Modern Applied Science; Vol. 10, No. 8; 2016
ISSN 1913-1844 E-ISSN 1913-1852
Published by Canadian Center of Science and Education

Evaluation of Compaction Index to Achieve Sustainable Urban Development Using AHP: Two Case Studies

Sona Bikdeli[1]

[1] Department of urban planning, Minoodasht Branch, Islamic Azad University, Minoodasht, Iran

Correspondence: Sona Bikdeli, Department of urban planning, Minoodasht Branch, Islamic Azad University, Minoodasht, Iran. Ph.D. candidate, College of science Geography and Urban Planning, Research Institute of ShakhesPajouh, Isfahan, Iran.

Received: February 12, 2016 Accepted: March 30, 2016 Online Published: June 15, 2016

doi:10.5539/mas.v10n8p98 URL: http://dx.doi.org/10.5539/mas.v10n8p98

Abstract

The search for an ideal city, which can express both technological advantages and healthy spirit of rural life based on enlightening ideas of social justice, has long been the major concern of most philosophers, social reformers, writers, architects and urban planners. Urban form is known as a source of environmental problems. The emergence of "sustainable development" as a common term has raised many discussions on urban forms. Different types of urban forms (corridor, compact, marginal and edge) have been evaluated for sustainable urban development. It is revealed that compact city is more sustainable than other forms. There is disagreement on potential effects of compaction. Using archival studies, surveys and questionnaires, the author evaluates the environmental sustainability of Yousefabad as a dense neighborhood, compared to Garnet Hill, by AHP to prove that compaction alone cannot bring the expected advantages. To achieve advantages of compaction in urban design, the author emphasizes that four basic criteria of compact city, density, sustainable transportation, mixed land-use and diversity, should be interrelated.

Keywords: compact city, compaction, sustainable transportation, variety, mixed land-use, AHP

1. Introduction

Considering the current urban populations, the need for housing is increasingly growing. Due to particular circumstances of time and place as well as wrong policies, horizontal development to suburbs has compromised the environment and increased the costs related to construction of infrastructure. The development of cities and introduction of sustainable development has highlighted the role of urban density in reduce the costs of urban development and providing higher quality, yet more economic, services despite the lack of resources (land, etc.). In this context, sustainability is defined as a holistic development that meets the needs of present generations without jeopardizing the ability of future generations to meet their own needs (Amiolemen et al.., 2012). Environmental sustainability includes landform/ microclimate, transportation, land-use, infrastructure efficiency, on-site energy resources, and site design. There are also five principles of a sustainable environment: healthy interior environment, energy efficiency, ecologically benign materials, environmental form, and good design (Couch & Dennemann, 2000; Zheng et al., 2014).

Discussions on sustainable urban development integrated the theories of development and improvement of modern city and led to new ideas in urban planning, among which the idea of compact city emphasizes the increase in urban density and its application in urban organization to provide more sustainable by changing the elements of physical form (Alberti et al., 2007; Beatley & Manning, 1997; Sharifi and Murayama, 2013). Some believe that high density and the mixed land-use of compact city reduce car dependence whereby fuel consumption, supports public transportation and pedestrian and bicycle traffic, and facilitates the access to better municipal services (Williams et al., 2000).

Currently, the increased utilization of motor vehicles has caused two major problems for cities, traffic and air pollution. Harry Richardson relates the main difference in cities of developed and developing countries to their transportation system; that is, high density with inadequate transportation system will not lead to environmental health and sustainability, but to unsustainability. As Richardson writes, ‘these all mean that dense cities of developing countries are unplanned, not the result of a predetermined plan. In contrast, density of these cities has occurred on their own and even with irregularity (Gordon & Richardson, 1989).

This study evaluates compaction and its effect in achieving sustainable urban development to prove that the increased density alone cannot be effective in achieving its advantages. Therefore, this study focuses on 1) compact city theory and its application in dense urban areas of developing countries, 2) compact city theory in Iranian cities, 3) effect of compaction in reducing travel distance and fuel efficiency.

2. Materials and Methods

2.1 Case Study

The studied area is Yousefabad Neighborhood located in District 6, Tehran. With 120 people per hectare gross population density, 244 individuals per hectare net population density, and 183% building density, Yousefabad can be considered as a dense neighborhood. Moreover, this neighborhood is mostly residential, which is an essential feature of compact city for validation of studies. To prove hypotheses, this study requires a series of traffic data related to the type and volume of trips, trip demand and travel distance as well as data regarding available vehicles and usage pattern of residents. For this purpose, households living in this neighborhood are surveyed. Cochran formula is used to determine the sample size at 95% confidence, P =0.45 and d= 0.1. The calculated sample size is 96, which is rounded here to 100.

However, AHP requires two variables to compare. Therefore, the compact neighborhood Garn Hill located in northwestern Glasgow, northern England, is selected for the comparison. In 1820, this neighborhood was expanded as a suburb, and it is currently connected to the city (Masnavi, 2000).

2.2 Data and Material

Relevant data on physical form, traffic, socioeconomic status of Yousefabad is extracted from available documents and surveys (studies, design and urban development issues of Tehran District 6, detailed design plans and regional development model 6, the comprehensive plan transportation and traffic, Tehran Master Plan (transport studies and transport network Communication comprehensive plan of Tehran)) . In addition, data is extracted from questionnaires distributed among samples.

2.3 Methodology

This study uses an analytic-comparative methodology. Therefore, criteria and sub-criteria are extracted from literature to evaluate the studied neighborhood. Then, properties of the criteria are measured in the studied neighborhood by studying relevant plans and documents. The data extracted from questionnaires and interviews is scientifically analyzed. Analytic hierarchy process (AHP) is used to determine the effectiveness of variables, their relationships and indexes including a series of qualitative and quantitative variables. AHP determines the weight of criteria to measure their effectiveness in achieving the goal.

3. Results

3.1 Compact City

Compact cities, characterized by relatively high density, mixed land-use and pedestrian-oriented habitation, have been proposed as one solution for sustainable urban planning. Many advantages of the compact city are recognized.

These are:

- Limited travel distance, and reduced emissions and greenhouse gases.

- Less car dependence, less fuel consumption for traffic, and more public transport.

- Less material and energy use for infrastructure construction, reduced length and service run of pipe lines, roads, etc.

- More opportunities for people to walk, encouraging community life and better surveillance to improve public safety.

- Compact residential built form helps to reduce heating loads in winter.

- High density prevents urban encroachment into the countryside.

- Maintenance of bio-diversity (Chen et al., 2008; Sen and Pattanaik, 2016).

Compact cities resist against excessive sprawling and assure that the entire city even outlying quiet areas have access to transportation system. Compaction, mixed land-uses and land-use escalation are three standards of compact city theory, which together can guarantee sustainable urban development (Jenks & Burgess, 2000).

Table 1 lists the features of compact city extracted from literature (Burton, 2000; Galster, 2001; Song, 2004;

Newman, 2005). Finally, four criteria (density, sustainable transportation, land-use combination and diversity) are extracted from observations for compact city in achieving urban environmental sustainability.

Table 1. Features of compact city

1. High residential areas and active population
2. Different types of land-uses
3. Delicate land-use (vicinity of various land-uses in relatively small sizes)
4. More social and economic interactions
5. Continuous growth (some lands may be vacant or parking lot)
6. Jurisdictional border lines
7. Urban infrastructures, particularly urban sewage system
8. Different types of transportation systems
9. High number of local and regional accesses
10. Very high degree of street connections (interior and exterior) including sidewalks and bicycle lines
11. High degree of street cover
12. Low space-place ratio
13. Single supervision on growth planning and development, or severe coordinated supervision and control
14. Adequate fiscal resources for allocating budget to urban facilities and its infrastructure

Table 2 summarizes the theories related to criteria of compact city extracted from literature.

Table 2. Summary of theories

Criterion	Definition		
Density	Increased density, increased density of development and activities		
	Theories	Theorist	Description
	75-125 people per hectare density (Amin Zadeh, 2008)	Tabibian	Increased buildings and population density + sustainable urban land use by developing undeveloped lands and redeveloping existing buildings
	Leisure walking between the farthest points in 10 minutes (Amin Zadeh, 2008)	Tabibian	
	6-7% energy savings by changes in form (density) and reduced car dependency (Wilkenfeld et al., 1995)	Stroton	
	Dense development in urban areas, reduced travel distances and reduced emissions of greenhouse gases (ECOTEC,1993)	Janks	
	43% lower fuel consumption compared to other forms (Newton, 2000)	Newton	
	Density and car dependency: Highest rate of care dependency in lowly dense cities in USA and Australia Lower car dependency in moderately dense cities in Europe Low car dependency in rich dense cities in Asia Higher car dependency in dense cities of developing Asia (Newman & Kenworthy, 1999)	Newman & Kenworthy	
	Suitable for pedestrians, cycling, effective public transportation and social interactions (Elkin et al.,1991)	Elkin	
	Combination of higher residential density, mixed land-uses and public transportation can reduce fuel consumption, travel time and distance and infrastructural costs (Buxton, 2000).	Buxton	
	Increased density, mixed land-uses and public transportation lead to shorter travel distance and time (Buxton, 2000).	Buxton	
	25-40 household per hectare density (Buxton, 2000)	Buxton	
	Effect of density in some travels (work travels) (Masnavi, 2000)	Masnavi	
	Compact city is not suitable for places with low job opportunities, because it leads to travel to neighbor settlements (Banister, 1997).	Banister et al	
Criterion	Definition		

Sustainable transportation	Suitable forms and sizes for walking, cycling, and efficient public transportation		
	Theories	Theorist	Description
	6-7% energy savings by changes in urban form (density) and reduced car dependency (Wilkenfeld et al, 1995)	Stroton	Car ownership and public transportation + Public transportation Working travel distance
	Strong correlation between car dependency and public transportation, rate of public transportation to traffic, road length, parking (Newman & Kenworthy,1999)	Newman & Kenworthy	
	Density is the main variable explaining energy consumption in public transportation system (Newman & Kenworthy, 1999).	Newman & Kenworthy	
	Density as the major factor of car dependency (Newman & Kenworthy, 1999)	Newman & Kenworthy	
	A sustainable urban form essentially includes dense developments which can provide public transportation, walking and cycling as choices (Newman & kenworthy, 1999)	Newman & Kenworthy	
	Development of areas near to public transportation (Buxton, 2000)	Buxton	
	Direct correlation between car ownership and increased number of trips (Hanson,1982; Ewing,1995; Naess et al.,1995)	Hanson, Ewing, Naess et all	
	Highly dense areas are less likely to depend on car (Levinson & Kumar, 1997; Naess et al.,1995)	Levinson & Kumar, Naess et al.	
	There is a weak mutual relationship between density and working travel time. Only 6.4% of changes in working travel time is related to the changes in density (Oberol, 2004)	Oberol	
	There is a weak correlation between population and public transportation (16.3%) (Oberol, 2004)	Oberol	
	There is a very weak and indirect relationship between density and car ownership (Oberol, 2004)	Oberol	
Criterion	Definition		
Diversity	Diversity in economic and social groups and diversity in activities		
	Theories	Theorist	Description
	Relations, social, behavioral and economic rules in different patterns of travel (Williams et al., 2000)	Simondz & Combez	Diversity in socioeconomic groups (income, age groups, culture, and behavior)
	Car ownership and income (Williams et al., 2000)	Simondz & Combez	
	Direct relationship between raised income and increased number of travels (Hanson,1982)	Hanson	
	Direct relationship between raised income and increased travel distance per person (Cervero, 1996)	Cervero	
	Direct relationship between raised income and increased energy consumption (Nass & Sandberg,1996)	Nass & Sandberg	
	Direct relationship between family size and number of travels (Hanson,1982; Ewing, 1995)	Hanson, Ewing et al	
Criterion	Definition		
Mixed land-use	Fair distribution of vertical and horizontal facilities and services for easy access of citizens		
	Theories	Theorist	Description
	More than 70% of consumed energy depends on land-use planning (Barton, 2009)	Barton	Suitable spread of vertical and horizontal facilities and services
	Suitable accessibility can change travelling behaviors of citizens (Reneland, 2000)	Reneland	
	Mixed vertical and horizontal land-use leads to sustainable land-uses, reduces number and distance of travels, and reduces energy consumption by building density (Williams et al., 2000)	Williams et al.	
	Mixed vertical land-use is a main solution for traffic (Williams et	Williams et al.	

al. 2000).	
Mixed land-uses have high percentage of pedestrians compared to single land-uses (Masnavi, 2000)	Masnavi
Public transportation is less used in compact areas with mixed land-uses (Masnavi, 2000)	Masnavi
Mixed land-use (vertical and horizontal distribution of facilities) = reduced car dependency (Frank & Pivo,1994)	Frank & Pivo
Dense city with mixed land-uses reduces private transportation by 70% (Masnavi, 2000)	Masnavi
High density with mixed land-uses can increase sustainability (Masnavi, 2000)	Masnavi
Positive effect of mixed land-uses on travelling behaviors (Frank & Pivo,1994; Cervero, 1996)	Frank, Pivo & Cervero

Based on literature review and the results listed in Table 2, sub-criteria of environmental sustainability are presented below:

Table 3. Suggested criteria and sub-criteria

Criteria	Sub-criteria
Density	1. Population density (people per hectare) 2. Building density (number of buildings per hectare) 3. Re-development of existing buildings 4. Extension of previous undeveloped lands
Sustainable transportation	1. Car ownership 2. Public transportation 3. Accessibility to preliminary services 4. Average working travel distance
Mixed land-use	1. Mixed horizontal land-use (distribution of facilities) 2. Mixed vertical land-use
Diversity	1. Diversity in socioeconomic level 2. Diversity in type of housing

According to AHP, the importance factor of criteria is determined by pairwise comparison of criteria. This study evaluates the effect of compaction on sustainable urban development. Importance factors are determined by the table (Saati's 9-point scale for pairwise comparison of criteria). The steps are described below.

3.2 Pairwise Comparison of Criteria

3.2.1 Option A: Garnet Hill

The structure of this neighborhood is based on the street grid model. The buildings are three- and four-storey. This neighborhood is heterogeneous for the existing mixed land-uses including residencies, stores, university, schools, kindergarten etc (stores at the street level and the residencies on top of the stores).

Table 4. Specifications of Garnet Hill

Specifications	Garnet Hill
Population density	110
Residential density	46
Average household size	2.2
Storey	3 and 4
Land-use	mixed

Reference: (masnavi.2000, p: 64-72).

3.2.2 Option B: Yousefabad

Density as criterion and population density (people per hectare) as sub-criterion

Population density of Yousefabad is 120 individuals per hectare, which is higher than the mean density of the District 6 and total density of Tehran. This is on the upper bound of the suggested density (75-125 people per hectare) by Tabibian. In general, population density of Yousefabad (120 people per hectare) is higher than that of Garnet Hill (110 individuals per hectare) as shown in Figure 1.

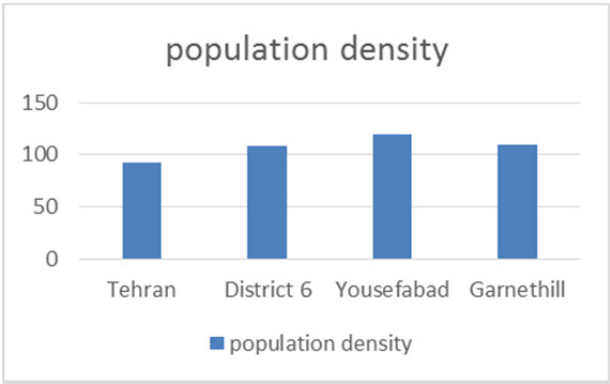

Figure 1. Comparison of population density in Yousefabad and Garnthill

Density as criterion and building density and residential density as sub-criteria

With 98.15 residencies per hectare, building density is higher in Yousefabad (183%) compared to Tehran (129%) and District 6 (175%) with 92.44 residencies per hectare as well as Garnet Hill with 46 residencies per hectare.

Density as criterion and development of previously undeveloped lands as sub-criterion

Because of its special urban architecture, there is minimum number of abandoned lands (without fence) in Yousefabad. There are some huts in an area between Vali Asr Street and Yousefabad and down the Gahan Ara Street; these huts have been possessed by the municipality to change the land-use to local accesses and green spaces. Moreover, 3.5% of total area of the neighborhood is allocated to vacant lands; as these lands are within the residential area, renovation will be started soon. As Garnet Hill was established by a street grid model, there is no undeveloped lands within the area.

Density as criterion and redevelopment of existing buildings as sub-criterion

Statistical analysis shows that Yousefabad is slowly renovated; most of this renovation has been focused on switching residential to servicing land-use, which has undermined the residential area. Yousefabad is mostly residential with few service-commercial spots. However, Yousefabad is undergoing changes in land-uses, which threaten the residential area. A large number of people travel daily within the city for work, shopping, recreation, visits, education and health purposes. Studies on urban travels and transportation indicate a relationship between land-use and travel attraction and present a model for the relationship between the number of attracted travels and land-uses (Figure 2).

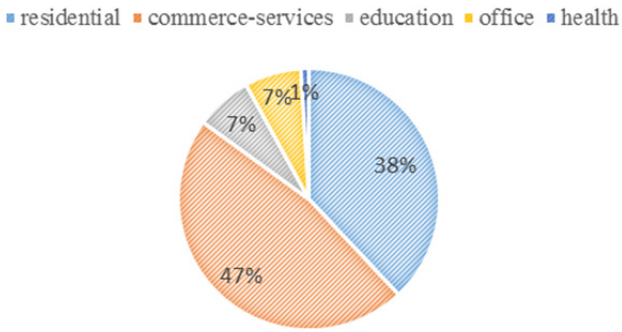

Figure 2. Number of attracted travels to the neighborhood in terms of the area allocated to the each land-use

As the results of questionnaires and calculations show, commercial-servicing land-uses (47%) followed by residential land-uses (38%) attract the highest number of travels. If the current renovation continues, congestion and traffic will be the biggest problem of the neighborhood. In contrast, Garnet Hill was developed as a suburban and the existing buildings were developed in mixed land-uses within the neighborhood.

Sustainable transportation as criterion and car ownership as sub-criterion

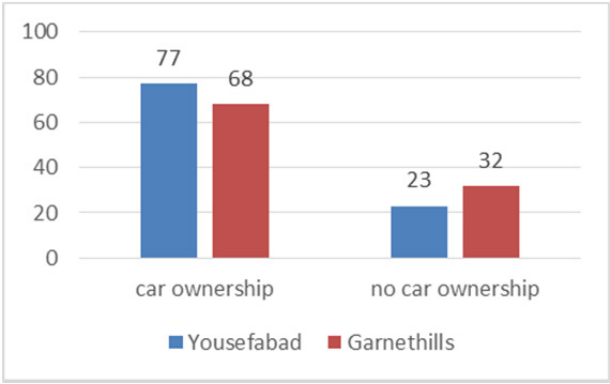

Figure 3. Comparison of car ownership in Yousefabad and Garnethills (%)

Sustainable transportation as criterion and public transportation as sub-criterion

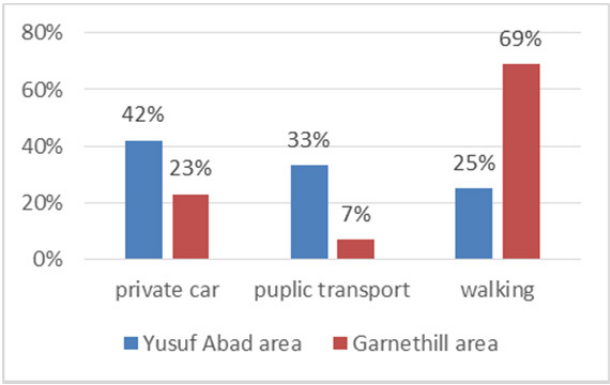

Figure 4. Comparison of access to urban facilities through different types of transportation in Yousefabad and Garnethills

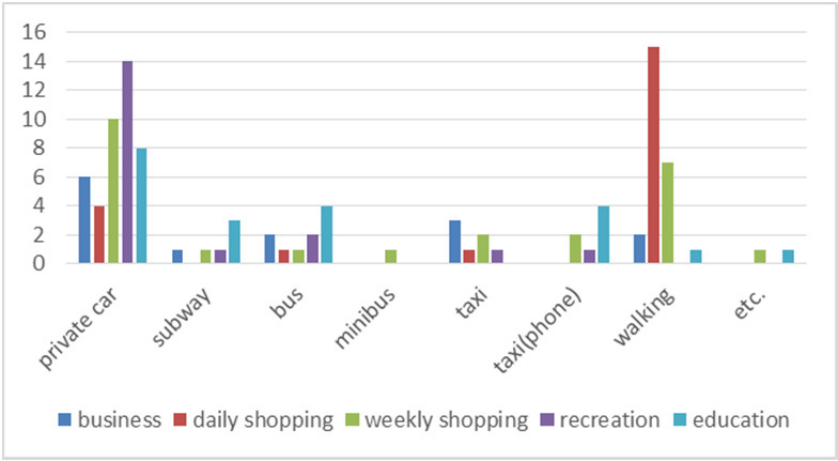

Figure 5. Access to urban facilities through different types of transportation in Yousefabad

Private transportation: private transportation is lower in Garnethills (24%) than Yousefabad (42%). Thus, car dependency is lower in Garnet Hill with mixed land-uses; private transportation is usually used for work, weekly shopping and visits. In Yousefabad, residents use private transportation for entertainment, weekly shopping, education, work and daily shopping purposes. However, only 19% of residents use private transportation for daily shopping. However, farther travel distances result from decentralized land-uses or not considering these distances when selecting the residency.

Public transportation: Public transportation is higher in Yousefabad (33%) than Garnethills. In Garnethills, travel distances are relatively short and can be walked.

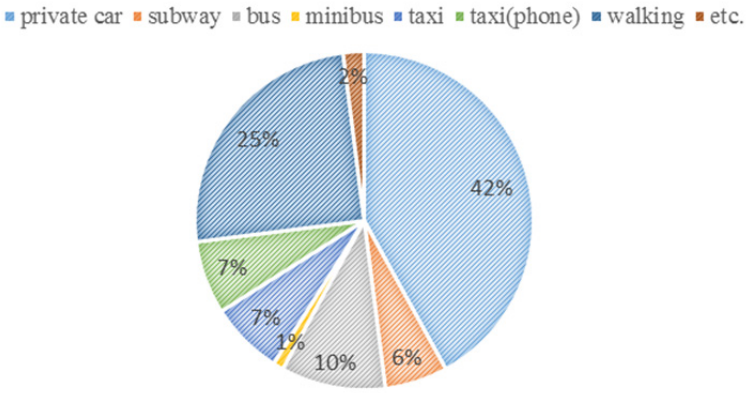

Figure 6. Types of transportations used in Yousefabad

Walking: Generally, the number of walk travels is considerably higher in Garnet Hill (69%) than Yousefabad (25%). Maximum number of walk travels is related to recreational, educational and daily shopping purposes, while minimum number of walk travels is related to working, weekly shopping and visiting purposes. As the results show, 96% of residents can take walk travels for daily shopping, while only 71% of them do so and the rest 19% prefer private transportation.

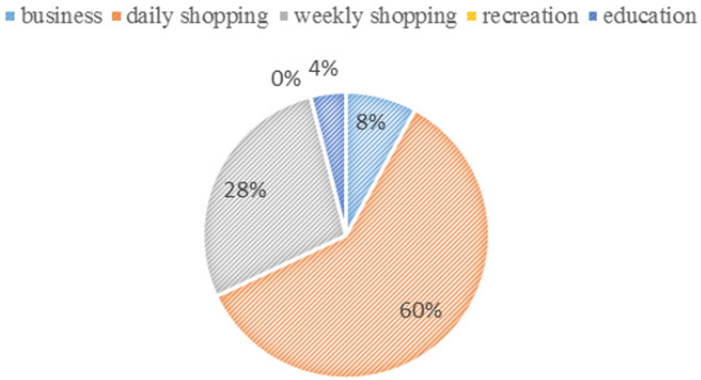

Figure 7. Walk trip purposes in Yousefabad

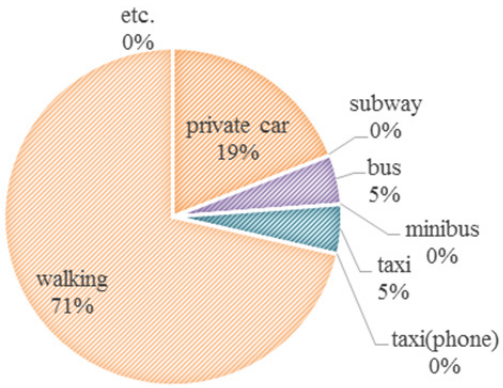

Figure 8. Types of transportations used for daily shopping in Yousefabad

Work distance is over 3 km for 52% and less than 500 m for 9% of the residents. However, only 4% take walk trips to the work. As shown in the figure, nearly 60% of the residents cannot access the medical, educational, sport, cultural and recreational services by walk trips.

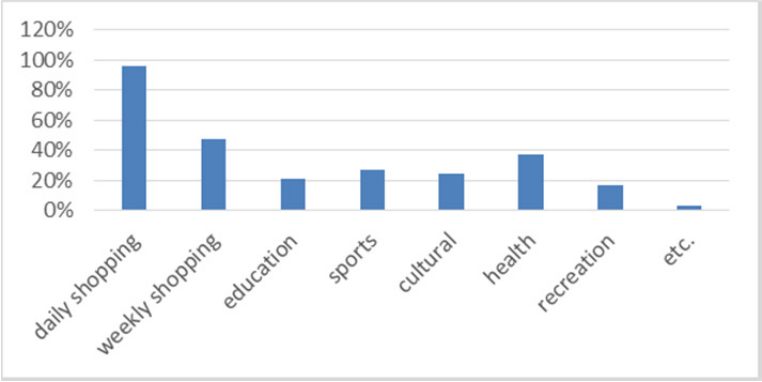

Figure 9. Access to services by walk trips

Sustainable transportation as criterion and access to preliminary services by walk trips as sub-criterion

See the section regarding walk trips.

Sustainable transportation as criterion and work distance as sub-criterion

The average distance traveled in a week for work trips is 40.70 miles (2-3 km daily) in Garnet Hill. In Yousefabad, the average distance traveled for work trips is over 3 km for 52%, 1-3 km for 24% and less than 1 km for 24% of the residents (Figure 10).

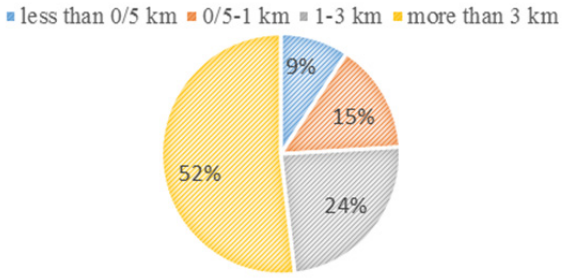

Figure 10. Average work distance

Mixed land-use as criterion and mixed horizontal land-use as sub-criterion

As noted earlier, car dependency is lower in Garnet Hill with mixed land-uses and 69% of travels are in the form of walk trips. This is due to the fair distribution of facilities within the neighborhood. Based on the studies on problems of urban development in the District 6, the lack of public welfare services such as education, health, green space, recreation and culture is estimated for three regions of the district, the results of which are presented below:

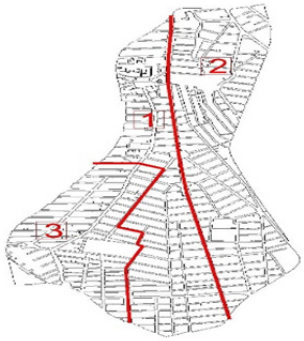

Table 5. Distribution of public welfare services in Region 1

Status		Status quo	Per capita		Shortage
Land use		Per capita	Tehran	District	
Public welfare services	Public education	3.74	1.76	2.074	-
	Social services	0.15	0.05	0.023	-
	Recreation	0.12	0.2	0.157	+
	Health	2.53	1.1	2.506	-
	Religion	0.32	0.35	0.229	-
	Culture	1.29	0.53	0.54	-
	Tourism	0.25	0.199	1.053	*
	Green space	1.36	9.12	5.047	+
	Sports	3.59	1.62	0.747	-
	Total	14.85	14.929	11.373	-

Table 6. Distribution of public welfare services in Region 2

Status		**Status quo**	**Per capita**		**Shortage**
Land use		Per capita	Tehran	District	
Public welfare services	Public education	1.796	1.76	2.074	+
	Social services	0.042	0.05	0.023	+
	Recreation	0.178	0.2	0.157	-
	Health	7.18	1.1	2.506	-
	Religion	0.239	0.35	0.229	+
	Culture	2.64	0.53	0.54	-
	Tourism	0.6	0.199	1.053	*
	Green space	6.1	9.12	5.047	-
	Sports	0.93	1.62	0.747	-
	Total	19.71	14.929	11.373	-

Table 7. Distribution of public welfare services in Region 3

Status		Status quo	Per capita		Shortage
Land use		Per capita	Tehran	District	
Public welfare services	Public education	1.546	1.76	2.074	+
	Social services	0.068	0.05	0.023	+
	Recreation	0.067	0.2	0.157	+
	Health	2.62	1.1	2.506	-
	Religion	0.295	0.35	0.229	-
	Culture	0.372	0.53	0.54	+
	Tourism	0.145	0.199	1.053	*
	Green space	0.734	9.12	5.047	+
	Sports	0.196	1.62	0.747	+
	Total	0.046	14.929	11.373	+

As noted earlier, 96% of residents take walk trips for daily shopping. Therefore, commercial facilities are well distributed in Yousefabad. However, education, cultural, sport, recreational, medical, social services as well as green spaces are not sufficient in Yousefabad. Improved distribution of these services can reduce private transportation and car dependency.

Mixed land-use as criterion and mixed vertical land-use as sub-criterion

According to Williams, mixed vertical land-use leads to more sustainable land use. Bernie believes that mixed vertical land-use can eliminate traffic. As noted earlier, people can access services by walk trips in Garnet Hill with mixed land-use; thus, facilities are well distributed horizontally and vertically. According to studies, Yousefabad contains residential, commercial, and servicing zones.

- Residential zone: a large part of the neighborhood is residential.
- Commercial-servicing zone: the zone can be divided into three areas:

- Commercial area (S-1) in Vali Asr Street
- Servicing area (S-4) including administrative services, higher education, education, culture, religion, catering, sports and urban facilities distributed in different parts of the neighborhood
- Mixed area (S-5) including both commercial and servicing land-uses distributed linearly along the Vali Asr Street and Asad Abadi Street

Accordingly, it can be concluded that the mixed vertical land-uses are weakly distributed in Yousefabad.

Diversity as criterion and socioeconomic diversity as sub-criterion

Analysis of socioeconomic data shows that Garnet Hill is a prosperous economy with good living conditions at moderate- to high-level standards. The average household size is 2.2.

Because of high house prices in Yousefabad, immigrants are less likely to move to this neighborhood; thus, the residential area is less occupied by the immigrant. Moreover, ecological isolation is lower in Yousefaad. Household size ranges from 3 to 4 persons. Literacy rate is above 9% within the neighborhood, except for the Region 9 (5-7%). In addition, income level of residents is moderate to high. Housing diversity is very low, so that 96% of the residential buildings are apartments. In Garnet Hill, all buildings are three- or four-storey apartments (Figure 12, 13).

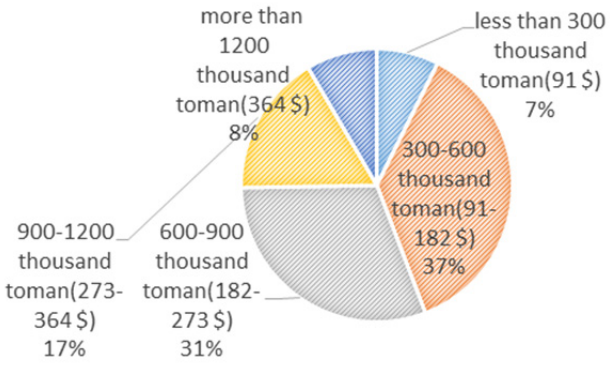

Figure 11. Income level of residents

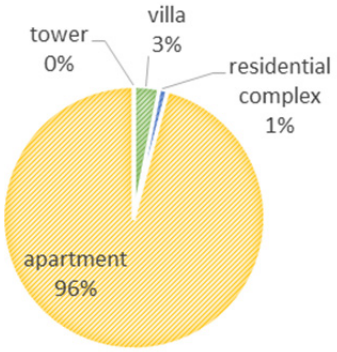

Figure 12. Type of residential buildings in Yousefabad

3.3 Data Analysis

As noted earlier, AHP is used to determine the importance factor of criteria. As the criteria are a series of qualitative and quantitative variables, AHP is the best method to measure these variables. The focus of this study is environmental sustainability; thus, the importance factor of criteria is determined by the table (Saati's 9-point scale for pairwise comparison of criteria).

Table 8. The matrix used to evaluate two options of environmental sustainability

Options	Density				Sustainable transportation				Mixed land-use		Diversity	
	population density (people per hectare)	residential building density per hectare	Development of previous undeveloped land	Redevelopment of existing buildings	car ownership	public transportation	walking distance	Working distance	Horizontal	Vertical	socioeconomic	housing
A	110	46	good	good	68%	7%	good	2-3km	good	good	low	non
Result	0.1439				0.1183				0.2671		0.0377	
B	120	98.15	relatively good	bad	77%	33%	relatively low	>3 km for 52%	relatively bad	bad	low	very limited
Result	0.3039				0.0299				0.0496		0.0423	

Consistency of judgements

The mechanism proposed by Saati for analyzing inconsistency of judgements is to calculate inconsistency rate (IR) by dividing inconsistency index (II) by random index (RI). Consistency of judgements is reasonable if IR ≤ 0.1; otherwise, the judgements need revision.

$$L=4.13875$$

$$CL = \frac{4.13875-4}{4-1} = 0.0462$$

$$CR = \frac{0.0462}{0.9} = 0.0513 < 0.1 \quad \underline{OK}$$

4. Conclusions

Considering the results descried earlier, following implications were derived for environmental sustainability of Yousefabad:

1. Considering the criteria of sustainable compact city, environmental sustainability is not in a good condition in Yousefabad.
2. Considering the compact city theory, sustainable transportation and mixed land-use are weak in Yousefabad.
3. High density as well as bad transportation system is one of the most important factors of unsustainability.

According to the conducted studies, transportation system is not in a good condition in Yousefabad. Moreover, 42% of residents prefer private transportation due to the 1) lack of minibus network which is highly flexible compared to the bus network; 2) lack of access to preliminary facilities by walk trips; 3) long distance between workplace and home; 4) behavioral models.

It can be concluded that weak transportation system as well as improper land-use planning is one of the major factors of unsustainability in the studied neighborhood.

References

Alberti, M., Booth, D., Hill, K., Coburn, B., Avolio, C., Coe, S., & Spirandelli, D. (2007). The impact of urban patterns on aquatic ecosystems: An empirical analysis in Puget lowland sub-basins. *Landscape and urban planning, 80*(4), 345-361. http://dx.doi.org/ 10.1016/j.landurbplan.2006.08.001

Amin Zadeh, B. (2008). Proceedings of sustainable urban development, the Institute of Tehran University Press.

Amiolemen, S. O., Ologeh, I. O., & Ogidan, J. A. (2012). Climate change and sustainable development: the appropriate technology concept. *Journal of Sustainable Development, 5*(5), 50.

Banister, D. (1997). Reducing the need to travel. *Environment and Planning B: Planning and Design, 24*(3), 437-449.

Barton, H. (2009). Land use planning and health and well-being. *Land Use Policy, 26*, S115-S123. http://dx.doi.org/ 10.1016/j.landusepol.2009.09.008

Beatley, T., & Manning, K. (1997). The ecology of place: Planning for environment, economy, and community. Island Press.

Burgess, R., & Jenks, M. (Eds.). (2002). Compact cities: Sustainable urban forms for developing countries. Routledge.

Burton, E. (2000). The compact city: just or just compact? *A preliminary analysis. Urban studies, 37*(11), 1969-2006.

Buxton, M. (2000). Energy, transport and urban form in Australia. Achieving sustainable urban form, 54-63.

Cervero, R. (1996). Mixed land-uses and commuting: evidence from the American Housing Survey. *Transportation Research Part A: Policy and Practice, 30*(5), 361-377. http://dx.doi.org/ 10.1016/0965-8564(95)00033-X

Chen, H., Jia, B., & Lau, S. S. Y. (2008). Sustainable urban form for Chinese compact cities: Challenges of a rapid urbanized economy. *Habitat international, 32*(1), 28-40.

Couch, C., & Dennemann, A. (2000). Urban regeneration and sustainable development in Britain: The example of the Liverpool Ropewalks Partnership. *Cities, 17*(2), 137-147. http://dx.doi.org/

10.1016/S0264-2751(00)00008-1

ECOTE, C. (1993). Reducing Transport Emissions Through Planning, HMSO, London.

Elkin, T., McLaren, D., & Hillman, M. (1991). Reviving the City: towards sustainable urban development. London: Friends of the Earth.

Ewing, R. (1995). Beyond density, mode choice, and single-purpose trips. *Transportation Quarterly, 49*(4), 15-24.

Frank, L. D., & Pivo, G. (1994). Impacts of mixed use and density on utilization of three modes of travel: single-occupant vehicle, transit, and walking. Transportation research record, 44-44.

Galster, G., Hanson, R., Ratcliffe, M. R., Wolman, H., Coleman, S., & Freihage, J. (2001). Wrestling sprawl to the ground: defining and measuring an elusive concept. *Housing policy debate, 12*(4), 681-717.

Galster, G., Hanson, R., Ratcliffe, M. R., Wolman, H., Coleman, S., & Freihage, J. (2001). Wrestling sprawl to the ground: defining and measuring an elusive concept. *Housing policy debate, 12*(4), 681-717.

Hanson, S. (1982). The determinants of daily travel-activity patterns: relative location and sociodemographic factors. *Urban Geography, 3*(3), 179-202. http://dx.doi.org/ 10.2747/0272-3638.3.3.179

Levtnson, D. M., & Kumar, A. (1997). Density and the journey to work. *Growth and change, 28*(2), 147-172. http://dx.doi.org/ 10.1111/j.1468-2257.1997.tb00768.x

Masnavi, M. R. (2000). The new millennium and the new urban paradigm: the compact city in practice. Achieving sustainable urban form, 64-73.

Naess, P. (1995). Travelling distances, modal split and transportation energy in thirty residential areas in Oslo. *Journal of Environmental Planning and Management, 38*(3), 349-370. http://dx.doi.org/ 10.1080/09640569512913

Naess, P., & Sandberg, S. L. (1996). Workplace location, modal split and energy use for commuting trips. *Urban Studies, 33*(3), 557-580. http://dx.doi.org/ 10.1080/00420989650011915

Newman, P., & Kenworthy, J. (1999). Sustainability and cities: overcoming automobile dependence. Island Press.

Newton, P. (2000). Urban form and environmental performance. Achieving sustainable urban form, 46-53.

Oberoi, A. (2004). CompactCities: analyzing the urban spatial structure in cities with growth restrictions (Doctoral dissertation, Massachusetts Institute of Technology).

Reneland, M. (2000). Accessibility in Swedish towns. Achieving sustainable urban form. E & FN Spon, Taylor & Francis Group, London, 131-138.

Sen, A., & Pattanaik, S. (2016). Politics of Biodiversity Conservation and Socio Ecological Conflicts in a City: The Case of Sanjay Gandhi National Park, Mumbai. *Journal of Agricultural and Environmental Ethics, 29*(2), 305-326

Sharifi, A., & Murayama, A. (2013). Changes in the traditional urban form and the social sustainability of contemporary cities: A case study of Iranian cities. *Habitat International, 38*, 126-134.

Song, Y., & Knaap, G. J. (2004). Measuring urban form: Is Portland winning the war on sprawl? *Journal of the American Planning Association, 70*(2), 210-225. http://dx.doi.org/ 10.1080/01944360408976371

Wilkenfeld, G., Faichney, G., Dames, Moore Pty I.td., Woodlands & Wetlands Pty I,td. (1995). Australia's National Greenhouse Analysis of Emissions, Department of the Environment, Sport and Territories, Canberra.

Williams, K., Jenks, M., & Burton, E. (2000). Achieving sustainable urban form. Taylor & Francis.

Zheng, H. W., Shen, G. Q., & Wang, H. (2014). A review of recent studies on sustainable urban renewal. *Habitat International, 41*, 272-279.