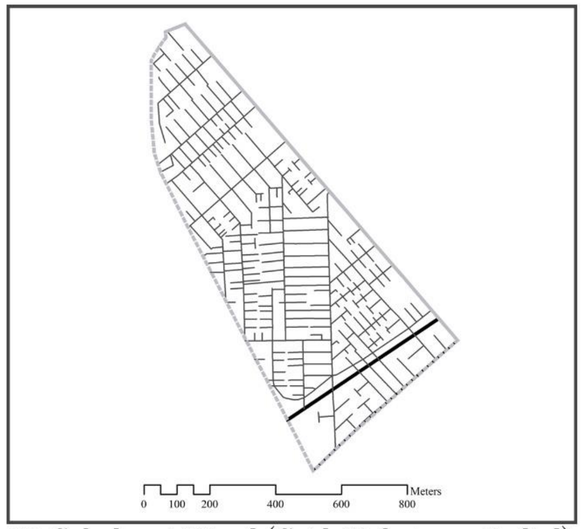
9. Zarkesh: Mixed (Grid- Tributary)



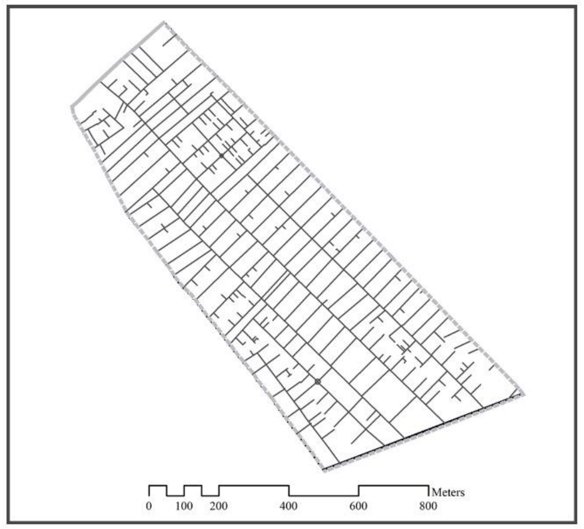
10. Tashilaat: Grid



11. Lashgar: Mixed (Grid- Tributary)



12. Sabalaan: Mixed (Grid- Tributary- Radial)



13. Vahidieh: Grid

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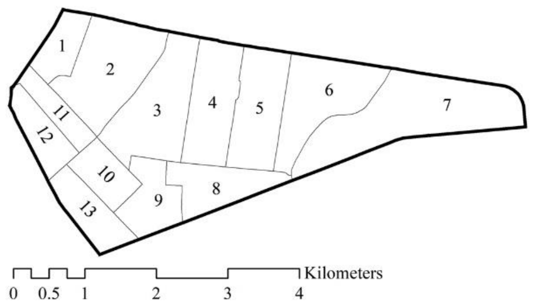
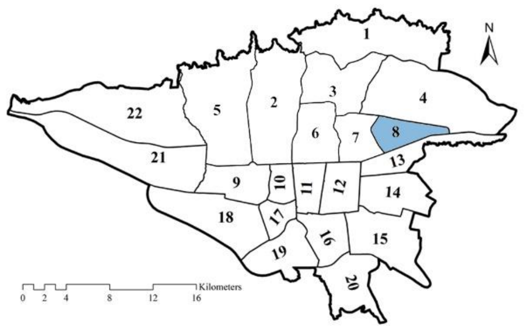
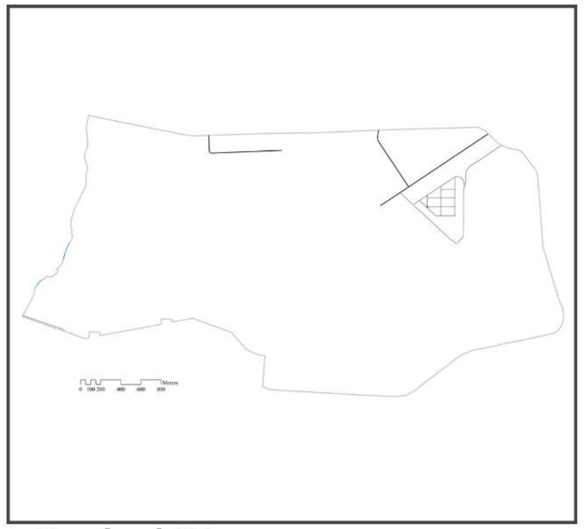
Legend:

Street
District Boundry
Water Bodies

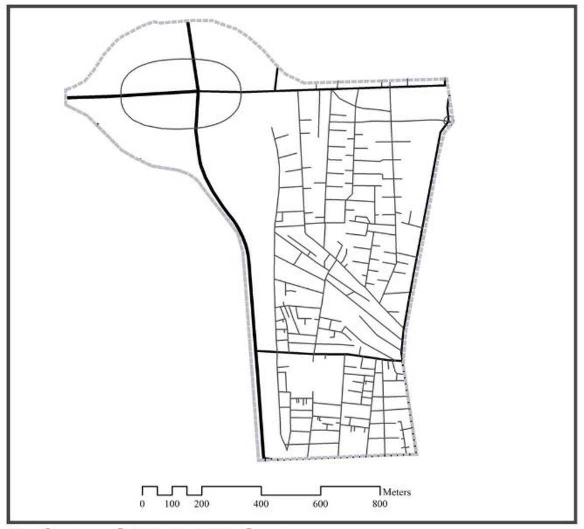


District 8



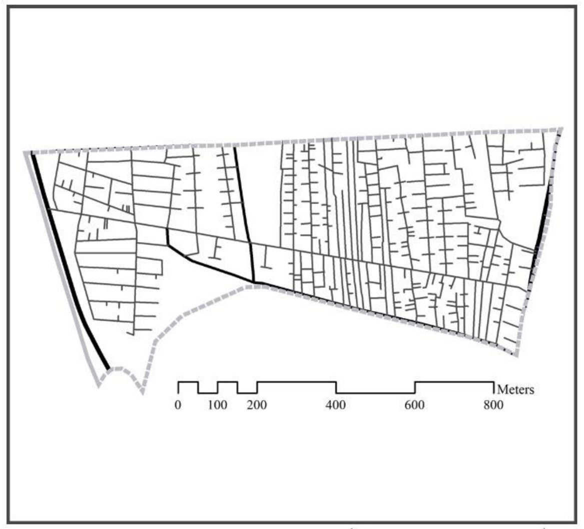


1. Furudgaah: Linear

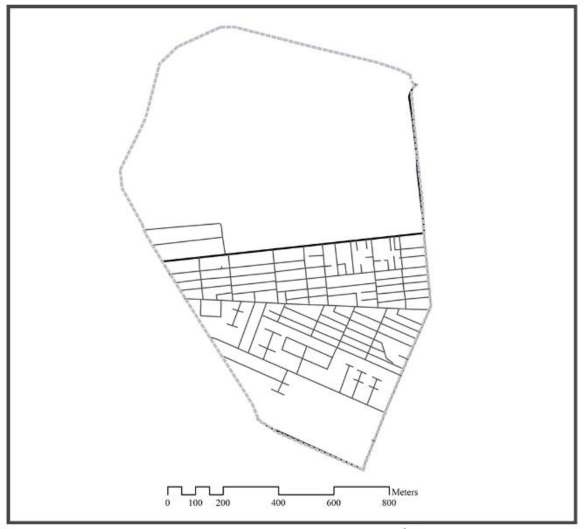


2. Ostaad Moin: Tributary

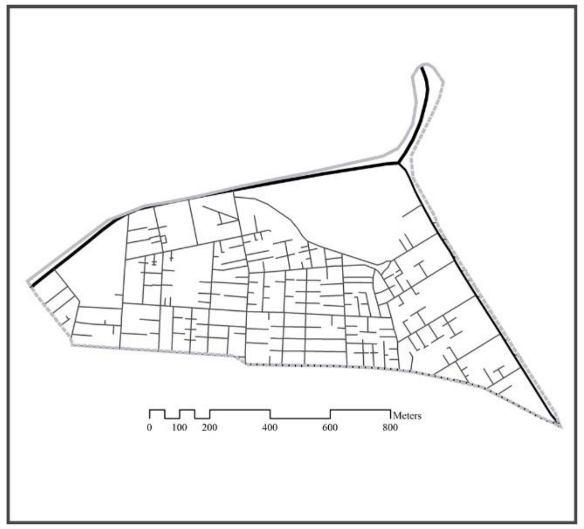
3. Dr. Hooshyar: Mixed (Organic- Tributary)



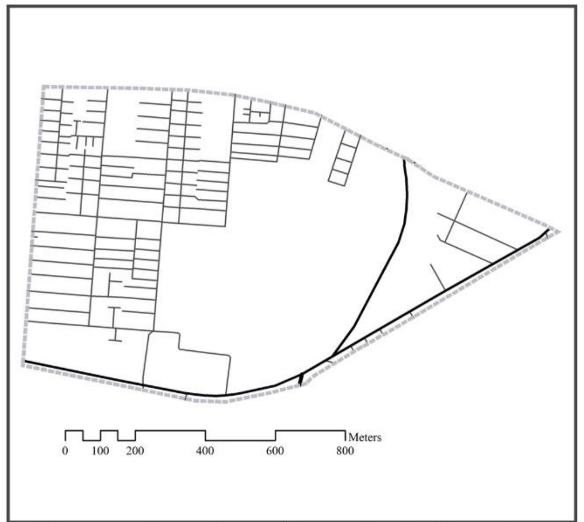
4. Shahid Dastqeyb: Mixed (Grid- Tributary)



5. Imamzadeh Abdollah: Mixed (Grid- Tributary)

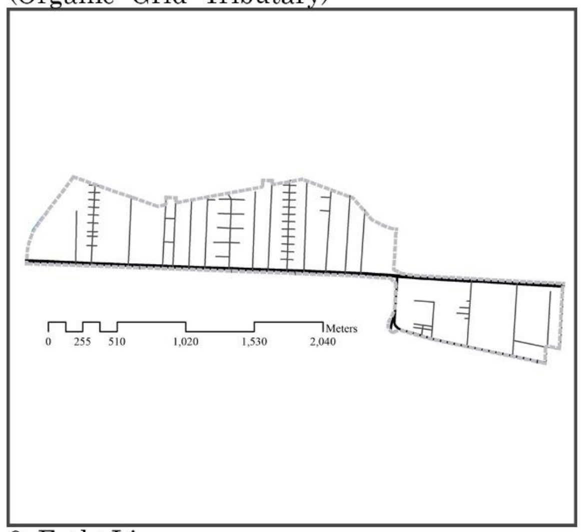


6. South Mehrabad: Mixed (Organic- Grid- Tributary)



7. Shamashiri: Mixed (Organic- Grid- Tributary)

8. Sar Aasiaab: Grid



9. Fath: Linear

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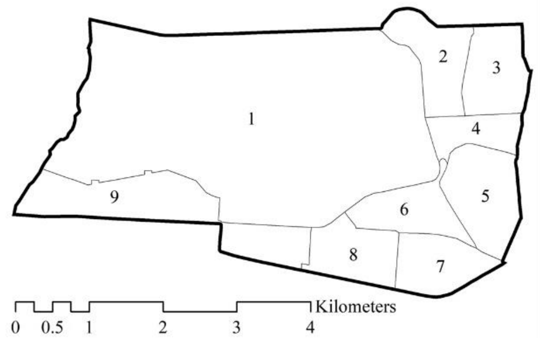
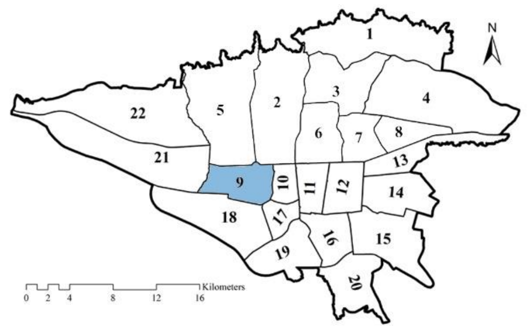


District 9

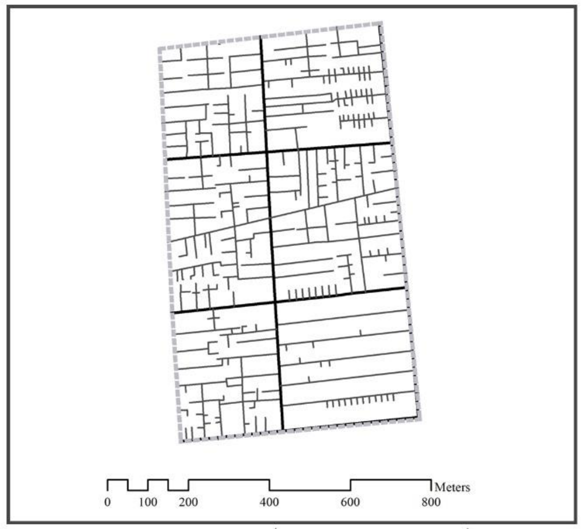


1. Zanjan: Tributary

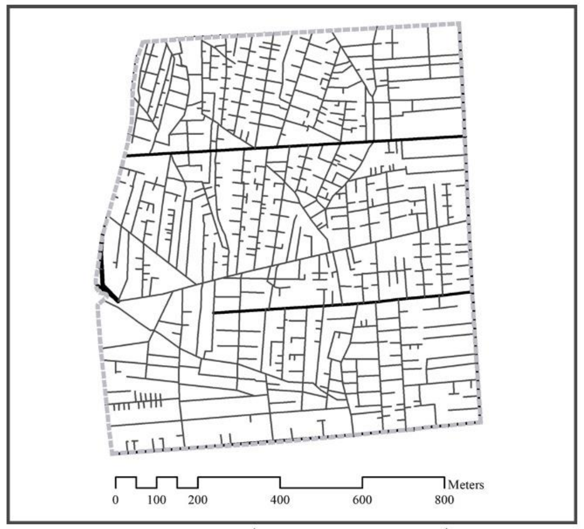
2. Kaaroon: Mixed (Grid- Tributary)

3. Salsabil: Mixed (Grid- Tributary)

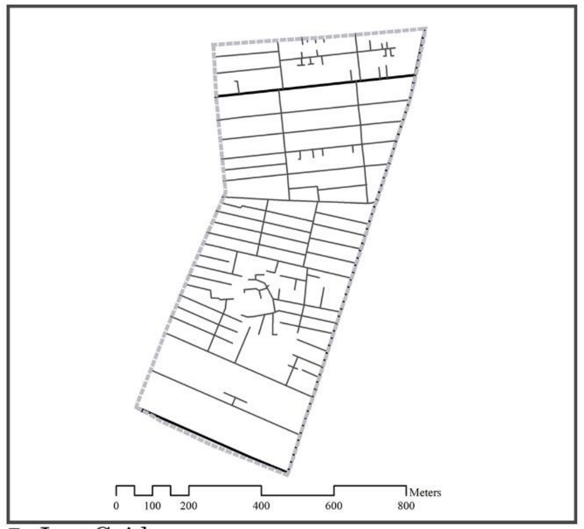
4. Imam Khomeini: Mixed (Grid- Tributary)



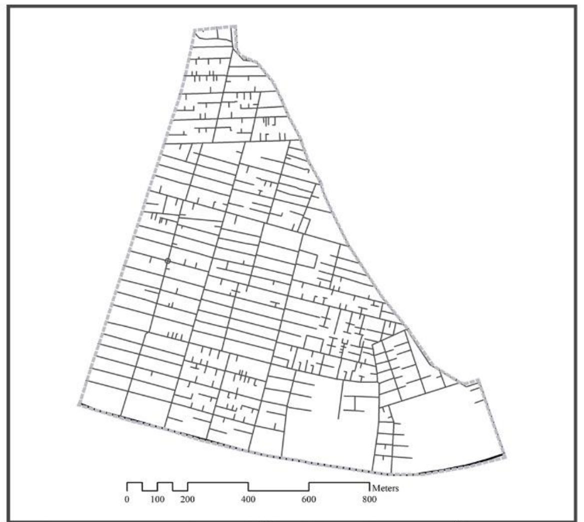
5. Mortazawi: Mixed (Grid- Tributary)



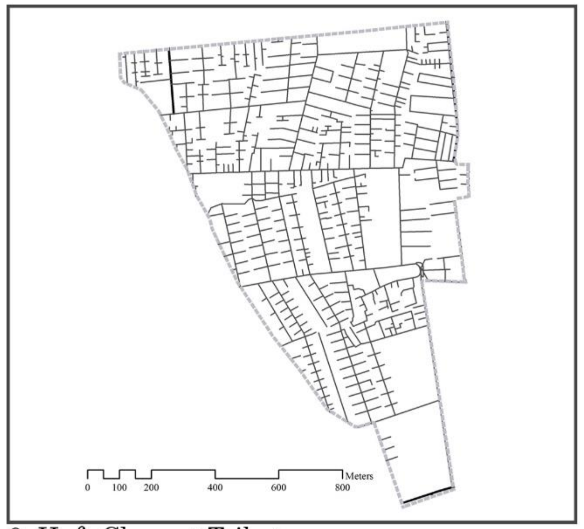
6. Hashemi: Mixed (Grid- Tributary)



7. Jey: Grid



9. Soleimani: Mixed (Grid- Tributary)



9. Haft Chenar: Tributary

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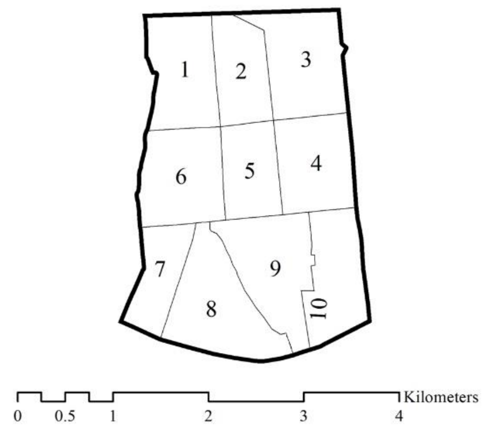
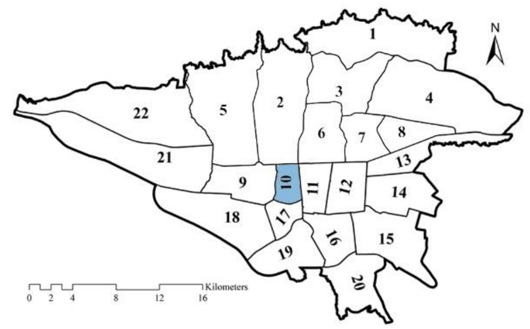
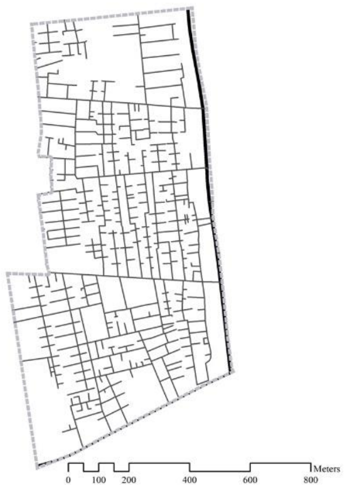
Street
District Boundry
Water Bodies



District 10





10. Beryanak: Tributary

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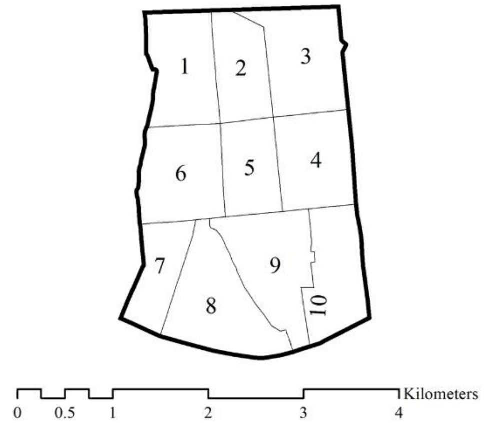

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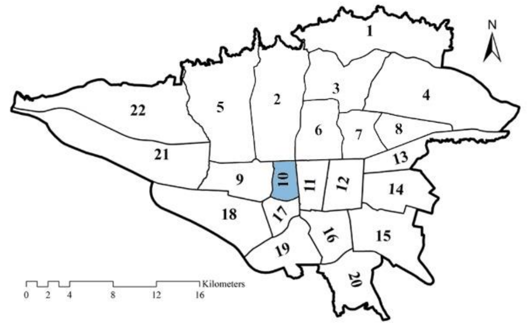

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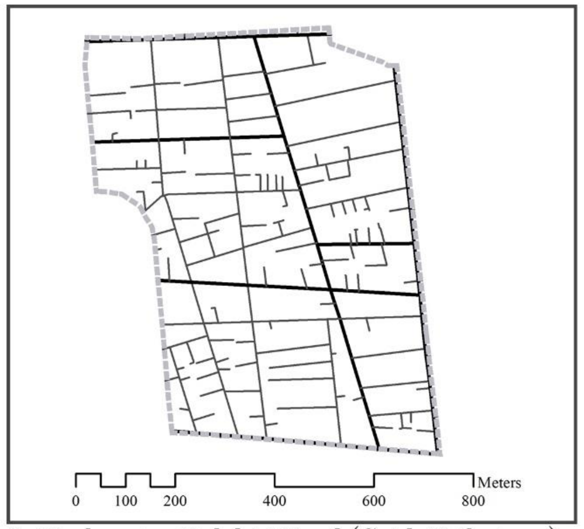
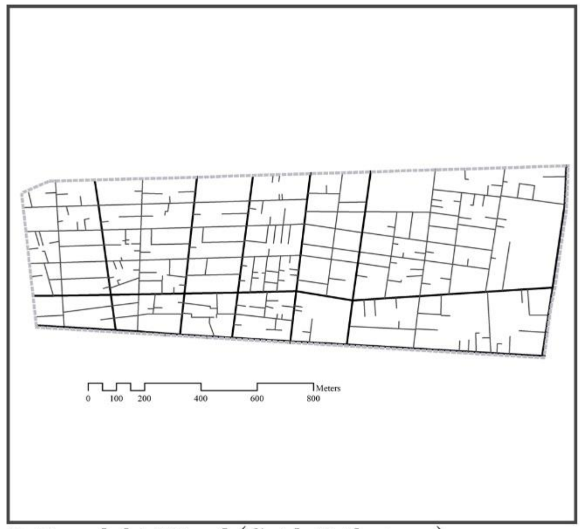
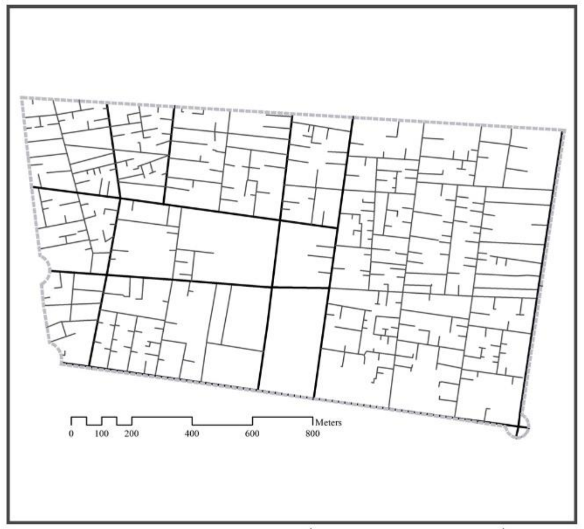
1. Jomhouri: Mixed (Grid- Tributary)



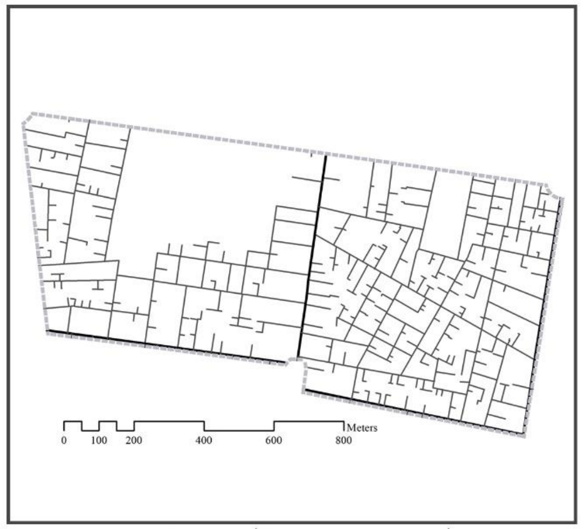
2. Heshmat-o Doleh: Mixed (Grid- Tributary)



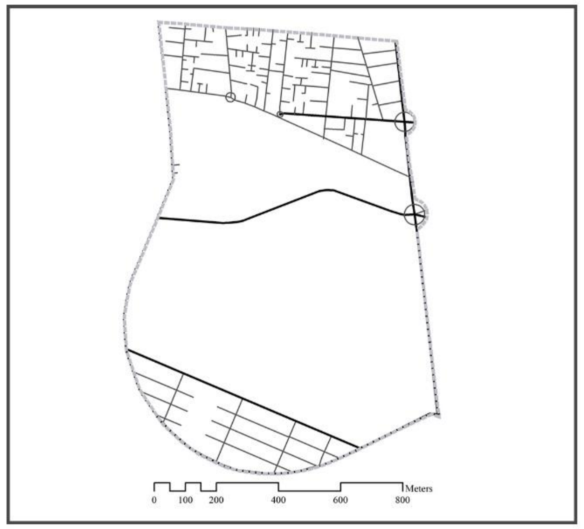
3. Enqelab: Mixed (Grid- Tributary)



4. Sheikh Haadi: Mixed (Grid- Tributary)



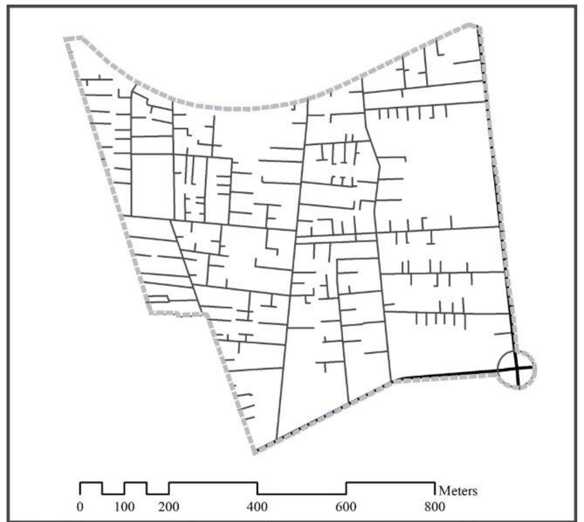
5. Monirieh: Mixed (Grid- Tributary)



6. Hor: Tributary

7. Eskandari: Tributary

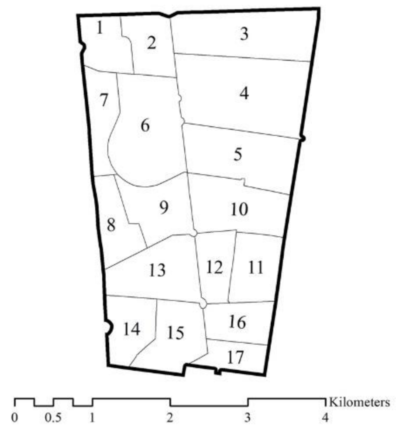
8. Salaamat: Mixed (Grid- Tributary)



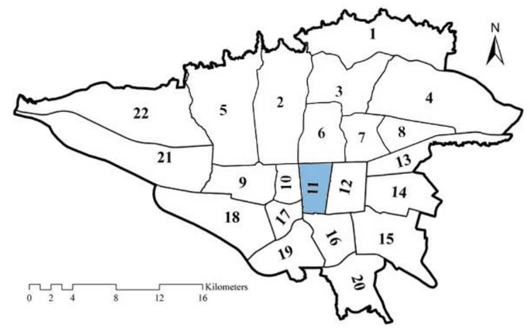
9. Makhsous: Mixed (Grid- Tributary)

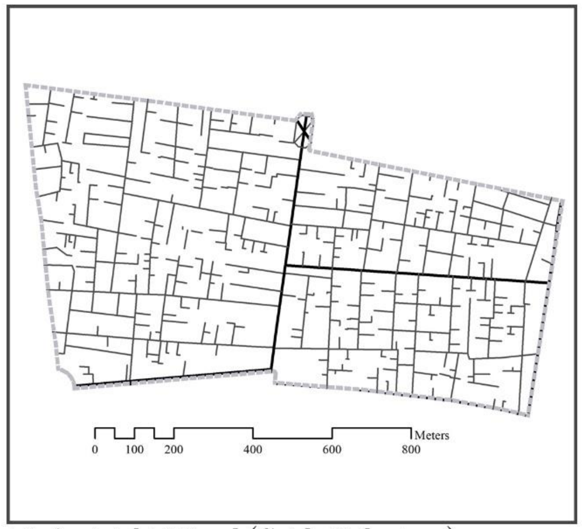
Legend:

Street
District Boundry
Water Bodies

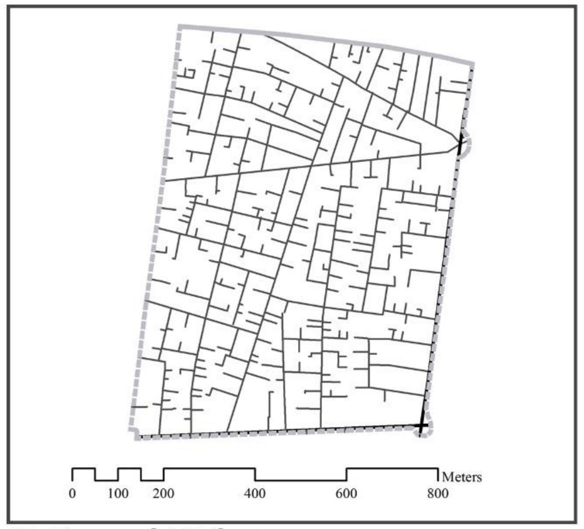


District 11

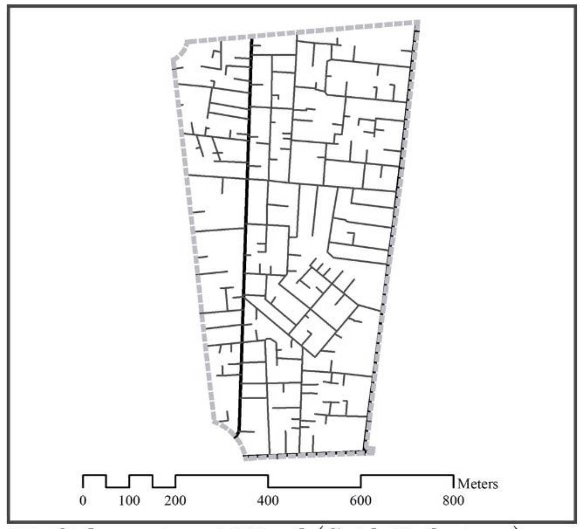




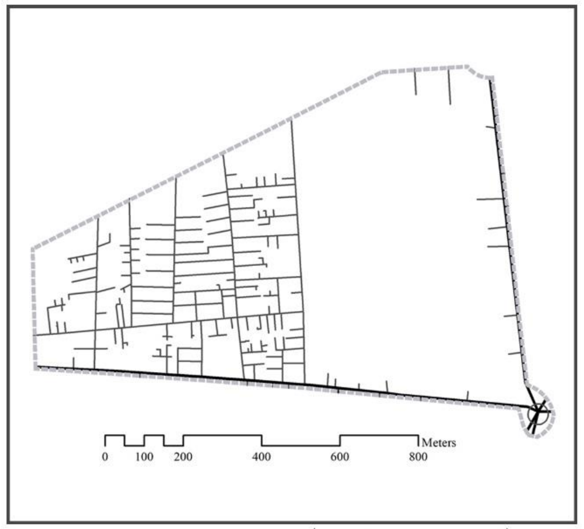
10. Amirieh: Mixed (Grid- Tributary)



11. Furuzesh: Tributary



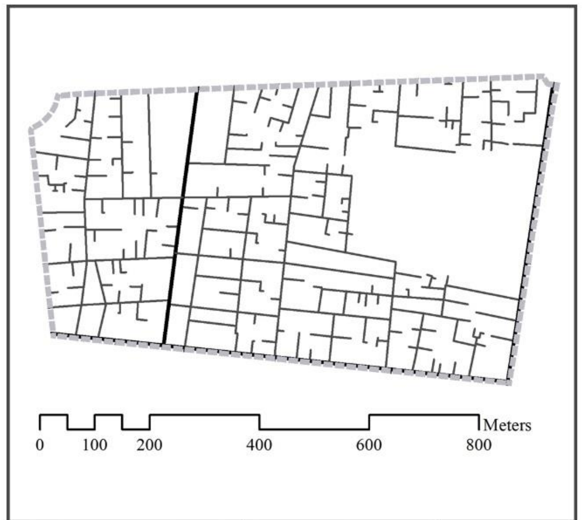
12. Qalamestaan: Mixed (Grid- Tributary)



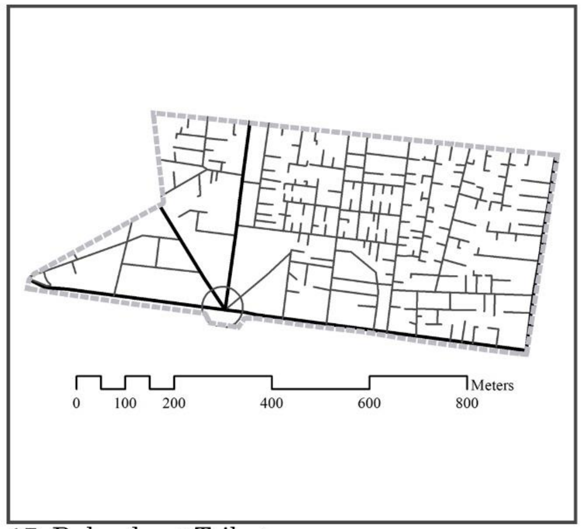
13. Helal Ahmar: Mixed (Grid- Tributary)

14. Abaasi: Mixed (Grid- Tributary)

15. Anbaar Naft: Mixed (Radial- Tributary)



16. Agaahi: Mixed (Grid- Tributary)



17. Rahaahan: Tributary

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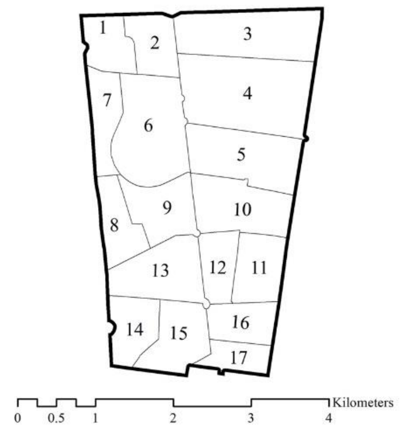
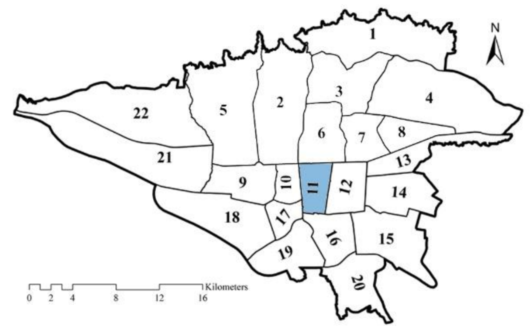
Water Bodies

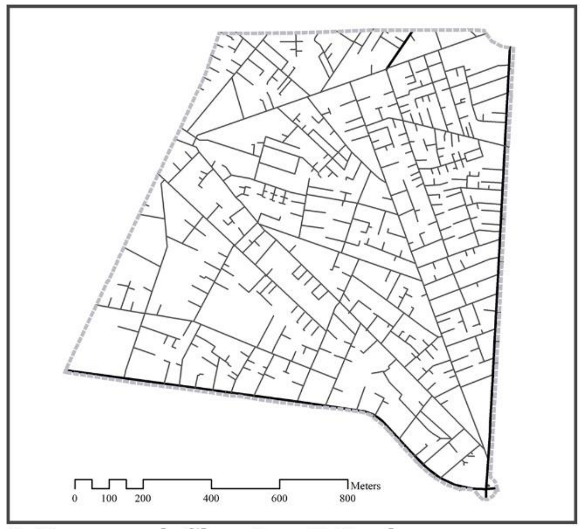


District 11

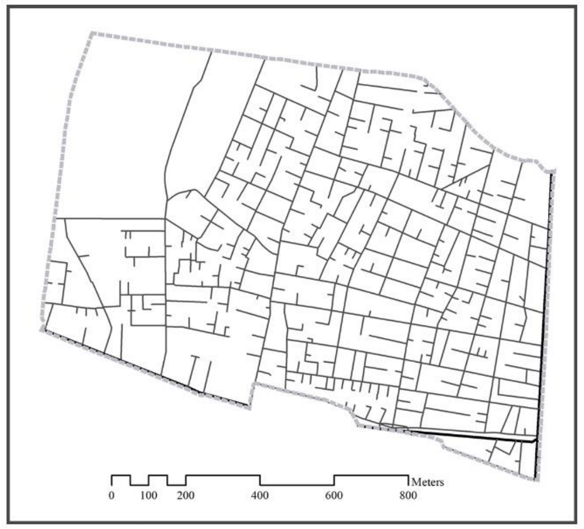


1. Ferdosi: Tributary

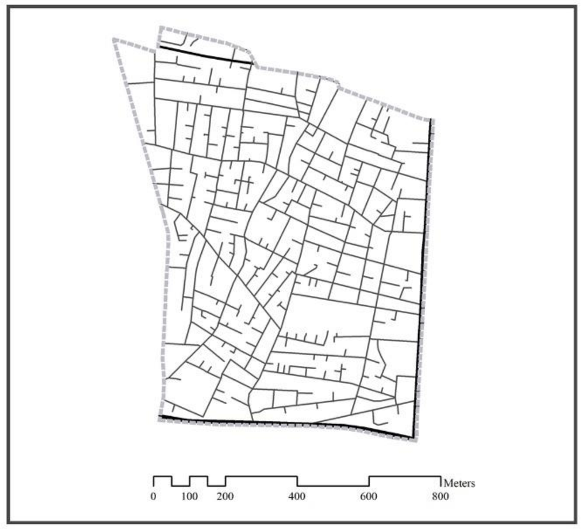
2. Baharestaan: Tributary



3. Darvwazeh Shemiran: Mixed (Radial- Tributary)



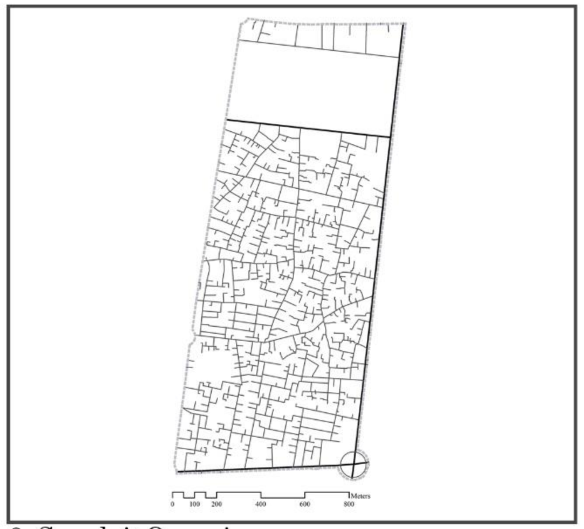
4. Iran: Tributary



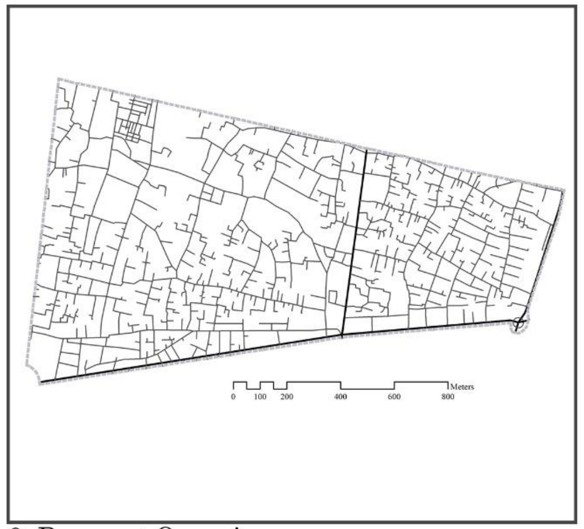
5. Abshaar: Organic

6. Imamzadeh Yahya: Organic

7. Pamenar: Organic



8. Sanglaj: Organic



9. Baazaar: Organic

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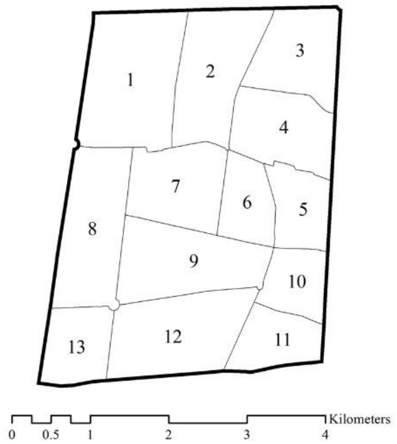
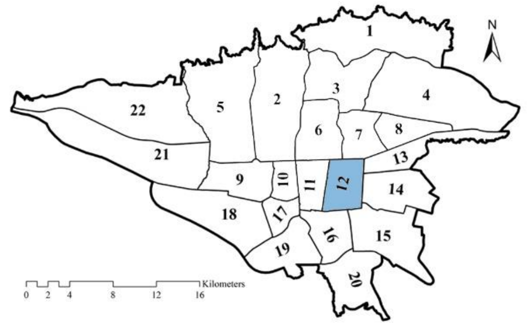
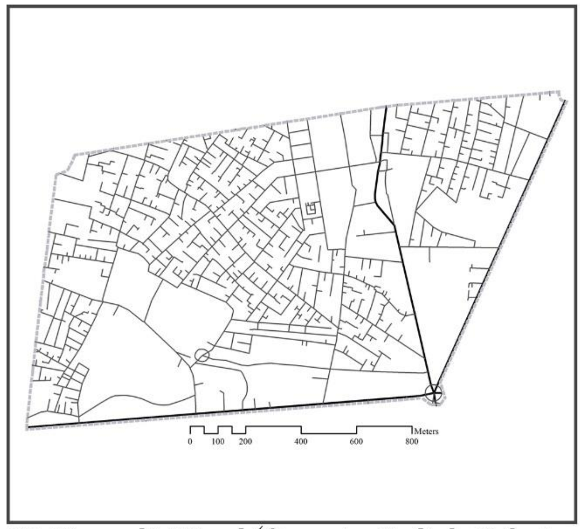


District 12



10. Qiyam: Mixed (Organic- Grid)

11. Kosar: Mixed (Grid- Tributary)



12. Harandi: Mixed (Organic- Radial- Tributary)

13. Takhti: Mixed (Grid- Tributary)

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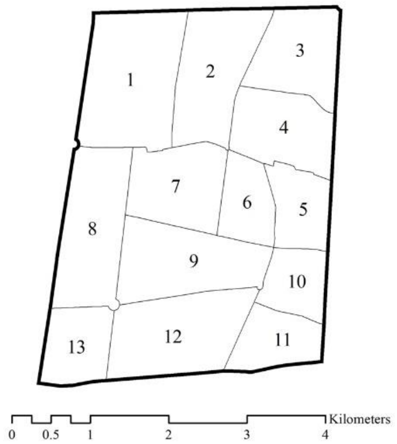
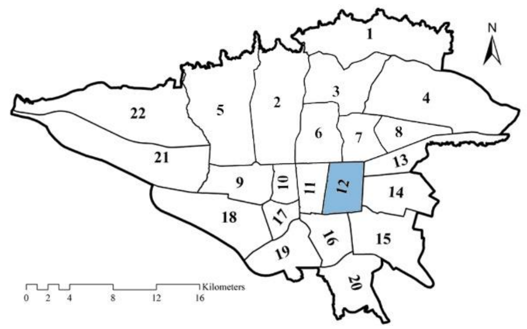
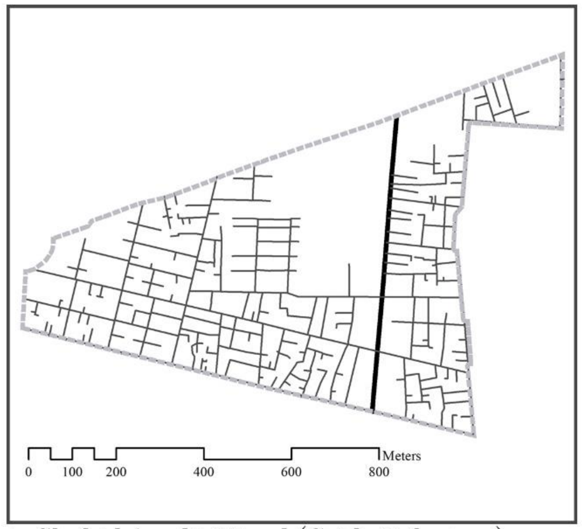
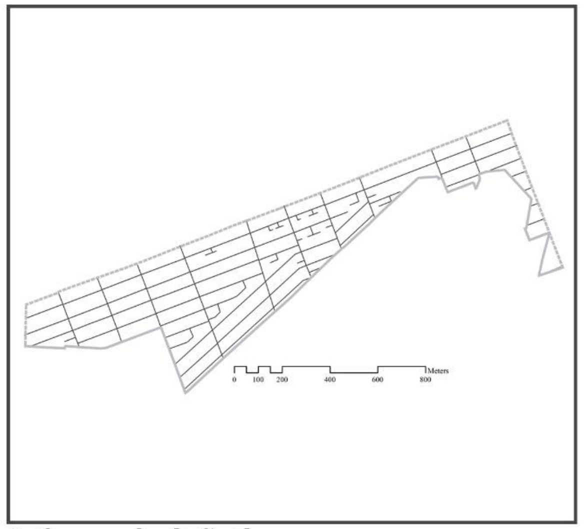


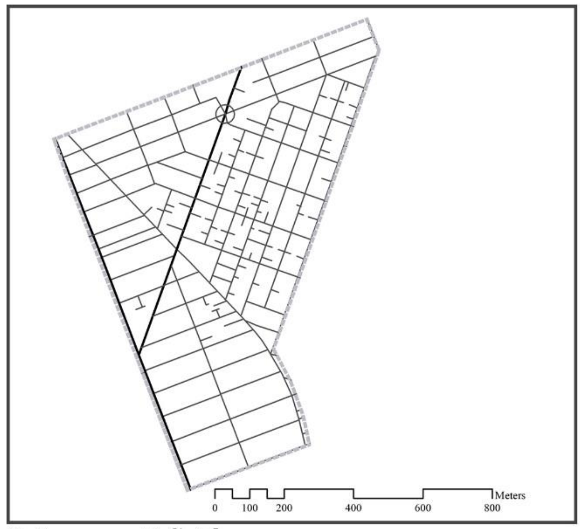
District 12



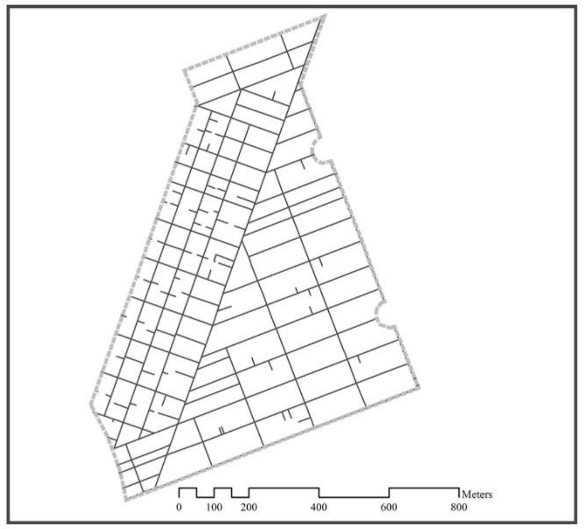


1. Shahid Asadi: Mixed (Grid- Tributary)

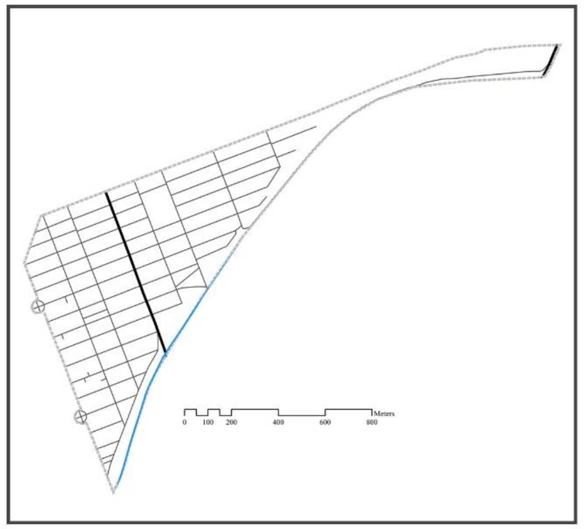

2. Qasemabad: Grid

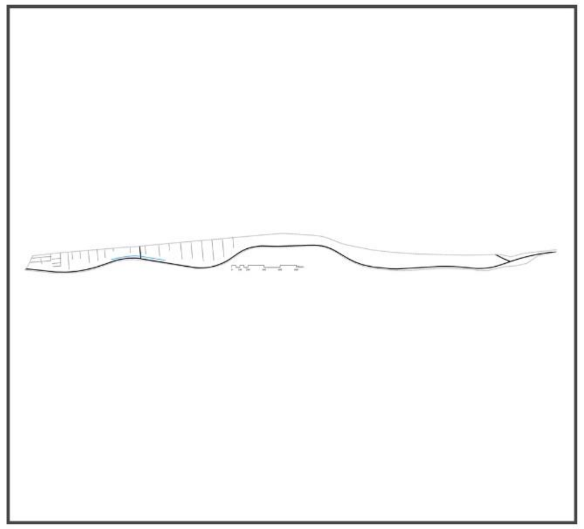


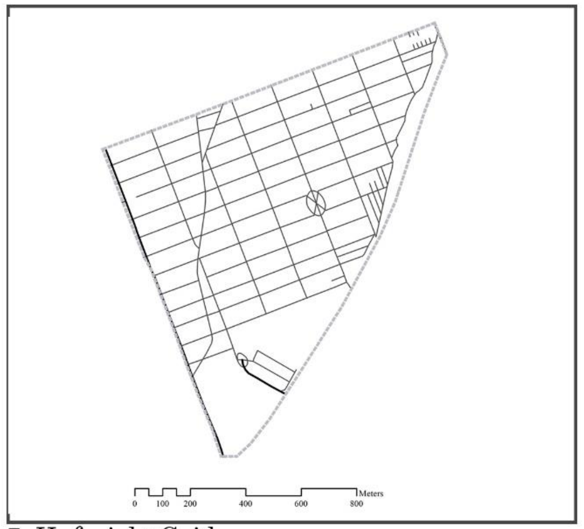
3. Imaamat: Grid

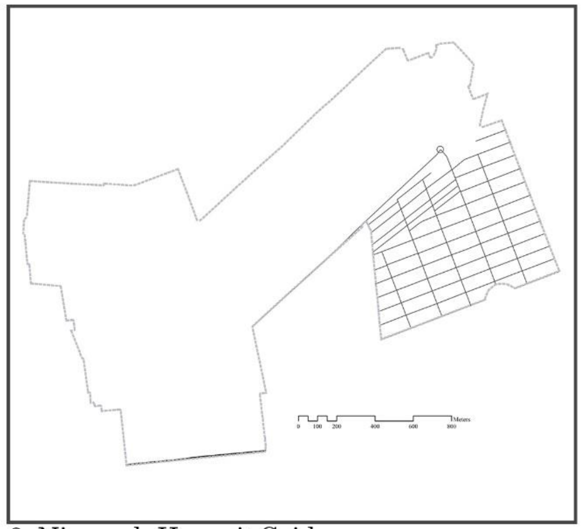


4. Shoraa: Grid


5. Aashtiaani: Grid


6. Sorkh-e Hesar: Linear


7. Hafezieh: Grid


8. Nirooyeh Havaei: Grid

9. Safa: Mixed (Grid- Tributary)

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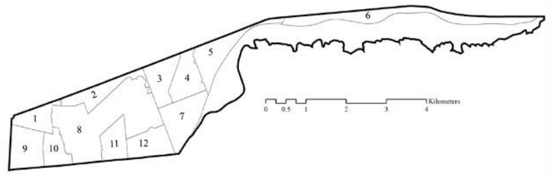
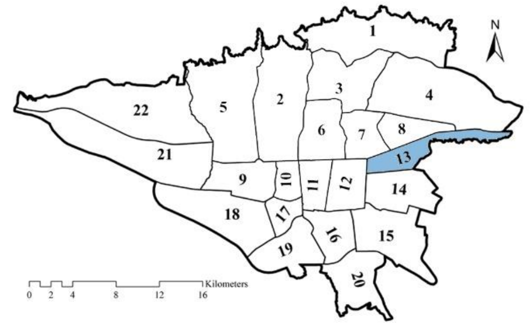
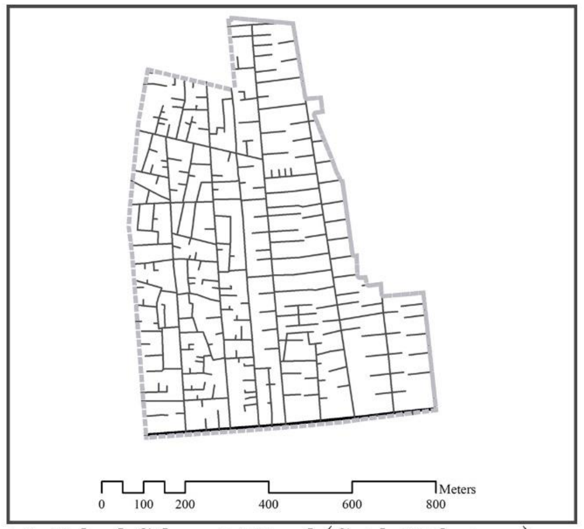
Legend:

Street
District Boundry
Water Bodies

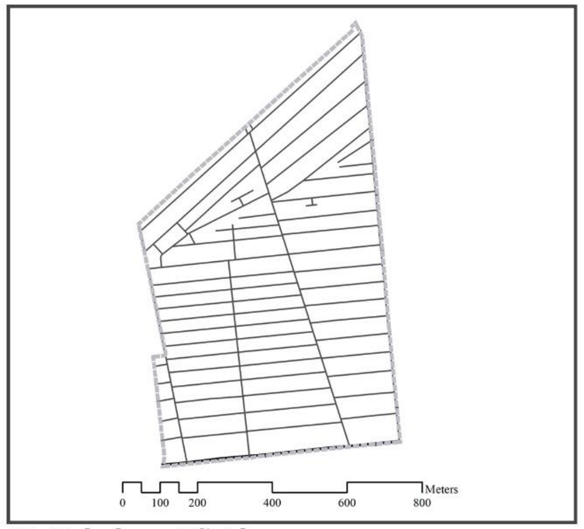


District 13

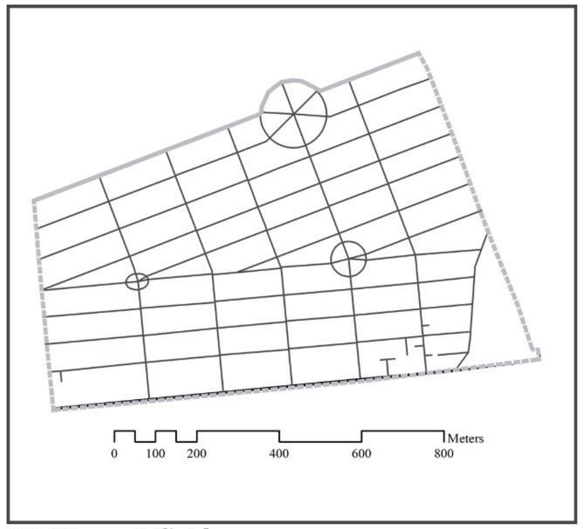




10. Zahed Gilaani: Mixed (Grid- Tributary)



11. Dehghaan: Grid



12. Pirouzi: Grid

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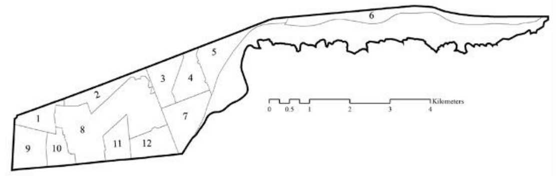
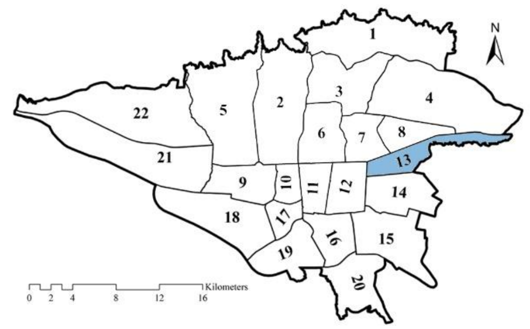
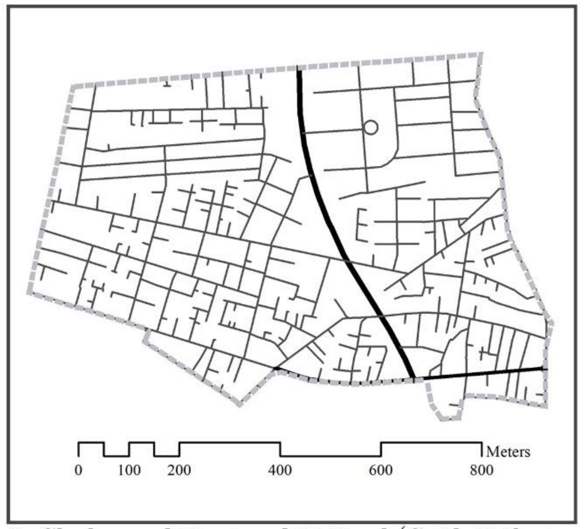


District 13

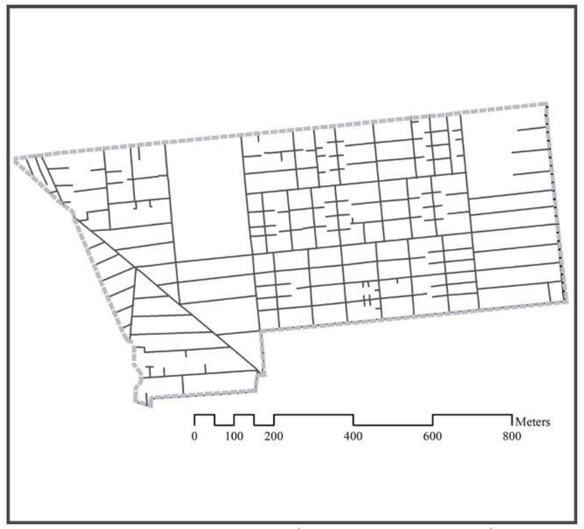


1. Shokoufeh: Mixed (Grid- Tributary- Radial)



2. Chaharsad Dastgaah: Mixed (Grid- Tributary)

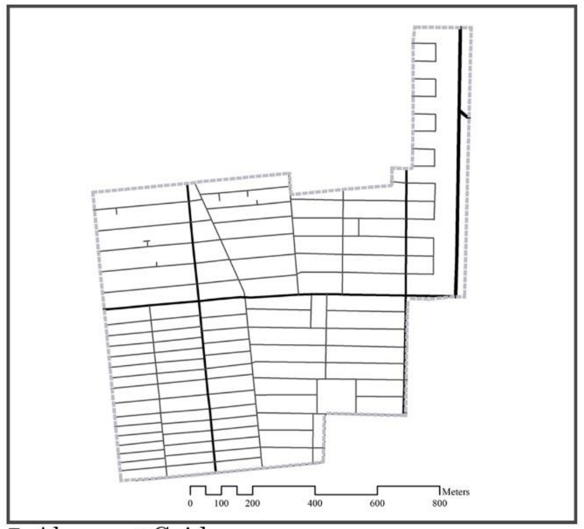
3. Javadieh: Mixed (Grid- Organic)



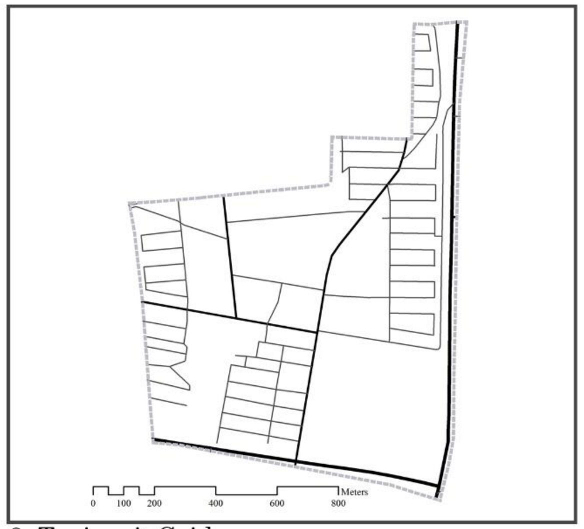
4. Sad Dastgah: Mixed (Grid- Tributary)

5. Parastar: Grid

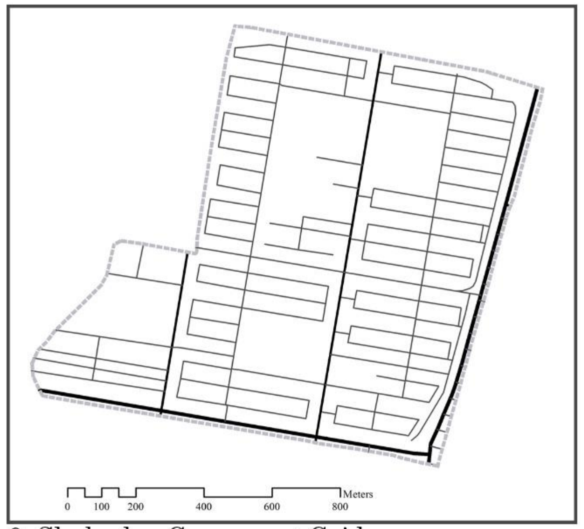

6. Qasr-e Firouzeh: Mixed (Grid- Tributary)



7. Abouzar: Grid



8. Taxirani: Grid



9. Shahadae Gomnaam: Grid

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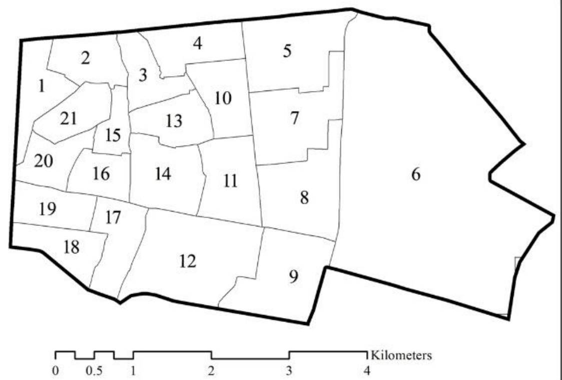
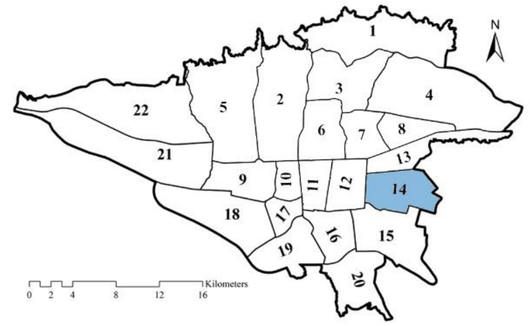
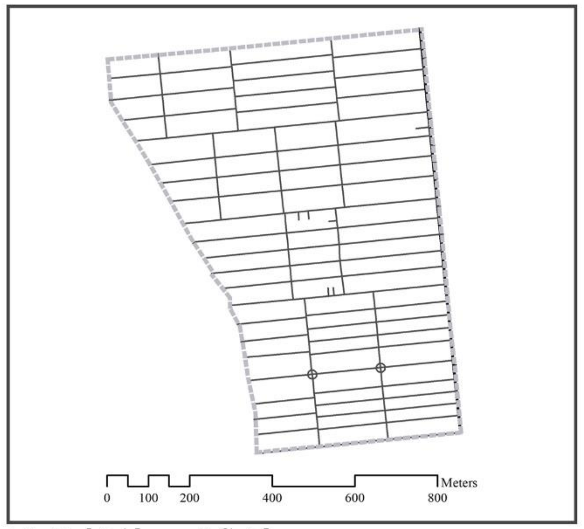
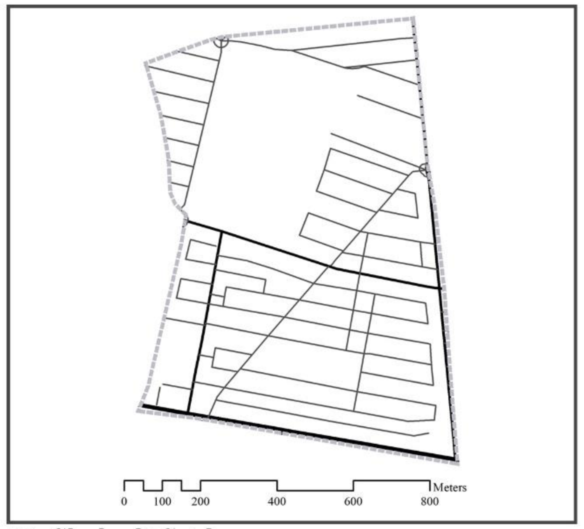


District 14

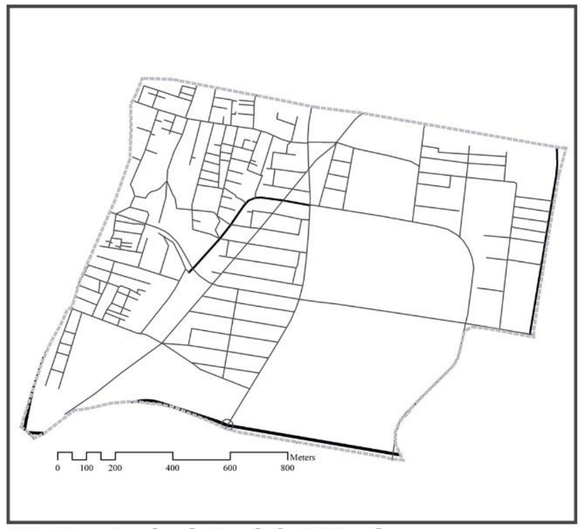




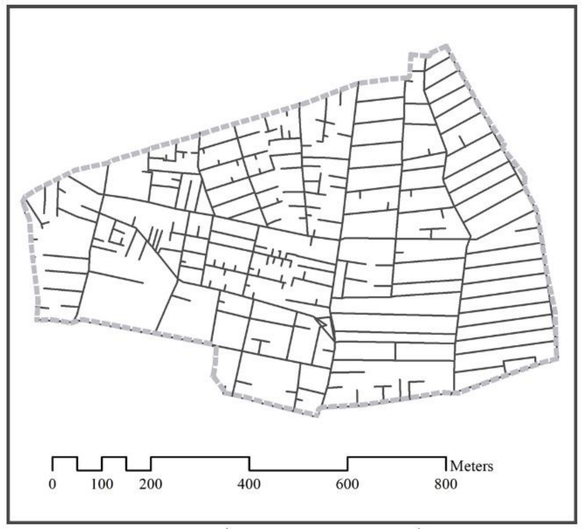
10. Nabi Akram: Grid



11. Shahed: Grid



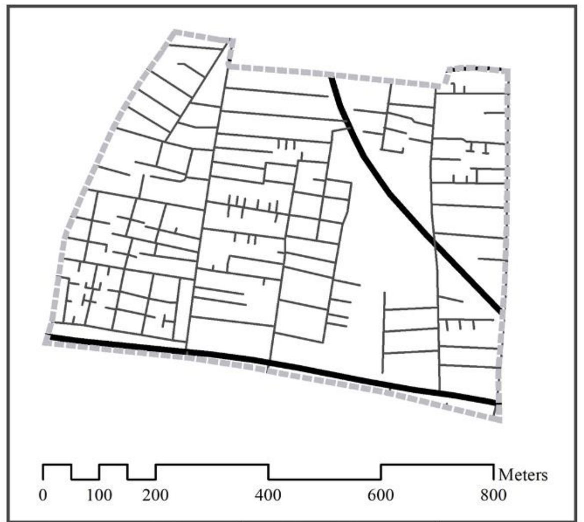
12. Hoseinabad Doulab: Mixed (Tributary- Organic)



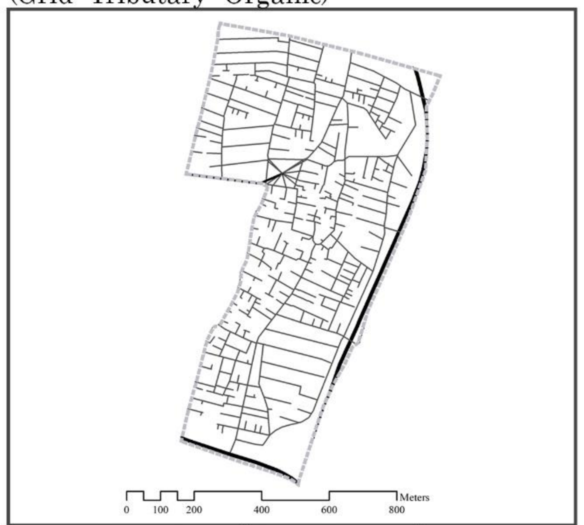
13. Shiva: Mixed (Grid- Tributary)

14. Saheb-al-Zaman: Mixed (Grid- Tributary- Organic)

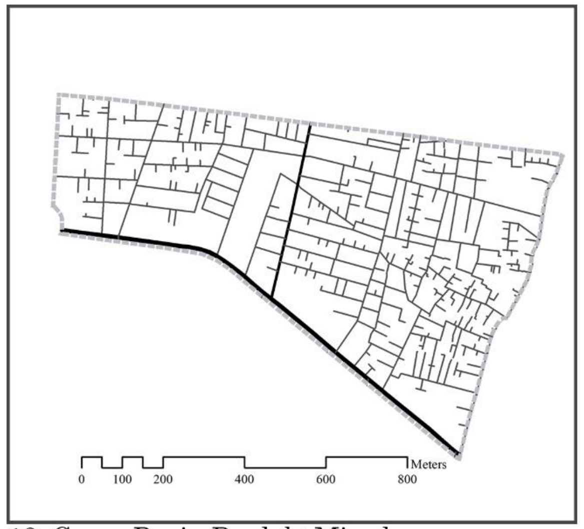
15. Sarsiab Doulab: Mixed (Grid- Tributary)



16. Shahin: Mixed (Grid- Tributary)



17. Doulab: Mixed (Grid- Organic)



18. Gozar Payin Doulab: Mixed (Grid- Tributary- Organic)

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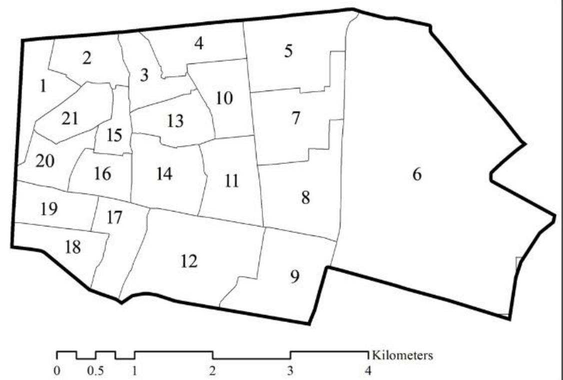
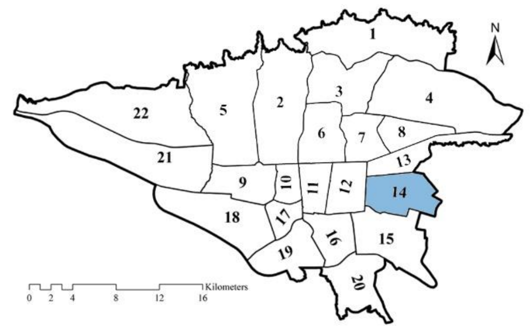
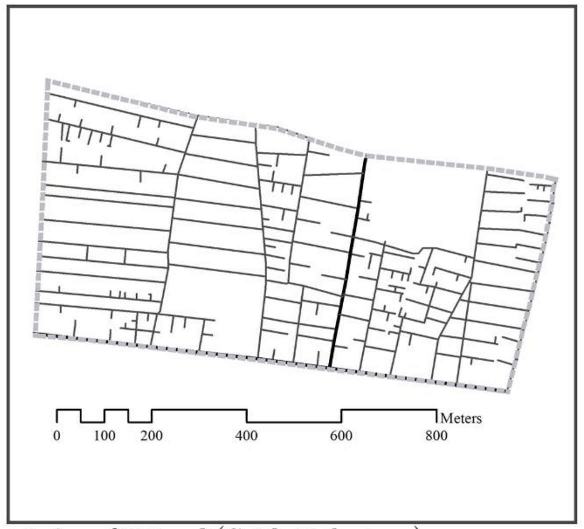
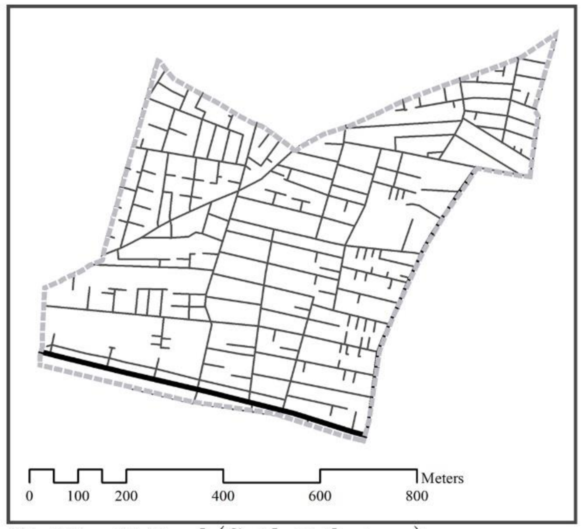


District 14

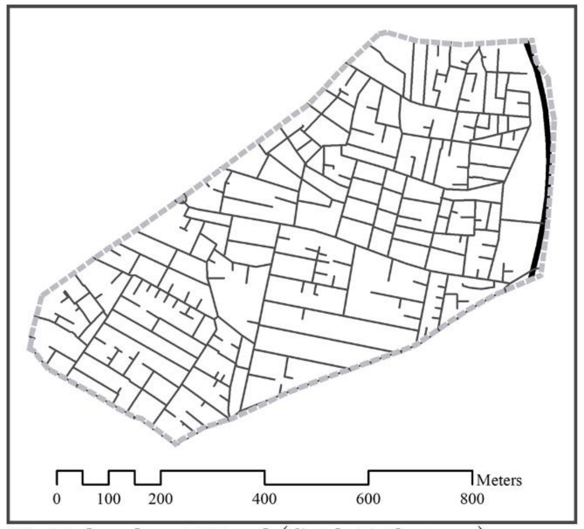




19. Aaref: Mixed (Grid- Tributary)



20. Mina: Mixed (Grid- Tributary)



21. Delgoshaa: Mixed (Grid- Tributary)

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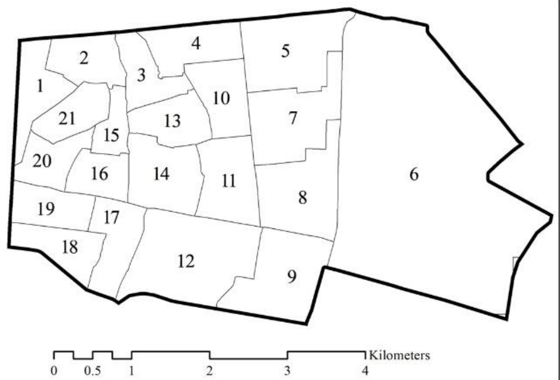
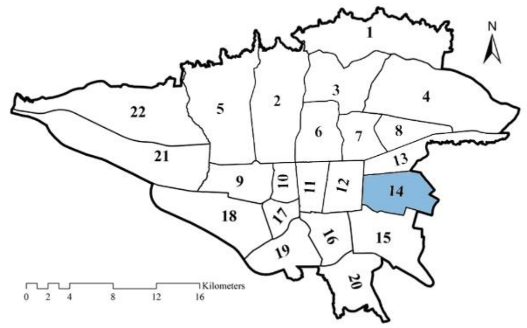
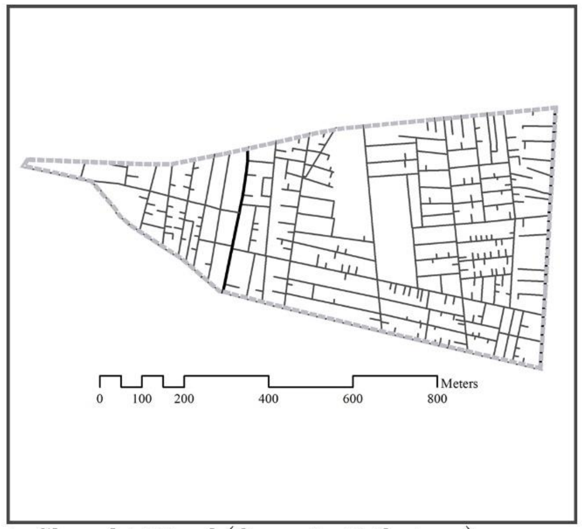
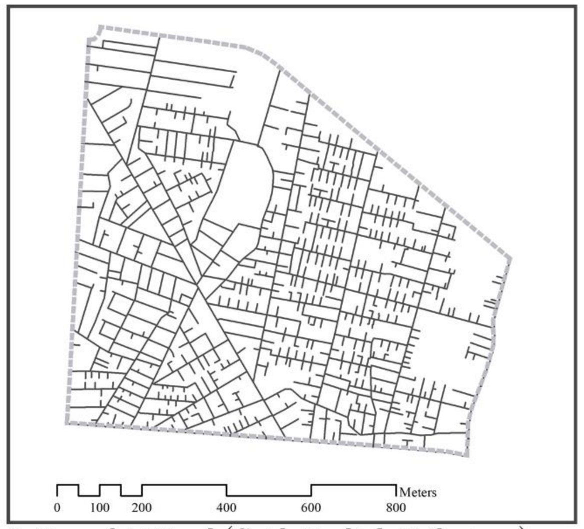


District 14

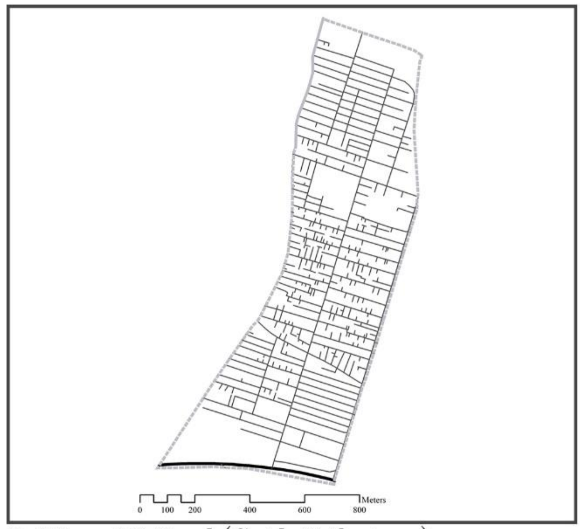




1. Shoush: Mixed (Organic- Tributary)

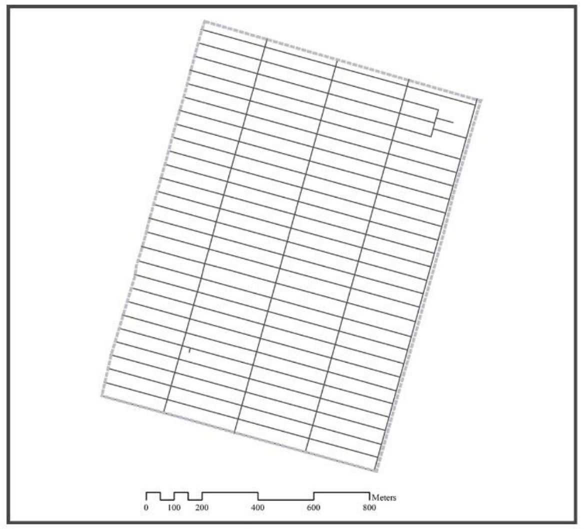


2. Tayyeb: Mixed (Grid- Radial- Tributary)

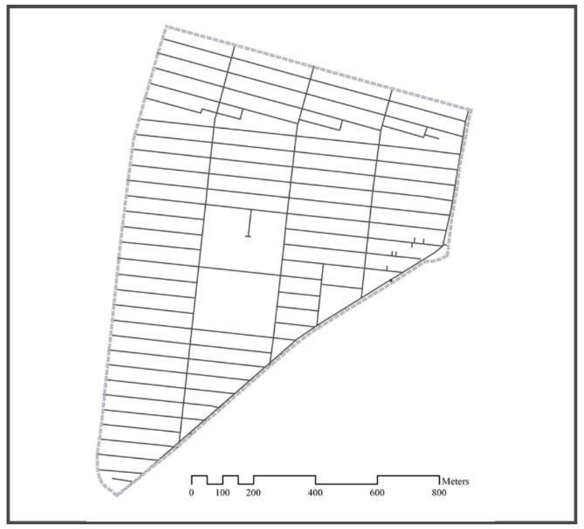


3. Minaei: Mixed (Grid- Tributary)

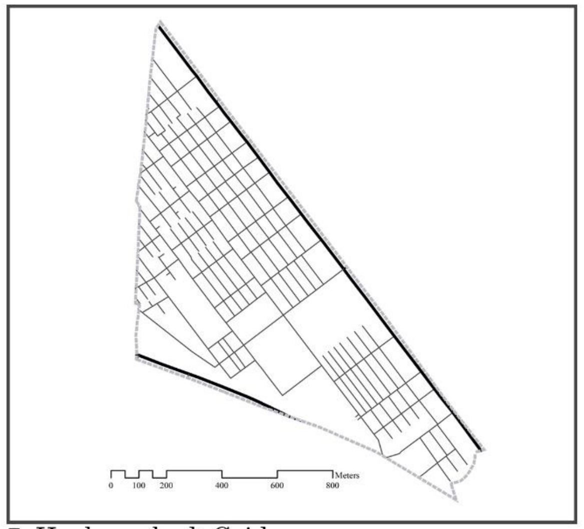
4. Abouzar: Grid



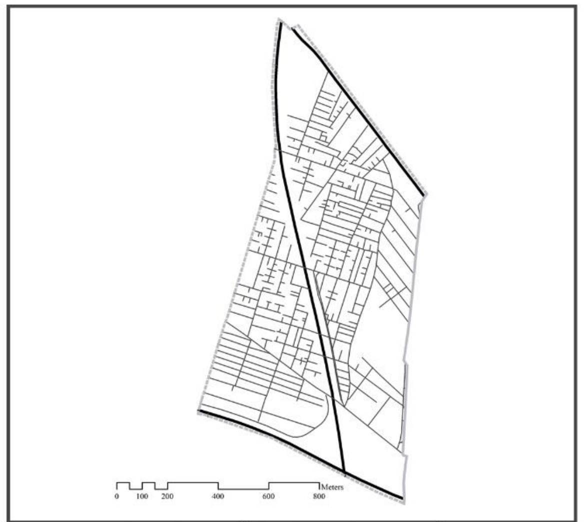
5. North Afsarieh: Grid



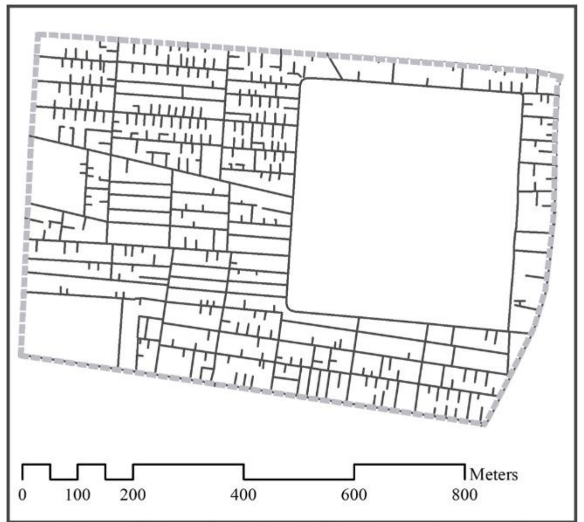
6. South Afsarieh: Grid



7. Hashemabad: Grid



8. Ataabak: Mixed (Grid- Tributary)



9. Valiasr (Bisim): Mixed (Grid- Tributary)

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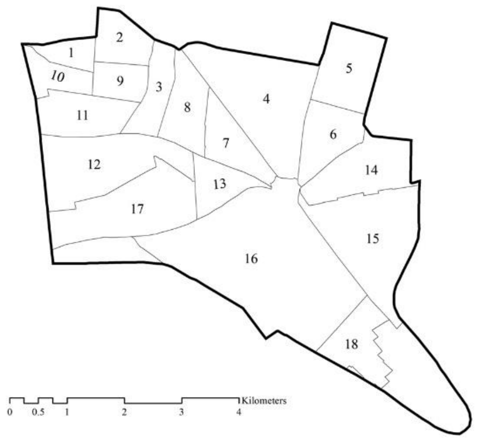
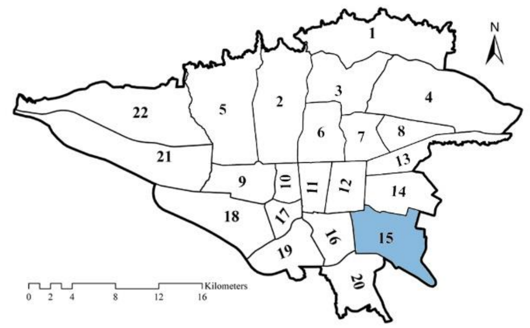
Legend:

Street
District Boundry
Water Bodies



District 15



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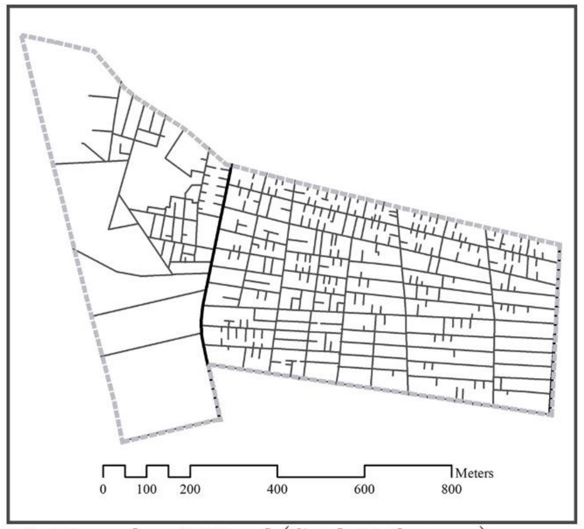
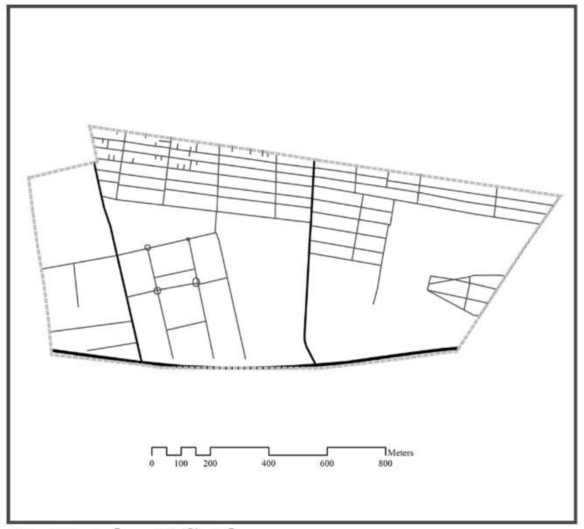
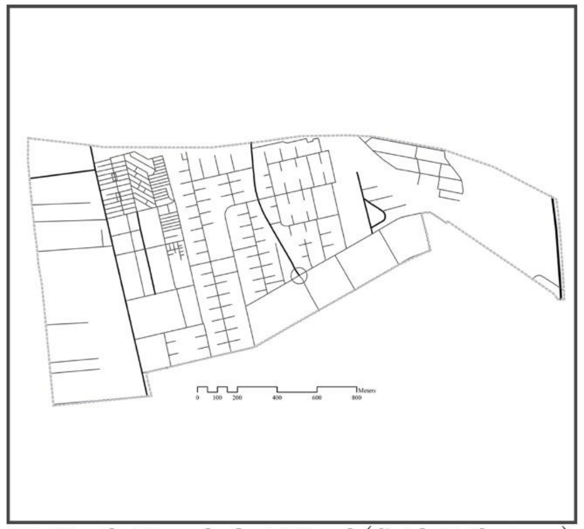
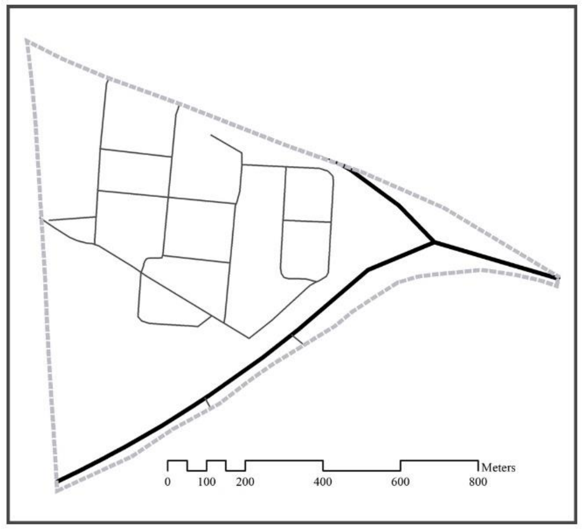


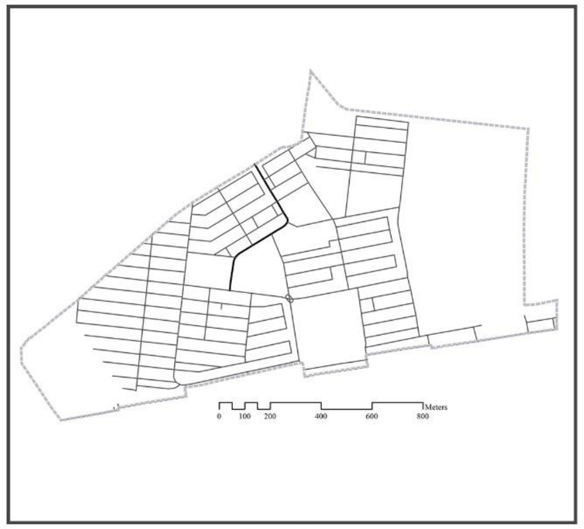
10. Mazaaheri: Mixed (Grid- Tributary)

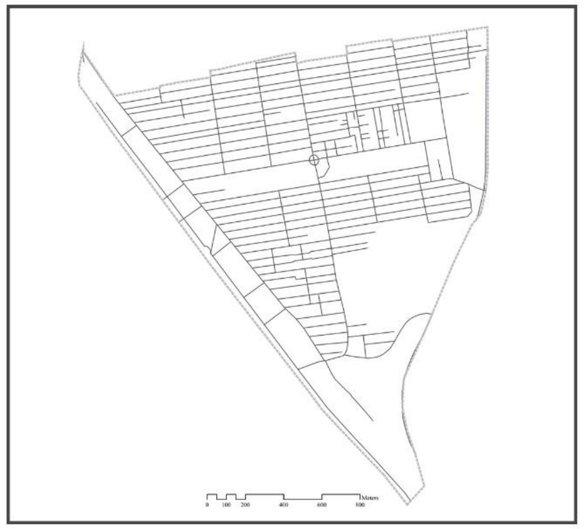

11. Motahari: Grid

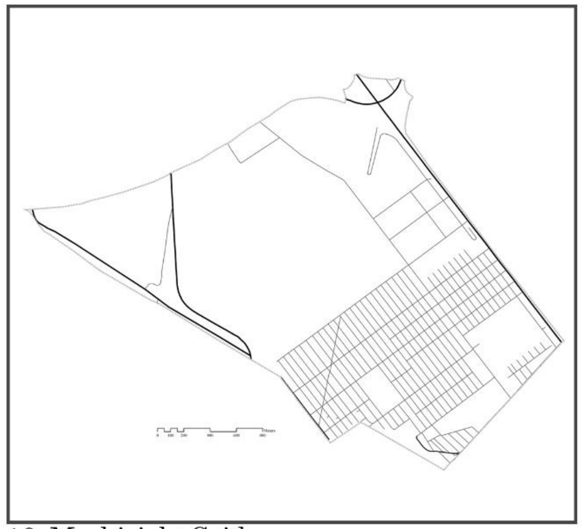

12. North Kianshahr: Mixed (Grid- Tributary)

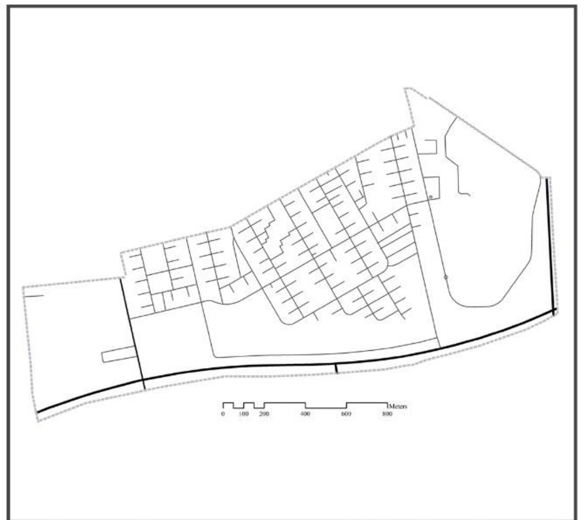


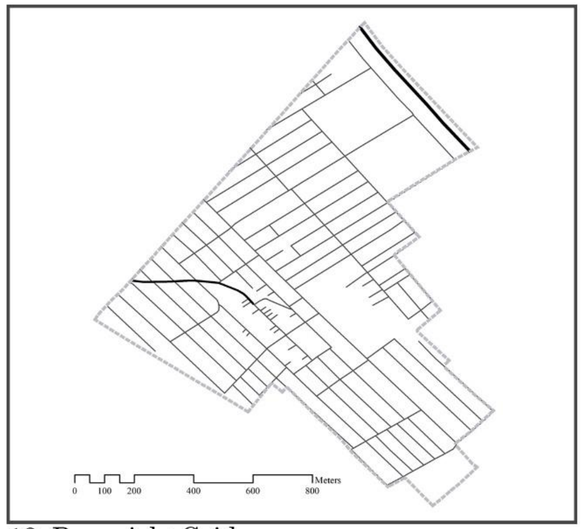
13. Shahid Boroujerdi: Imitated Organic


14. Islamabad-Walfajr: Grid

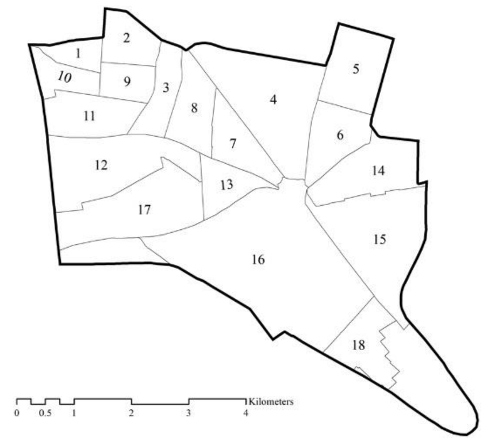

15. Masoudieh: Grid

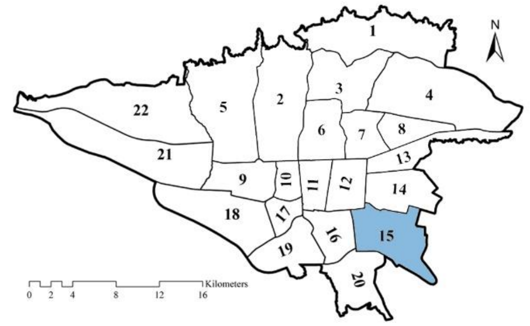

16. Moshirieh: Grid

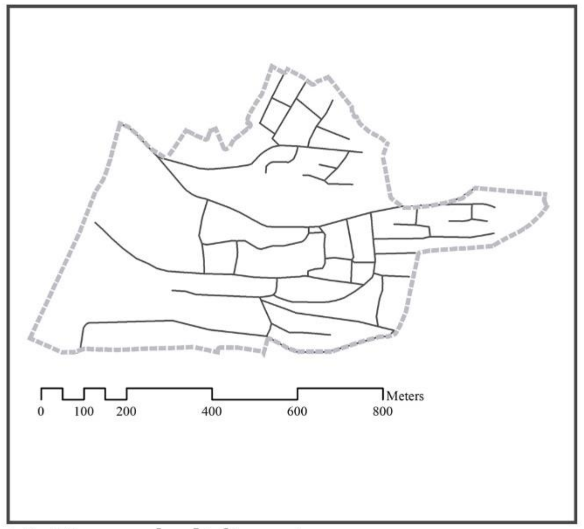

17. South Kianshahr: Mixed (Grid- Tributary)
Jomhouri Eslami Complex: Imitated organic



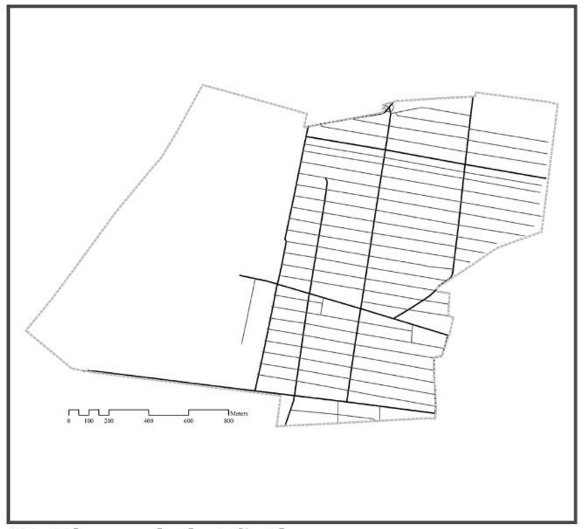
18. Razavieh: Grid


District 15





19. Mesgarabad: Organic


20. Khavarshahr: Grid

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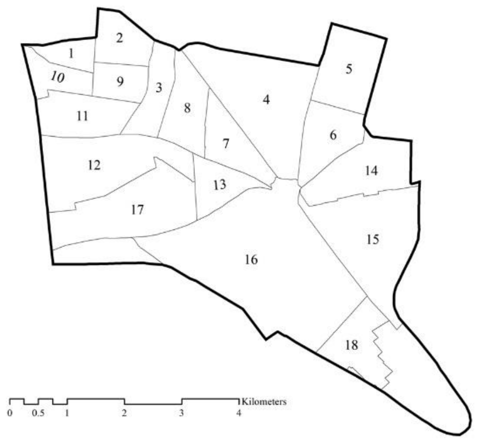
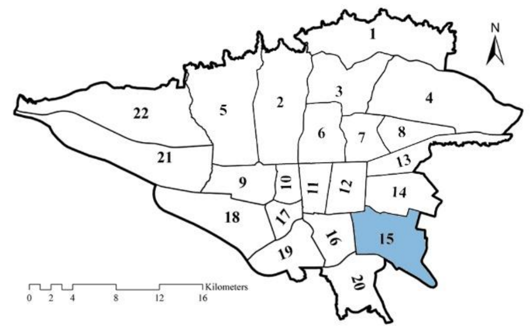
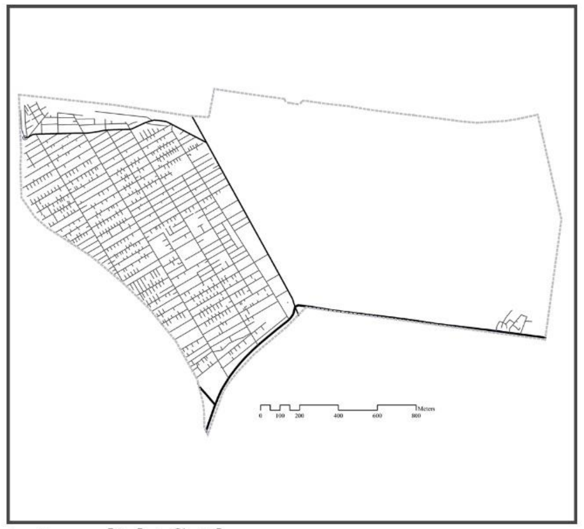
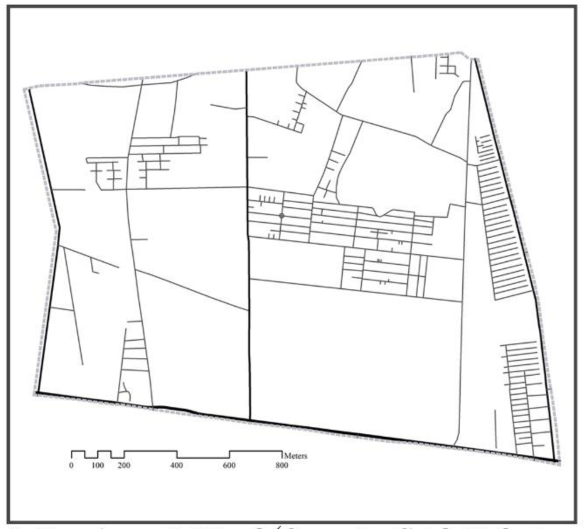


District 15





1. Jawadieh: Grid



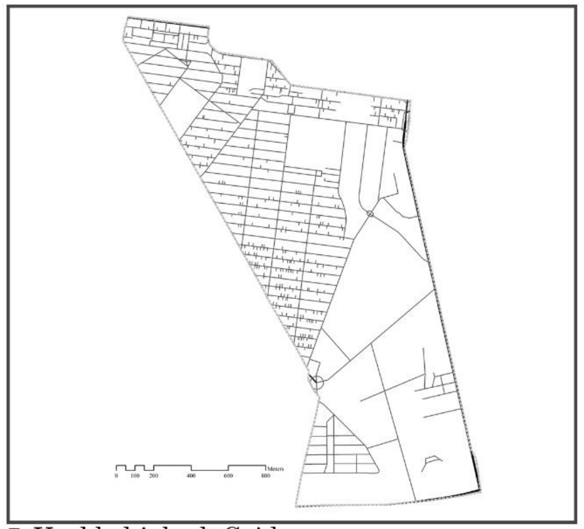
2. Baq Aazari: Mixed (Organic- Grid- Tributary)

3. Besat: Grid

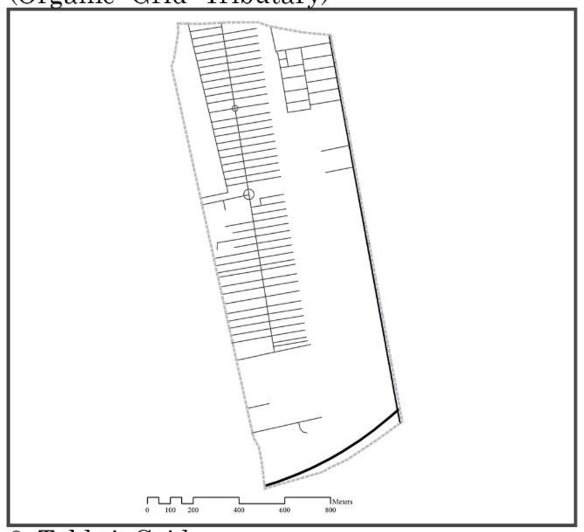
4. Khazaaneh: Mixed (Grid- Organic)

5. East Naziabad: Mixed (Organic- Grid- Tributary)

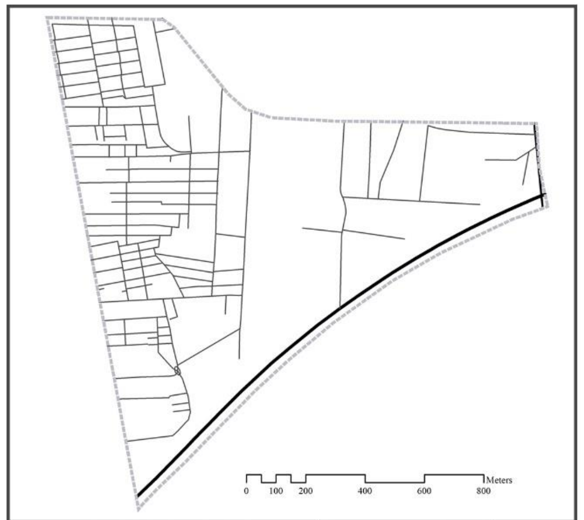
6. Naziabad: Grid



7. Yaakhchiabad: Grid



8. Takhti: Grid



9. South Aliabad: Mixed (Organic- Grid)

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7.5. Appendix E. List of Tehran's street networks based on the neighborhoods

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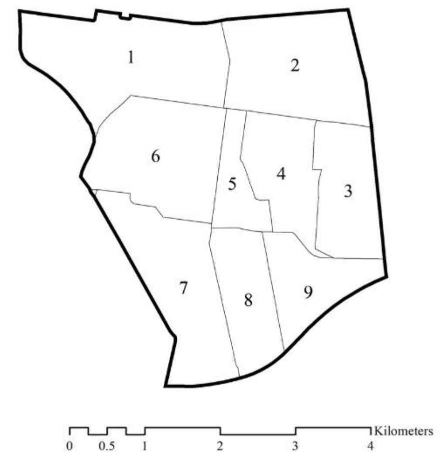
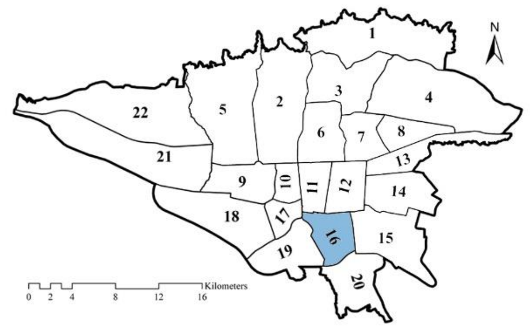
Legend:

- Street
- District Boundry
- Water Bodies



District 16



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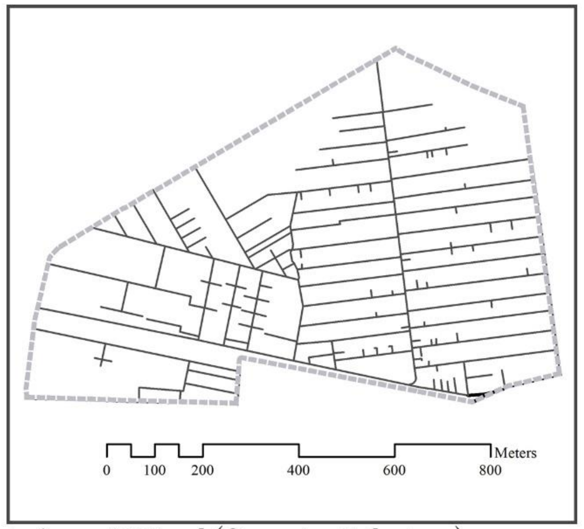
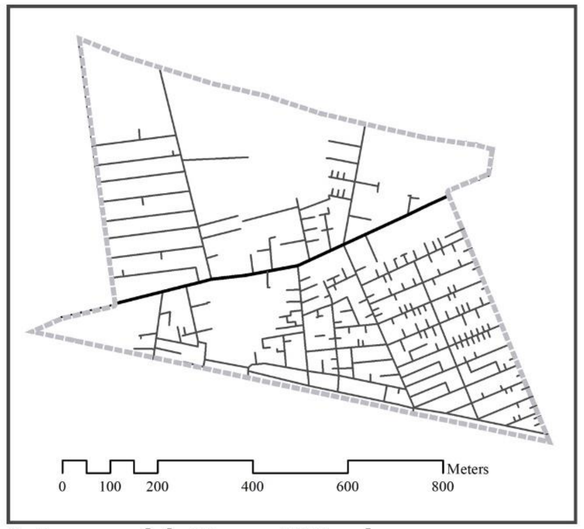
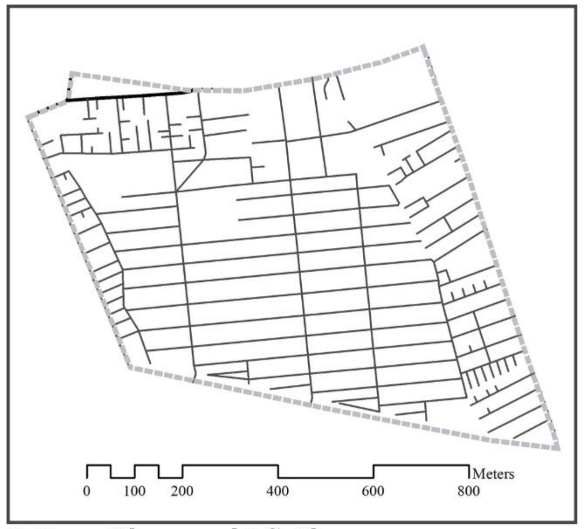


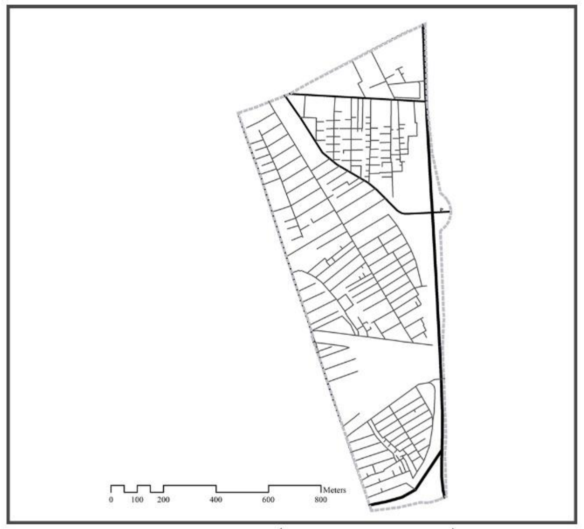
1. Aazari: Mixed (Organic- Tributary)

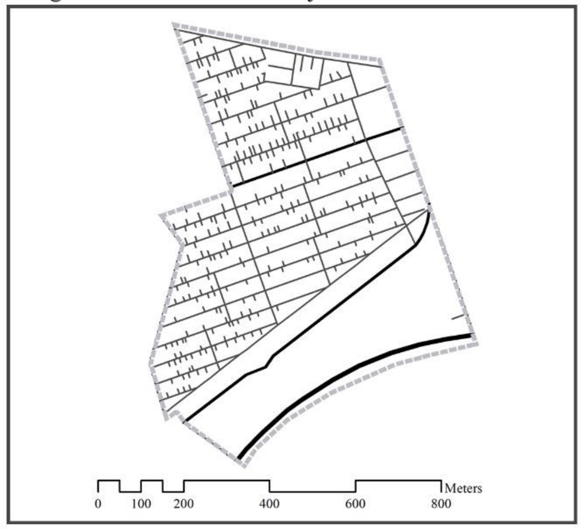


2. Imamzadeh Hassan: Mixed (Organic- Grid- Tributary)

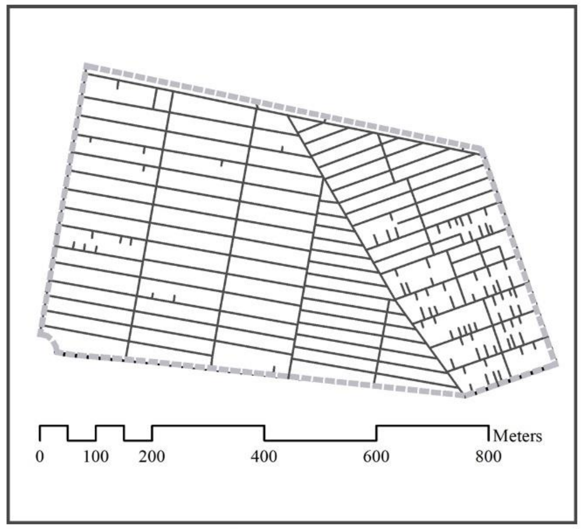


3. Baaq Khazaaneh: Grid

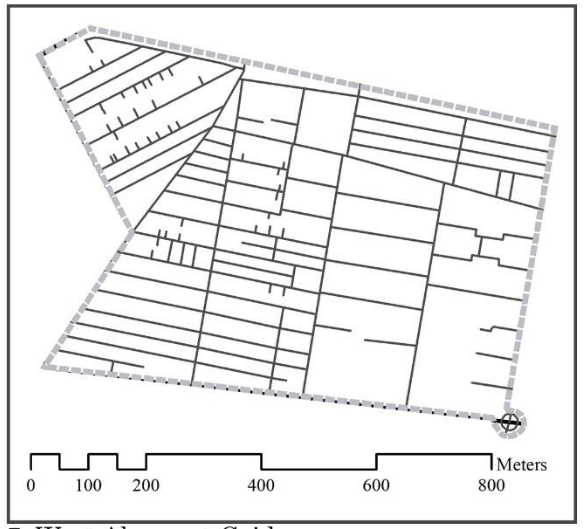

4. Khazaaneh: Mixed (Grid- Organic)



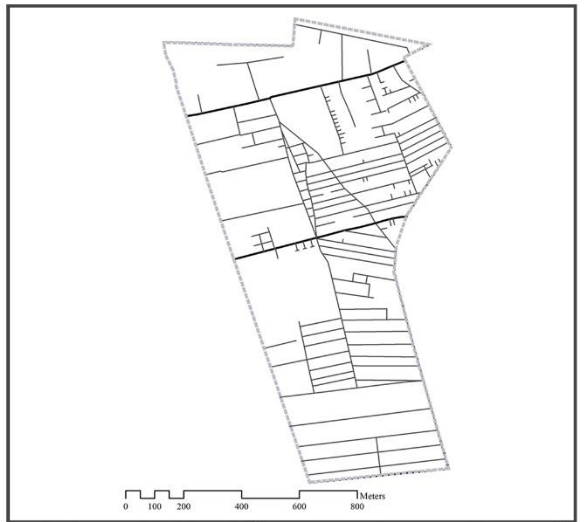
5. Moqaddam: Grid

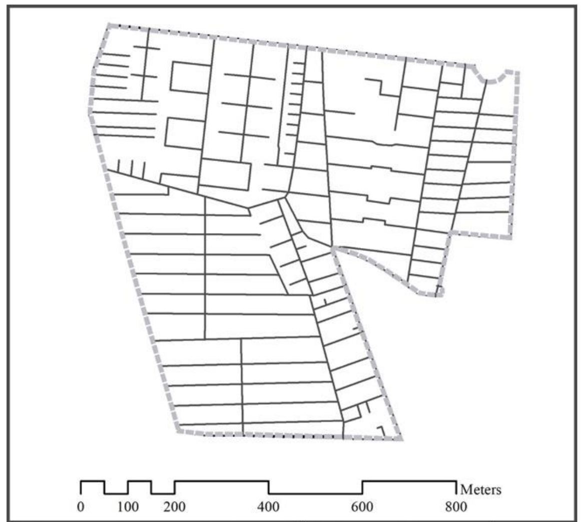


6. East Abouzar: Grid



7. West Abouzar: Grid


8. Yaftabad: Mixed (Organic- Grid- Tributary)



9. Imam Sajjad: Mixed (Grid- Tributary)

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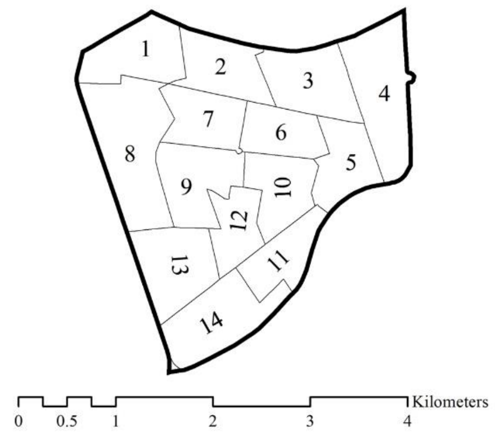
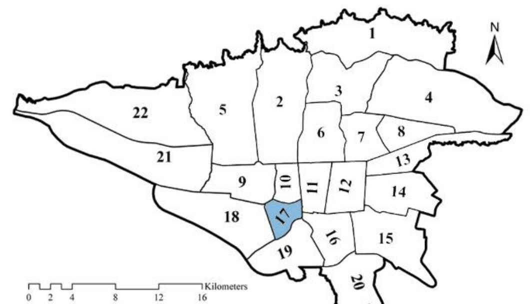
Legend:

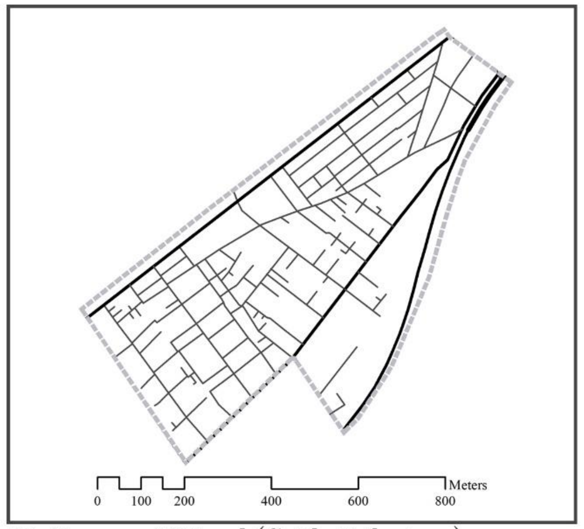
Street
District Boundry
Water Bodies



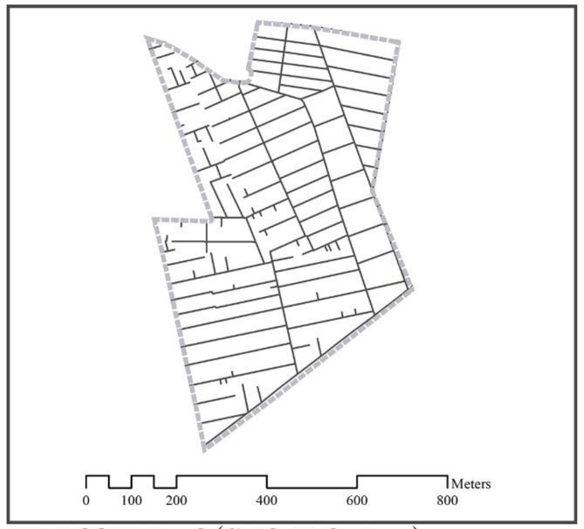
District 17



10. Golchin: Grid

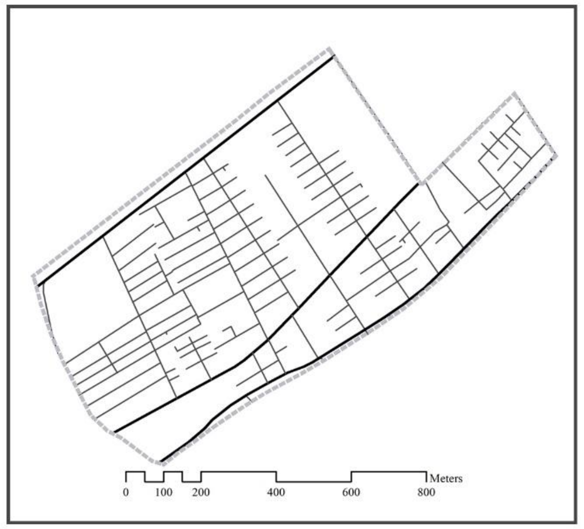


11. Zamzam: Mixed (Grid- Tributary)



12. Jalili: Mixed (Grid- Tributary)

13. Wasfnard: Mixed (Organic- Grid- Tributary)



14. Zahtaabi: Tributary

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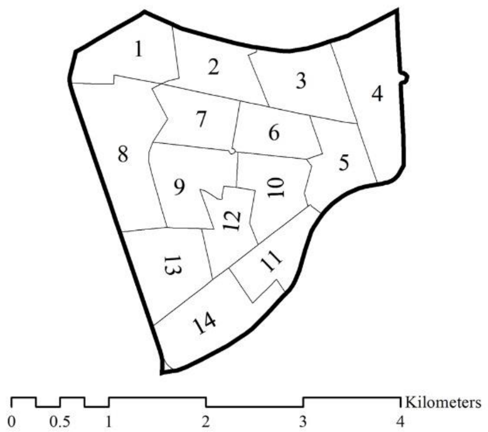
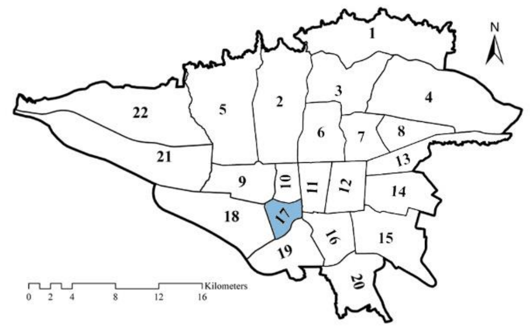
Street	
District Boundry	
Water Bodies	



District 17



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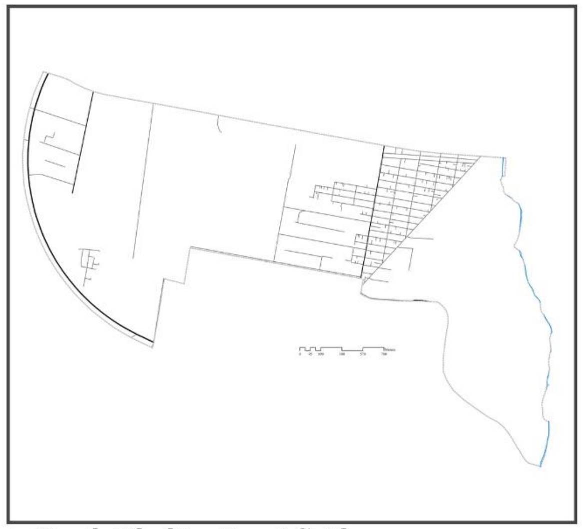
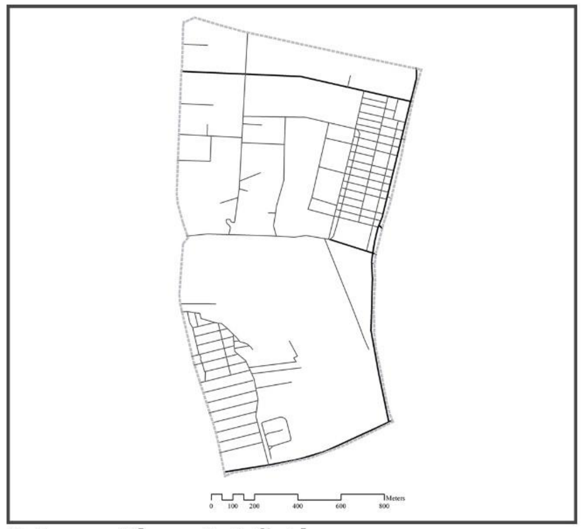


1. North Khalij-e Fars: Grid

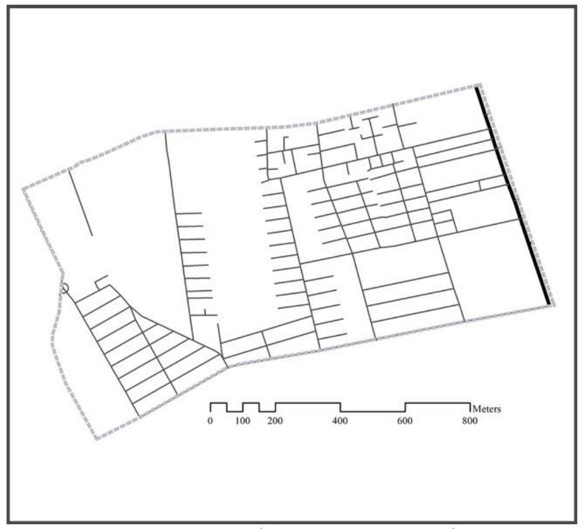
2. Hefdah Shahrivar: Mixed (Grid- Tributary)



3. Imam Khomeini: Grid

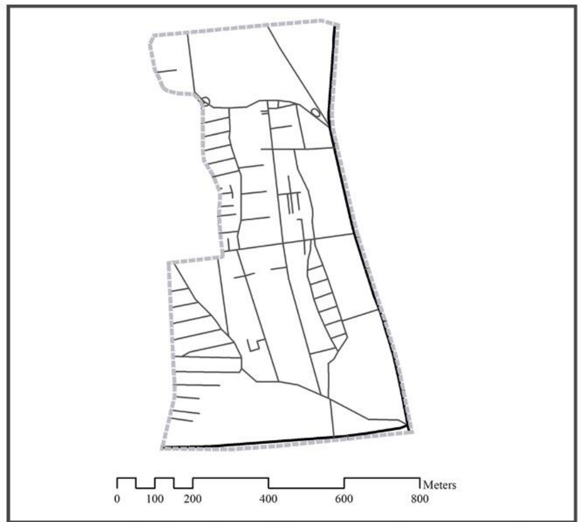
4. Ferdous: Grid

5. Tolid Darou: Mixed (Grid- Tributary)

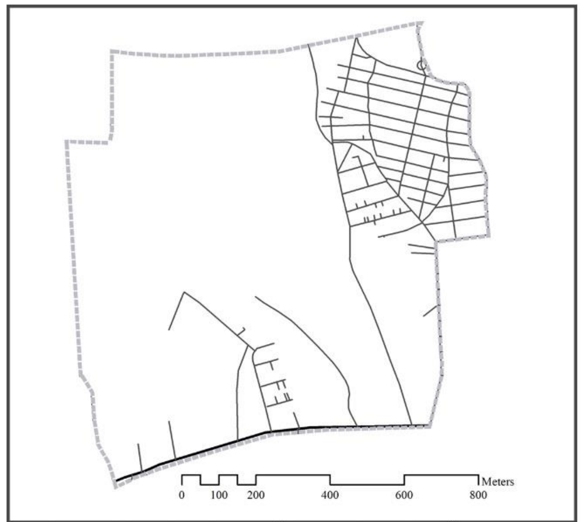


6. Behdasht: Mixed (Grid- Tributary)

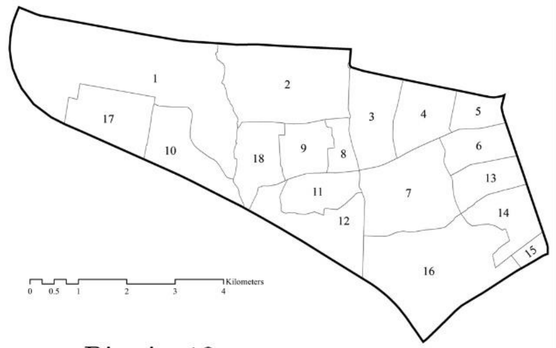
7. Yaakhchiabad: Grid



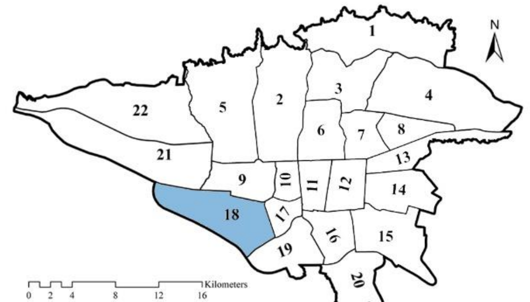
8. Shamsabad: Mixed (Organic- Tributary)

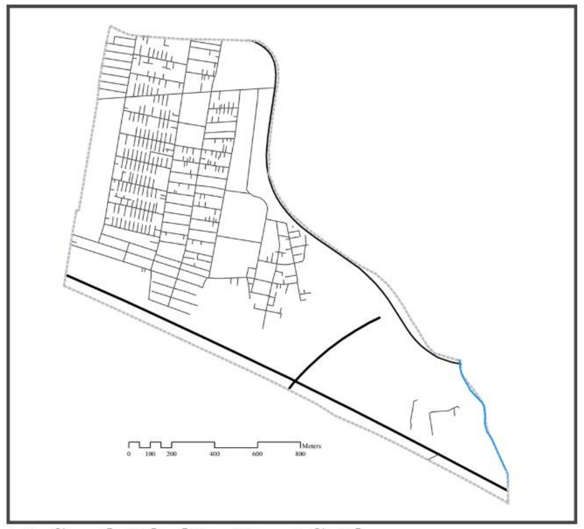


9. Shaadabad: Mixed (Organic- Grid)

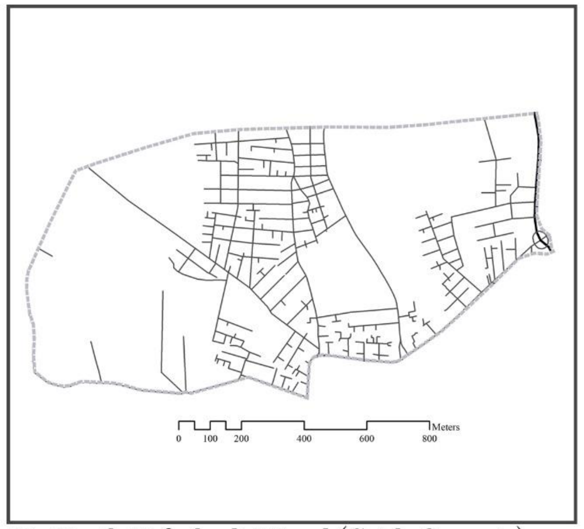


District 18

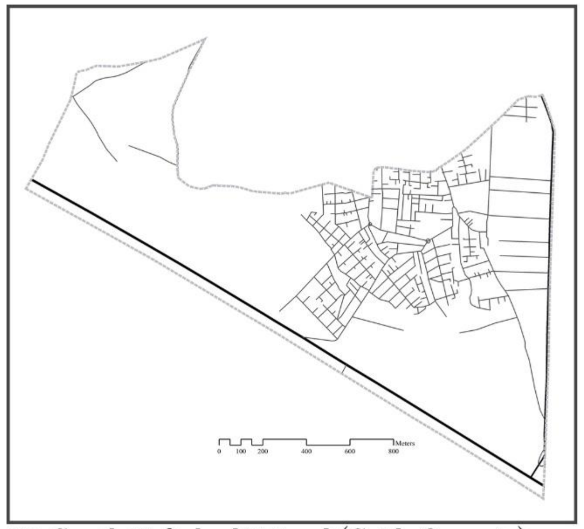




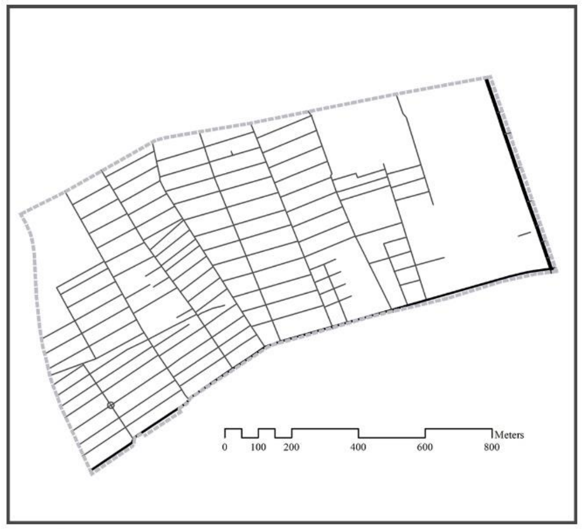
10. South Khalij-e Fars: Grid



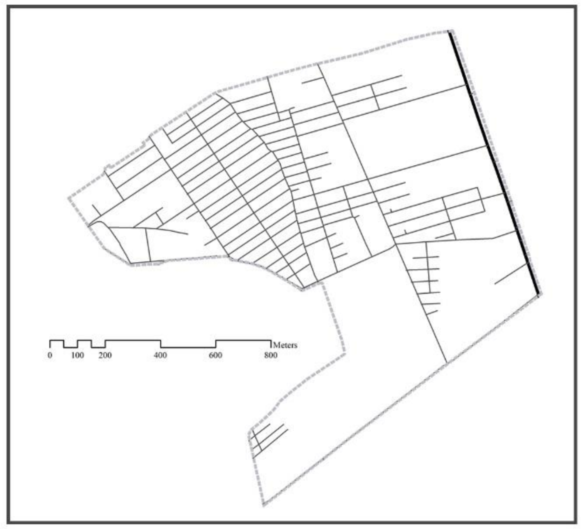
11. North Yaftabad: Mixed (Grid- Organic)



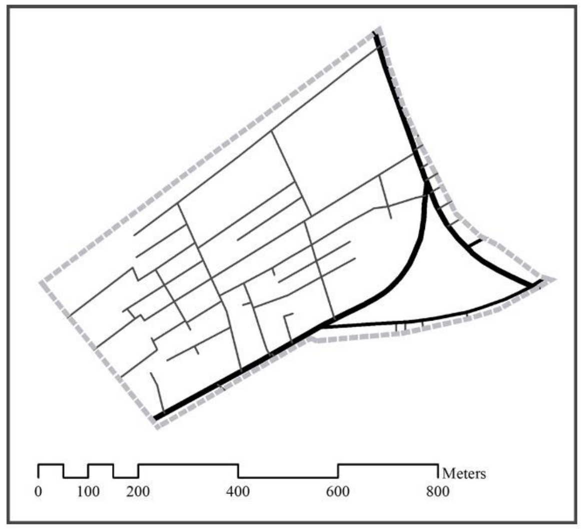
12. South Yaftabad: Mixed (Grid- Organic)



13. North Valiasr: Grid



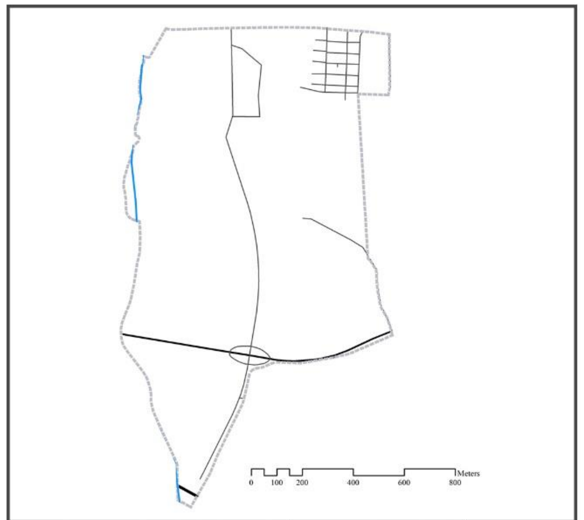
14. South Valiasr: Grid



15. Sadeqieh: Tributary

16. Shahid Rajaei: Grid

17. Norouzabad: Mixed (Grid- Tributary)



18. Saeedabad: Mixed (Organic- Grid)

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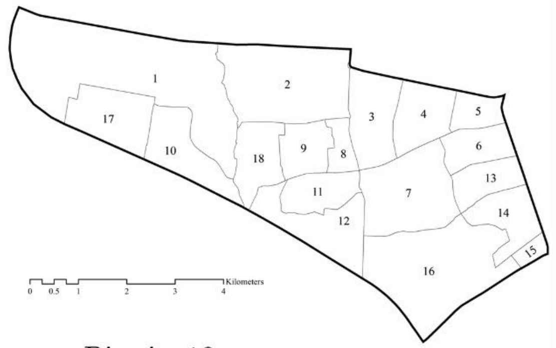
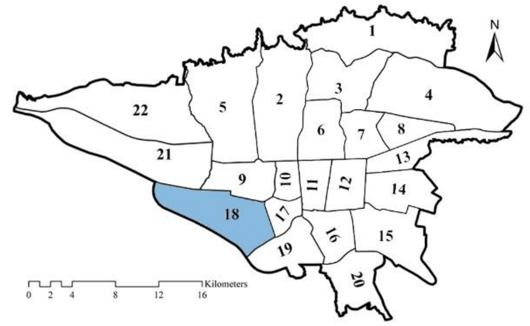
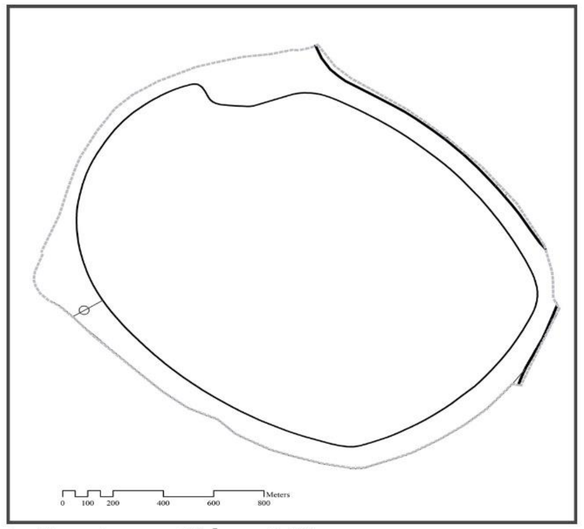
Legend:

Street
District Boundry
Water Bodies

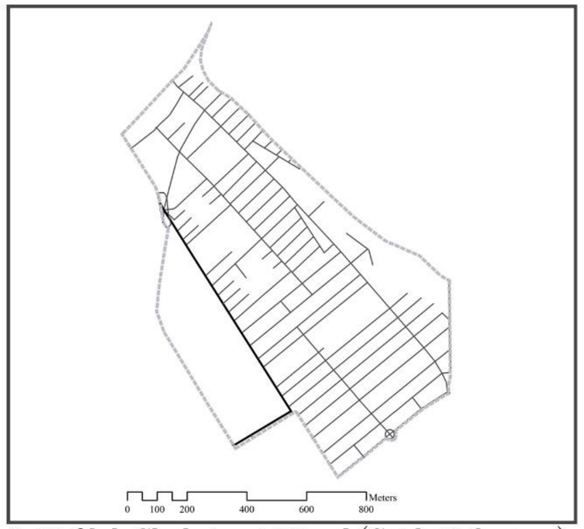


District 18



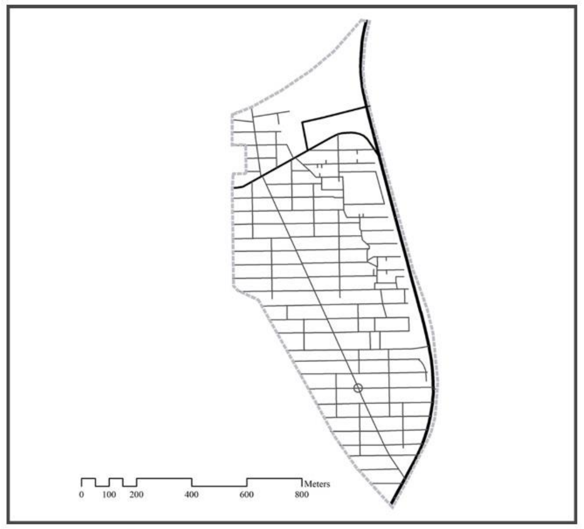


1. Boustaan-e Velayat: Ring

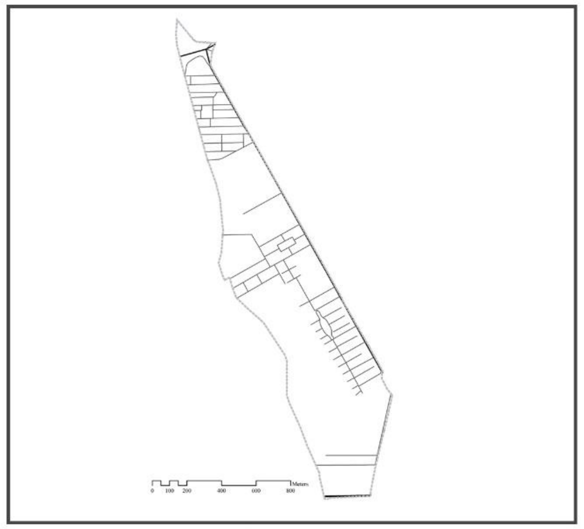


2. Hefdah Shahrivar: Mixed (Grid- Tributary)

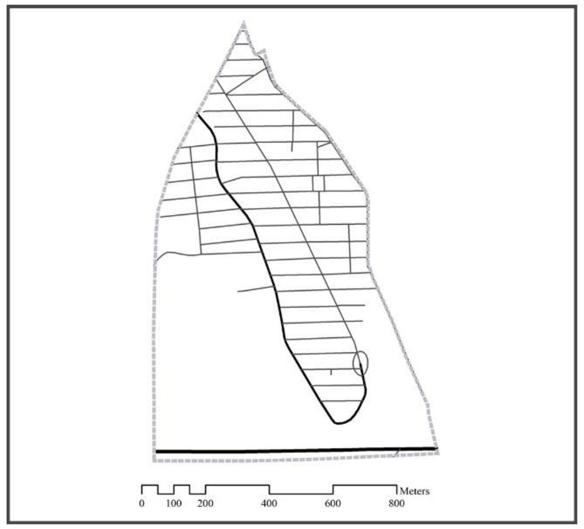
3. Khaniabad Nou: Grid



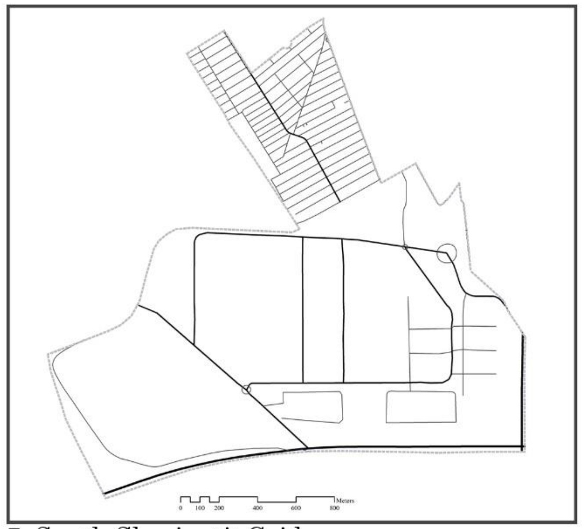
4. North Khaniabad: Grid



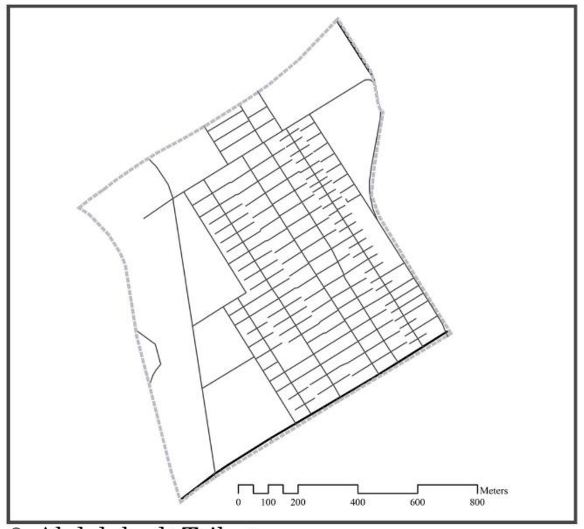
5. Bahmanyar: Grid



6. South Khaniabad: Grid



7. South Shariaati: Grid



8. Abdolabad: Tributary

9. Nematabad: Mixed (Organic- Grid)

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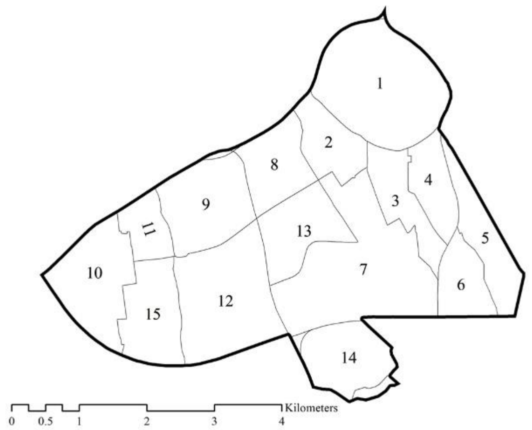
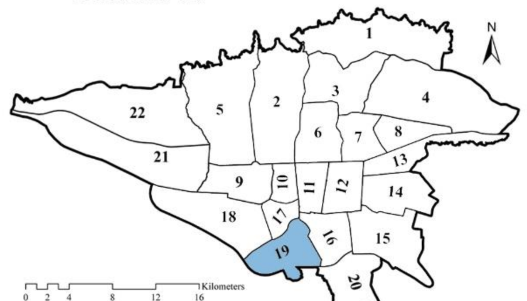
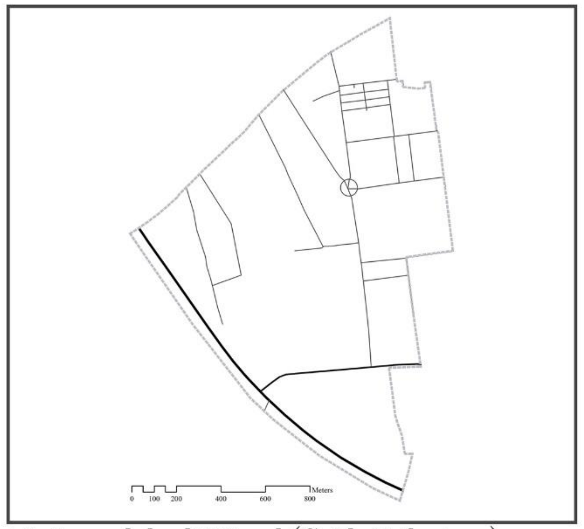
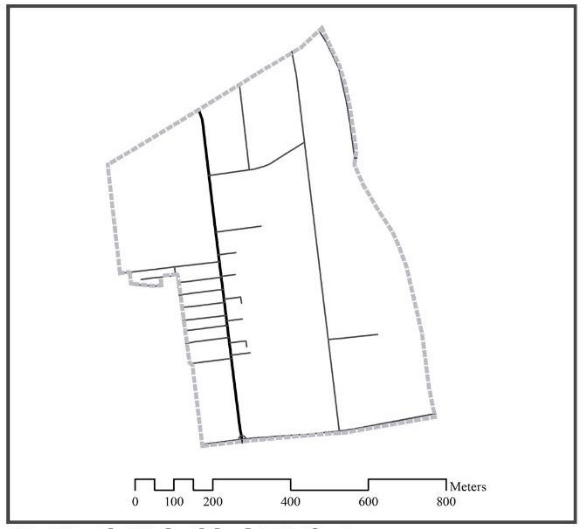


District 19



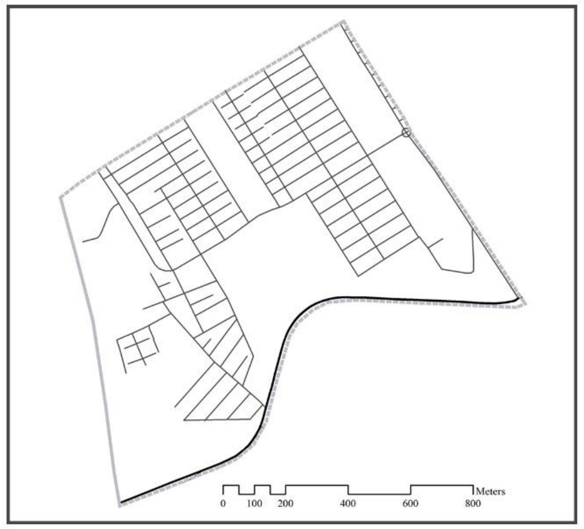


10. Ismaelabad: Mixed (Grid- Tributary)

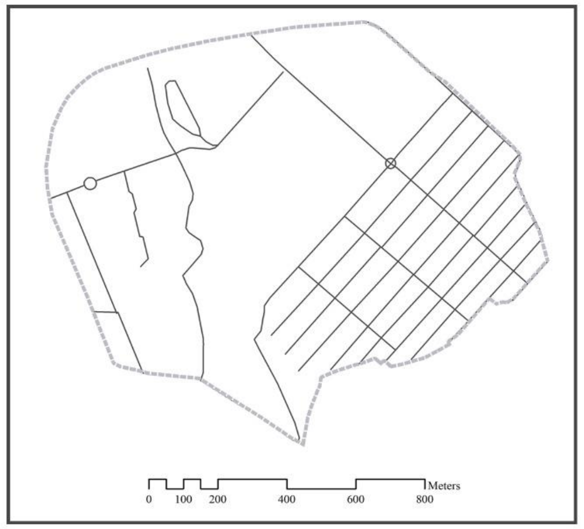


11. North Dolatkhah: Tributary

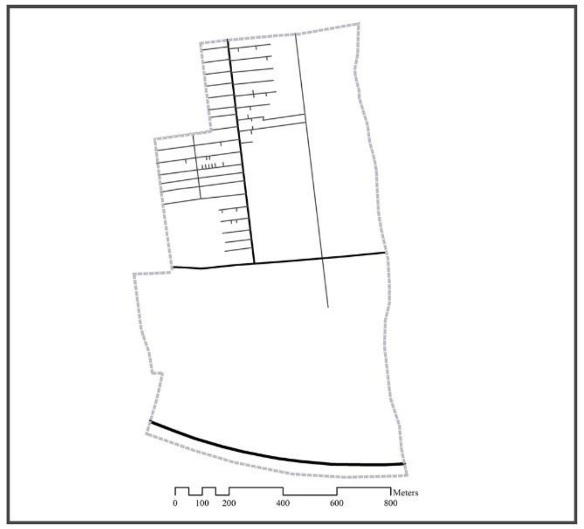
12. Shahid Kazemi: Mixed (Organic- Grid)



13. Shokoufeh: Grid



14. Shahrak-e Resaalat: Grid



15. South Dolatkhah: Tributary

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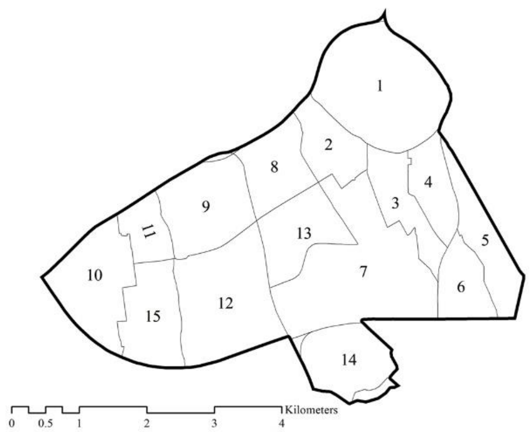
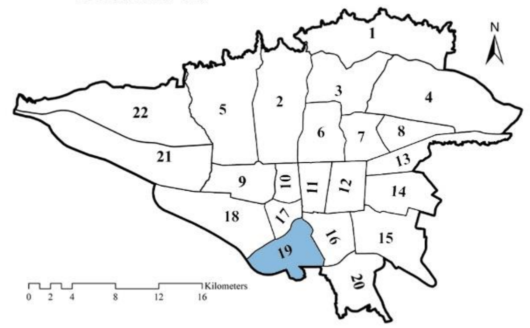
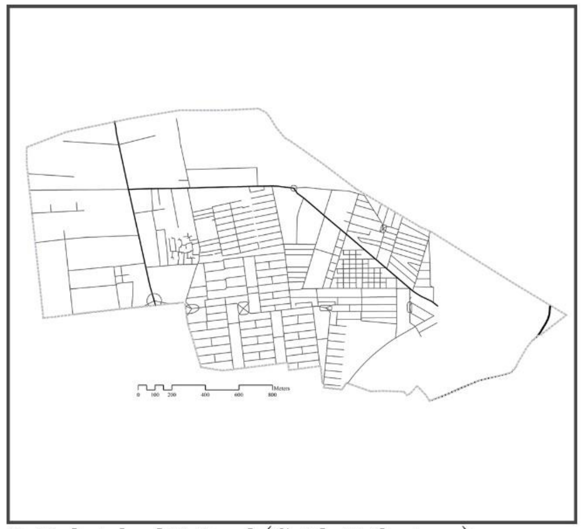


District 19

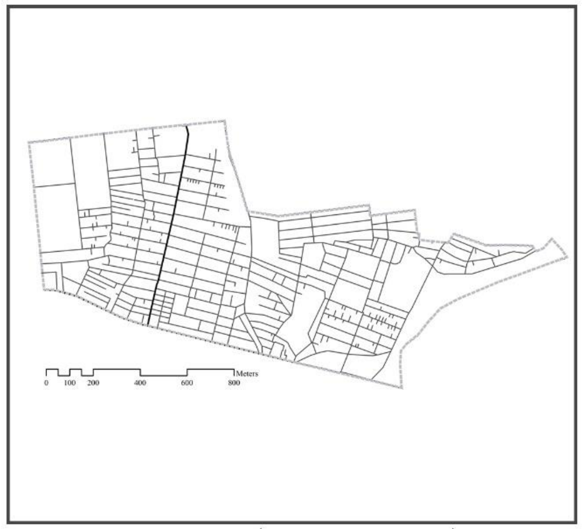


1. Sizdah-e Abaan: Mixed (Organic- Grid)

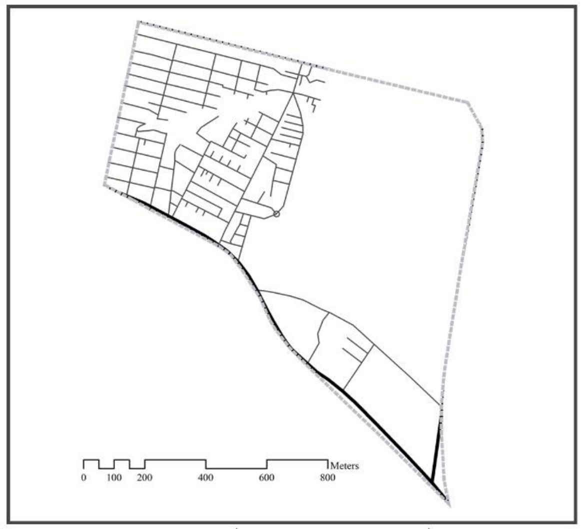
2. Javanmard-e Qasab: Mixed (Organic- Tributary)



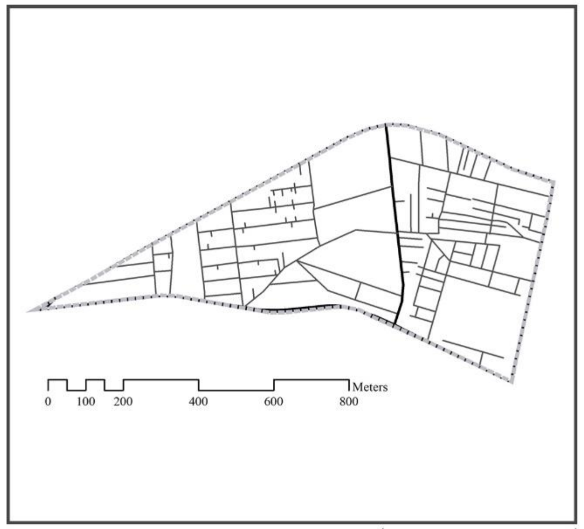
3. Dolatabad: Mixed (Grid- Tributary)



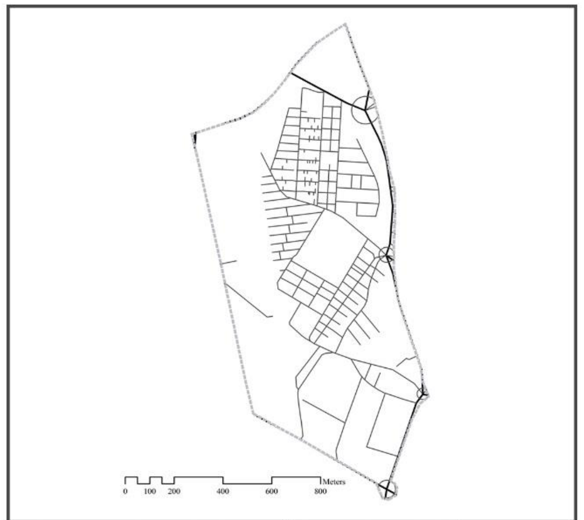
4. Shahadat: Mixed (Grid- Tributary)



5. Safaieh: Mixed (Grid- Tributary)

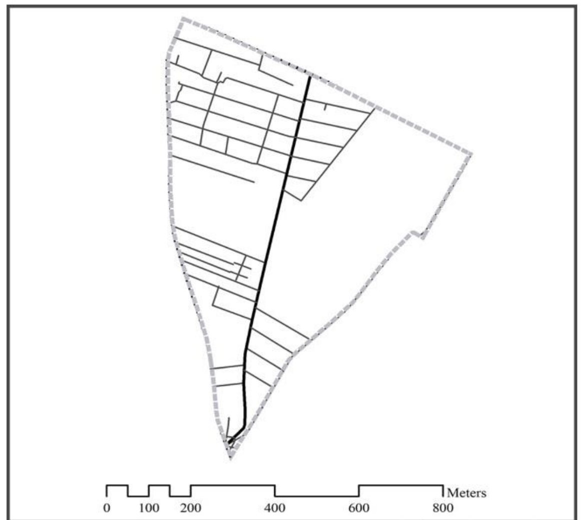


6. Mansourieh Mangol:Mixed (Grid- Tributary)



7. Hamzeabad: Mixed (Organic- Grid)

8. Deylaman: Grid



9. Ebn-e Baboue Qayouri: Mixed (Grid- Tributary)

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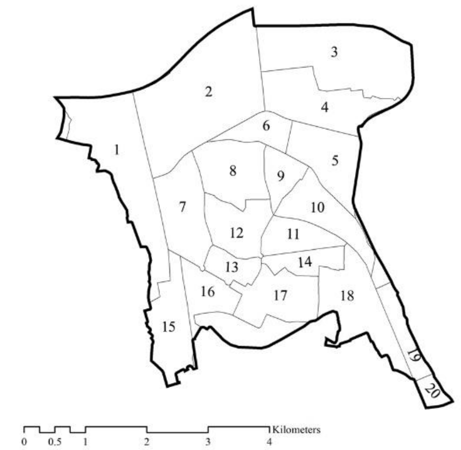
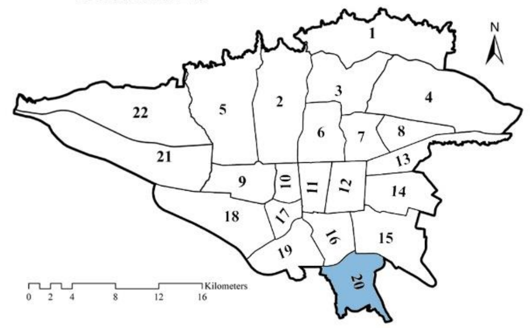
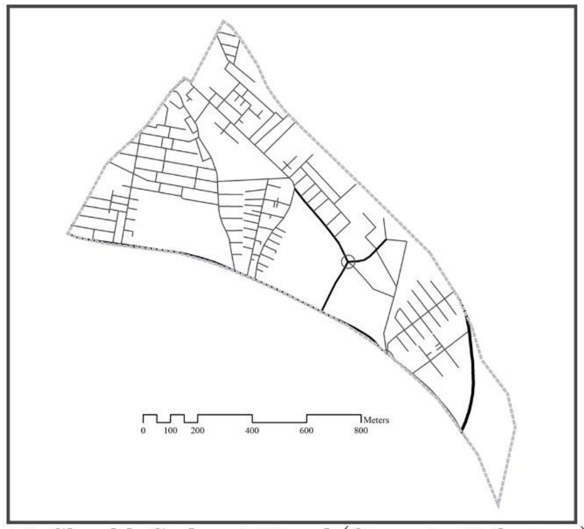
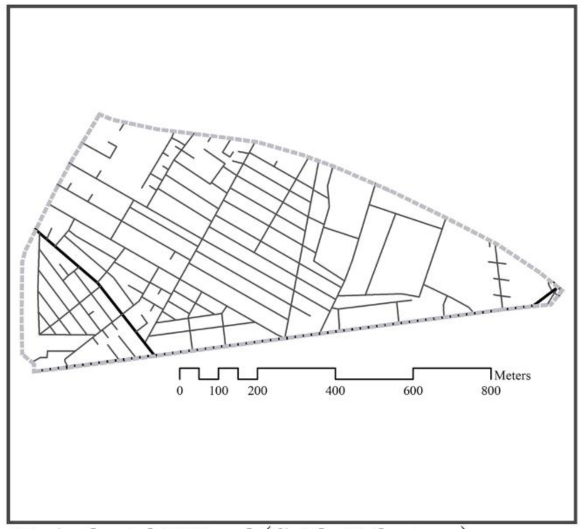


District 20

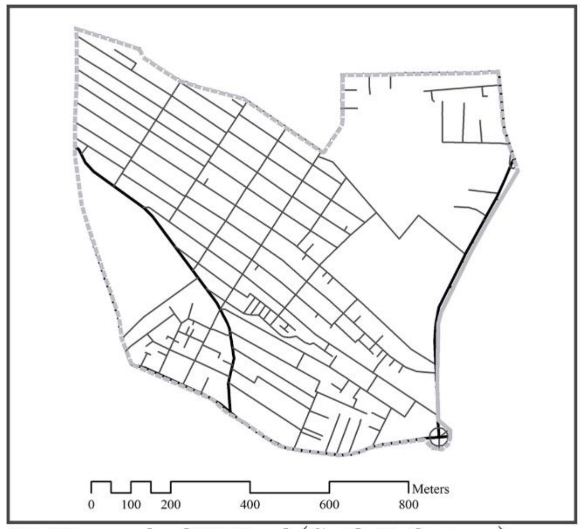




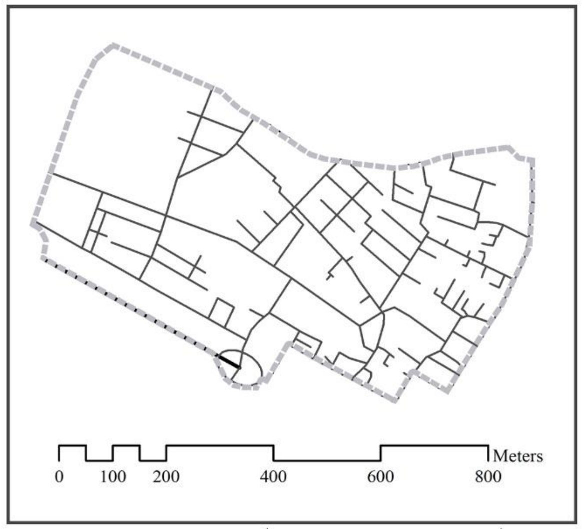
10. Sheykh Sadouq: Mixed (Organic- Tributary)



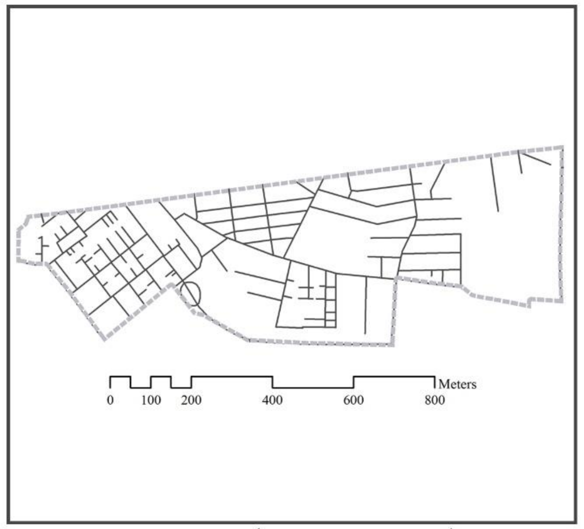
11. Aqdasieh: Mixed (Grid- Tributary)



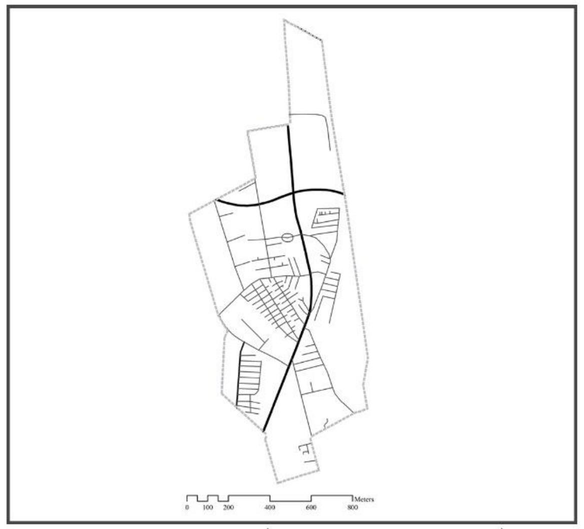
12. Firouzabadi: Mixed (Grid- Tributary)



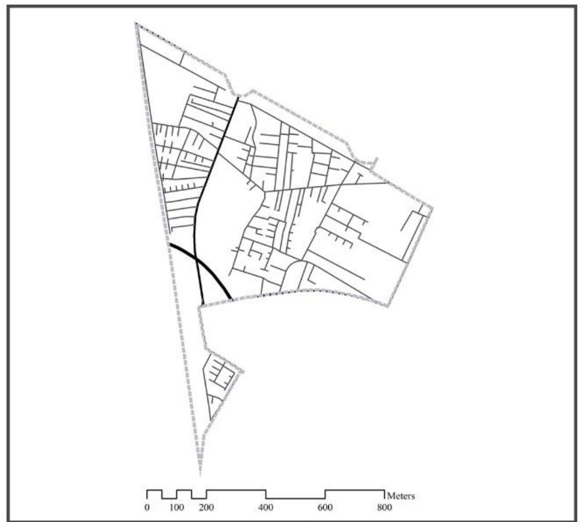
13. Sar Tkht: Mixed (Organic- Tributary)



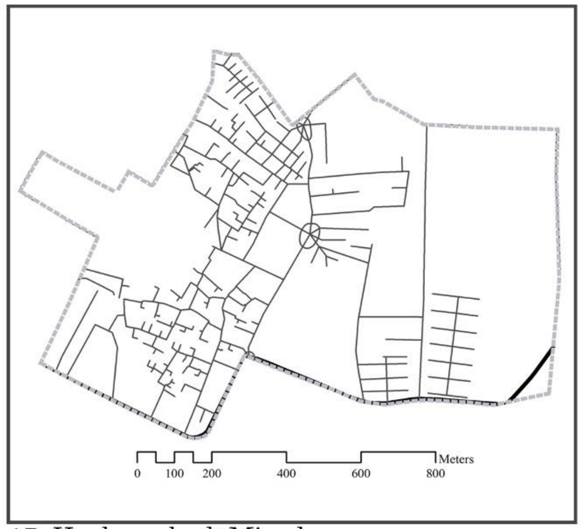
14. Estakhr: Mixed (Grid- Tributary)



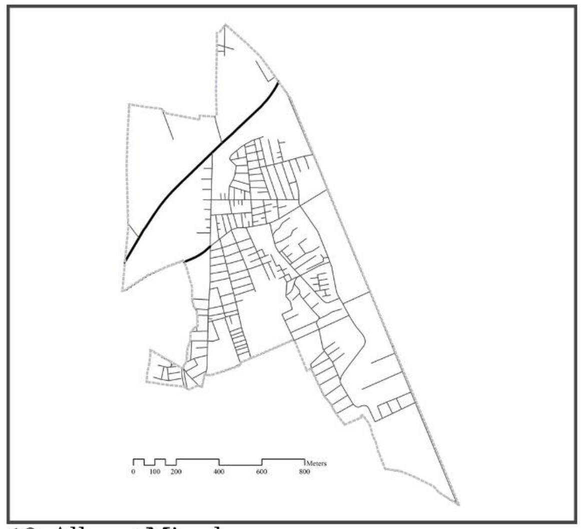
15. Beheshti: Mixed (Organic- Tributary)



16. Shahid Avini: Mixed (Organic- Grid)



17. Hashemabad: Mixed
(Organic- Grid- Tributary)



18. Allaen: Mixed
(Organic- Radial- Grid- Tributary)

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7.5. Appendix E.
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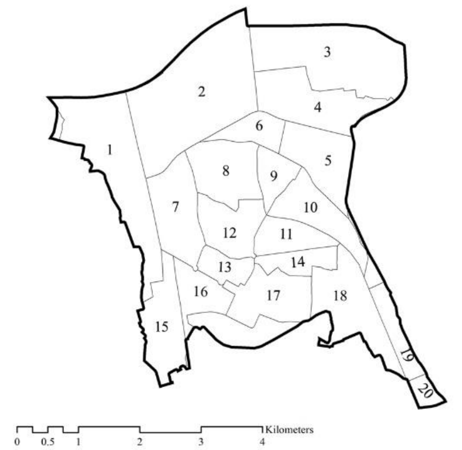
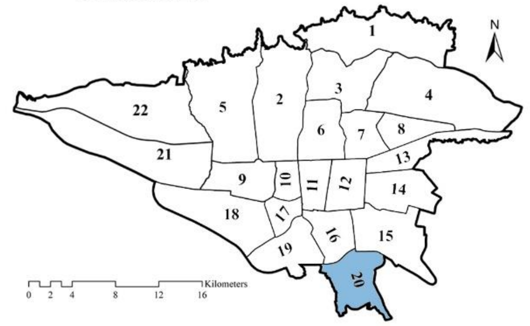
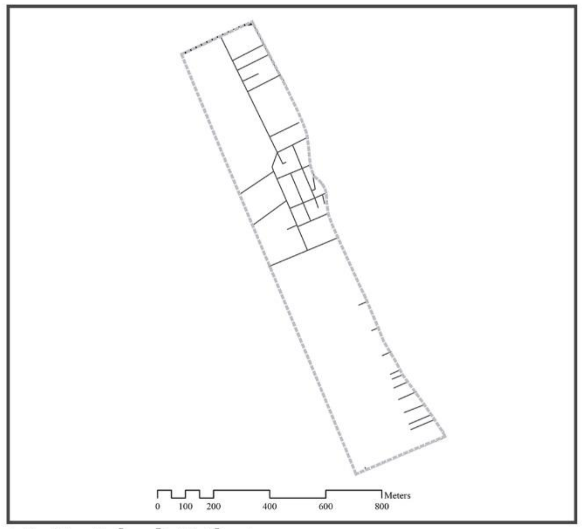
Legend:

Street
District Boundry
Water Bodies

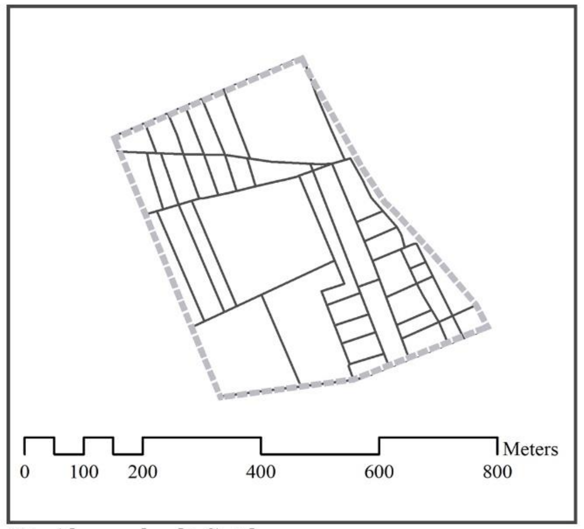


District 20





19. Taqiabad: Tributary



20. Abaasabad: Grid

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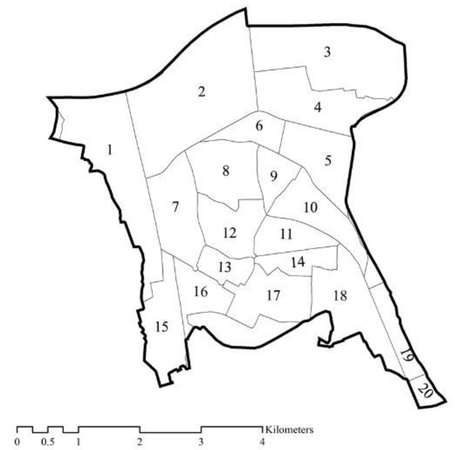
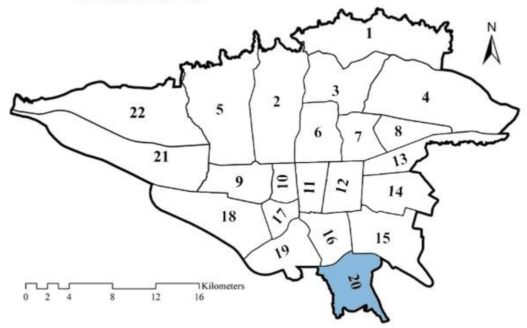
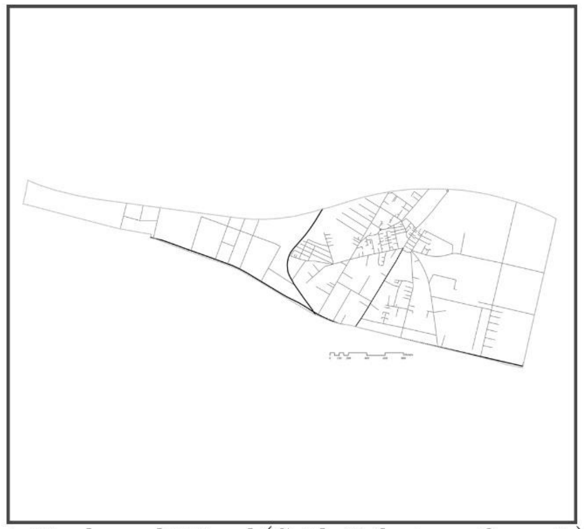
Legend:

- Street
- District Boundry
- Water Bodies

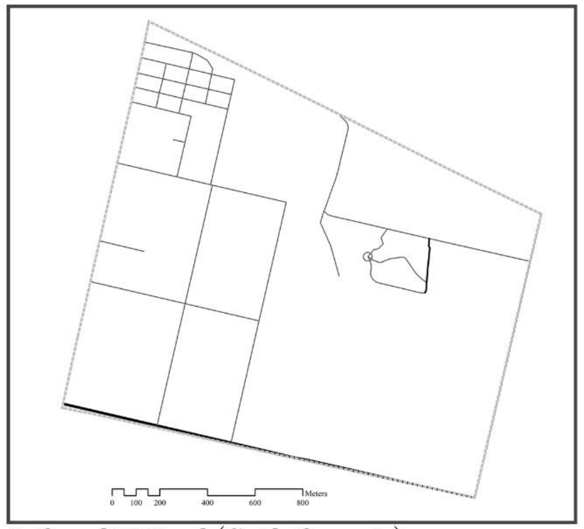


District 20

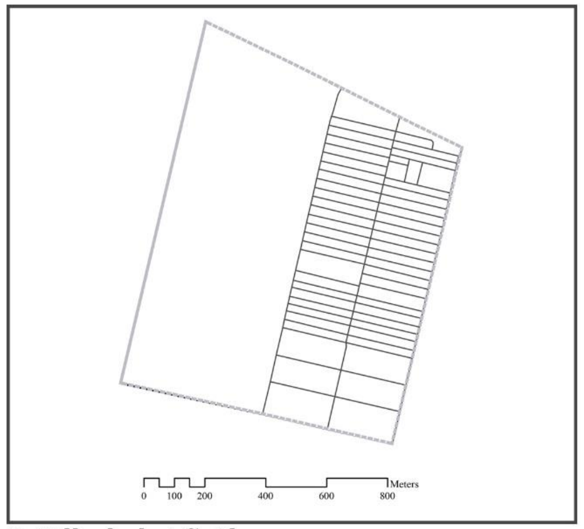




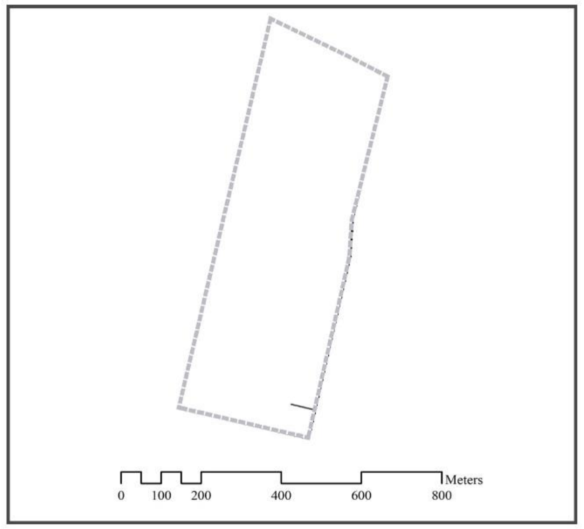
1. Vardavard: Mixed (Grid- Tributary- Organic)



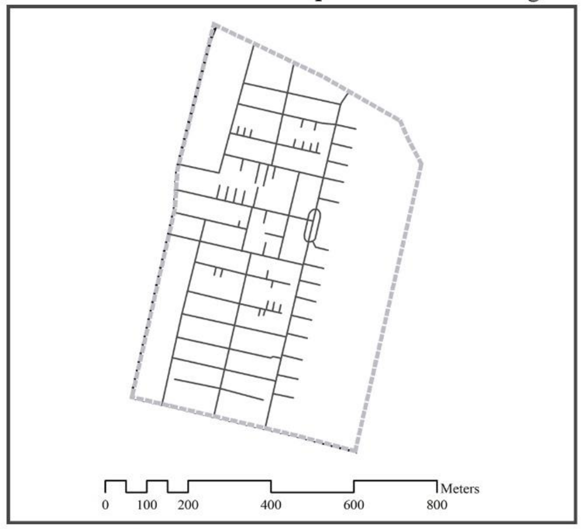
2. Qazali: Mixed (Grid- Organic)
Ghazali Residential Complex: Imitated Organic



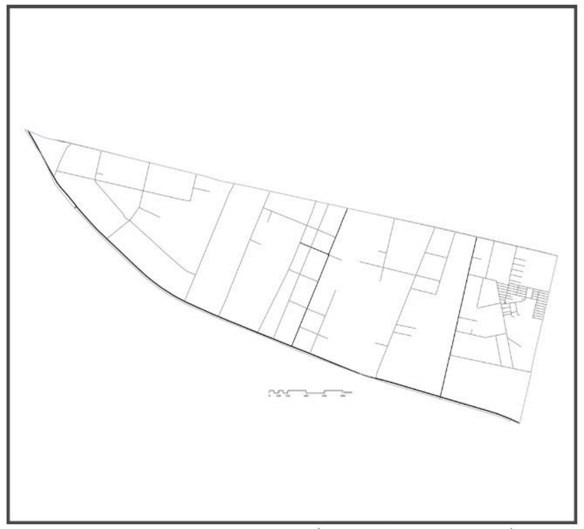
3. Villashahr: Grid



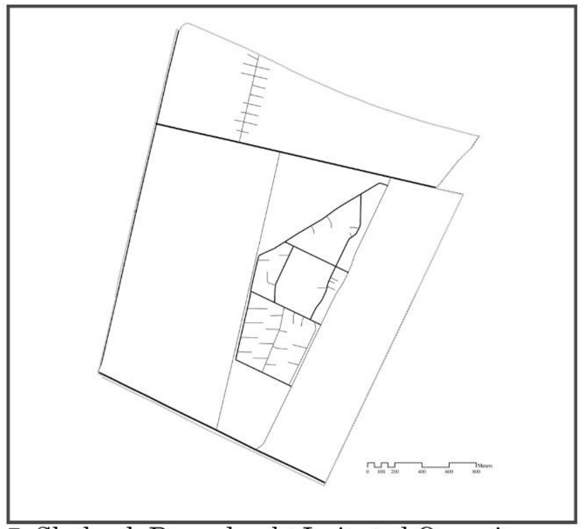
4. Shahrak-e Shahrdari: Grid



5. North Chitgar: Grid

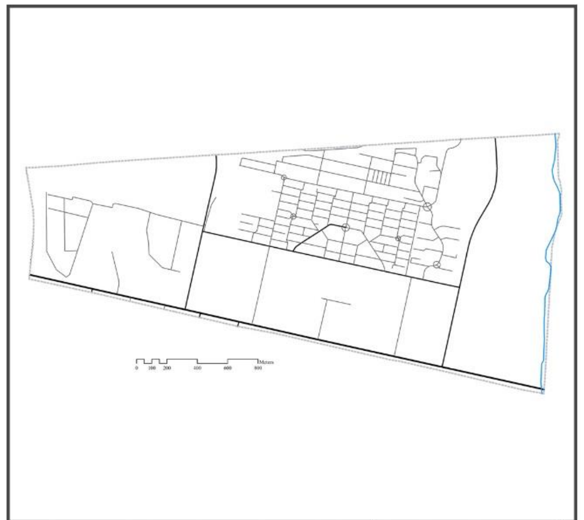


6. South Chitgar: Mixed (Grid- Tributary)



7. Shahrak Daneshgah: Imitated Organic

8. Shahrak Esteqlal: Mixed (Grid- Tributary)



9. Shahrak Farhangian: Mix (Grid-Tributary)
Shahrak-e Azadi: Mix (Grid- Radial)

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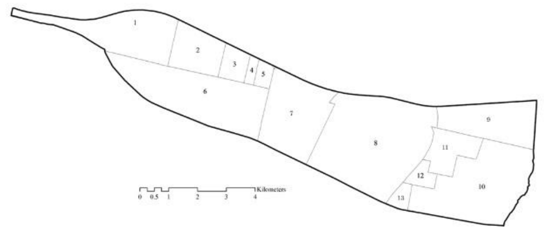
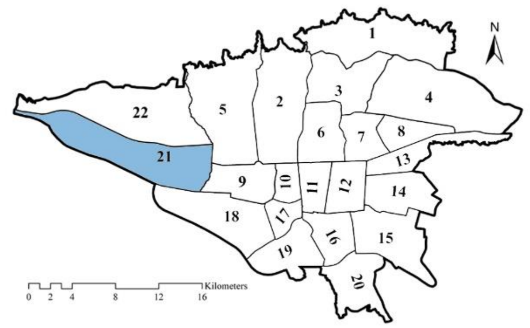
Legend:

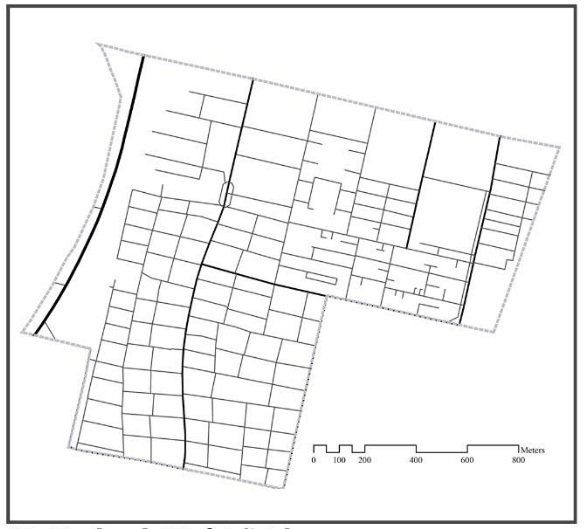
Street
District Boundry
Water Bodies



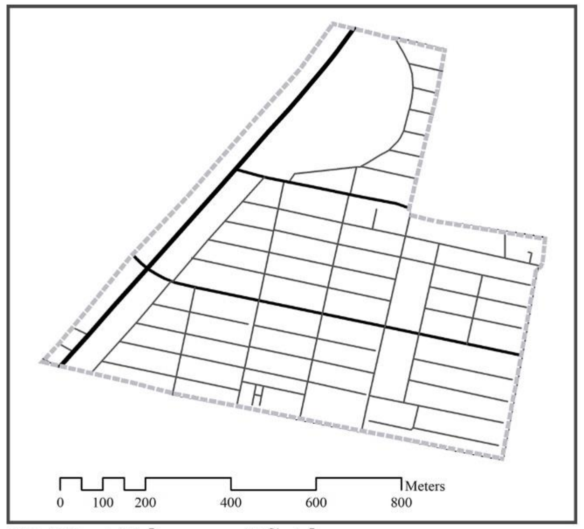
District 21



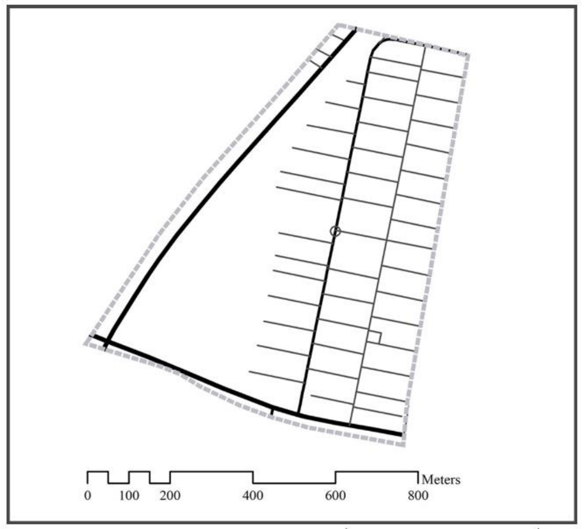
10. Pasdaran: Grid



11. Bashqah Naft: Grid



12. West Tehransar: Grid



13. Shahrak Darya: Mixed (Grid- Tributary)

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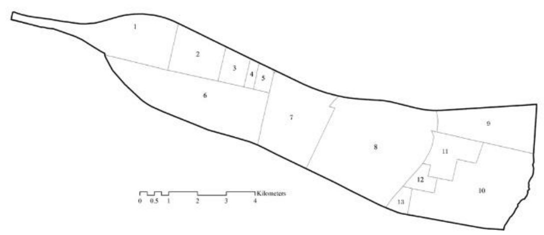
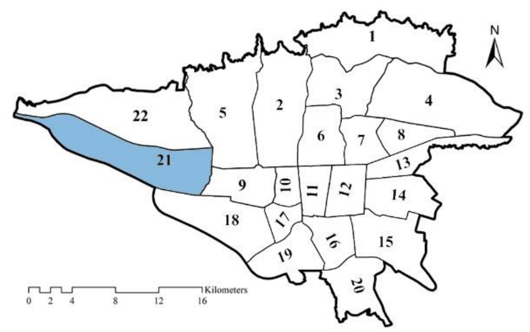
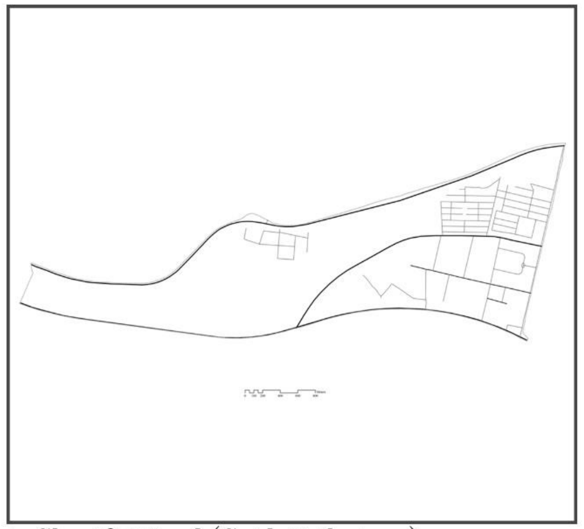
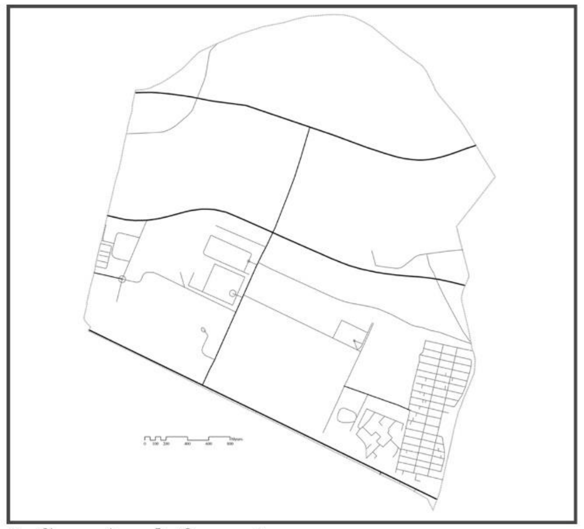


District 21

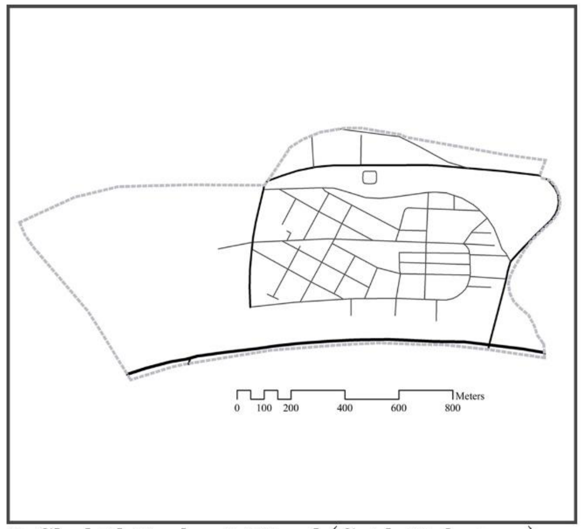




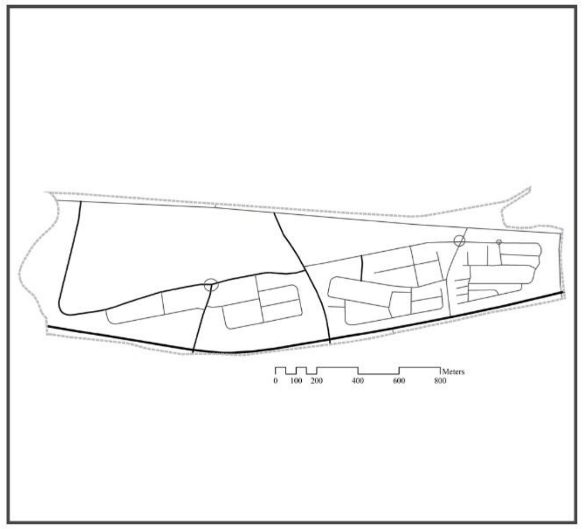
1. Sharif: Mixed (Grid- Tributary)



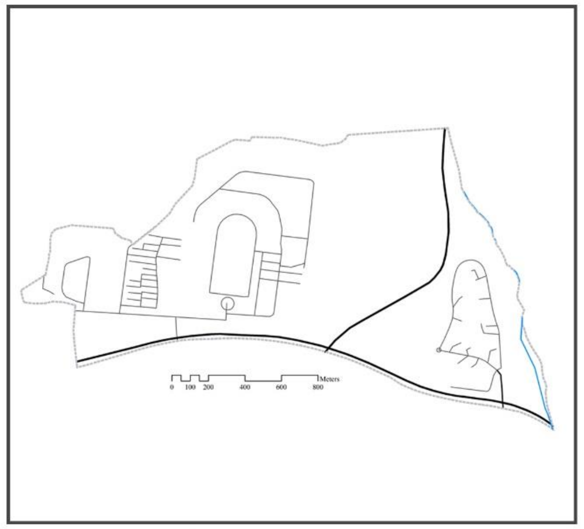
2. Sarv Azad: Organic
Azadshahr: Grid



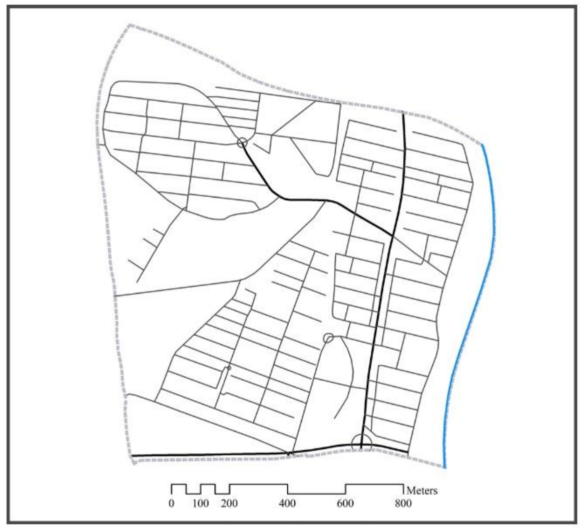
3. Shahid Bagheri: Mixed (Grid- Tributary)



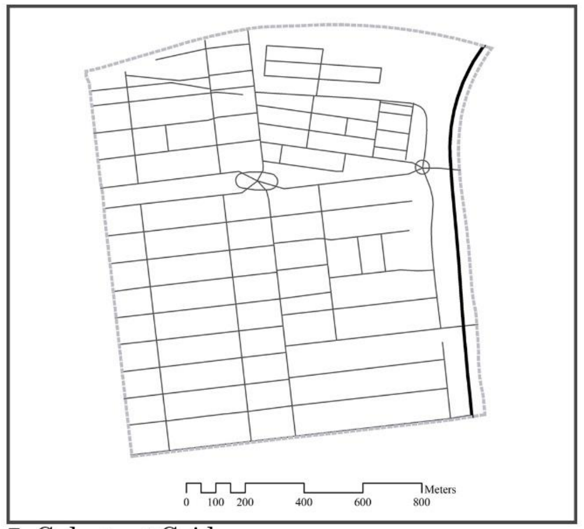
4. Abshar-e Tehran: Imitated organic



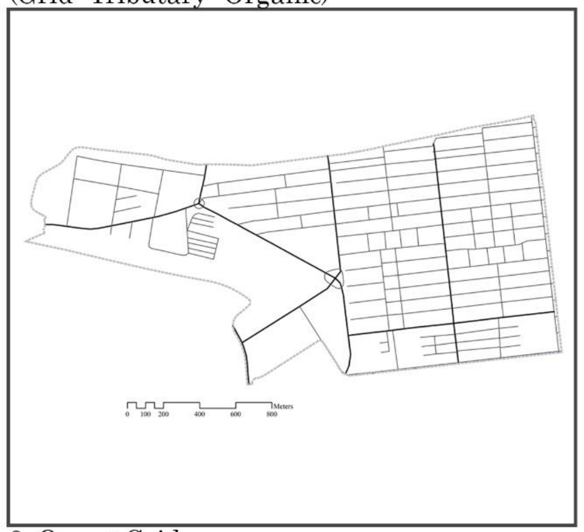
5. Dehkadeh Olampik: Mixed (Grid- Tributary- Organic)



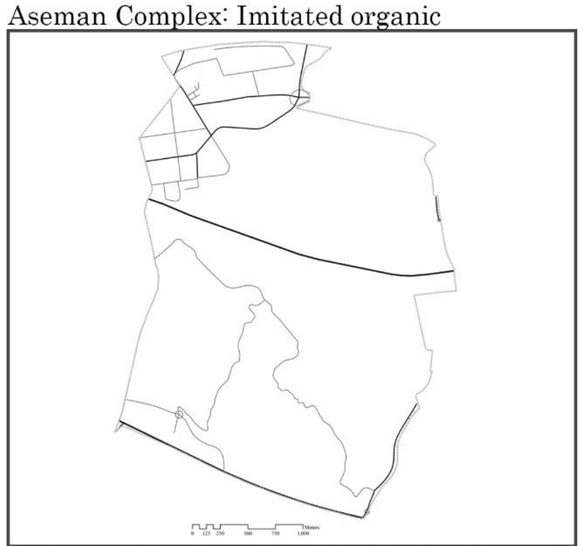
6. Daryach-e-ye Shohadaye Khalije Fars: Tributary
Aseman Complex: Imitated organic



7. Golestan: Grid



8. Qaem: Grid



9. Shahrak Farhangian: Mix (Grid-Tributary)
Shahrak-e Azadi: Mix (Grid- Radial)

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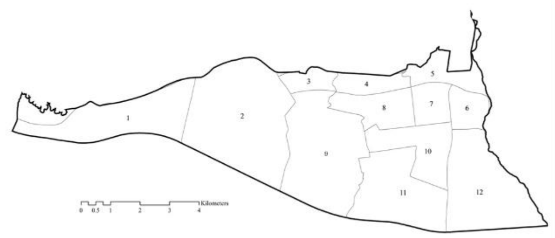
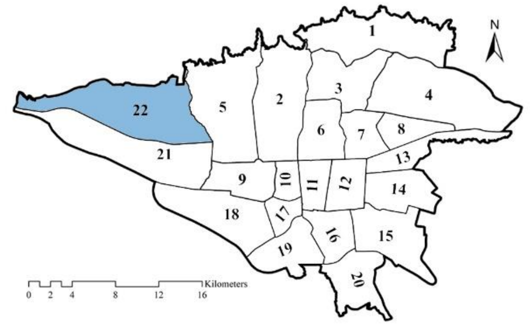
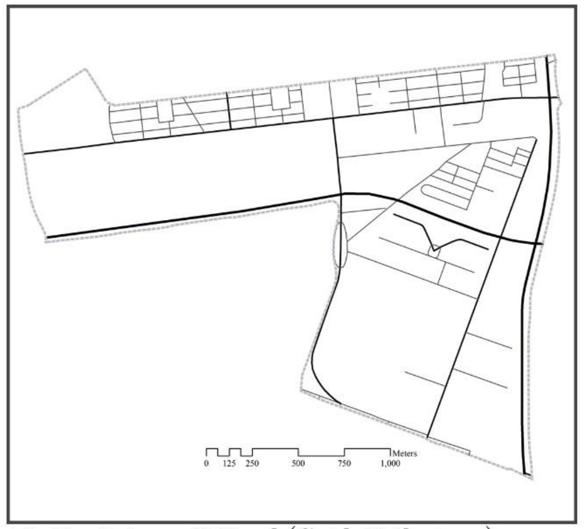


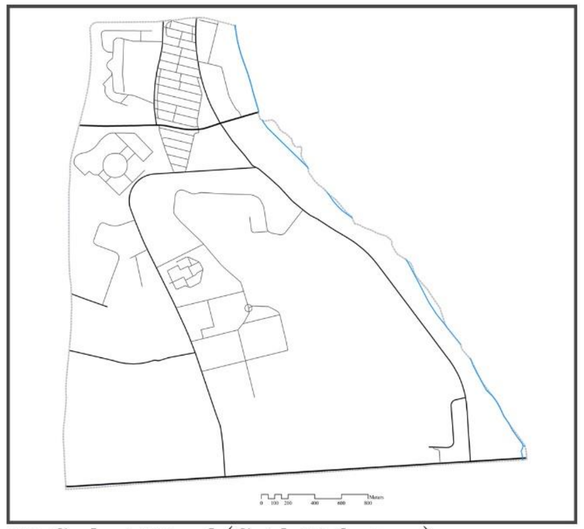
District 22





10. Havinirouz: Mixed (Grid- Tributary)

11. Kouhak: Mixed (Grid- Tributary)



12. Sadra: Mixed (Grid- Tributary)
Shahrak-e Sadra: Imitated Organic

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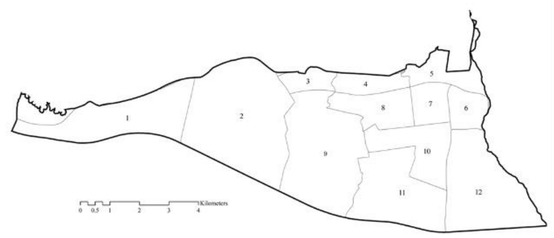

District 22