sustainability

Article

Which Fabric/Scale Is Better for Transit-Oriented Urban Design: Case Studies in a Developing Country

Mohammad Hamed Abdi [1] and Ali Soltani [2,3,*]

[1] Urban Planning and Spatial Development Department, School of Architecture, Universidad Politécnica de Madrid, Avda. Juan de Herrera 4, 28040 Madrid, Spain; mh.abdi@alumnos.upm.es
[2] UniSA Business, City West Campus, University of South Australia, Adelaide 5001, Australia
[3] School of Art & Architecture, Shiraz University, Shiraz 7188637911, Iran
* Correspondence: ali.soltani@unisa.edu.au

Abstract: The goal of this study was to find out how suitable the existing design of urban forms is for adopting transit-oriented development (TOD) basic ideas. Within a major metropolis and a medium-sized city, three varieties of Iranian urban fabric (historic, transitional, and modern) around transit stations were selected using the case study research technique. Then, for two sizes of station areas (macro) and street scales (micro), several TOD design dimensions were evaluated. The results of the comparative research indicated that Iranian cities offer greater chances for TOD design in inner urban areas (including historical and transitional urban forms), whereas microscale characteristics are less reliant on the kind of urban form.

Keywords: public transit; transit-oriented development (TOD); transit station; walkability; case study; Iran

check for updates

Citation: Abdi, M.H.; Soltani, A. Which Fabric/Scale Is Better for Transit-Oriented Urban Design: Case Studies in a Developing Country. *Sustainability* **2022**, *14*, 7338. https://doi.org/10.3390/su14127338

Academic Editor: Luigi Dell'Olio

Received: 5 May 2022
Accepted: 10 June 2022
Published: 15 June 2022

1. Introduction

The sustainability paradigm and integrated transportation land-use planning are inextricably linked, and TOD is one of the urban development models that is directly related to sustainability [1], with its primary goal (paying attention to the needs of current and future generations concurrently) addressed by environmental protection, social development, and economic prosperity [2]. TODs address this by offering a well-established network and conveniently accessible region made possible by efficient public transportation services [3].

TOD practice would ideally give varied users a network of interconnected high-quality locations to live, work, and perform the majority of their daily activities, eliminating their need for automobiles. In practice, TOD's macroscale, plans and policies might be coordinated with the project's urban design feature [4]. TOD design tools make basic TOD principles (such as land use and transportation integration, proximity, and liveability) a reality.

Calthorpe focused largely on a number of urban design guiding tenets for public spaces and municipal structures, street design, walking and cycling transportation, and the public transportation (PT) system [5]. Ewing proposed 23 pedestrian- and transit-friendly design elements, such as medium-to-high densities, diverse land uses, safe crossings, accessible recreational and public areas, and a grid-like roadway network [6]. The TCRP (Transportation Cooperative Research Program) study also contained information on the mutual advantages of a place-making attitude to promoting liveable urban areas and transit with offered design-oriented techniques [7]. This report's number 52 specifically addressed the design concerns for TOD schemes, recommending a trinity of density, land-use mixture, and the quality of public settings as transit-oriented design elements at the level of station [8].

Furthermore, Dunphy et al. praised 10 concepts for PT growth in American cities that are encouraging for TOD design, such as shared vision, interactor partnership, and an integrated mix of activities [9]. The ULI (Urban Land Institute) guideline recommendation clarified pedestrian- and transit-oriented design qualities by grouping them into eight streetscape qualities that influence walking behaviour in relation to PT [10]. More specifically, Jacobson and Forsyth systematically provided a set of appraising tenets for the TOD design on an American basis which inspired further TOD design studies worldwide [11,12].

Overall, research on dimensions for evaluating the link between physical characteristics and walkability may be divided into two major scales of neighbourhood, macroscale, or built space and street, microscale, or public open space [13–16]. At the macroscale, the "5Ds" model was used to define the measurements discussed above. The model incorporates three aspects of "density", "diversity", and "design" known as "3Ds", developed by Cervero and Kockelman [17], as well as "destination accessibility" and "distance to transportation", proposed by Ewing and Cervero [18,19]. "Destination accessibility" was combined with "diversity" owing to overlap between them [19], and "distance to transit" was substituted with "access to transit" since transit accessibility was also included in this study.

In all, 23 previous studies, including observational community audits, were re-evaluated in terms of microscale metrics. This resulted in nine design metrics, including functional and visual–aesthetic dimensions at microscale.

Figure 1 presents a TOD design assessment framework, including macrolevel dimensions (i.e., density, diversity, design, and access to transit), as well as microlevel ones (infrastructure and access, land uses and activities, and streetscape), coupled with related TOD design measures/qualities.

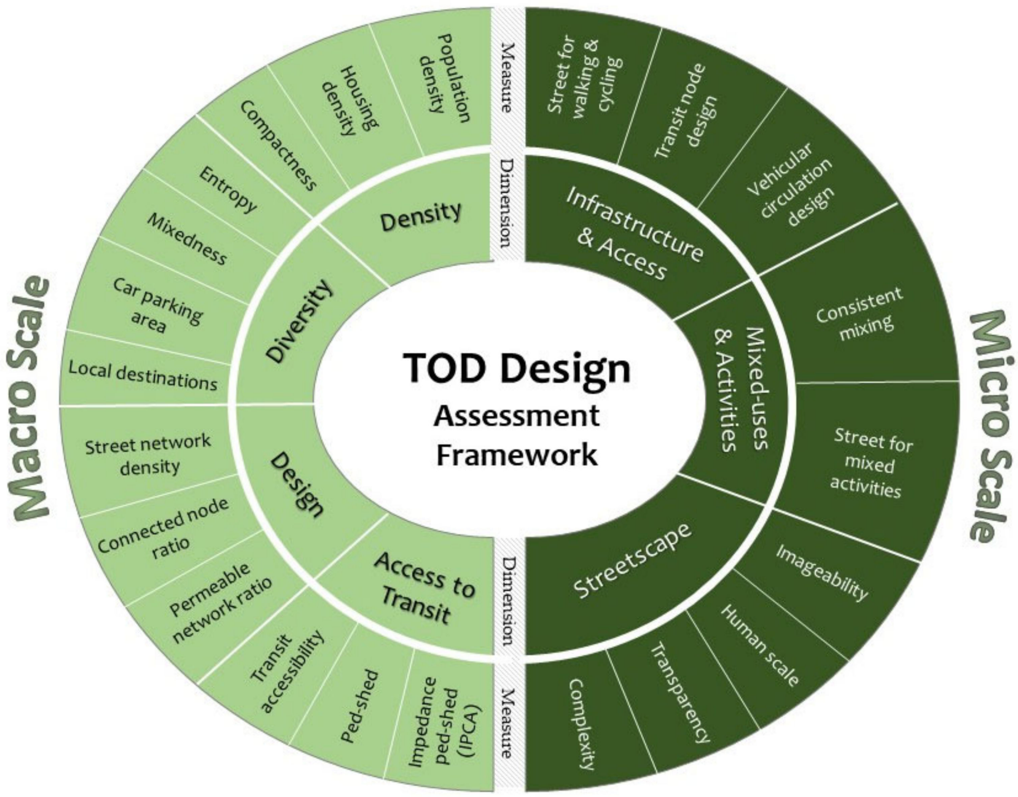


Figure 1. TOD design assessment framework.

Population density (pp/ha) in the framework above refers to the number of dwellers per catchment area (gross) and residential area (net) [20] and housing density (du/ha) by replacing "dwelling units" for "dwellers" in the previous definition [21]. "Compactness" (ha) is computed through the total area of developable sites which are constructed within the catchment area [22]. The first diversity measures are as follows: "entropy", computed using the equation of LUE = $-1(\Sigma pi \times \ln(pi)ni = 1)/\ln(n)$ (where i denotes the land-use categories $(1, 2, \ldots, n)$, n is the total number of land-use categories existing in the research area, and pi is the proportion of area covered by land use i) [17], "mixedness", computed using the equation of MI = $\Sigma LNi/\Sigma(LN + LR)i$ (where LN is the total area of buffer i under non-residential land-use activities, and LR is the sum of areas that are residential within i) [23], and "car parking area" (ha), the total land allocated to off-street parking [22]. The last metric is the number of local destinations (or service accessibility) per square kilometre catchment area (1000 m station buffer) [24].

The design dimension includes three geometric measures: "street network density" (kilometre length of streets per square kilometre area of station buffer) [25], "connected node ratio" (percentage of three or more ways junctions per total number of intersections per buffer area) [21], and "permeable network ratio" (frequency of three- and four-way intersections per kilometre of street network) [20]. According to the last factor of this scale, "transit accessibility" is considered as the number of subway stations and bus stops per (built-up) buffer area [15]. The "pedestrian catchment area (Ped-Shed)" is defined as the ratio of the network distance from a subway/bus station to the Euclidean distance from the same station [26], whereas the IPCA excludes high-speed lines [26].

In terms of microscale dimensions, "street for walking and cycling" investigates the extent to which required conditions and facilities are provided, and street environments are well maintained and clean, "transit node design" investigates its integration with transit station as a community centre [4], and "vehicular circulation design" considers the extent to which car traffic is controlled to protect the social function of space. Street activities promoting pedestrian movements (positive uses at both the street and the building scales) are measured to assess "consistent mixing" [25]. The "street for mixed activities" metric assesses how much street space is available for various activities and behaviours, and how well the street environment can accommodate them.

The final dimension, "streetscape", assesses the extent to which the attendance and design quality of public open space and landscaping cause to capturing curiosity, evoking feelings, and leaving a lasting impression in streets ("imageability"); the presence and quality of building height and street elements can pair street surroundings with the extent and ratio of human features ("human scale"), and the presence and quality of active uses and street wall features ensure an opulent experience [27].

Although previous studies already attempted to make use of urban design elements on walking within the station areas in part [11,12,15,28–32], there was little consideration paid to the characteristics of transformed urban forms, as well as the contribution of various design qualities, with regard to the TOD principles, while cities are confronted with a variety of urban fabrics, and TOD-specific design guides are not on the agenda. Additionally, one single scale (often neighbourhood and occasionally streetscape) was previously addressed—mostly based on the context of the developed world—while the study of the TOD walkability merits multiscale attention. In addition, the research approach was maintained to be objective as much as possible to reduce the participation of personal judgment.

The transformations of urban design practices from the traditional period to modern times in Iran has been associated with the emergence of cars and their requirements, which have dictated the existing structure of urban settings [33,34]. Despite the fact that a wide range of urban forms and design characteristics can be found across Iranian cities of the past (seventh century AD to the present), their traditional urban form is defined by a set of similar design strategies adopted to meet the local needs [34–37]. For instance, there have been some regional, climate-responsive strategies paying attention to sociocultural factors such as specific "neighbourhood" (Mahalleh in Persian) structures and functions, mixture, compactness, network hierarchy and coherence, and most importantly, building upon the basis of pedestrian needs and social activities [34,38]. However, many characteristics linked with traditional urban forms cannot be replicated in modern urban communities. Following World War II, the increase in car-based movements and the related adaptions under Modernism damaged and separated significant traditional features in Iranian cities [34].

Overall, the transformation resulted in four types of existing urban fabrics, including the historic form and three others attributed to the contemporary urbanism: modified historic or transitional, contemporary grid or new fabrics [39,40], and modern informal [39]. The first kind of fabric (i.e., historic tissue) corresponds with huge physical, social, and economic decline, such that the majority of the damaged urban areas are inside such neighbourhoods, which are often located in downtown regions [41]. Second, modified historic urban fabric, also known as "transitional" fabric, generally surrounds historic communities and is distinguished by a semi-organic network, uneven fine-grained characteristic, and lack of recognisable urban planning or design patterns. As cities grew in population in the second half of the 20th century and beyond, they were gradually updated to handle vehicle movements, street networks were enlarged, and quarters were constructed.

A grid street network, which can be found in practically all new projects created in recent decades across the country, helps to identify contemporary metropolitan regions.

The primary purpose of this article is to define design preconditions for TOD on the basis of the pattern of urban forms in order to respond to the fundamental issue of how amenable the present design of Iranian urban forms is to embracing TOD core principles.

Accordingly, additional sub-questions were addressed in this study:

- Which design dimensions/qualities in Iranian cities are most likely to stymie or encourage TOD?
- Which types of existing Iranian urban fabrics best enable TOD design morphologically?
- What are the differences in designing TODs between neighbourhood (macrolevel) and streetscape (microlevel) characteristics?

To address these questions, the present study was based on a case study [42] in which the TOD-ness of three kinds of Iranian urban fabric were comparatively examined. On this basis, this paper enjoys a mixed approach that includes both qualitative and quantitative indicators tested in previous empirical studies [4,15,17,19,20,22,24–26,28,43–47].

2. Data and Methods

2.1. Case Study Research Method

The case study research method was used in this study. This technique provides an in-depth description, analysis, and extensive research of a particular subject and phenomenon [48,49]. In reality, the case study technique investigates a phenomenon in a specific setting utilising a range of sources and perspectives to uncover numerous elements of the phenomenon [50]. This research approach is commonly used in the fields of planning and urban studies, where real-life subjects are analysed and documented in order to formulate and test a hypothesis [51], such as Healy who investigated three urban regions in Europe in terms of making spatial strategies [52]. In terms of survey design and experimental methodologies, the method also reveals the causal relationships in real-life complex interferences [53]. As a benefit, case study research allows researchers to have a more intimate perspective, allowing them to delve further into the subject knowledge [54].

Although most case studies focus on qualitative data linked to the subject, quantitative data are occasionally employed to gain a better understanding of the case and its context [55]. Case studies can be undertaken in the form of comparative research in order to analyse specific examples of planning activity [56], as in the current study, which compares three types of Iranian urban form within two cities in terms of TOD-ness.

2.2. Study Area

Tehran and Qazvin were targeted in order to select sampled station catchment areas (called "sites" here) to perform macro- and microscale analyses. The decision was to choose Tehran as a large-sized metropolis (among cities with over one million inhabitants) and Qazvin as a bus-based, medium-sized city (among cities with 300 to 600 thousand inhabitants) as representatives of Iranian major cities (Table 1) with the TOD system in a 10-year plan [57]. Both cities have made recent attempts to create TOD-focused urban development programmes such as pedestrianised walkways and bicycle networks; furthermore, they were selected as pilot cities by the Iranian Ministry of Road and Urban Development (MRUD) to primarily apply TOD policies [58]. More importantly, they were more accessible in terms of data and literature than the other cities.

Table 1. Characteristics of selected cities.

City	Population * (n)	Population Density (pp/km^2) **	Annual Population Growth: (Birth and Migration) (%) *	Mode Share (%) ***				
				Private Car	Taxi	Bus	BRT	Subway
Tehran	8,693,706	8000	+1.50	51	23	9	7	10
Qazvin	402,748	9000	+5.54	48	25	27	0	0

* Based on the latest national census statistics [59]; ** [60]; *** [61,62].

Both cities are placed in the upper middle of Iran, at the intersection of the east–west railroad (including the symbolic Silk Road) and north–south corridors (Figure 2), on the southern slopes of the Alburz mountains, with a moderate climate traditionally providing a excellent central position to live, work, and access and govern the remaining territory.

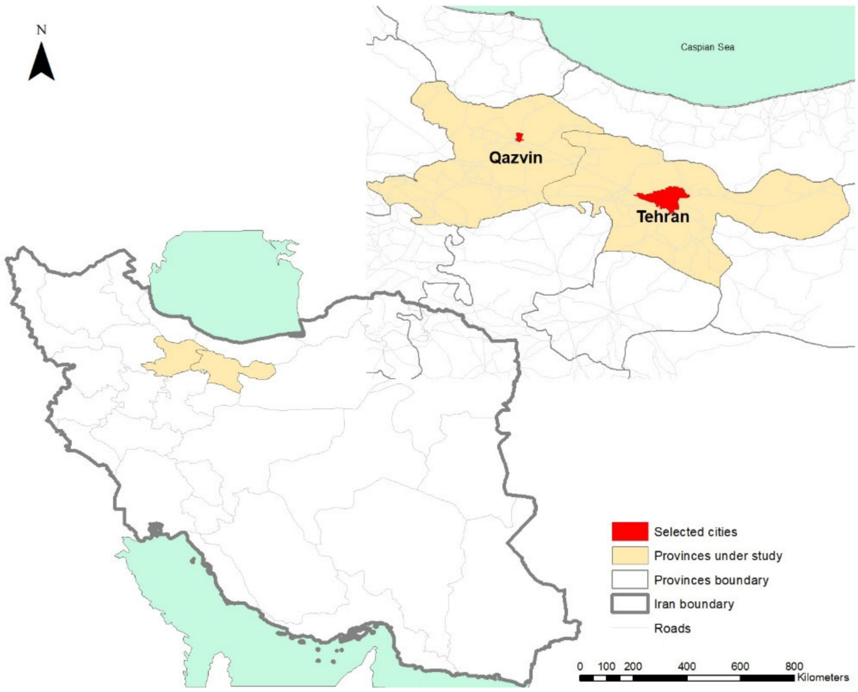


Figure 2. Location of selected cities in Iran. Source: authors.

Tehran is noted for a varied range of economic activity and services (including health and education), the largest market, and the seat of political and administrative authority. This resulted in Tehran Municipality absorbing 31% of total national immigrants (2006) [62], making it the most significant destination for Iranian immigrants. As a result of several decades of industrialisation, employment in the service, administrative, and industrial sectors (employing 99% of the working population) has become the general class in Tehran, leaving little room for agriculture, which employs only 1% of the working population [63]. In Qazvin, the service and industrial sectors account for 52% and 45% of total jobs, respectively. As a result, both cities have much lower unemployment rates in comparison with the remaining provinces and other Iranian settings.

Both cities have seen a significant increase in size under contemporary urban planning, and this, along with the city's outward extension in the form of peripheral residential areas and housing estates, as well as satellite towns, has resulted in a fractured urban fabric in recent decades. They have grown in size due to natural factors such as historic orchards in Qazvin, the northern Alburz Mountain, and the southern desert near Tehran. Meanwhile, a large set of informal settlements have grown as a result of the increasing demand for land [64].

The macrolevel analysis refers to the scale of station area in the present study. To select samples of each station area type, the typology of urban fabric was adopted regarding the transformation of urban form and its design features (i.e., historic, transitional, and contemporary). Therefore, three subway precincts in Tehran (Sites 1, 2, and 3), as well as three bus station locations in Qazvin (Sites 4, 5, and 6), were selected for additional data collection (Figure 3), whilst the informal fabrics were removed due to the lack of basic PT services. The data for these areas were captured from the Tehran master plan [65] and Qazvin master plan [66]. The borders of the stations were drawn around them using preset, straight-line walking distances. According to ITDP [22], catchment zones for both bus stops and subway stations were chosen on the basis of a radius of 1000 m (314.15 ha). In addition, several investigations were conducted on the basis of a radius of 500 m (78.53 ha) such as Ped-Shed—an area enclosed by the walking distance from transit stations—for bus station areas and street-level analyses.

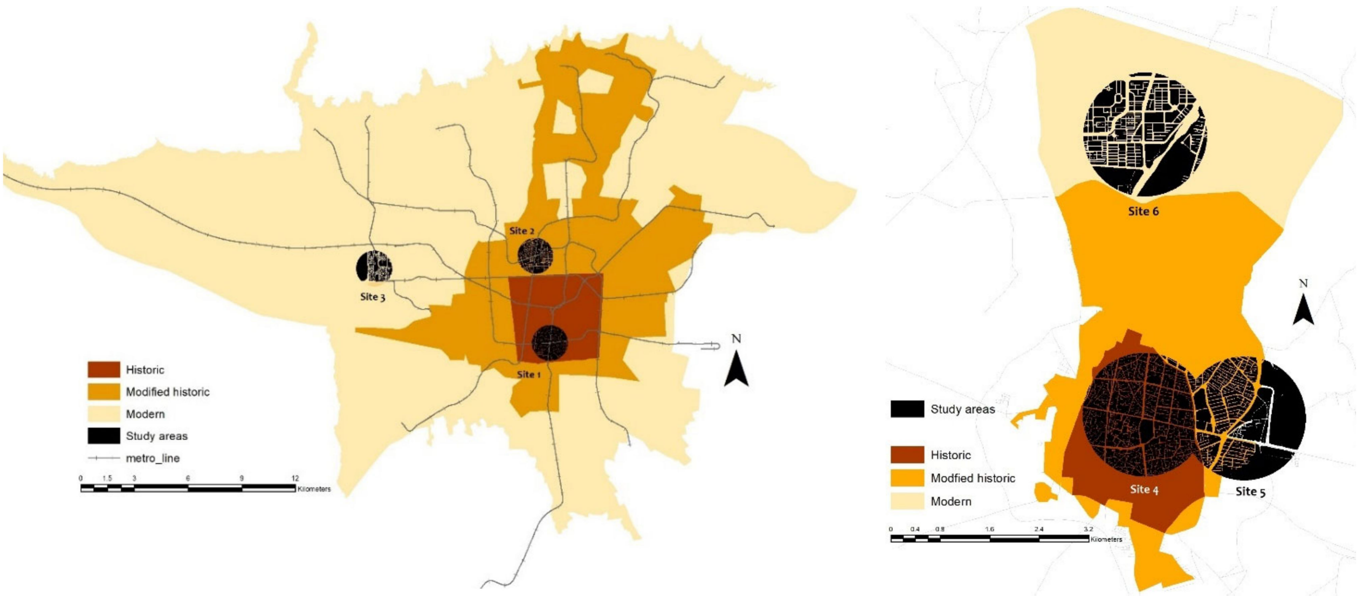


Figure 3. Typology of urban fabric and location of catchment areas in Tehran (**left**) and Qazvin (**right**). Source: authors.

For the purpose of this study, two types of streets were chosen, as the single type of public open space, to conduct the microlevel studies, because they are the most common type of public open space and tend to be the dominant forms among others in Iranian cities (i.e., nonlinear urban forms of squares and plazas). Within a 500 m buffer of the stations, 13 major streets plus five residential, local ones were chosen, totalling 110 key block faces (Figure 4).

Figure 4. The location of selected streets (n = 18) within a 500 m buffer of transit stations. Source: authors.

2.3. Data Collection and Analysis

Overall, two kinds of methods were utilised in this study:

1. Macroscale mapping and GIS analysis. National census tracts, local statistics yearbooks, city planning papers, formal governing maps and GIS data in use, technical plans and reports, and academic research schemes were used as data sources in this study. Among the macroscale measures, population and housing densities were estimated by census tract data (2011) published by the Statistics Centre of Iran [67]. Spatial data were obtained from databases of the Tehran and Qazvin master plans released by Tehran municipality and the local department of MRUD in Qazvin. In addition, the date for land areas allocated to Off-street parking (i.e., car parking area) and the number of PT stations (i.e., Transit accessibility) were obtained from the most recent edition of the statistical yearbook for the Tehran and Qazvin municipalities and updated with open-source data (Open Street Map). Similarly, Open Street Map was used to obtain local destinations. In this study, Arc GIS 10.8 was used to retrieve and analyse the acquired spatial information.
2. Direct microscale observation. The required data were gathered by personally observing the selected streets. There were two data collecting rounds (June 2019 and August–September 2020) with three trained observers. To and from the stations, the observers walked the whole length of each street within a 500 m buffer (i.e., walk-by observation). In addition to the fixed-route observation, unstructured observation was undertaken to gather information on specific subjects or places. The streets were monitored on weekdays during morning and evening peak hours (7 a.m.–9 a.m. and 6 p.m.–8 p.m.) for a total of 4 days, with the goal of recording utmost human activity and vehicular traffic behaviour within the street's built environment. The overall weather quality was appropriate with no wind, rain, or snow. The observations

ranged in length from 20 to 60 min for each street, depending on site conditions. Snapping field notes and taking photographs (handheld and fixed-point picturing) were principal means to capture data. Google Street View 360° pictures were also used limitedly in Tehran where accessible.

3. Results and Discussion

3.1. Station Area-Level Design

This section indicates the recorded results for macroscale TOD design measures on the basis of the transformation of the urban form and the resulting urban fabrics.

3.1.1. Density

According to Table 2, in comparison, the mean rates of both gross population and housing density were higher in the historic fabrics (163.93 pp/ha and 48.59 du/ha, respectively) due to the crowd of small, low-rise, and compact dwellings and workplaces, while "net" densities increased from historic to contemporary fabrics (from 378.28 pp/ha and 112.15 du/ha to 806.42 pp/ha and 251.60 du/ha, respectively), because of the high intensity of residential use (not compacted) in contemporary areas. In general, the findings confirmed that compacted low- and medium-rise buildings caused high urban population densities in Iran.

Table 2. Descriptive statistics of density measures for the three urban fabrics and the two cities.

Dimension	Measure	Urban Fabric								
		Historic			Modified Historic			Contemporary		
		Tehran (Site 1)	Qazvin (Site 4)	Mean	Tehran (Site 2)	Qazvin (Site 5)	Mean	Tehran (Site 3)	Qazvin (Site 6)	Mean
Density	Gross population density (pp/ha)	173.84	154.03	163.93	107.99	81.16	94.57	123.17	105.59	114.38
	Net population density (pp/ha)	416.49	340.07	378.28	313.32	315.67	314.49	1223.12	389.71	806.42
	Gross housing density (du/ha)	52.02	45.16	48.59	30.47	23.32	26.89	41.20	25.48	33.34
	Net housing density (du/ha)	124.61	99.70	112.15	88.42	90.70	89.56	409.14	94.05	251.60
	Compactness (%)	98	97	97.5	98	61	79.5	93	84	88.50

3.1.2. Diversity

The land-use dispersion pattern displayed that residential land use predominated in most sites (Table 3), with its mean share decreasing from historic (43%) to contemporary fabrics (19%). In terms of historical landmarks, the land-use model revealed that residential areas were enclosed by a ribbon of commercial uses, the majority of which were located on the edges of main roadways. Although mixed-use and active frontage in the historic place is typically regarded favourably (described below), it deprives inner blocks of access to destinations and drives automobile use to the boundary margins, failing to generate a feeling of place [68].

The traditional usefully defined system of land-use pattern "in separate quarters" gave way to a pattern in which mixed land use in centres and single-residential use in peripheries predominated. There were two major changes in the spatial distribution of uses from transitional to contemporary fabric: (1) appearance of planned, linear, and rectangular green spaces, and (2) distribution of commercials, offices, and other services with larger scales and modern uses (e.g., universities, hospitals, and malls).

According to Table 3, the mean entropy value was higher than half (0.75). Interestingly, the mean value of mixedness in the study areas was just 0.5, displaying a balanced residential/non-residential land-use pattern. From a diversity perspective, these rates are promising for planning Iranian TODs since they suggest a higher degree of mixing and, thus, a higher level of TOD-ness in the studied areas. Of the six study areas, the contemporary (planned) areas had a superior degree of mixed land-use regarding just dedicated lands (0.8), not the volume and distribution of services and facilities, while their general imbalanced mixedness ratio (0.67), between residential and non-residential uses, might guide such zones towards mono-functionality and raise daily work and non-work trips to the central urban areas; these are places where parking is desirable and its spatial requirements are becoming more important. In this sense, the results showed a agglomeration of off-street parking lots in the historic catchment areas (27,896.5 m^2), mainly on the edge of main routes and near attractive travel destinations.

In terms of destination accessibility, the results displayed that, generally, the concentration of destinations existed in the historic areas, whereas contemporary sites suffered from a lack of local destinations. As previously stated, the outward distribution of destinations towards transitional areas resulted in increased accumulation of services in the large city of Tehran, much larger than in the centres. When comparing Tehran and Qazvin, Tehran had a greater average number of destinations (264.5), but Qazvin's historic centre (257) had a higher concentration, implying a prime city centre in Qazvin and a lack of developed modern centres in the city. With regard to "destinations number per residents", one could argue that the historic fabrics (Sites 1 and 4) are still scarce of local destinations owing to densely populated areas, whereas there is a fair balance between "total destinations" and "destinations number per residents" in other study areas. According to Figure 5, among classified destinations, the average number of destinations was higher for "food retail" and "financial" (38.5 and 33.3, respectively). "Education" and "recreation" were also lower than other destinations (13).

Table 3. Land-use patterns and descriptive statistics of diversity measures for the three urban fabrics and the two cities.

Dimension	Measure	Urban Fabric								
		Historic			Modified Historic			Contemporary		
		Tehran (Site 1)	Qazvin (Site 4)	Mean	Tehran (Site 2)	Qazvin (Site 5)	Mean	Tehran (Site 3)	Qazvin (Site 6)	Mean
Diversity	Entropy	0.79	0.69	0.74	0.74	0.68	0.71	0.80	0.80	0.8
	Mixedness	0.44	0.38	0.41	0.50	0.34	0.42	0.84	0.50	0.67
	Car parking area (ha)	2.27	3.30	2.78	1.72	0.92	1.32	0.83	0.00	0.42
	Local destinations (#)	229	257	243	300	78	189	66	36	51

Source: authors.

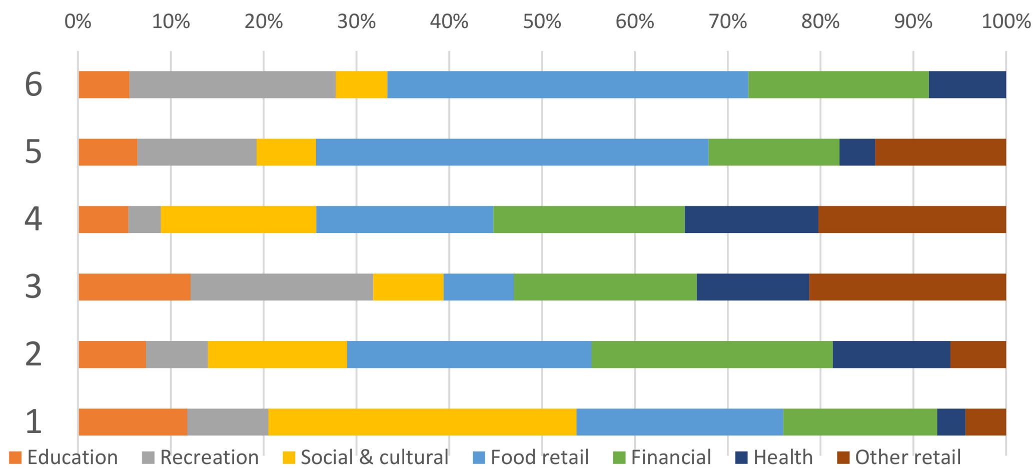


Figure 5. Frequency of local destinations per cathcment areas. Source: authors. Site 1 (Tehran, historic); Site 2 (Tehran, modified historic); Site 3 (Tehran, contemporary); Site 4 (Qazvin, historic); Site 5 (Qazvin, modified historic); Site 6 (Qazvin, contemporary).

3.1.3. Design

In line with the case study selection, the figure-ground maps demonstrate that the street network pattern changed from centre to periphery (Table 4). In general, central regions had a (semi-)organic pattern with a larger proportion of land occupation and block number, whereas recently built-up areas had an orthogonal grid-like pattern with a lower occupation rate and fewer block numbers than the former.

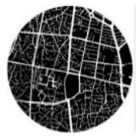
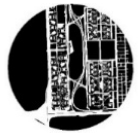
Table 4 shows that the average street density for all locations was around 20 km/km^2. The chart also reveals that more than 70% of total junctions were three and four-way, meaning that almost three-fourths of street networks were internally linked. The average permeable network ratio was around 10, implying that there was one junction per 100 m of roadway length. This demonstrates that the mean grid spacing in Tehran and Qazvin, as well as in central and modern regions, was quite close to the codes for street network design (about 100 m) [6,68,69].

The inter-fabric comparison showed that the historic fabrics (Sites 1 and 4) had high mean values of street network density and permeable network ratio (27.08 km/km^2 and 14.26 intersections per km^2, respectively), with values decreasing from the centres to peripheries, while connected node ratio, a proxy for grid pattern [16], was lower for the central areas (62%). While Iranian city centres (typically equipped with historic fabrics) had the longest total street network divided into short parts, they mainly featured twisting, narrow alleyways that were not joined together by cul-de-sacs.

3.1.4. Access to Transit

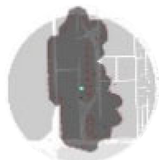
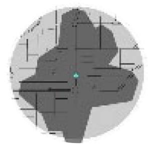
According to the descriptive statistics in Table 5, there were on average 12 transportation possibilities per developed square kilometre area. The average proportion of actual walking distance to theoretical pedestrian catchment area (distance as a crow flies) was 0.70, showing that 70% of PT precincts had physical access to the station. When highways and major arterial roadways were eliminated (i.e., IPCA), the value dropped as predicted (55%). In terms of the genuine pedestrian catchment area rate, the mean value was greater in central regions (84.5%) and lower in contemporary areas (52.5%). As assessed for "permeability", shorter street segments provided more walking coverage for historic sites than bigger blocks and long streets in modern locations, which may reduce the true maximum walking distance to transportation choices. Indeed, these ratios tend to favour walkability, resulting in TOD-centred design in key areas.

Table 4. Comparative analysis of study areas street pattern and other physical characteristics.

Dimension	Measure	Urban Fabric								
		Historic			Modified Historic			Contemporary		
		Tehran (Site 1)	Qazvin (Site 4)	Mean	Tehran (Site 2)	Qazvin (Site 5)	Mean	Tehran (Site 3)	Qazvin (Site 6)	Mean
Design	Street pattern (ground map)			-			-			-
	Land occupation share of built-up area (%)	75.48	73.16	74.32	69.68	39.11	54.40	64.51	55.08	59.80
	Mean residential parcel area (m^2)	156	183	169.50	320	205	262.50	3954	261	2107.5
	Number of blocks included	326	333	329.50	348	188	268.00	40	202	121.00
	Mean block area (m^2)	8009	7339	7674.0	6508	8454	7481.0	60,673	11,480	36,076.5
	Street network density (km/km^2)	27.64	26.52	27.08	20.37	15.85	18.11	14.95	15.40	15.18
	Connected node ratio (%)	62	62	62.00	76	69	72.50	76	82	79.00
	Permeable network ratio (n per km^2)	14.63	13.88	14.26	7.67	9.26	8.47	5.49	7.24	6.37

Source: authors.

Table 5. Ped-Shed ratio for the three urban fabrics and the two cities for access to transit measures.

Dimension	Measure	Urban Fabric								
		Historic			Modified Historic			Contemporary		
		Tehran (Site 1)	Qazvin (Site 4)	Mean	Tehran (Site 2)	Qazvin (Site 5)	Mean	Tehran (Site 3)	Qazvin (Site 6)	Mean
Access to transit	Ped-Shed *			-			-			-
	Transit accessibility (n per km^2)	10.3	17.1	13.7	11.8	3.5	7.6	15.1	12.6	13.8
	Ped-Shed (%)	78	91	84.5	72	74	73	42	63	52.5
	IPCA (%)	-	42	42	68	51	59.5	35	-	35

Source: authors. * Legend: station buffer; Ped-Shed; transit station.

3.2. Street-Level Design

There is agreement that Iranian public spaces fall short of providing pedestrian-friendly environments, but it was necessary to determine which elements reflect this and where there are opportunities for improvement, compensating for the shortcomings of macroscale design where data were unavailable. The results revealed that streetscapes in the studied areas were drivers. However, there were several common design features depending on microscale design dimensions for each urban fabric, which are summarised below.

3.2.1. Infrastructure and Access

Despite different recorded scores (Table 6), the direct observations revealed that study streets had some common characteristics in terms of walkway and cycleway attributes. While basic sidewalks were available on nearly all street segments studied (not more than 40% of the total street width), only two streets had cycling paths with limited biking facilities, and they were sometimes used by motorists and pedestrians (Figure 6a). Residential streets were less likely to have clearly defined bicycle and pedestrian lanes (Figure 6b).

Table 6. Mean scores (1 to 5) for "infrastructure and access" measures for studied streets across the study areas.

Measure	Indicator	Historic		Modified Historic		Contemporary	
		Site 1	Site 4	Site 2	Site 5	Site 3	Site 6
Street for walking and cycling	Walkway and cycleway attributes	2.7	3.3	3.6	3.0	2.3	3.6
	Facilities for walkers and cyclists	2.4	2.3	3.0	1.9	1.5	1.8
	Maintenance and cleanliness quality	2.4	2.7	4.1	3.8	3.3	3.7
Transit node design	Transit station amenities and design	3.6	2.4	3.6	2.8	2.8	1.2
	Transit node as a community centre	3.7	4.7	4.3	1.9	1.0	1.3
	Integration with street	3.7	3.3	4	2	1.7	1.3
Vehicular circulation design	Parking design	1.8	2	1.8	1.0	1.0	1.8
	Traffic impact	1.3	1.5	1.5	1.0	1.0	1.0

Source: authors.

Figure 6. Observed situation for "street for walking and cycling" measure across the study streets. Source: photographs by authors. (**a**) Vali-Asr St. (Site 2), (**b**). Maleki St. (Site 5), (**c**). Vali-Asr St. (Site 2), (**d**) Bsij St. (Site 6), (**e**) Razmandegan St. (Site 6), and (**f**) Khayyam St. (Site 1).

Few seating spaces in major streets, poor carriageway lightings (Figure 6c), poor signage for vehicular visibility, no wayfinding maps, limited biking facilities, missing equipment for visually disabled people (e.g., traffic lights with auditory signals), and rare facilities for disabled persons were among the major observed items concerning walking and cycling facilities (Figure 6d). In terms of street cleanliness, footpaths were generally paved, clean, and well maintained (Figure 6e). However, some activities, mostly along central streets, resulted in garbage being dumped outside along pedestrian routes (Figure 6f). During the field observation, vandalism, graffiti, and broken windows were rare, aside from a few deteriorated buildings in the central streets.

Although each station environment had its own design elements, there were a few similarities depending on the placement of the station surroundings and street. According to Table 6, in general, two kinds of station environment and transit node design were found in the study areas: central station environments (Site 1, 2, and 4) and peripheral station environments (Site 3, 5, and 6). According to Table 6, observations of vehicular circulation design revealed that, regardless of street position in the city (centre or periphery), the Iranian street design method was unable to restrain vehicular circulation to improve active travel and facilitate social street activities, due to the priority given to car movement, in terms of available, free parking space everywhere, and imbalanced street design for motorised and non-motorised movements. While core fabrics are commonly assumed to be walkable settings, they failed to limit traffic effects and establish parking spaces in tandem with modern areas.

3.2.2. Mixed Uses and Activities at Street Level

This microscale aspect of transit-oriented design attempt to reveal in what way streets react to the demands and activities of multilateral users. The capability of some major and residential streets was evaluated in terms of consistent mixing and providing streets for mixed activities and users, as shown in the Table 7.

Table 7. Observed situation for "consistent mixing" and "street for mixed activities" measures across the study streets.

Measure	Observation	Sample Street Observation	
		Central (Sites 1, 2, 4)	**Peripheral (Site 3, 5, 6)**
Consistent mixing	• Small commercial units in the central areas • Dwellings in the peripheral developments • Dwellings along residential streets (central and peripheral) • Vertical mixed uses in central (Image 1) • Mono-functional "big boxes" with nonactive uses in peripheries (Image 2) • Many undeveloped parcels in peripheries	 Image 1. Vali-asr, Site 2	 Image 2. Basij St., Site 6
Mixed activities	• Streets for easy and fast "car" access • Presence of motorists in pedestrian realm (Image 3) • Focal vehicular zone vs. marginalised pedestrian realm • Unsafe and unpleasant walking in residential streets and alleys • Dominant motorists and marginalised pedestrian activity (Image 4)	 Image 3. Vali-asr St., Site 1	 Image 4. Golha St., Site 3

Source: authors.

3.2.3. Streetscape

In addition to the functional components discussed above (such as infrastructure and land uses), streetscape (visual–aesthetic) features can influence pedestrian behaviour and create a pleasurable pedestrian experience. On the basis of the field notes and images of the places, they were assessed on a four-point scale (i.e., "none", "low", "moderate", and "high") (Table 8).

Table 8. Ranking of the quality of street features with regard to the urban design qualities.

		Urban Fabric												
		Historic					Modified Historic				Contemporary			
Street Feature		Khayyam (Tehran)	Mowlavi (Tehran)	Imam (Qazvin)	Naderi (Qazvin)	Ferdosi (Qazvin)	Vali-Asr (Tehran)	Keshavarz (Tehran)	Karim-Khan (Tehran)	Shahid-Beheshti (Qazvin)	Saremi (Tehran)	Golha (Tehran)	Razmandegan (Qazvin)	Basij (Qazvin)
Imageability	Courtyard, park, and plaza	0	0	0	1	0	0	2	0	2	1	2	2	1
	Natural landscape	0	0	0	1	0	0	1	0	0	1	0	0	0
	Noise	3	3	2	3	3	3	3	3	3	2	2	2	1
	Specific building form	1	2	2	2	0	1	1	1	0	1	0	0	0
	Identifiable building	3	3	3	3	3	3	3	2	1	0	2	1	1
	Historic building	1	1	1	0	0	0	0	0	0	0	0	0	0
Human scale	Small planter	1	1	1	2	1	2	2	1	1	1	0	1	2
	Furniture	2	3	2	3	2	3	3	2	1	1	0	1	1
	Street-level windows	3	3	3	3	3	3	3	1	1	0	2	1	1
	Pavement texture	2	1	2	2	2	3	2	1	0	2	1	2	2
	Parked cars	2	2	1	2	2	2	2	3	2	2	3	2	1
	Building details	2	2	2	1	1	1	1	1	1	0	1	1	1
	Building height	1	1	1	1	1	2	2	2	1	2	1	2	2
Transparency	Street-level windows	3	3	3	3	3	3	3	1	1	0	2	1	1
	Façade continuity	3	3	3	2	3	3	3	2	1	1	2	2	2
	Active uses	3	2	3	3	3	2	2	1	0	0	2	1	1
	Street vendor	1	2	2	2	1	2	1	0	0	0	0	0	0
	Street trees	3	2	3	3	2	2	3	2	2	1	0	2	3
	Building details	2	1	1	1	1	1	1	0	0	0	1	1	0
Complexity	Building type and number	3	2	2	3	2	3	2	2	3	1	1	2	1
	Architectural diversity	2	2	1	2	1	3	2	3	1	1	0	1	1
	Building ornamentation	2	2	1	2	2	2	2	2	1	1	1	1	1
	Light and shade by trees	3	3	3	2	2	2	3	1	2	1	0	2	2
	Street furniture	2	3	2	3	2	3	3	2	1	1	0	1	1
	Signage	2	3	2	3	2	3	3	2	1	1	2	0	0

Source: authors. Ranking key: none; low; moderate; high.

The examination of streetscape attributes revealed that different components had variable effects on urban design quality. However, almost all of the central major streets scored higher for the four qualities: imageability (due to a higher portion of historic buildings and specific design forms); human scale (due to building height and on-street components); transparency (due to street-level windows, façade continuity, and active uses); complexity (due to a variety of building and architectural features, and furniture and signage presence); complexity (due to a variety of building and architectural features, and furniture and signage presence). The top five ranking main streets were those enmeshed in the historic and transitional fabrics around transit stations.

Contemporary main streets, on the other hand, received lower total rankings. Nonetheless, such roadways offered various advantages and benefits. For example, they were "imageable" due to high rankings in "park, plaza, and courtyard", as well as a less loud environment. They were also spatially "defined" and "transparent", as were the core principal roadways, owing to "shaded trees" and "on-street parking."

3.3. Synthesis: An Inter-Scale Analysis of Urban Forms

It is generally acknowledged that an urban setting is walkable when the design attributes create desirable, walkable circumstances in terms of both the urban form and the street sizes. According to Figure 7, the bulk of opportunities may be found in neighbourhood-level (macro) physical characteristics that include compacted, packed station environments with reasonably mixed uses and linked streets. At the microlevel, however, streets in neighbourhoods often have poor pedestrian and bicycling conditions and confortable automobile access (i.e., functional dimensions), while giving superior settings physically and artistically.

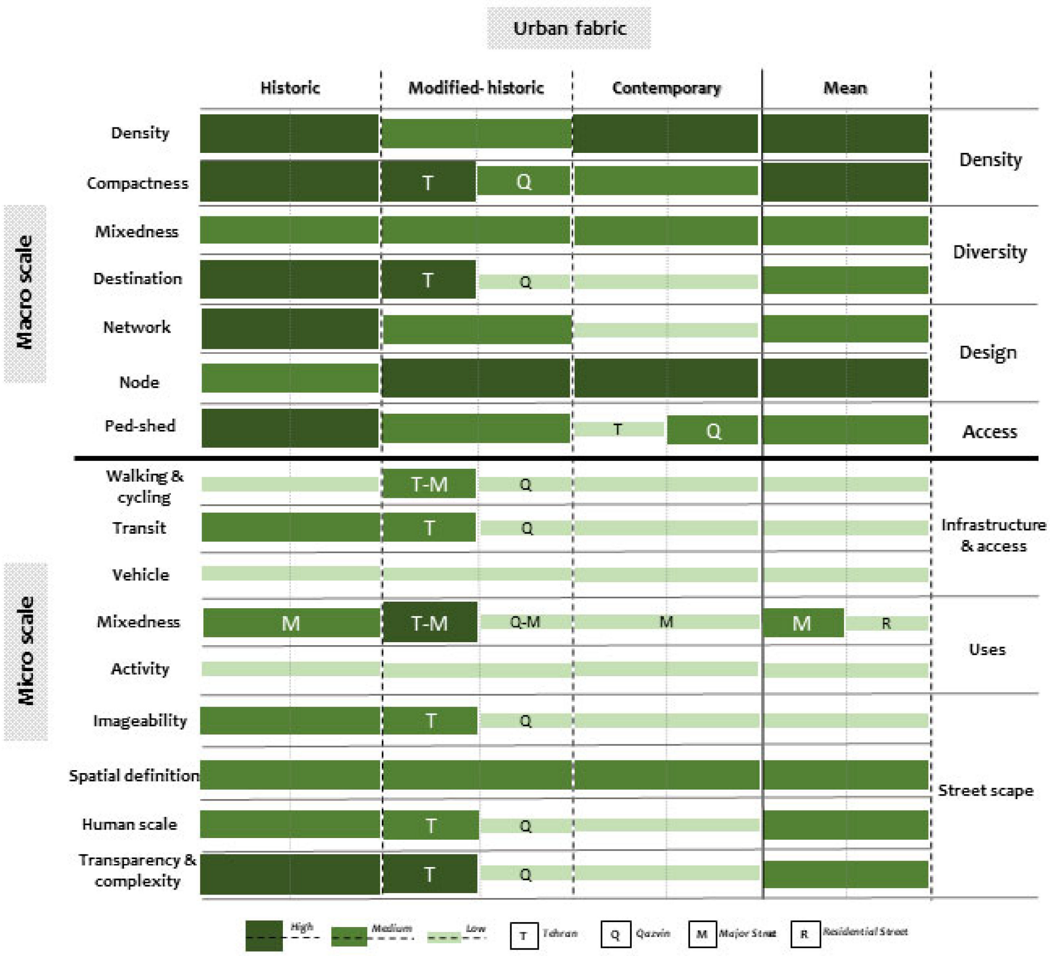


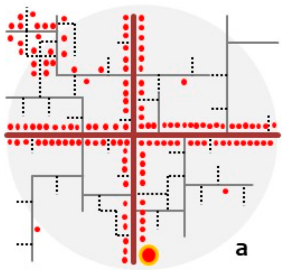
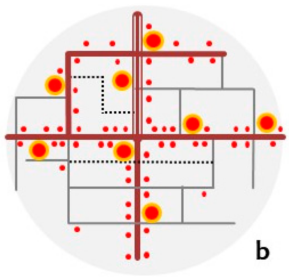
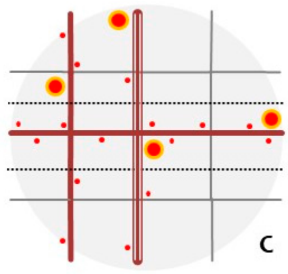
Figure 7. The degree to which macro- and microscale dimensions/qualities can produce pedestrian- and transit-friendly areas surrounding transit stations of triple urban forms. Source: authors.

As a result, some disparities exist between various distinct functional dimensions of macro- and microscales, as described below.

When different urban forms and neighbourhood (station area) types were studied, the discussion on land-use variety showed a separate model for the combination. The placement and provision of facilities in the transitional and contemporary developments demonstrated how each kind of station area provides amenities for people (Table 9), despite the fact that the degree of mixing among case study areas can be rated as generally acceptable.

However, street-level appraisal of usage and activities seldom encourages improved accessibility and stimulates social activities. In actuality, car-centric design solutions deny streetwalkers a feeling of community and limit the value of public areas. Aside from the flaws in transportation design and policy, this makes cities more car-dependent and may be a contributing factor to increased car ownership and use in Iranian cities [70].

Table 9. An abstracted model of the location and formation of servicesacross typical urban fabrics.

Synthesis Map	**Urban Fabric**		
	Historic	**Modified Historic**	**Contemporary**
Street network and activities			
	Expressway/Avenue Major Street	Secondary Street Alley/Cul-de-sac	Small-Scale Services Large-Scale Services
Notes	Commercial ribbons along main streets, as along with centred retails (Bazaar)	A higher number of large-scale facilities along with small-scale services oriented to major streets in this form	Distributed facilities throughout new developments

Source: authors.

The calculations found that the street network is most often interconnected at the size of neighbourhoods and station areas, but microlevel investigations revealed that walkways and cycleways are seldom interconnected and facilitated along roadways. This suggests that the higher position in "connectedness" is attributable mostly to the automotive network, rather than the pedestrian network. This may be in contrast to the design initiatives advocated to ameliorate the negative consequences of the neo-traditional (grid-like) paradigm (i.e., interconnected street network) in which cut-through traffic and its velocity are governed by linked pedestrian and limited-access roadways. It should be noted that this might be due to the prioritisation of vehicles based on Modernist-styled street design, as well as the marginalisation of walking-oriented social activities.

However, it is widely acknowledged that streets not only serve as a physical movement channel, but also support a variety of activities such as interacting, growing, moving, gathering, greening, shopping, and playing simultaneously as a public open space and place [71–73].

The multiscale TOD design study also indicated that different urban forms react differently to TOD-based design principles. It is considered a matter of faith that historic forms can improve the walkability of urban surroundings. The inter-form comparison research, however, demonstrated that they can only do so with the support of certain design aspects—largely at the scale of urban fabric—while the others fail. In terms of microscale attributes, the findings revealed that they were less dependent on the sort of urban design, although a distinction between main and residential streets made more sense. Nonetheless, the central regions had the highest marks on the micro-scale elements of visual–aesthetic (streetscape) urban design.

Walking, cycling, and social activities are more enjoyable in traditional urban shapes and important streets within these forms. In contrast, new developments are lacking in most areas (for example, walkability), notably in streetscape features. Bahrainy and Khosravi discovered that under-construction (newly built-up) places, particularly in Iranian new towns, generate discontinuous and dangerous pedestrian environments [74]. However, such projects house a sizable proportion of the population and are still extensively employed building patterns in the nation. Meanwhile, transitional textiles might serve an intermediary function, bringing the physical qualities of this form closer to the historic fabric in Tehran while representing the characteristics of modern advances in Qazvin. This would serve as a reminder of the growing importance of socioeconomic considerations, as well as the influence of the central business zone on urban form and street design features in Tehran's huge metropolis.

4. Conclusions, Implications, and Future Work

This study examined the conditions for TOD design in Iran, as well as other related sub-questions, on the basis of numerous TOD urban design dimensions derived from a typo-morphological examination of urban form. In fact, the main contribution of this research is to expand on the evident fact of historic urban fabric capability (i.e., the study hypothesis) by investigating the design dimensions/qualities, as well as the various scaling potentials.

The findings not only confirmed this idea, but also allowed us to identify the missing qualities of each urban fabric and how they may restrict pedestrian activity. It has been established that, in general, Iranian cities have greater prospects for TOD in their inner cities (including historic and, sometimes, transitional urban forms). Further enhancements should thus, be created mostly in the periphery, where TOD initiatives are shown to be most effective [75]. Another significant conclusion was that macroscale urban structure traits (such as density, mixedness, and connectedness) fit better into TOD requirements in Iranian cities than microscale ones such as streetscape characteristics. The evidence from other developing countries also confirms this; while urban density in the developing world, for example, is higher than its American, Australian, and European counterparts [76,77], design practices are still car-oriented, and pedestrian (social) activities are hindered in most urban environments in developing cities [75], such as using subway bridges and tunnels for pedestrian crossings [77], narrow lanes and lack of parking for cyclists at stations [78], dedicating the whole frontage of houses to vehicle access found in new developments [79], wide streets and large setbacks [80], the dearth of urban design promotions, i.e., streetscape improvement [76] and green areas [81], and poor physical integration of transit nodes with the surrounding environment [80,82,83].

This is important because macro or structural features are even more troublesome to modify than streetscape or street design. Such occasions will play a major catalysing role in shifting travel behaviour and priorities towards a more sustainable mode of movement such as PT and active transport [77].

In reaction to car-based design practises in Iranian cities, a number of in-depth modifications to design regulations and procedures might assist. Policymakers should take a harder stance on this and eliminate the regulatory and standard hurdles described as a "straitjacket" by Southworth and Ben-Joseph [73] (p. 105). City officials and practitioners should also move beyond "beautification" or cosmetic design projects with political goals [62]. This also yields recommendations for Iranian policymakers, urban designers, and public space managers to broaden their horizons on the practices, such that the diverse facets of the built environment [18,84,85] should be on the agenda to encourage pedestrians: from physical to social, from macroscale to street-level, and from functional to aesthetic dimensions. At macroscale where "location" and "connection" were the focus, the findings may help Iranian policymakers and designers to understand the fact that the location of transit nodes at community centres and their connection with other services and destinations on the basis of walking and cycling accessibility are crucial to new design agendas across neighbourhoods. This finding has important implication for city officials to move from putting unnecessary emphasis on high-density planning—with the aim of revenue making—to human-scale, intense development in newly built-up areas. The inner cities network may undergo restructuring (connecting dead-ends) during ongoing regeneration programs, while peripheries should be complemented with a network of pedestrian-oriented routes. With regard to land use and destinations, a distribution of small-scale destinations is recommended for contemporary fabrics, and progressing large supermarkets and malls must be strongly avoided. However, due to the problems found at the microlevel design of station environments, this observational study suggests that priority must be placed on design dimensions associated with this level: through connecting walkways and cycleways equipped with facilities (all fabric types), reducing the number and size of carriageways in street (peripheries), making space for social street life (peripheries), diversified building types and active frontage (peripheries), and public space definition with visual qualities and street objects (all fabric types).

This work contributes to the existing knowledge of TOD urban design by providing an evaluative framework for simply assessing the degree to which the current design of station areas is in compliance with the TOD core principles. This framework placed priority on both the macro- and microlevel design dimensions, while its previous counterparts considered macro or micro-scale qualities in a fragmented manner, lacking a comprehensive image of walking environment quality. In addition, the microscale of the framework was one of the limited versions designed on the basis of not only pedestrian condition, but also TOD necessities (e.g., centrality of PT station). In this sense, the priority placed on "infrastructure and access" makes this framework specific compared to previous versions. More specifically, it could add to the well-known framework of MI-UDQ [27] by taking functional dimensions into consideration. Furthermore, attention was paid to making linkage with more tangible, physical features, concerning the context of Iranian cities. Overall, multiscale and multilayered (macro- and microscale design qualities) analysis of TOD station environments can greatly extend our knowledge of TOD design requirements, addressing the deficiencies associated with the previous TOD frameworks [6,30]. This will be of interest to developing countries, where integration of mobility network and urban design quality is not a priority, leading to ever-increasing traffic challenges [33,70,86], whilst systematic data and design toolkits are mostly missing [69].

However, the results have certain limitations in terms of generalisability. The key ones at the macroscale are connected to data availability, where it was supposed that there is an equitable distribution of people and dwellings across the studied regions, which may not be true in reality. It was not possible to investigate the influence of floor area ratio (FAR) and building height on land-use mixedness and density for all research regions due to space constraints. The study was additionally constrained by a lack of uniform land-use categorisation for two cities, urban transport data (e.g., mode share), and walkability (e.g., footway completeness), as well as somewhat archaic information (2011). Another flaw in this study that might have influenced the microlevel analytical measurements was a probable bias during street observations. Although qualitative field notes and photography contributed to a better understanding of individual characteristics than constructing a "walking index", subjective judgments utilising field notes and photographs raised the likelihood of inaccuracy. The researchers had to make a conclusion on the basis of a number of differing intra-observer evaluations of a single roadway, which was the outcome of the many circumstances observed. This was precisely the case for the qualitative appraisal of aesthetic (streetscape).

Future studies might involve a more in-depth examination of certain TOD design themes. Firstly, because key environmental design difficulties were generally related with microscale challenges, they may be useful in operationalising this study's microscale framework for TOD walkability in the context of a single or a group of cities or the Urban Design Qualities Framework (i.e., streetscape design qualities in the present study) by Ewing and Handy [27]. Furthermore, given the restricted number of case studies in this study, it is useful to understand the reflection of diverse urban forms throughout Iranian urban contexts. It is now necessary to perform an inter-city research that includes many additional case studies (cities) based on their spatial dimension, weather, PT system, regional position, economic and environmental concerns, traffic pattern, and urban morphology. The selected stations can be compared with identical examples from both developing and developed nations. A micro-morphology study combining graph theory, space syntax, and social network indices [79,86–89], along with behavioural research of pedestrians utilising such stations, would assist in finding the discrepancy between physical characteristics and mobility patterns [85]. Reviewing the content of local and national governmental documents and regulations with regard to the incorporation of the principles of TOD [70], and segmentation of the population according to the adequacy of TOD for various socioeconomic groups [90] are additional windows for further investigation.

Author Contributions: Formal analysis, M.H.A.; Investigation, M.H.A.; Methodology, M.H.A. and A.S.; Validation, A.S.; Visualization, M.H.A. and A.S.; Writing—original draft, M.H.A.; Writing—review & editing, A.S. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by the Iranian Ministry of Science, Research, and Technology, Department of Scholarships and Student Affairs Abroad.

Acknowledgments: A part of this paper was excerpted from the PhD research thesis of the first author at the Technical University of Madrid (UPM). The authors would like to thank the UPM's directory of research for supporting this study.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Renne, J.L.; Hamidi, S.; Ewing, R. Transit commuting, the network accessibility effect, and the built environment in station areas across the United States. *Res. Transp. Econ.* **2016**, *60*, 35–43. [CrossRef]
2. World Commission on Environment and Development. *Our Common Future*; Oxford University Press: New York, NY, USA, 1987.
3. Medved, P. A Contribution to the structural model of autonomous sustainable neighbourhoods: New socio-economical basis for sustainable urban planning. *J. Clean. Prod.* **2016**, *120*, 21–30. [CrossRef]
4. Jacobson, J.; Forsyth, A. Seven American TODs: Good practices for urban design in Transit-Oriented Development projects. *J. Transp. Land Use* **2008**, *1*, 51–88. [CrossRef]
5. Calthorpe, P. *Next American Metropolis: Ecology, Community, and the American Dream*; Princeton Architectural Press: Princeton, NJ, USA, 1993.
6. Ewing, R. *Pedestrian- and Transit-Friendly Design: A Primer for Smart Growth*; American Planning Association: Tallahassee, FL, USA, 1996.
7. TCRP (Transit Cooperative Research Program). *The Role of Transit in Creating Livable Metropolitan Communities*; Transportation Research Board: New York, NY, USA, 1997.
8. TCRP (Transit Cooperative Research Program). *Transit Oriented Development and Joint Development in the United States: A Literature Review*; Transportation Research Board: New York, NY, USA, 2002.
9. Dunphy, R.; Deborah, M.; Pawlukiewicz, M. *Ten Principles for Successful Development around Transit*; ULI—The Urban Land Institute: Washington, DC, USA, 2003.
10. Ewing, R.; Bartholomew, K. *Pedestrian- and Transit-Oriented Design*; Urban Land Institute: Washington, DC, USA, 2013.
11. Pojani, D.; Stead, D. Transit-Oriented Design in the Netherlands. *J. Plan. Educ. Res.* **2015**, *35*, 131–144. [CrossRef]
12. Kong, W.; Pojani, D. Transit-oriented Street design in Beijing. *J. Urban Des.* **2017**, *22*, 388–410. [CrossRef]
13. Southworth, M. Designing the Walkable City. *J. Urban Plan. Dev.* **2005**, *131*, 246–257. [CrossRef]
14. Maxwell, J. Designing for "Life between Building": Modeling the Relationship between Streetscape Qualities and Pedestrian Activity in Glassgow, Scotland. Doctoral Dissertation, University of Strathclyde, Glasgow, UK, 2016.
15. Lamour, Q.; Morelli, A.; Marins, K. Improving walkability in a TOD context: Spatial strategies that enhance walking in the Belém neighbourhood, in São Paulo, Brazil. *Case Stud. Transp. Policy* **2019**, *7*, 280–292. [CrossRef]
16. Koo, B.; Guhathakurta, S.; Botchwey, N. How are Neighborhood and Street-Level Walkability Factors Associated with Walking Behaviors? A Big Data Approach Using Street View Images. *Environ. Behav.* **2021**, *54*, 211–241. [CrossRef]
17. Cervero, R.; Kockelman, K. Travel demand and the 3Ds: Density, diversity, and design. *Transp. Res. Part D Transp. Environ.* **1997**, *2*, 199–219. [CrossRef]
18. Ewing, R.; Cervero, R. Travel and the Built Environment: A Synthesis. *Transp. Res. Rec. J. Transp. Res. Board* **2001**, *76*, 265–294. [CrossRef]
19. Ewing, R.; Cervero, R. Travel and the Built Environment: A Meta-Analysis. *J. Am. Plan. Assoc.* **2010**, *76*, 265–294. [CrossRef]
20. Brownson, R.; Hoehner, C.; Kristen Day, M.; Forsyth, A.; Sallis, J. Measuring the Built Environment for Physical Activity; State of the Science. *Am. J. Prev. Med.* **2009**, *36*, S99–S123. [CrossRef]
21. Jeffrey, D.; Boulangé, C.; Giles-Corti, B.; Washington, S.; Gunn, L. Using walkability measures to identify train stations with the potential to become transit oriented developments located in walkable neighbourhoods. *J. Transp. Geogr.* **2019**, *76*, 221–231. [CrossRef]
22. Institute for Transportation and Development Policy. *TOD Standard V3.0*; ITDP: New York, NY, USA, 2017.
23. Zhang, Y.; Guindon, B. Using satellite remote sensing to survey transport-related urban sustainability; Part 1: Methodologies for indicator quantification. *Int. J. Appl. Earth Obs. Geoinf.* **2006**, *8*, 149–164.
24. Witten, K.; Pearce, J.; Day, P. Neighbourhood Destination Accessibility Index: A GIS tool for measuring infrastructure support for neighbourhood physical activity. *Environ. Plan. A* **2011**, *43*, 205–223. [CrossRef]
25. Dvorak, B.; Li, W.; Newman, G.; Zhan, X.; Zhao, J.; Zhu, X. *Multimodal Transportation Systems and Transit Oriented Development: Concepts for Bryan-College Station, Texas, and Texas A&M University*; Department of Urban Planning and Landscape Architecture, College of Architecture, Texas A&M University: College Station, TX, USA, 2015.

26. Schlossberg, M.; Brown, N. Comparing Transit Oriented Developments Based on Walkability Indicators. *J. Transp. Res. Board* **2004**, *1887*, 34–42. [CrossRef]
27. Ewing, R.; Handy, S. Measuring the Unmeasurable: Urban Design Qualities Related to Walkability. *J. Urban Des.* **2009**, *14*, 65–84. [CrossRef]
28. Singh, Y.; Lukman, A.; Flacke, J.; Zuidgeest, M.; Van Maarseveen, M. Measuring TOD around transit nodes—Towards TOD policy. *Transp. Policy* **2017**, *56*, 96–111. [CrossRef]
29. Ameli, S.; Hamidi, S.; Garfinkel-Castro, A.; Ewing, R. Do Better Urban Design Qualities Lead to More Walking in Salt Lake City, Utah? *J. Urban Des.* **2015**, *20*, 393–410. [CrossRef]
30. Bivina, G.; Gupta, A.; Parida, M. Walk Accessibility to Metro Stations: An analysis based on Meso- or Microscale Built Environment Factors. *Sustain. Cities Soc.* **2020**, *55*, 102047. [CrossRef]
31. Ortega, E.; Martin, B.; Lopez-Lambas, M.; Soria-Lara, J. Evaluating the impact of urban design scenarios on walking accessibility: The case of the Madrid 'Centro' district. *Sustain. Cities Soc.* **2021**, *74*, 103156. [CrossRef]
32. Stojanovski, T. Urban design and public transportation—Public spaces, visual proximity and Transit-Oriented Development (TOD). *J. Urban Des.* **2019**, *25*, 134–154. [CrossRef]
33. Soltani, A.; Pojani, D.; Askari, S.; Masoumi, H.E. Socio-demographic and built environment determinants of car use among older adults in Iran. *J. Transp. Geogr.* **2018**, *68*, 109–117. [CrossRef]
34. Sharifi, A.; Murayama, A. Changes in the traditional urban form and the social sustainability of contemporary cities: A case study of Iranian cities. *Habitat Int.* **2013**, *38*, 126–134. [CrossRef]
35. Motealleh, P.; Zolfaghari, M.; Parsaee, M. Investigating climate responsive solutions in vernacular architecture of Bushehr city. Housing and Building National Research Center. *HBRC J.* **2018**, *14*, 215–223. [CrossRef]
36. Moghadam Baboli, F.; Ibrahim, N.; Sharif, D. Design Characteristics and Adaptive Role of the Traditional Courtyard Houses in the Moderate Climate of Iran. *Procedia Soc. Behav. Sci.* **2015**, *201*, 213–223. [CrossRef]
37. Khalili, M.; Amindeldar, S. Traditional solutions in low energy buildings of hot-arid regions of Iran. *Sustain. Cities Soc.* **2014**, *13*, 171–181. [CrossRef]
38. Jamei, E.; Ahmadi, K.; Chau, H.; Seyedmahmoudian, M.; Horan, B.; Stojcevski, A. Urban Design and Walkability: Lessons Learnt from Iranian Traditional Cities. *Sustainability* **2021**, *13*, 5731. [CrossRef]
39. Soltani, A. Iran. In *The Urban Transport Crisis in Emerging Economies*, 1st ed.; Pojani, D., Stead, D., Eds.; Springer: Cham, Switzerland, 2017; pp. 127–143.
40. Noohi Tehrani, A. Morphology of Yazd Urban Textures and Their Comparison. *J. Appl. Environ. Biol. Sci.* **2016**, *6*, 71–82.
41. Mirzakhani, A.; Turró, M.; Jalilisadrabad, S. Key stakeholders and operation processes in the regeneration of historical urban fabrics in Iran. *Cities* **2021**, *118*, 103362. [CrossRef]
42. Rashid, Y.; Rashid, A.; Warraich, M.; Sameen Sabir, S.; Waseem, A. Case Study Method: A Step-by-Step Guide for Business Researchers. *Int. J. Qual. Method* **2019**, *18*, 1609406919862424. [CrossRef]
43. Forsyth, A.; Jacobson, J.; Thering, K. Six Assessments of the Same Places: Comparing Views of Urban Design. *J. Urban Des.* **2010**, *15*, 21–48. [CrossRef]
44. Rodríguez, D.; Brisson, E.; Estupiñán, N. The relationship between segment-level built environment attributes and pedestrian activity around Bogota's BRT stations. *Transp. Res. Part D* **2009**, *14*, 470–478. [CrossRef]
45. Rodriguez, D.; Vergel-Tovar, C. Urban development around bus rapid transit stops in seven cities in Latin-America. *J. Urban.* **2017**, *11*, 175–201. [CrossRef]
46. Talen, E.; Jeong, H. Does the classic American main street still exist? An exploratory look. *J. Urban Des.* **2018**, *24*, 78–98. [CrossRef]
47. Taleai, M.; Taheri Amiri, E. Spatial multi-criteria and multi-scale evaluation of walkability potential at street segment level: A case study of Tehran. *Sustain. Cities Soc.* **2017**, *31*, 37–50. [CrossRef]
48. Yin, R. *Case Study Research: Design and Methods*; SAGE Publications: Thousand Oaks, CA, USA, 2013.
49. Almughairy, A. Reinventing Urban Space in Riyadh's Neighborhoods. *J. Archit. Plan. Res.* **2017**, *34*, 295–308.
50. Baxter, P.; Jack, S. Qualitative Case Study Methodology: Study Design and Implementation for Novice Researchers. *Qual. Rep.* **2008**, *13*, 544–559. [CrossRef]
51. Watson, V. Shifting Approaches to Planning Theory: Global North and South. *Urban Plan.* **2016**, *1*, 32–41. [CrossRef]
52. Healey, P. *Urban Complexity and Spatial Strategies: Towards a Relational Planning for Our Times*, 1st ed.; Routledge: London, UK, 2006. [CrossRef]
53. Mitic-Radulovic, A.; Lalovic, K. Multi-Level Perspective on Sustainability Transition towards Nature-Based Solutions and Co-Creation in Urban Planning of Belgrade, Serbia. *Sustainability* **2021**, *13*, 7576. [CrossRef]
54. Sergio Andrés, V. *Housing Informality beyond The Urban Poor: Spatialities, Public Institutions, and Social Injustice in Rich Settlements of Bogotá*; Gran Sasso Science Institute: Italy, Rome, 2021; Available online: https://iris.gssi.it/retrieve/dfe4cef7-4d1a-ea31-e053-6605fe0a48e4/2021_PhDThesis_Vieda%20Martinez.pdf (accessed on 5 May 2022).
55. McCombes, S. Case Study Definition, Examples & Methods. Retrieved from Scribbr. Available online: https://www.scribbr.com/methodology/case-study/ (accessed on 5 May 2022).
56. Farthing, S. *Research Design in Urban Planning: A Student's Guide*; SAGE Publications Ltd: Thousand Oaks, CA, USA, 2016. [CrossRef]

57. Mirmoghtadaee, M.; Abdi, M. A National Guideline for Transit-Oriented Development: Challenges and Prospects for the Iranian Edition. *Space Ontol. Int. J.* **2021**, *in press*.
58. Mirmoghtadaee, M.; Haghverdian, F.; Salehi Moghadam, A. *Guideline for Transit Oriented Development for Medium-Sized Cities*; BHRC: Tehran, Iran, 2021. (In Persian)
59. SCI (Statistical Centre of Iran). *The Detailed Results of Iranian National Census 2016*; I.R.I.: Tehran, Iran, 2018.
60. Demographia. Demographia World Urban Areas (Built Up Urban Areas or World Agglomerations). Retrieved from Demographia. 25 June 2020. Available online: http://demographia.com/db-worldua.pdf (accessed on 7 July 2020).
61. Road and Urban Development Organization of Qazvin. *City Development Strategy of Qazvin. Sharestan Consultant Engineering*; Road and Urban Development Organization of Qazvin: Qazvin, Iran, 2010.
62. Terhan Municipality. *Statistical Yearbook 2018–2019*; Telecommunication and Information Technology Organization: Tehran, Iran, 2019.
63. Tehran Municipality. *Tehran Statistical Yearbook*; Information and Communication Technology Organization of Tehran Municipality: Tehran, Iran, 2019.
64. Hosseinali, F.; Alesheikh, A.; Nourian, F. Agent-based modeling of urban land-use development, case study: Simulating future scenarios of Qazvin city. *Cities* **2013**, *31*, 105–113. [CrossRef]
65. HCUPA. *Tehran City Master Plan Document*; Ministry of Road and Urban Development: Tehran, Iran, 2007.
66. Road and Urban Development Organization of Qazvin. *Qazvin City and Hinterland Comprehensive Plan*; Urban Development Organization of Qazvin: Qazvin, Iran, 2015.
67. SCI (Statistical Centre of Iran). *Tehran Census Tract Data*; SCI: Tehran, Iran, 2011.
68. Davies, L. *Urban Design Compendium*; English Partnerships, the Housing Corporation: London, UK, 2000.
69. Canepa, B. Bursting the Bubble; Determining the Transit-Oriented Development's Walkable Limits. *J. Transp. Res. Board* **2007**, *1992*, 28–34. [CrossRef]
70. Abdi, M. What the newcomers to transit-oriented development are confronted with? Evidence from Iranian policy and planning. *J. Transp. Geogr.* **2021**, *92*, 103005. [CrossRef]
71. Marshall, S. The Street: Integrating Transport and Urban Environment. In *Handbook of Transport and the Environment*; Hensher, D.A., Button, K.J., Eds.; Emerald Group Publishing Limited: Bingley, UK, 2003; Volume 4, pp. 771–786.
72. Lacofano, D.; Malhotra, M. *Streets Reconsidered: Inclusive Design for the Public Realm*, 1st ed.; Routledge: New York, NY, USA, 2019.
73. Southworth, M.; Ben-Joseph, E. *Streets and the Shaping of Towns and Cities*; Island Press: Washington, DC, USA, 2003.
74. Bahrainy, H.; Khosravi, H. The impact of urban design features and qualities on walkability and health in under-construction environments: The case of Hashtgerd New Town in Iran. *Cities* **2013**, *31*, 17–28. [CrossRef]
75. Suzuki, H.; Cervero, R.; Iuchi, K. *Transforming Cities with Transit: Transit and Land-Use Integration for Sustainable Urban Development*; World Bank: Washington, DC, USA, 2013.
76. Cervero, R. Linking urban transport and land use in developing countries. *J. Transp. Land Use* **2013**, *6*, 7–24. [CrossRef]
77. Abdi, M.; Lamíquiz-Daudén, P. Transit-oriented development in developing countries: A qualitative meta-synthesis of its policy, planning and implementation challenges. *Int. J. Sustain. Transp.* **2020**, *16*, 195–221. [CrossRef]
78. Deng, T.; Nelson, J. Bus Rapid Transit implementation in Beijing: An evaluation of performance and impacts. *Res. Transp. Econ.* **2013**, *39*, 108–113. [CrossRef]
79. Thomas, A.; Deakin, E. Land Use Challenges to Implementing Transit-Oriented Development in China: Case Study of Jinan, Shandong Province. *J. Transp. Res. Board* **2008**, *2077*, 80–86. [CrossRef]
80. Salzberg, A.; Mehndiratta, S.; Liu, Z. Urban Rail Development in China; The Challenges Ahead. *J. Transp. Res. Board* **2012**, *2275*, 49–57. [CrossRef]
81. Wu, I.; Pojani, D. Obstacles to the creation of successful bus rapid transit systems: The case of Bangkok. *Res. Transp. Econ.* **2016**, *60*, 44–53. [CrossRef]
82. Babalik-Sutcliffe, E.; Cengiz, E. Bus Rapid Transit System in Istanbul: A Success Story or Flawed Planning Decision? *Transp. Rev.* **2015**, *35*, 792–813. [CrossRef]
83. François Doulet, J.; Delpirou, A.; Delaunay, T. Taking advantage of a historic opportunity? A critical review of the literature on TOD in China. *J. Transp. Land Use* **2017**, *10*, 77–92.
84. Yang, L.; Dam, K.; Majumdar, A.; Anvari, B.; Ochieng, W.; Zhang, L. Integrated design of transport infrastructure and public spaces considering human behavior: A review of state-of-the-art methods and tools. *Front. Archit. Res.* **2019**, *8*, 429–453. [CrossRef]
85. Su, S.; Zhou, H.; Xu, M.; Ru, H.; Wang, W.; Weng, M. Auditing street walkability and associated social inequalities for planning implications. *J. Transp. Geogr.* **2019**, *74*, 62–76. [CrossRef]
86. Lamíquiz, P.; López-Domínguez, J. Effects of built environment on walking at the neighbourhood scale. A new role for street networks by modelling their configurational accessibility? *Transp. Res. Part A* **2015**, *74*, 148–163. [CrossRef]
87. Soltani, A. Social and urban form determinants of vehicle ownership; evidence from a developing country. *Transp. Res. Part A Policy Pract.* **2017**, *96*, 90–100. [CrossRef]
88. Cubukcu, E.; Mensi, B.; Horoz, C. The Relation Between Urban Morphology and Physical Environmental Qualities: Comparing Walkability in Neighborhoods via Analyses of Spatial Statistics and Indices of Graph Theory and Space Syntax. *J. Nat. Appl. Sci.* **2019**, *23*, 658–665. [CrossRef]

89. Scorza, F.; Fortunato, G.; Carbone, R.; Murgante, B.; Pontrandolfi, P. Increasing Urban Walkability through Citizens' Participation Processes. *Sustainability* **2021**, *13*, 5835. [CrossRef]
90. Bierbaum, A.; Vincent, J. Putting Schools on the Map: Linking Transit-Oriented Development, Households with Children, and Schools. *J. Transp. Res. Board* **2013**, *2357*, 77–85. [CrossRef]