

## Composing Optimization Framework of Building Density Effects on Transport Demand and Its Infrastructure Construction (Case Study: Region 4 of Qom Municipality)

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*Received: May 2, 2015*

*Accepted: October 18, 2015*

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### ABSTRACT

Separation of urban planning and urban transport planning to cause serious dilemma in the city, especially major cities. Therefore, it is important to transport planning decisions and land use are coordinated and integrated with each other to be able to complement each other rather than act in conflict with each other. The aim of this study was to investigate the relationship between building density and urban transport systems in order to design appropriate strategies to analyze the effects of density changes on urban transport infrastructures with a focus on building density. This research is an applied study that carried out in descriptive- analysis Method. The sample of population are experts and employees covered by the regional 4 of municipality in Qom metropolitan. The results showed that most of the existing planning has been caused urban sprawl growth and dependence on cars in advertently. So that the bulk of investment in transportation improvements, has been dedicated to expand the highway, limiting the density and composition of development. With these conditions, it must be said increasing density in existing urban structure is acceptable, but the fact that these changes will created problems in urban transport, it is necessary to consider these impacts before any planning.

**KEY WORDS:** Density, building density, urban infrastructure, transportation.

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### INTRODUCTION

Analyzing patterns of urban growth, whether distributed or clever (compressed) show that land use and transport are two inseparable elements. Compact and dense cities that are mostly in Europe and Southeast Asia are based on trips with public transport, walking and cycling. In low-density cities that have formed in the US, Australia and Canada, today with problems such as increasing the number of trips by motor vehicles, increasing the length of trips, increasing fuel consumption and air pollution are faced. So we can say, land use and transport are two sides of the same coin. In fact, decisions will be effect on each other. As a result, it is important to transport and land use planning decisions are coordinated and integrated with each other, because they can act together in order to complement rather than conflict with each other [1]. The meaning of "transport" and "land use" in principle is dependent on the relationships between them, and not the nature of each one on its own. According to this view, "transport" generally refers to the movement, and how this shift in different conditions of land uses is. Movement is essentially a geographical sense, because it is inevitably the passage through the space-place, the time and cost [2]. The density issue from the various aspects of economic, social, environmental and physical can be analyzed. Economic dimension of density is perhaps the most important issue, because the national economy, local and household economy have impact on urban congestion. One of the most important economic issues of congestion is the cost of urban infrastructure. Experience shows with increasing population density infrastructure and land preparation costs are decreased. In this regard, economically the eve of the urban population is one of the most controversial and important issues of policy and management. For example, it can be noted that the balance between land use and transportation. When the proposed density increase the transportation capacity and be out of threshold capacity, congestion should be reduced and or transportation system should be coordinated with congestion. In both cases, heavy social and economic costs are imposed on the city [3]. Urban infrastructure, such as road networks, water supply system, electricity supply, telecommunications, gas, sewage collection and disposal of solid links with the topic of urban density. On the one hand, the capacity of the existing infrastructure, is determining factor in calculating the capacity of the region's population density. The density of population causes to justifies of the economic, environmental and technical of special and different infrastructure systems. In fact, infrastructural network play the vital artery of the city. These arteries have a certain capacity threshold for nutrition of tissues with different densities [4]. Transport, links different types of land uses to each other. The concept of access as ultimate goal of transport is a key concept for understanding the relationship between transport and land use and their total effects on each other. In fact, transport will improve spatial relationships between activities or

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land uses. This interaction is measured through access concept including the availability of urban space and the ease of reaching those [5]. The relationship between land use and transportation constitute a closed loop that such equilibrium systems will be established transportation systems. Land use and density define the demand for urban transport together. The relevance of this relationship establish for the rate of the activities of the people in the land determine people's movements degree [6]. Building density and establishing high-rise buildings have quantity and quality significant impact on the urban spaces and access system. Among them, a large volume of urban trips are produced, absorbed and shifted by them. So, the access network around the high-rise buildings due to the high demand on travel by residents, are always under the pressure of traffic. Therefore, if planning and site selection of high building with urban transport network is not synchronized, it can be expected that the problems of urban transport will be increased [7]. The relationship of urban per capita with density is one of the serious discussions [8]. Per capita of streets and roads in the cities of Australia and the United States, is about 2 to 4 times European cities and 7 to 9 times Asian countries. Two urban groups that have the highest dependence on private car are low-density cities in the US and Australia. Meanwhile, the average densities of European cities are significantly less dependent on cars. This point has led attention of policy makers to encourage denser urban development in order to reduce the burden for providing infrastructure [9]. Sprawl growth lead to increased costs of infrastructure and public services [10]. Borchal and Mukherjee found that sprawl growth increase local road based on miles by 10%, the annual public service costs by 10% and housing costs by 8% [11]. In recent years, the Iranian's cities, in one hand has observed the density reduction in new urban areas and on the other hand, in some parts of city, central areas because of the public interest for the construction has observed the increase in density. But the importance point is coordination among building density and urban transport network and road and transport infrastructure in general. Region 4 of Qom municipality is one of the areas that with population growth in recent years, has faced with increasing in building density once. Thus, this study aimed to investigate the effects of building density on demand and transport infrastructure to develop a framework for optimization of building density.

## METHODS AND MATERIALS

This study from aim aspect is an applied research and based on method is an survey - analytical study. To gather information, a questionnaire was designed that containing 11 questions at Likert scale and four open-ended question to become conscious of the demographic characteristics of respondents. Face validity of the questionnaire indices by referring to the judges and their advice was confirmed. To assess the reliability of questionnaire, Cronbach's alpha was calculated for different parts that was higher than the 0.9 that showed high reliability of measurement tool. Data analysis in this study was performed using the SPSS 21. In descriptive statistics, the charts and frequency tables were used and in inferential statistics, one-sample t-test for testing was used. The study samples were 200 experts and employees covered by the municipality of region 4 of Qom metropolitan and 100 subjects were chosen via simple random sampling method with using Cochran formula.

### Introducing the study area

Region 4 of Qom have new tissue and gross population density of 55 persons in per hectare. The analysis of building floors shows that most of the buildings of the city of Qom (96%) are one floor and two floors and only four percent of the buildings are 3 floors and taller, although 12 percent of the buildings in the region 4 are three floors and higher. As specified in the table below, more than 55 percent of buildings higher than 4 floors of the city are located in the region of 4, while region 4 only 14% of the city buildings is included.

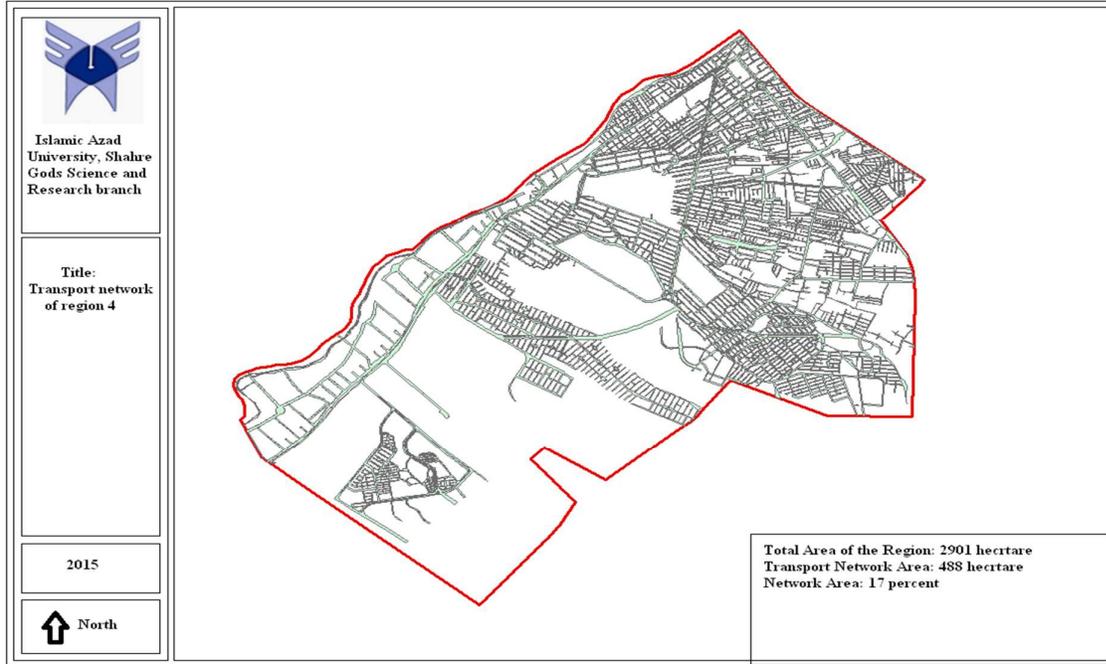
The mean of building floors in the city is 1.42 with a standard deviation of 0.67. While in the region of 4, mean of building floors is 1.68 with a standard deviation of 0.98. The higher standard deviation in this area than in the city represents the difference between the floors of buildings in this area is higher than the city.

Table 1: Comparison of the number of floors in the city of Qom and Zone 4

Comparison of the number of floors in the city of Qom and Zone 4 (percent)	Number of building in the Zone 4	Number of building in the city of Qom	Number of floors
13	26022	200235	1 and 2 class
33	2151	6427	3 floors
53	758	1429	4 floor
59	424	722	5 floors
52	196	375	6 floors
61	98	160	7 to 9 floors
64	9	14	10≥
14	29658	2.9362	Total
-	1.68	1.42	Mean
-	0.98	0.67	Standard Division (SD)

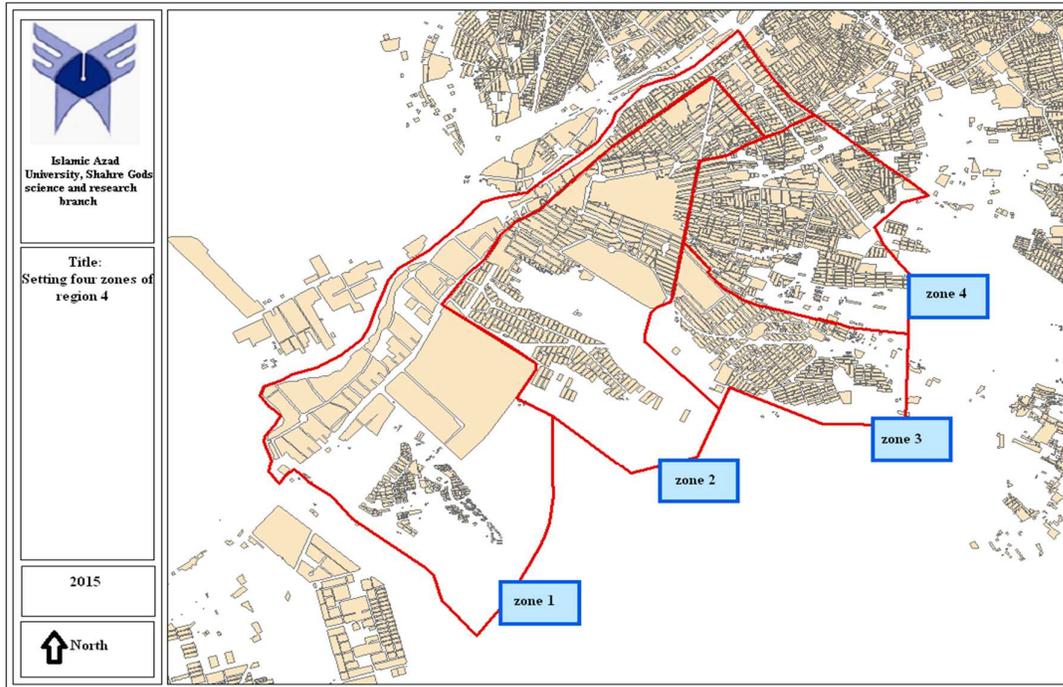
Moreover, zone 4 with an increase in the number of floors and building density is faced. However, Article 100 and Article 5 of Commission statistics for places and for the whole city have not registered, but it seems that a significant share of the violations are occurred in this area, so that the area with the high volume of abuse and violations are losing their planned identity.

Map 1- Transport network of region 4



At present, there are including of 4-service area.

Map 2- Setting four zones of region 4



**Findings**

**The descriptive findings**

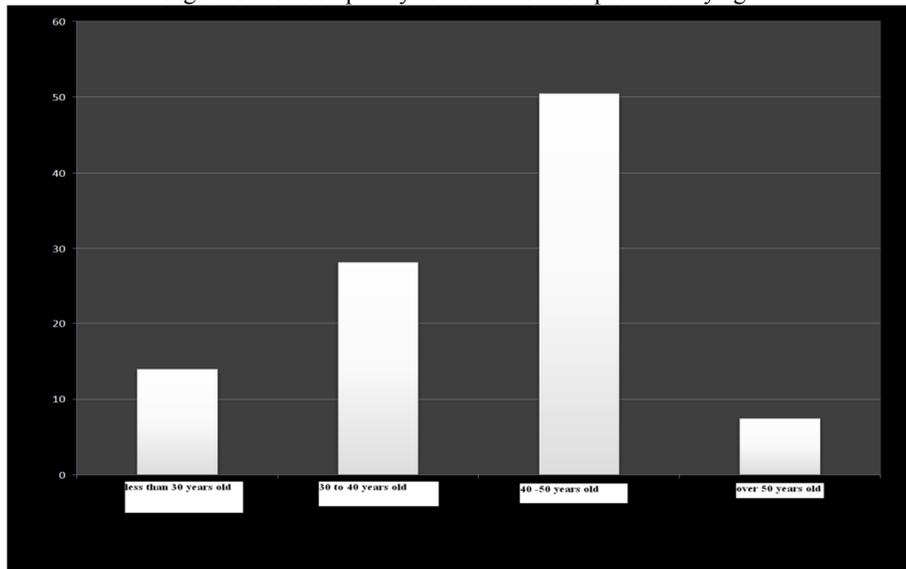
As mentioned, the population samples were 200 experts and employees covered by the municipality of region 4 of Qom metropolitan and 100 subjects were chosen via simple random sampling method with using Cochran formula. Frequency distribution of respondents in terms of gender as tables 2 shown were 75% man and 25% women.

Table 2. The frequency of respondents by gender

%	gender
75	man
25	women
100	Total

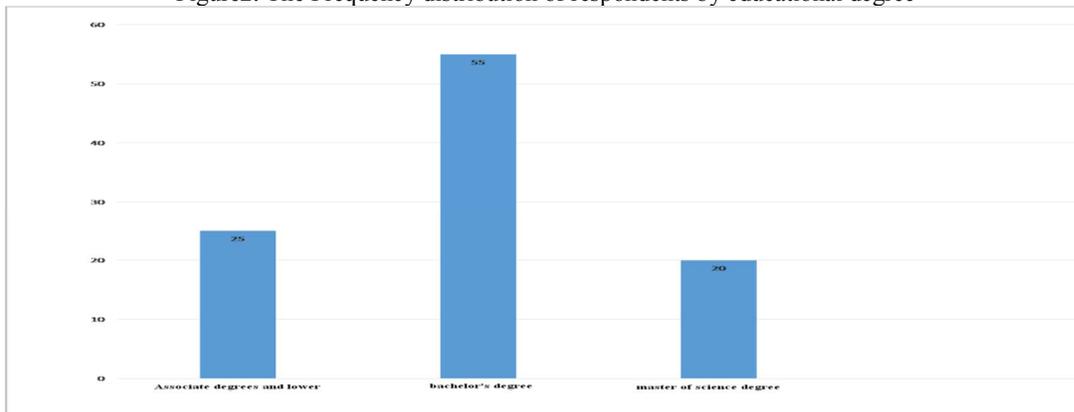
14% of respondents were less than 30 years old. 28% of respondents were 30 to 40 years old. 51% of people with most frequency were 40 to 50 years old and only 7 percent of people were over 50 years old.

Figure 1- The Frequency distribution of respondents by age



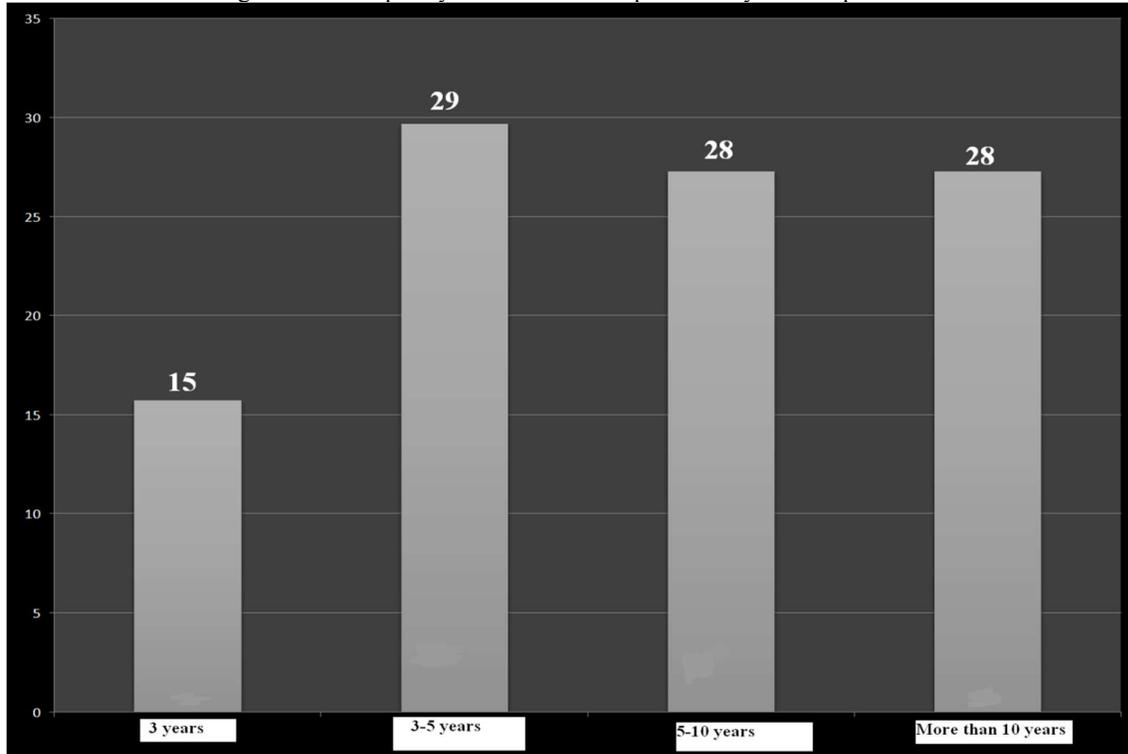
25% of people had associate degrees and lower. 55 percent of respondents had bachelor's degree. 20% of the population had Master of Science degree.

Figure2: The Frequency distribution of respondents by educational degree



15% of people had less than 3 years of work experience. 29% of respondents had 3-5 years of work experience. 28% of the samples had 5-10 years work experience. People who had more than 10 years of work experience were 28% of the samples.

Figure 3: the frequency distribution of respondents by work experience



**The results of analytical research**

**Test the normal distribution of variables**

Before performing statistical analysis on the data to choose appropriate statistical test it is necessary to test normal and non-normal distribution of data.

The Kolmogrov-Smirnov test was used to achieve this goal to the normality of the study variables (Buildings density sales, According to the transport infrastructures in determining the optimum density, urban management policies in the field of density) was investigated. The results of data normal distribution test showed variables distribution are not normal.

Table 3 - test the normal distribution of variables

Urban management policies in the field of density	According to the transport infrastructures in determining the optimum density	Buildings density sales	Variables
0.185	0.187	0.170	Kolmogrov-Smirnov test
0.000	0.000	0.000	Sig.

Therefore, to analyze the assumptions used nonparametric tests. T-test was used to test the hypothesis.

**Hypotheses Test:**

**Hypothesis 1:**

It seems that sales of building density by municipalities, will be imposed the high cost of infrastructure development in the city again.

Table 4: Table T test to confirm the first hypothesis

	T-test values					
	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference	
					Lower	Upper
Q 1. no capacity for accepting population	4.863	99	0.000	0.660	0.57	0.75
Q 2. Increased demand in the public transport system	4.450	99	0.000	0.300	0.17	0.43
Q 3. Inefficient transport infrastructures, including bus fleet	3.563	99	0.001	0.250	0.11	0.39
Q 4. Increasing population and construction density in urban zone experimentally and lawless.	4.52	99	0.000	0.897	0.766	0.906
Q 5. Neighborhood with public transportation network	3.73	99	0.002	0.023	0.29	0.01

### Inferential Statistic for hypothesis 1

To confirm this hypothesis, the answers to questions 1, 2, 3, 4 and 5 questionnaires were used. According to the table 4 significant level in no capacity for accepting population, increased demand in the public transport system, inefficient transport infrastructures, including bus fleet, increasing population and construction density in urban zone experimentally and lawless and neighborhood with public transportation network variables has been calculated that was less than 0.05. Therefore, it can be stated that it seems that sales of building density by municipalities, will be imposed the high cost of infrastructure development in the city and considered hypothesis was confirmed.

### Hypothesis 2:

It seems that attention to the urban transport infrastructures is necessary to determine the building density.

Table 5: Table T test to confirm the second hypothesis

	T-test values						
	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference		
					Upper	Upper	
Q 6. The organizing road network in the private transport system help to decentralization of different urban areas.	3.179	99	0.002	0.204	0.08	0.33	
Q 7. Increasing the share of public transport fleet help to decentralization of private transport system in urban areas.	4.062	99	0.000	0.301	0.15	0.45	
Q 8. Among the reasons for underdevelopment of transportation systems in Iran is lack of long-term strategy for the development of transport systems in the high dense regions.	3.838	99	0.000	0.252	0.12	0.38	
Q 9. Lack of a defined relationship between the development of transport and urban development is one of the causes of urban transport underdevelopment.	4.45	99	0.000	0.300	0.17	0.43	
Q 10. In denser neighborhoods of the city (especially within the area of 4) the number of trips by car has reduced and the demand for public transport has increased.	3.563	99	0.001	0.250	0.11	0.39	
Q 11. increasing urban densities significantly reduced vehicle trips per capita.	4.063	99	0.000	0.270	0.14	0.40	
Q 12. With the increasing density, population has been more willing to walking and cycling.	1.560	99	0.000	0.120	-0.03	0.27	

**Inferential Statistic for hypothesis 2**

To confirm this hypothesis, the answers to questions 6 to 12 questionnaires were used. According to the table 5, significant level for variables has been calculated that was less than 0.05. Therefore, it can be stated that attention to the urban transport infrastructures is necessary to determine the building density and considered hypothesis was confirmed.

**Hypothesis 3:**

It seems that due to wrong policies on urban management in high-density urban areas and in areas with a low density is faced with negative effects.

Table 6: Table T-test to confirm the third hypothesis

	T-test values					
	t	df	Sig.	Mean Difference	95% Confidence Interval of the Difference	
					Upper	Upper
Q 13. integration in the development of construction will reduce building congestion.	7.228	99	0.000	0.417	0.30	0.53
Q 14. The process of building and population development of the city of Qom is uncontrollable	8.736	99	0.000	0.495	0.38	0.61
Q 15. The centralization of the planning system, is one of the reasons for underdevelopment of transportation.	0.688	99	0.004	0.146	-0.27	0.57
Q 16. High population congestion and tend to High density in neighborhoods units be more the result of negative impact of limited markets of the housing and land than planning direct decisions.	2.825	99	0.006	0.204	0.06	0.35
Q 17. In most cases, proposals of urban development projects are not implemented in cities; in fact some of the areas that for them high or down population densities has been forecasted, in contrast to the proposals we are faced with dramatic changes.	3.563	99	0.001	0.250	0.11	0.39
Q 18. The bulk of the urban development plan prepared for the region under study, the issue of how to determine the optimal density, notice is negligible.	3.179	99	0.002	0.204	0.08	0.33

**Inferential Statistic for hypothesis 3**

To confirm this hypothesis, the answers to questions 13 to 18 questionnaires were used. According to the table 6, significant level for variables has been calculated that was less than 0.05. Therefore, it can be stated that due to wrong policies on urban management in high-density urban areas and in areas with a low density is faced with negative effects and considered hypothesis was confirmed.

**RESULTS AND DISCUSSION**

Importance of calculation of density as a means of planning and urban design is because the mention index reflects a certain degree of the most important characteristics of the plan. Density indicates the crowded and buildings on the ground and indicating the amount of open space is used by households.

The construction density changes and in particular the construction density increase, is closely related to population density. In other words, the population is an important factor in determining urban land use. As we know urban land uses that three different groups of residential, roads and municipal services can be divided do not protect of changes in the density percent fluctuations.

Reduce or increase the size of the population in a city have a direct impact on the amount of land uses and reduce or increase the size of the required land of these uses.

However, one of the problems that cities face today's world, especially in big cities, is excessive increase of building density.

This idea at first was considered in order to the best exploit of the center lands of town. Because on the one hand the desire for density and concentration of economic entities had been increased the demand for land in the city center greatly, and on the other hand, the supply of land in this area was limited. So, increasing building density as a solution to increase in the level of infrastructure was exploited. This solution was used widely and gradually, in addition to the economic use of land uses, such as industrial, official and commercial was used at residential uses.

Theoretically, increasing the construction density in case of housing seems to be almost unlimited, but due to the need to allocate, a portion of land to the uses of land (streets, open and green spaces, and many types of facilities) is limited. The interaction between these three variables will have serious limitations in the density of construction in the housing sector. Neglecting this fact, serious deficiencies in urban transport and urban services will be caused.

Urban land uses due to the nature of its system, are in constant and interaction contact by the communication network and traffic flows. For this reason, urban transport planning as the most effective tool to guide the development and shaping of the urban environment have been identified.

So, the increase coordination between land use planning (construction density) and urban transport can eliminate the caused problems. The first hypothesis of this study were:

" It seems that sales of building density by municipalities, will be imposed the high cost of infrastructure development in the city again".

The idea of increasing density is based on this principle that high density can be solved many issues in connection with limitations, especially land and cost and in this context to prevent the loss of land as the main natural and vital factor of urban development.

On the other hand, sailing the concentration in recent years has become one of the main sources of income for the municipalities. This view is justified in relation to economic issues. Low density leads to increasing costs of urban infrastructure and so the per capita cost of these services will be increased.

The results of the testing first hypothesis showed that in all cases the significance level was less than 0.5. it is worthy that for questions 1, 2 and 4 p value were  $p= 0.000$ , for question 3 amount of p value was  $p= 0.001$ , for question 5 p value was  $p= 0.002$ , that all of significant levels were less than 0.05. Based on result can be achieved that this hypothesis is accepted in accordance with the above procedure.

However, according to the results of the t- test can be concluded that building density sale is causing lack of capacity for accepting population in the region 4 that this has caused inefficiencies in existing infrastructure and thus, the municipality for welfare of the citizens have to repay the cost in this sector. In addition, density changes have a major impact on the transport network and traffic and production and attract pattern of trips. In other words, there are the significant relationship between increase in density and increasing urban transportation problems such as traffic.

While congestion building is as a tool for urban development, using it as a source of revenue for municipalities should be called irrational action. Sales of rocketing density don't have a historical record and on the views and experiences of urban development has not been observed in other countries. The term "sold" may be in terms of "added value of the land" or charge of construction effect (Impact fees) reviewed. Such phenomena are in the world, but these tools are not general, but are clear and consistent with effects and real needs. Really, possibility of buying additional density is a false purchase right that without thought has been given to citizens.

In genera lit can be said, the increasing building density has different strengths and weaknesses points. The strengths of this increase can be named economically justified to prevent the spread of the city horizontally, agricultural lands preservation, earn money for municipalities and increase the production of housing.

On the other hand, increasing building density regardless of the principles and standards of urban development have many weaknesses points that disruption of population density, defined as an unstable source of income, the difficulties of providing services to citizens, lands speculation and bribery, lack of attention to the modernization and improvement of old tissues and worn- out are noteworthy.

The second hypothesis of this study was:

"It seems that attention to the urban transport infrastructures is necessary to determine the building density".

The results of the testing second hypothesis showed that in all cases the significance level was less than 0.5. it is worthy that for questions 6, p value was  $p= 0.002$ , for questions 7,8 and 9 amount of p value were  $p= 0.000$ , for question 10, p value was  $p= 0.001$ , that all of significant levels were less than 0.05. Based on result can be achieved that this hypothesis is accepted in accordance with the above procedure.

According to the results of t-test, it can be concluded that before constructing any productive source or uses changes, necessary studies to assess the effects of additional trips and the resulting traffic congestion on the roads and key intersections of road network around should be investigated. It is important in order to provide the necessary reforms and facilities to meet the needs of the post-construction projects and in condition of access lack to facilities, the manufacture is prevented. In addition, the effects of changes in population and building density on communication and access network can be reviewed in the traffic volume, the traffic nodes and communication network per capita.

Compliance with the ceilings of the assigned average for the density of building the overall balance between motorized traffic generated by building and arterial roads capacity will be established.

To benefit high density from effective and everyday services, efficient public transport is essential. But in the low density that is based on private cars cannot be expected to have a good public transportation system. The high density that the road space is limited, an efficient public transportation network is needed. Building density are affected on the number and type of trips and travel vehicle, and increasing density in a residential area causes the number of trips by private car is reduced.

In general can be said that building density has major qualitative and quantitative effects on urban spaces and access system and produce and absorbs a large amount of inter-city travel. So, the access network according to travel demand volume is always influenced by traffic pressure and if building density are not determined based on road network and in general, the transport infrastructure in specific region, should be expected problems of traffic and urban transport is increased.

The third hypothesis of this study was:

"It seems that due to wrong policies on urban management in high-density urban areas and in areas with a low density is faced with negative effects".

The results of the testing third hypothesis showed that in all cases the significance level was less than 0.5. it is worthy that for questions 13 and 14, p value were  $p= 0.000$ , for questions 15 amount of p value was  $p= 0.004$ , for question 16, p value was  $p= 0.006$ , for question 17, p value was  $p= 0.001$  and for question 18, p value was  $p= 0.002$ . All of significant levels were less than 0.05. Based on result can be achieved that this hypothesis is accepted in accordance with the above procedure.

According to the results of t-test, it can be concluded, the building density is not shaped based on systematic urban planning, but it is due to the negative and important effects the limited markets of housing and land and speculation of land and buildings. In this case, mismanagement have been negative impact on the building density in urban areas.

In general building density in one hand, can be solve many urban problems such as lack of land, housing, optimize utility costs, prevent horizontal growth of cities, and on the other hand itself can be created the problems and deficiencies such as increasing population and housing density, infrastructure and urban services disruptions, urban traffic, physical and environmental adverse effects in urban space.

The urban management with adopting right policies can be created optimum density in the city, according to the criteria outlined above. While, building density is derived from the various principles and standards that urban management can be planned and managed the cities based on these factors in various aspects. It is expected that the role and effect of economic, social, cultural, environmental and physical are considered in an Integrated form and for this purpose, urban per capita, urban land uses and building densities are phenomenon which will affect each other in order to the principles and criteria to be fulfilled. Therefore, the building density phenomenon cannot be affected of one of the factors, or cannot be as a tool to achieve one of the goals of urban management. These findings indicate that the sample distribution according to the Kolmogrov-Smirnof test test were not normally distributed and therefore, in order to test the hypothesis t- test analytical method is used, and all three hypotheses mentioned have been verified.

### **Conclusion and suggestions**

Density and the change in density in an urban area, have a major impact on transport network and the traffic pattern of production and absorption of the trip. It can be said to elative answer to the current distress situation it is necessary instead of just horizontal expansion of cities, which in turn effects and high costs of the city, especially on urban transport, to consider the issue of urban development in height. As in this study, especially the study area can be seen, city in the form of unbridled has been dispersed development.

But the idea of city development in height, in order to increase the effectiveness and efficiency of urban transport systems and in general, all the urban utilities, must be considered before designing. In such a way that the networks are proportional to the urban transport system arise.

In this case, the vertical development of the city not only from the standpoint of land use is much more advantageous, it can be somewhat transport problem of large cities that today have reached a critical stage to give much relief. In addition, the type and density play an important effect in planning urban transport. According to this point that determine the density is the main tasks of urban planners, it necessitates with a series of scientific and practical works determine density in accordance with the urban transportation system and the optimal level of concentration density, with regard to infrastructure of transportation and travel demand is determined.

The decision on increasing the building density cannot be taken without regard to other living conditions. increasing the building density requires the provision of other urban facilities and equipment that converts

residential units to home environment by providing the proper relationship between economic, social, cultural and environmental.

Building density has direct and logical correlation with population density. But increasing the building density does not necessarily mean an increase in population and population density in a range. In fact, without increasing the building density and simply by shrinking infrastructure of residential units, population density increase can be occurred. In other words, by constant building density can be reached the different population density.

If the increase in building density leads to increased population density, the effects will be noticeable on different aspects. For example, fluctuations in housing prices and increased access and traffic issues which occurred in the study area and in recent years has led to fluctuations in the prices of housing and traffic problems have been aggravated.

Notice to the role of architecture and urban design and the distribution types of land use per capita, have a serious impact on traffic changes. This is a subject that has not been accepted by municipal managers, study are without considering the interaction between traffic and congestion, and urban development has been designed. In summary, citizens without transportation demand management cannot hope to solve the traffic problem. Based on the results of this study the following suggestions are presented:

- Preparing extraction standard of permitted density of construction, not only based on the price of land and housing, but also coordinated with the existing road network and its future development plans in order to reduce transport and traffic problem.
- It is clear that effects of structural density changes and consequent changes in population density on access and communication networks can be reviewed in the traffic volume, the traffic nodes and communication networks per capita and communication. So, can be suggested that policies, planning and decision-making process in relation to changes in the density of construction is based on the principles and criteria should be considered.
- Considering the interaction of land use planning and urban transport planning in the process of providing urban planning documents
- Providing level of compression to different areas and determining the hierarchy for them in a way consistent with urban transport planning, particularly in the field of trips production and attract.
- It is necessary related factors on the construction density associated with predicting the consequences of decisions at different scales are considered.
- Due to the primary motivation to emergence of term “density sales” that have been to earn income for cities and in the form of municipalities self-sufficiency, it is necessary that Cities sustainable sources of income, whether in the form of laws and regulations and whether in terms of new revenue sources be defined. It is important the methods and sources of earning income for municipalities do not ignore and neglect the principles and standards of urban development.

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