Scientific Research and Essays Vol. 6(13), pp. 2695-2709, 4 July, 2011
Available online at http://www.academicjournals.org/SRE
DOI: 10.5897/SRE10.1187
ISSN 1992-2248 ©2011 Academic Journals

Full Length Research Paper

Evaluating integration between public transportation and pedestrian-oriented urban spaces in two main metro stations of Tehran

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Accepted 23 May, 2011

Goods and people movement is one of the most fundamental challenges of urban development in the contemporary world. Public transportation, among different modes of inner city transportation, has gained special attention. In addition, quality and magnetism of urban public spaces that are related to the broadening of pedestrian-orientation have been introduced as the main indicators of the development of cities. Each of the above subjects will be studied in developed countries. The necessity of doing researches for the purpose of evaluating the relationship between these notions, especially regarding urban design approach, has become more obvious. However, developing countries, including Iran, have not paid attention until recently to both public transportation and pedestrian areas within a more comprehensive urban development approach. The purpose of this paper is to study and evaluate integration between public transportation and pedestrian-oriented urban spaces in the Tehran metropolitan area focusing on two main metro stations of the city. A documentary research through valid sources (articles, researches and studies of transportation master plans), along with on-site investigations by participant observation methods, has been utilized to substantiate this study. After introducing the theoretical framework of the subject, the evaluating criteria of the subject have been proposed and then two case studies have been compared and analyzed based on them. The findings demonstrate that concentrated development on the public transit nodes integrated to pedestrian-oriented urban spaces would have many positive effects on the whole urban structure. Qualitative aspects of urban spaces are more important than quantitative ones in attraction of pedestrians and efficiency of transit stations.

Key words: Public transportation, pedestrian-oriented urban spaces, DOT, TRD, TOD, Tehran's metro stations.

INTRODUCTION

Movement within the urban environment is dynamic and is the main factor in urban life. Also, it is the prolonging element for all social, economical and cultural activities in the cities. To accommodate movements, the pathways and transportation facilities are the utmost important elements forming the infrastructure of cities, "transportation is indeed both a maker and breaker of cities" (Clark, 1957). In addition, in recent decades, due to rapid population growth in the cities by utilization of personal cars, the impact on public transportation and spaces related to them have gained greater attention for the inner city transportation systems. Having an efficient public transportation system is required as one of the components of a sustainable city: "many find public transportation as the key for the construction of a sustainable city. Therefore, it seems that the network plan prepared in the 1960s and prior to that along private transportation is not compatible with objectives of a sustainable city. There is always an important relation between the form of the city and its transportation system" (Cliff and Shirley, 2008).

On the threshold of the third millennium, it is critical to facilitate pedestrian movement as the only mode of transportation for travelling through the city beginning and ending with vehicles. Thus, creation and development of pedestrian oriented urban spaces has become one of the

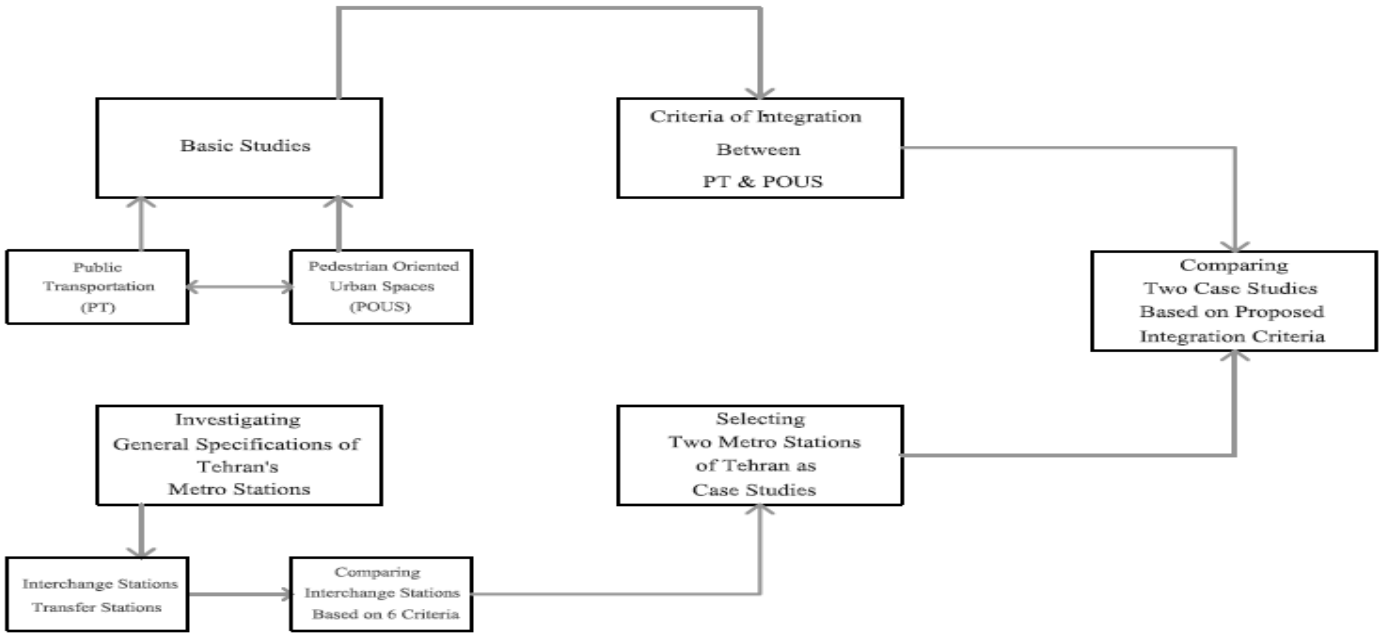

Figure 1. Research process.

most important indicators of “life quality” in cities. In this regard, public transit nodes that are in fact the common points between public transit systems and urban spaces and pedestrian movement have great importance, while comprehensive use of the potential peripheral lands surrounding public transit stations has been the focus of many practical studies and activities in pioneer cities especially in the latter years of the past century. In developing countries such as Iran (which is transiting from an automobile orientated society to mass transit oriented development and non-motorized transportation), there are many shortcomings in studies and practical areas.

This paper attempts to survey the integration of two main metro stations of Tehran - the only city in Iran that has a subway - with pedestrian-oriented urban spaces. It also aims at identifying and putting in place the indications for integration between public transportation and pedestrian-oriented spaces, in order to become a pattern for similar cities elsewhere within Iran and other countries.

Basic framework of the research

Based on the nature of this type of study and subject matter, and due to the limited available documents and articles in reliable local manuscripts and specialised magazines, the research method of investigation in the internet was used. Investigating the integration between public transportation and pedestrian-oriented urban spaces, focusing on the main metro stations of Tehran, will be the main objective of this research. Since there have not been any related valid sources, studies or reports, assessment of the subject is strictly based on the authors’ studies. Data on Tehran’s main metro stations have been obtained through local investigations by different participant observation methods, including detailed field notes, visual materials, informal conversations, direct observations, collective discussions and self-analysis.

In order to conduct the investigation, two case studies were selected among 13 main interchange stations based on compiled information that included six major criteria. The fieldwork includes case study observations in two locations (Imam khomeyni and Sadeqiyeh metro stations); the first in the central and historical district and the latter in the new western development of Tehran. The investigation of two case studies in Tehran is based on both design and implementation issues, and the opinions of 20 experts including that of the author. Consequently, the method of data collection for this research has resulted in a qualitative approach with an analytical procedure based on analytical hierarchy process (AHP). The research process has been illustrated in Figure 1. Even though there are related researches conducted on transit oriented development (TOD) in the western cities, only a few studies have been done for urban areas in developing countries. However, those researches do not contain very detailed investigations on the relation of public transportation stations with pedestrian oriented urban spaces. Thus, conducting specific researches in this area in developing cities like Tehran seems essential due to physical, social, economical and cultural

Table 1. System hierarchy according to the level of service (SYSTRA, 2007).

Systems	Maximal capacity (passengers/hour)	Commercial speed (kph)	Average station spacing (m)
Express rail system (MRT)	60,000	60	2,500-3,000
Urban rail system (MRT) (Conventional metro)	60,000	40	1,000-1,500
Monorail system	30,000	35	800-1,500
Light rail system (LRT)	30,000	30	800-1,500
Tram system	12,000	25	600-1,000

differences of the cities.

Studying the role of public transit on urban development

In a general classification, different transportation methods in cities can be divided into three groups: 1) private transportation, 2) semi-public transportation, and 3) public transportation. Private transportation includes different modes such as walking, biking and personal car, while semi-public transportation includes vehicles such as vans, mini-buses, city cars, high-occupancy vehicles (HOV), car pooling and taxis in some countries. Public transportation has the capacity of displacing more passengers than private and semi-public transportation. Different definitions have been provided for this kind of transportation. Based on one of the most complete definitions, “public transportation includes all transportation systems containing two specifications: the passengers do not travel in their own car and the trip is performed collectively and not exclusively” (Taghizadeh, 2007). Moreover, the passengers of public transportation systems are divided into two main groups: (1) the people who have working trips to central business districts of the city and who are known as commuters or choice riders, and (2) the ones who do not have access to private car and are normally called captive riders (Banks, 2007).

Different categorizations have been propounded concerning inner city public transportation, but according to the most prevalent definitions, basically three types of public transport are used in cities, either separately or in conjunction with one another. They are buses and trolley buses, light rail (trams) and railways (Richards, 2001). Therefore, different public transportation modes can be categorized into three main groups: 1) bus systems (guided busway and bus rapid transit), 2) light rail transit (LRT) systems (trams, monorails and MonoMetro) and 3) mass rapid transit (MRT) systems (rail road systems from suburbs to cities and vice-versa, systems of suburbs, rapid rail systems and prevalent subways). In addition, different kinds of rail transportation systems are distinguished according to two main factors of speed and capacity. Speed depends on different factors such as average of stations’ distance, slope specifications of the path, traffic congestion, and rate of right-of-way. By increase of speed and capacity of rail system, the exclusiveness of right-of-way will be added.

In most types of light rail systems, such as trams that move on the ground level of streets, the right-of-way is common and compatible with other vehicles; as a result, the speed of these vehicles is reduced. In some other types of light rail systems, the pathway is separate; however, in specific places such as some junctions and levelled intersections, other vehicles have the right-of-way by observance of respective regulations, while mass rapid rail transit systems have a completely separated pathway without any movement interference with other vehicles having exclusive right-of-way. This leads to maximum speed, most displacement capacity and most reliable services available in such systems. In Table 1, different types of rail systems are compared with each other based on the level of servicing. Transportation affects city development both directly and indirectly. On the other hand, development of cities influences transit networks and systems. Among them, public transportation due to its higher functional capacity can influence the city in a more vast scale; thus, it requires more attention: “public transportation should be considered in basic decisions about form and identity of a city and its metropolitan area as the most effective mode and in most trips as the only possible substitution for automobile” (Vuchic, 1999).

According to the importance of public transportation, diverse studies have been conducted in different countries in order to evaluate related projects. For example, the federal transit administration of America (FTA) has proposed four criteria: 1) cost effectiveness, 2) transit supportive land use and future patterns, 3) mobility improvements, and 4) environmental benefits (FTA, 2007) for new starts and small starts project justification. Mutual relations between public transportation and urban development that can be investigated from the beginning of the twentieth century by emergence and a vaster application of public transportation vehicles have had diverse trends. The most important approaches in this regard in the time order are categorised into four groups: 1) development oriented transit (DOT), 2) automobile oriented transit (AOT), 3) transit related development TRD), and 4) transit oriented development (TOD). Development oriented transit that means creation of added value on performed developments via public

(transit was applied in the beginning of the twentieth century, specifically in the cities of North America, where suburb tramway was applied by private sector developers for adding value to residential units by linking occupations in a city centre to residential centres in peripheral areas.

According to the definition: “principles of development oriented transit emphasizes a pedestrian oriented street network, street facing architecture, a mix of free land-uses and application of public transportation” (http://www.calthorpe.org), only the areas of stations are propounded as the centre of activity and investment and the peripheral urban fabric is not much considered. The middle decades of the twentieth century and years after the Second World War that were synchronized with vast automobile production, accelerated with a decrease in public transport usage and stoppage of many rail systems, have been known as the automobile oriented transit period. In this era, even public transportation systems were servicing private cars. For this, in most regions, bus systems that are similar to private cars in terms of method and pathway of movement were transformed to a main type of public transport system. In addition, the existing suburb rail network stations were designed, assuming that most people would drive to stations instead of walking, biking or taking the bus. As a result of this, many stations were surrounded by large amounts of parking rather than being integrated into the neighbourhoods they served; these large surface parking lots or structures created barriers between the station and the community (Dittmar et al., 2004).

With the emergence of negative effects of domination of private cars on the structure of cities from the 1970s, a new approach was formed towards reuse of public transportation in different societies. Thus, in the ending decades of the twentieth century, a new concept was propounded as transit related development (TRD), which is known with other expressions such as transit joint development (TJD) and transit adjacent development (TAD) too. TRD can be known as development of peripheral lands of public transportation stations and use of related potentials in these areas for maximum economic income performances. Therefore, other physical, social aspects of development are not much considered in this approach which shows: “transit-proximate development could include buildings with extensive parking facilities typical of suburban locations, a lack of mixed-use development (housing, workplaces and shopping in the same place), or a lack of extensive pedestrian facilities that would make it easier for people to reach the public transport node” (http://en.wikipedia.org/wiki/transit-proximate-development).

Finally, in the ending years of the twentieth century, a new concept was propounded with the name of transit oriented development (TOD) or transit friendly development (TFD) as the most supplementary approach concerning development around public transit. Therefore, one of the most complete definitions stipulate that transit-oriented development (TOD) is compact, with mixed use development close to new or existing public transportation infrastructure that serves housing, transportation and neighbourhood goals. Its pedestrian-oriented design encourages residents and workers to less often drive their cars, but ride on mass transit more (http://www.apta.com). In addition, it is mentioned to some specifications, such as existence of mixed usage around the stations, considering the qualities of neighbourhood design, reduction in use of private car and development of transport modes compatible with public transportation (specifically walking and biking) as the most important indicators of TOD. Also, six performance criteria including: “location efficiency (the ease of avoiding auto use), value recapture (from the perspective of the resident or user of TODs), liveability (quality of life features such as less air pollution, less congestion and more mobility), financial return to the investors, choice of housing type/retail opportunities/travel modes, and efficient regional land use patterns” (Belzer and Autler, 2002) have been suggested to define the success of TODs. It has been mentioned with two main scales: “neighbourhood and city scale” (Calthorpe, 1993) for TOD, and while considering neighbourhood scale, it is necessary to develop the use of public transportation and qualify social life. This is not sufficient in disregarding the macro level and creation of relation between micro scale developments: “Islands of TOD in a sea of freeway-oriented suburbs will do little to change the fundamental travel behaviour or the sum quality of regional living. The key to making TOD work is to make sure that it is well coordinated across a metropolis” (Cervero, 1998). Generally, TOD is facilitating a comprehensive and multi-dimensional approach: “transit-oriented development is a combination of regional planning, city revitalization, suburban renewal and walkable neighbourhoods. It is a cross-cutting approach to development that can do more than help diversify our transportation systems; as such, it can offer a new range of development patterns for households, businesses, towns and cities” (Calthorpe, 1993). Table 2 presented the evaluation of effectiveness of diverse dimensions of TOD on the city.

General principles for creation of pedestrian oriented spaces in cities

Urban spaces or public realms are the main place of citizens’ social life. “In urban public realms, the most contact, relation and interaction happen between people. These spaces include the whole parts of urban area that people have physical or visual access to. Therefore, these places include streets, parks, junctions and surrounding buildings” (Tibalds, 2004). Moreover, “the public sense of space, being open, and performance of social interactions” (Pakzad, 2005) have three main

Table 2. Evaluation of effectiveness of diverse dimensions of TOD on the city.

TOD effectiveness aspect	Description	Type and intensity of effectiveness
Physical	Density, diversity, neighbourhood design quality, existence of mixed uses around terminals, development of non-motorized transportation, especially walking and biking	Direct-maximum
Social	Increase of probability of face-to-face confrontations as a result of pedestrian movement, increase of social and environmental liveability, increase of social interactions	Indirect-minimum
Economical	Increase of the value of lands adjacent to public transit stations, peripheral lands and stations are the potential of economical development and urban renovation, increase of commercial activities and tax incomes around stations	Direct-average
Environmental	Decrease in use of private cars, reduction in single-rider vehicle trips, reduction of ownership of cars in families settled in the pedestrian shed of stations, increase in use of public transit and non-motorized transportation	Indirect-average

Table 3. Street typology based on primary users (ITDP, 2006).

Street type	Mode				
	DART	Motor vehicles	Vehicle parking	Bicycles	Pedestrians
BusWay	***			*	**
Through		**	*	*	**
Shared		*	*	**	**
Pedestrian				**	***

Key: *- allowed mode, ** - secondary mode, *** - priority mode. Parking is dependent on width of street.

indicators of urban spaces and these spaces are finding their meaning by the presence of human activity. One of the most important aspects of human presence in urban spaces, which causes liveability and dynamics in these spaces and increases their social role, is walking: "What makes pedestrians distinctive is that they are open and slow. These qualities enable walkers to truly experience and interact with their urban environment. It is walking that knit the structures, spaces and people of a city together" (http://spacing.ca/ped-dylan01.htm).

On the other hand, while urban spaces include diverse elements such as squares, entrances, coastal banks and stairs, maybe the most remarkable public realms that can be considered as a bed for walking are pathways and specifically streets. The street has always been part of the movement structure in a city. Based on primary users, there are different typologies of streets, which govern the design. One important study recommended four basic types of streets: (1) through, (2) shared, (3) pedestrian and (4) busways (Table 3). Through streets prioritize vehicles and pedestrians, while shared streets are similar to the Woonerf concept where pedestrians are comfortable walking and vehicles are permitted. Pedestrian streets are reserved largely for non-motorized traffic (ITDP, 2006). Busways are the paths with the highest social role, which walkers dominate (http:// www.nelsonnygaard.com). They are public places with full-time or part-time restrictions on motor vehicle usage and are a major priority for people on foot, people riding bikes, and pushing carts. "Containing both social space and movement space, walkable streets connect buildings and activities across space" (Carmona et al., 2003).

Walkability is indicative of the general condition of walking in an area and is observed on different scales of site, street, neighbourhood and city. "Walkability takes into account the quality of pedestrian facilities, roadway conditions, land use patterns, community support, security and comfort for walking" (http://www.vtpi.org/tdm/tdm92.htm). According to this, the mean of pedestrian oriented spaces is urban spaces in which pedestrian movement is prioritised and all necessary facilities and equipment for pedestrians' comfort are provided. By this definition, these spaces can be considered from wide and quality sidewalks to walk streets and complete urban pedestrian networks. In order to create pedestrian-oriented spaces in cities, recognition of criteria and factors, which can encourage citizens to walk is essential. On the other hand, according to the

Table 4. Indicators for evaluation of pedestrian orientation capacity for increase of physical quality of environment (Moeini, 2006).

Context	Criteria	Definition	Proposed criteria
Pedestrian orientation capacity, the space having potential for walking: good facilities for pedestrians + network	Security	1) Reaching safe and sound to destination. 2) Increase of physical environment's quality. 3) The opportunity to cross the street in safety and least risk.	1)Pass 2) Sidewalk's structure. 3) Light 4) Rate of crime
	Nicety, attractiveness, desirability	1) Identity giving to physical environment. 2) Prioritizing displacement and pedestrian movement. 3) Preparation of standards for movement of pedestrians. 4) Planning for promotion of security, content and satisfaction of pedestrian. 5) Creation of an attractive environment by putting benches, information boxes, etc.	1) Street furniture 2) Climate and weather 3) Topography 4) Physical obstacles 5) Pedestrian infrastructures
	Selecting trip type/type of transportation	1) Selecting the objective and method of trip to destination by considering facilities, cost, existing time. 2) Selection of public/private vehicle, biking, or walking. 3) Selecting a healthy and cheap method of transportation for covering short distances for going shopping, park, school, etc.	1) Facilities (vehicle for trip). 2) Cost 3) Time
	Access/displacement	1) Easy and appropriate access for all users from any origin to any destination in all pedestrian pathways. 2) Sufficient legibility of access. 3) Safe displacement facilities for people to get to necessary services.	1) Displacement (movement) 2) Movement substitutions. 3) Land-use.
	Education/public health	1) Reduction in use of private motor vehicles. 2) Increase of public health by education. 3) Encouraging people to walk and bike. 4) Reduction of air pollution, reduction in use of fossil fuels by encouraging people to walk and increase public health.	1) Education of pedestrian's safety. 2) Zebra cross. 3) Encouraging people to walk. 4) Cleanliness of pedestrian areas. 5) Rate of pollution reduction. 6) Rate of fossil fuel consumption reduction.

Table 4.Contd

Connectivity	1) Connectivity of pedestrian pathways from origin to destination. 2) Connectivity of pedestrian pathways in short distances and those spaces in which motor vehicles do have not access.	Rate of connectivity of pedestrian pathways from origin to destination.
Relation between land-use, transportation and pedestrian	1) Creation of diverse land uses for access to occupations and relation with transportation. 2) Developing diverse land uses to encourage people to walk in short distances. 3) Development of diverse land uses and close to standards for use of facilities for pedestrians in condition of existing. 4) Other facilities for desirability in the environment	1) Density of mixed land-use. 2) Rate of environmental desirability concerning diversity of land-uses.
Access to pass stations	1) Importance of pass stations for producing pedestrian trips. 2) Creation of proper relation between neighbours by the objective of increasing comfort and environment quality. 3) Reduction of use of private cars. 4) Safety and proper access for pedestrians for reaching to pass stations.	1) Level of access to stations. 2) Type of access. 3) Distance to stations.
Behavior of pedestrian based on social cultural criteria	1) Besides mentioned indicators, the cultural role of displacement topic and local indicators propounded in this regard in Iran cannot be neglected. 2) Complete freedom of movement and action for man and woman (young and old) without being afraid of their type of dress, sense of being seen by people or street troubles either by government or people help selection of method of displacement in the form of walking for short distances.	1) Lack of habit of walking especially among dogmatic families and women. 2) Sense of not being seen in public. 3) Lack of freedom in selecting type of dress. 4) Fear of probable risks.

specifications of pedestrian movement, improvement of environmental quality for facilitating pedestrian movement can affect other social, economical, cultural and urban transportation aspects, and as a result, cause liveability and dynamics of urban life. Reid (2004) in the report of “Pedestrian and transit oriented design: Preliminary principles for smart growth” mentions that the entire users of public transportation are also pedestrians. For this, pedestrian oriented design is transit oriented too (IPA, 2004). In a study on 14 pedestrian master plans in Europe and the U.S.A., and its evaluation based on the vernacular condition of Iran, issues such as “security, attractiveness, selecting the type of transportation, access, education and public health, connectivity, the relation between land-use and pedestrian, access to transport stations and behaviour of pedestrians based on cultural and social regulations” (Moeini, 2006) have been propounded as the main criteria for evaluation of pedestrian orientation capacity in order to increase the physical quality of urban spaces (Table 4). Much evidence available shows us that some basic characteristics are necessary for creating a walkable street in cities.

For example, Dom Nozzi refers to 16 essential ingredients that a community must use to create and sustain a walkable street: 1) convivial concentration of pedestrians, 2) residential densities, 3) human-scaled dimensions, 4) active and diverse retail, 5) traffic-calming, 6) 24-hour activity, 7) narrow lots, 8) weather protection, 9)

wide sidewalks, 10) unobtrusive equipment, 11) active building fronts, 12) modest turn radii and crossing distances, 13) proximity, 14) short block lengths, 15) vista termination and 16) appropriate businesses (http://www.walkablestreets.com/walkingred.htm). At the end, generally all items that are effective in the creation of a pedestrian oriented urban space can be divided into two general groups: exterior factors that point out the relation of the area with peripheral fabric, and interior factors that consider details of the physical quality and design of pedestrian pathway. However, the common point of the criteria in whole is the increased sense of place, human scale, and prevention or reduction of elements related to motorized transportation in the pedestrian area.

Criteria of integration between public transportation and pedestrian oriented urban spaces

Generally, the criteria propounded for evaluation of pedestrian orientation capacity and creation of pedestrian oriented spaces in terms of integration with public transportation can be studied from the aspect of exterior factors (creation of connection with public transportation systems and stations) and interior factors (development of pedestrian orientation and more attraction of pedestrians). Along this, it seems that the quintet criteria can be compiled including: land-use, physical specifications and landscape of the pathway, suitable urban facilities and equipment for pedestrians, intensity of residential density in pedestrian sheds, safety and cultural-social norms.

On the other hand, the main elements of public transportation (except human factors) generally include three parts: (1) infrastructures, (2) stations and (3) transportation equipment. Among them, the public transportation stations that are considered as the points of commencement, change and end of trip, can be studied as the common point with urban spaces and pedestrian movement, that is, "as a geographic element, a rail station has two principles of contradicted identities: a node, which is a point of access to trains and increasingly to other transportation networks; and simultaneously, a place, which is a specific section of the city that concentrates on infrastructures and a diverse set of buildings and open spaces" (Bertolini and Spit, 1998). Transit stations, beside transportation and physical aspects, have much vast social, cultural and economic functions and can be investigated at least from two general aspects: interior (different kinds of population with attractive facilities, specifically by concentration on pedestrians like diverse kinds of urban furniture and necessary provisions for making relations with other transportation modes) and exterior (maximum attraction and production of trip in relation with peripheral fabric).

While the interior factors are effective in giving quality to stations, the exterior factors are more important in relation to urban spaces. However, the indicators of public transportation can be determined along the pedestrian oriented urban spaces generally as four issues: 1) rate of attraction and production of trip, 2) connection with other transportation modes, 3) vehicular access and respective facilities, and 4) functional scale and potential for future development. According to the quintet criteria compiled for pedestrian oriented urban spaces in relation to public transportation, and the four criteria which were also proposed for public transportation in relation to pedestrian oriented urban spaces, nine criteria could be proposed for integration between transit and pedestrian oriented urban spaces. These are presented in Table 5 in addition to related assessment measures.

Specifications and the process for selection of two main metro stations of Tehran

Among the stations of different public transportation systems, metro stations have the most importance along the subject of research, due to the functional scale and maximum displacement capacity. For this, the Tehran metropolis can be studied as the only city of Iran that is currently facilitated from the subway system. According to the Tehran long-term urban rail network provided by SYSTRA company, this proposed network includes "276 stations inside the urban area of Tehran, 54 transfer stations, and 13 main interchange stations" (SYSTRA, 2007). In this regard, it is specified that by comparing diverse types of metro stations: monoline (majorly with local-district functional scale and access to only one line), transfer (with district-urban functional scale and intersection of at least two inner-city metro lines and displacement from one line to another) and main interchange (with regional trans-city functional scale and the place for interchange from inner-city lines to suburb express lines, or to other public transportation modes), the main interchange stations have had the most effectiveness on peripheral urban spaces; and for this, they are considered as critical subjects along this research.

In order to select two cases among the 13 main interchange metro stations of Tehran as the study samples, six criteria were considered and they include: (1) number of intersecting lines (maximum of 20 points), (2) exploitation of station (maximum of 10 points), (3) rate of trip attraction (maximum of 20 points), (4) active peripheral building structure (maximum of 20 points), (5) existing data research backgrounds (maximum of 10 points), and (6) pedestrian orientation potential in the surrounding area (maximum 20 points). Moreover, each passing line from the station (5 points), activeness of the station (10 points), the station being under construction (5 points), each 30,000 passengers' displacement per daily trip at the station (1 point), compression of building structure of peripheral area (10 points), diversity of land

Table 5. Nine criteria proposed for evaluation of the integration between public transportation and pedestrian oriented urban spaces.

No.	Title of criterion	Description of criterion	Evaluating measures of criterion
1	Land use of peripheral area	Existence of mix land use, 24 h activities, compatible land uses	Share of 24 h land uses, rate of incompatible land uses, share of peripheral mix land uses
2	Physical and landscape specifications of peripheral area	Spatial proportions, sidewalk's width, vista termination	Proportion of walkway's width to average of façade's height, average of sidewalk's width, length of blocks, active building fronts, rate of obstructive equipments
3	Intensity of movement and suitable urban facilities for pedestrian	Pedestrian density, design of surfaces, furniture, plants and greenery, light, recreation facilities, artistic works	Pedestrian density, rate of suitable pavement of walkways, area of green space, no. of lights, rate of play and entertainment equipments, rate of artistic works' presentation, no. of fountains, narrow lots, weather protection
4	Residential density in pedestrian shed	Rate of residential land use in 800 m radiant of station's area	Maximum percentage of residential land use among peripheral land uses, rate of largeness and fineness of land properties of residential area
5	Security and cultural-social norms	Facilitating sense of psychological security in the area, non-existence of cultural and social obstacles for development of pedestrian orientation	Rate of light of pathways, rate of public security of area, distance from criminal gathering centres, rate of legal and custom support of local community from pedestrian orientation
6	Rate of trip attraction and production	Trips to the area from other regions, density of produced trips in the area to other regions	Total of trips done in a station, no. of through transportation lines
7	Suitable connection with other transportation modes	Predicting suitable provisions of second transportation in relation to station area	No. of bus lines in station's area, no. of taxi lines, existence of parking lots and bike lanes, existence of trams and monorail
8	Suitable vehicle access and related facilities	Streets' level of servicing, streets' width (for emergency cars), public parking lots	Suitable vehicle pathways and peripheral highway network, capacity of adjacent public parking lots, rate of traffic calming provisions, modest turn radii and crossing distances
9	Functional scale and potential for future development	Functional scale (transregional to local), potential for changing functional scale	No. of free land properties, area of adjacent free lands, percentage of occupancy area of station's area

uses in peripheral structure (10 points), any study on the adjacent area of station (2 points), any researching background in the surrounding area of the station (2 points), prediction of walk streets in the surrounding area in master and detail plans (10 points), and intensity of pedestrian movement density in the peripheral area (10 points) composed a maximum of 100 points of these six criteria as the assessment measures.

In Table 6, the main interchange metro stations have been compared and ranked according to the criteria mentioned, and as a result, two stations – Imam khomeyni and Sadeghie - have been selected as case studies by acquiring the highest points. The position of Imam Khomeyni and Sadeghie stations in relation to each other based on Tehran long-term urban rail network has been illustrated in Figure 2. Imam Khomeyni square metro station is located in the central region and old area of Tehran (Figure 3), while Sadeqiyeh metro station is located in the dense residential area and relatively new urban development in the west of Tehran (Figure 4). "Imam khomeyni station area is 24,000 sq. m and Sadeqiyeh is 29,800 sq. m" (www.tehranmetro.com) and according to the functional ranking provided by Tehran's metro company, Imam khomeyni station has trans-city performance and Sadeqiyeh station has urban performance (Tehran urban and suburban railway development office, 2003). In addition, based on the Tehran long-term urban rail network plan, Imam khomeyni station was predicted as the intersection of one suburb express line and two urban lines and Sadeqiyeh

Table 6. Comparison of main interchange metro stations of Tehran based on determined criteria

No. of interchange station	Name and location of station	No. of crossing lines	Exploitation of station	Rate of trip attraction	Peripheral building structure	Research data and background	Pedestrian potential of surrounding area	Total scores
1	Haghani	20	10	12.5	5	4	0	51.5
2	Poonak sq.	15	0	4	20	0	10	49
3	Lavizan forest park – Mellat sq.	15	0	12	10	0	5	42
4	Nasr	15	0	10	20	0	10	55
5	Resalat sq.	15	0	11	20	0	5	51
6	Sadeqiyeh	15	10	13	20	8	20	86
7	Azadi	15	10	17.5	20	4	5	71.5
8	Imam khomeyni	15	10	20	15	10	20	90
9	Rah Ahan sq.	15	0	11	10	4	5	45
10	Shamshiri sq.	10	0	7	10	0	0	27
11	Azadegan Exp.	15	0	5.5	0	0	0	20.5
12	Khavaran Ahang/Shargh Exp.	10	0	1.5	0	0	0	11.5
13	Basij sq.	15	0	7.5	10	0	0	32.5

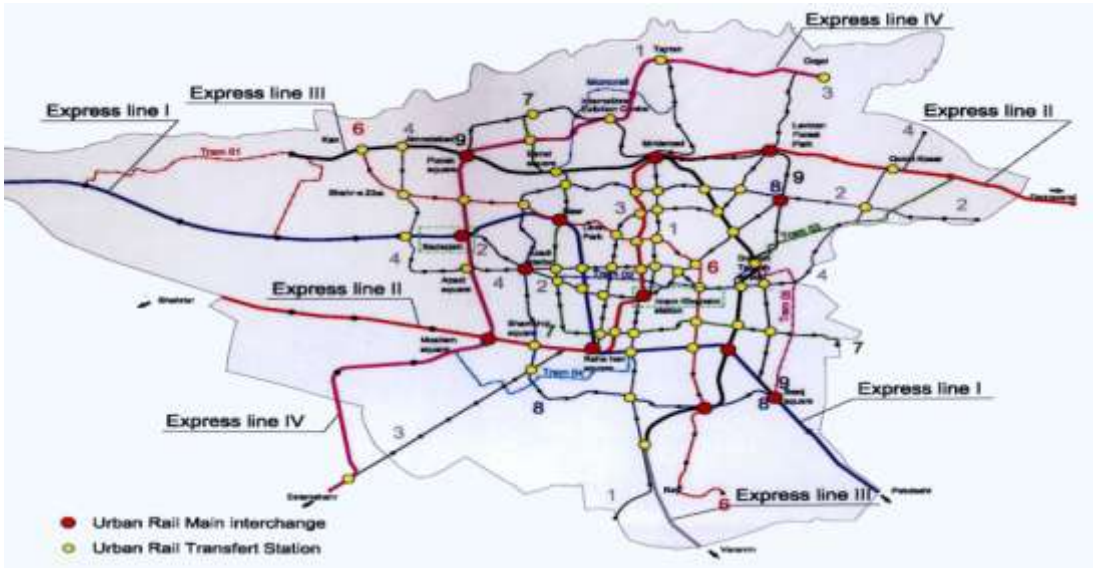

Figure 2. The position of Imam khomeyni and Sadeqiyeh main interchange stations in Tehran long-term urban rail network (SYSTRA, 2007).

Figure 3. The position of Sadeqiyeh metro station in relation to Sadeqiyeh square as the most important focal point of western district of Tehran (http://www.googlemaps.com).

Figure 4. The position of Imam khomeyni metro station in relation to Imam khomeyni square and city park as two main places of central district of Tehran (http://www.googlemaps.com).

station as the intersection of two suburb express lines and one urban line. Among the main interchange metro stations of Tehran, Imam khomeyni station would have a daily displacement of 596,800 passengers by the plan's vision (2030) as the first rank and Sadeqiyeh station with a daily displacement of 392,800 passengers would have

Table 7. Adjustment study of Imam Khomeyni and Sadeqiyeh stations concerning 9 criteria and related measures.

Title of criterion	Assessment measures of criterion	Imam score of Khomeyni station	Score of Sadeqiyeh station
Land use of peripheral area	Share of 24 h land uses	1	10
	Rate of incompatible land uses	1	10
	Share of peripheral mix land uses	0	1
Physical and landscape specifications of peripheral area	Proportion of sidewalk's width to average of façade's height	9	3
	Average width of sidewalks	8	2
	Length of blocks	7	9
	Active building fronts	2	8
	Rate of obstructive equipments	8	8
Intensity of movement and suitable urban facilities for pedestrians	Rate of pedestrian density in sidewalks	8	2
	Rate of suitable pavement of sidewalk	8	2
	Green space area	10	3
	No. of lights	2	2
	Rate of play and entertainment equipments	8	2
	Rate of artistic works' presentation	5	2
	No. of fountains	10	0
	Narrow lots	0	0
	Weather protection	0	0
Residential density in pedestrian shed	Percentage of residential land use among peripheral land uses	1	10
	Rate of largeness and fineness of land properties in residential area	1	10
Security and cultural-social norms	Rate of light of pathways	3	3
	Rate of public security of area	3	9
	Distance from criminal gathering centres	2	8
	Rate of legal and custom support of Pedestrian orientation	4	4
Rate of trip attraction and production	No. of trips done in a station	10	5
	No. of transportation lines	8	8
Suitable connection with other transportation devices	No. of bus lines in station area	9	6
	No. of taxi lines	7	7
	Existence of bike's parking and lanes	0	10
	Existence of trams and monorail	0	0

Table7. Contd

Suitable vehicle access and related facilities	Proper roads and peripheral highway network	5	8
	Capacity of adjacent public parking	5	10
	Rate of traffic calming provisions	5	5
	Modest turn radii and crossing distances	10	10
Functional scale and potential for future development	No. of lots and area of neighbouring free lands	1	4
	Feasibility study of lands ownership	1	1
	Percentage of station's occupation area	0	5
Total scores of station		**162**	**187**

the third rank after Azadi sq. station (SYSTRA, 2007).

Comparing two case studies based on proposed integration criteria

Two selected case studies in relation to 9 main criteria and 36 proposed assessment measures were evaluated based on field studies, interviews with experts, and study of researching backgrounds, and in each case, the results were ranked in numeral spectrum of 1 to 10 quantitatively. The conclusion of this study is presented in Table 7. In order to analyze the quantitative data gained from the adjustment study of two stations (Imam Khomeyni and Sadeqiyeh), the use of a method having the capacity of evaluating several criteria simultaneously seemed essential. For this, the analytical hierarchy process (AHP), which is specifically compatible with the issues of inner-city transportation, was applied. However, AHP method can be applied when decision making confronts several competitor options and decision criteria. As such, a combination of qualitative criteria with quantitative ones is possible in AHP simultaneously (Nikmardan, 2007).

The base of AHP method is on binary comparison of criteria and options and finally mixing them with each other in order to get the final result. The selected elements shall be comparable with each other and the comparison proportion is located in a spectrum of 1 to 9. In addition, the necessary data for composition of options were compared with the matrix relative to each criterion and the matrix for comparing the criteria relative to the objective shall exist in order to expect output from this method. For this, the software of expert choice that is one of the most prevalent software related to this method was applied and the matrix of weight giving of nine criteria relative to each other were entered in the software as the primary input data (Table 8). In order to achieve the best results, these nine criteria were rated based on the average opinions of 20 experts including that of the author. At the end, the output of this method showed that trip attraction and production rate and intensity of pedestrian movement had the maximum weight among other criteria and the functional scale and potential for future development had the least importance.

The result of the final comparison of options in relation to criteria and their weight indicated small superiority of Sadeqiyeh station than Imam Khomeyni station concerning integrity of public transportation with pedestrian-oriented urban spaces (0.504 against 0.496). In addition, the rate of inconsistency of the input data that indicate contradictions and incompatibility in judgments was determined to be equal to 0.01. This was compared to the maximum acceptable amount in AHP method, in which 0.1 confirmed high accuracy and compatibility of the criteria's weights. In order to compare existing public transportation stations or optimal site selection of new stations, a similar process can be applied for studying the integration between transit stations and pedestrian-oriented urban spaces.

CONCLUSION

Public transportation stations are considered as the common point of two key elements: transportation systems and pedestrian-oriented urban spaces. For this, compilation of criteria that

Table 8. Comparison and weight giving matrix of 9 criteria based on AHP.

Title of criterion	No. of criterion	1	2	3	4	5	6	7	8	9
Land use of peripheral area	1	1	1	1/2	2	1	1/2	2	3	7
Physical and landscape specifications of peripheral area	2	1	1	1/2	2	1	1/2	2	3	7
Intensity of movement and suitable urban facilities for pedestrians	3	2	2	1	3	2	1	2	3	9
Residential density in pedestrian shed	4	1	1/2	1/3	1	1/2	1/3	1	2	6
Security and cultural-social norms	5	1	1	1/2	2	1	2	2	3	7
Rate of trip attraction and production	6	2	2	1	3	2	1	2	3	9
Connection with other suitable transportation modes	7	1/2	1/2	1/2	1	1/2	1/2	1	2	6
Vehicle suitable access and related facilities	8	1/3	1/3	1/3	1/2	1/3	1/3	1/2	1	4
Functional scale and potential for future development	9	1/7	1/7	1/9	1/6	1/7	1/9	1/6	1/4	1

cause integrity of these two elements can play an important role in balanced development of cities besides increasing their quality. In addition, concentrated development on the public transit nodes from spatial, physical and economic aspects would have direct and indirect effects on urban structure in terms of social and environmental features. A study of nine proposed criteria for integration between public transportation and pedestrian-oriented urban spaces indicated that the rate of trip attraction and production, movement intensity and suitable urban facilities for pedestrians have been among the essential issues in the first place, and elements, such as: land use, physical and landscape specifications of peripheral area, security and cultural-social norms are in the second place, while the functional scale and potential for future development have the least importance in this regard.

Adjustment comparison of the proposed integrity criteria on two selected stations among 13 main interchange metro stations of Tehran metropolis - the largest city in the Middle East with a subway - specified that only quantitative aspects and creation of appropriate physical equipment (width of sidewalks, suitable pavement of pedestrian pathways, area of green spaces, play and entertainment equipment, rate of trip attraction and production) is not sufficient for attraction of pedestrians and efficiency of stations, especially the qualitative aspects and social-cultural issues (security, existence of minimum active population leading to appropriate residential density, compatibility and 24 h land uses) have great importance in this regard. As it was concluded in the result of the assessed criteria, Imam khomeyni metro station, while located in the valuable historical area of the centre of Tehran and facilitating better physical equipment for pedestrians, received less scores as compared to Sadeqiyeh station that is located in the new area of the west of Tehran and which provides less facilities for pedestrians. Therefore, a holistic approach considering qualitative and quantitative aspects as well as relation between macro and micro levels is necessary for the transit oriented developments.

Urban planners and designers should consider public transportation stations not only as developed areas enjoying different facilities, but also as focal points which can modify their adjacent neighbourhoods. Furthermore, local governments and city administrator should decide about the transit stations areas in regard to all citizens' benefits and long-term social-environmental dimensions instead of few investors' interests and short-term economical issues. Finally, considering integrity criteria of public transportation and pedestrian-oriented urban spaces in site selection of new stations and modifying the situation of existing stations can have effective role both in the increase of efficiency/attraction of transportation systems and in the balanced development of the whole structure of the city.

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