# Studying the Effective Factors on urban Densification
## By Analytical Hierarchy Process Method (AHP)
## (Case study: Isfahan's fifth district

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**Abstract**

Nowadays, urban planners are encountered with Urban sprawl in the large cities, especially in the developing countries. In order to control this condition they have taken different policies, one of these policies are increase density. The aim of this research is to determine the optimal building density in Isfahan's fifth district. To analyze this subject, firstly the selected district was divided into several quarters (neighborhoods), the indicators in each quarter were studied and weighted according to their suitability for the proposed density, then the weight of each index was established by the use of comparison matrix and eventually the suitability of each quarter was determined to propose the increase of density. The findings of the presented research indicate that because of the specific qualifications of the district, such as the existence of the valuable historic fabric of Jolfa and its neighborhood with Zayande-Rood, the historical center of the ChaharBagh-e-Bala and width of the passages and …, it`s better to avoid the increase of density in this district; and finally some suggestions is presented in order to determine an optimal density for this region.

**Keywords**: Densification, Isfahan municipality, Analytical Hierarchy Process, increase of densi

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## Introduction

The rapid growth and the horizontal expansion of the cities have had a great impact on the intensification of the economic, social, political, managerial and environmental issues (Azizi, 2003 ,p.13), so that the growth of the metropolitan will be even more than the urbanization growth in the future (Ath`hari, 2003 ,p. 65). On one hand, the administrative expenses of the cities will greatly increase because of their horizontal expansion. (Yazdani, 2003,p. 46) On the other hand, concentration of the population, formation of metropolitan and subsequently migration are such normal and even essential processes of the nations` lives and will be intensified in the future (Ath`hari, 2003 ,p.67). But these processes must be accomplished gradually, so that the necessary infrastructures will be prepared in parallel. To achieve stability, it`s necessary to drive development to the existing urban areas; the cities` expansion to the surroundings and the agricultural lands is so undesirable; therefore, the desirable development will be achievable just through the increase of density, of course the high density has some deficiencies too. So, it has been prescribed by many planners in the cities of high density, as the most sustainable urban form and design; and the increase of density is taken into consideration in most of the cities in the world (Toufigh, 2003,p. 11).

Isfahan, as the third most populous metropolis of Iran, is faced with the interference of the urban confines with the confines of the surrounding cities and towns. So, this city has a significant importance in Iran`s urban system. With regards to the increasing population growth of this city, the policy of "offer and sale of the excess density" has come into force here. But has the increase of density been carried out according to the suitable criteria? Specifically since this city possesses global prestigious monuments.

The increase of inappropriate elevation of the buildings in the fifth district of Isfahan by its valuable historic and environmental fabric, has encountered this district to many problems like high buildings that is still being built on the sidelines of Zayande Rood, and this will lead to the formation of a physical barrier around the river and the prevention of the air flow (Atec consulting engineers, 2009) and also has disrupted the landscape and the vision of the city.

Advantages and disadvantages of the high and low density

Several philosophers and planners like Plato, Aristotle, Thomas More, Leonardo Davinci, Ebenzer Howard, Louis Mumford and etc. have studied the concepts of "density" and "the optimum size of the city" and have proposed one specific size as the maximum acceptable size (Golany, 1976,p. 143).

High density is capable of solving many problems relating to the limitations, especially land and costs; and also will prevent the waste of land as the main natural and vital factor of the development of the cities. The other explanation for this subject goes to the economic issues; in fact, low density leads to the increase of the cities` infrastructure expenses and this, by its part, increases the service costs. The potential power of the central fabric is the other reason for such arrangements; in other words, a great number of the existing facilities in the urban fabrics are more than the needs of the residents of such areas and are not applied favorably. Therefore, there is no need to develop the suburban and must efficiently apply the excess equipment of the existing fabric.

despite the positive aspects of high density, there are some weak points too, for example, the decrease of the life criteria related to the public welfare, the loss of freedom for choosing accommodation, high costs of constructing tall buildings due to superior technology and at last, high costs of maintenance (Masnavi, 2003 ,p.102 -88). In table 1 summery of Advantages and disadvantages of the high and low density is showed.

The research records

- Azizi (1997): in this article he has embarked on the factors and the effects of the theoretical viewpoints on the recognition of the issue of density in urban designs.

- Sho`aybi (2002): he has studied and criticized the

policy of offering the excess density in Tehran, the calculation method and the formula of the excess density sale price in Tehran and eventually presented some solutions.

- Azizi (2003): he has compiled a book on the principles and the criteria of determining the urban density during the research project of the department of urbanization and architecture; and the internal and external experiences have been presented there.

- Adabkhah, et al. (2003): during a research he has developed a new model of determining the maximum density of the district with the emphasis on the tolerable capacity of the urban passage network. As he was aware of the multiplicity of the effective factors of density, he has applied the urban infrastructures and among those just the infrastructure passage network (roadway traffic) in his model. He pointed out that this model can also be developed in all various urban installations and infrastructures by the application of some changes and adaptations of related indicators to that. So, there will be an upper limit for the maximum density due to the existing capacity of the district.

- Mashhoudi (2003): he has studied the construction density and its relationship with the land and building prices, and the household income by examining the economic features of the dwelling in the cities of Iran. At the end of the research, he has proposed an appropriate density for each one, due to the various conditions of the separable plots.

- Ghorbani (2004): he has studied the urban density to systematize the urban spaces of Tabriz in his PHD thesis.

- HosseinZadeh Dalir and Hadily (2005): they have studied the role of urbanization policies and proceedings in the distribution of the urban densities in the city of Tabriz.

- BaniFatemi and Koohi (2006): they have studied the factors and the outcomes of the urban population density and have offered the comments of some intellectuals on density and eventually have proposed some solutions on determining the optimal density.

- Taghvaei and Saraei (2006): they have concluded that half of the surface area of the city of Yazd in recent decades is the false area and there will be no need for the increase of areas in the next 25 years.

- Azizi and Malek Mohammad Nejad (2007): they have concluded that there have been provided a more favorable residential environment in the conventional housing complexes than the tall samples; and low density and the existence of the open and verdant space and its effect on the physical-spatial qualities of the environment leads to the overall score superiority of the conventional sample than the tall sample.

- Eslami and Iravani (2008): in a research on the construction density and the endogenous development, they have concluded that the urban development process in Isfahan is not in the same direction with the notion of the endogenous and sustainable development.

- Sho`le (2008): he has studied the documents and the approved rules and regulations about density during the past years in Tehran. He has acknowledged that the non-expert interventions like the excess density sale and the indiscriminate and unplanned constructions in the dwelling department specifically in Tehran metropolis, without considering the variety and the differences of the urban lands and just to earn money by municipality, will lead to the decline of the urban environmental features and also the instability in safety, health and welfare of the citizens and the environmental fields.

- Danesh Poor et al. (2009): they have concluded that because of the aggregation of the users in a limited area and the significant exploitation of energy in tall buildings, it`s necessary to take into consideration the sustainability approach in the process of design and the operational phase.

- Karimi et al. (2009): they have concluded that the adverse urban density is one of the basic difficulties of today cities and may be the origin of some disorders like the unbalanced distribution of the utilities, heavy traffic, etc. He has developed a model for the optimal density determination and has applied that in some places such as the KhomayniShahr in Isfahan.

- Azizi and Arasteh (2011): they have explained the

urban dispersion according to the construction density index in the city of Yazd. In this research the relationship between the construction density and the population density, the area of the plots, the land price and the distance from the downtown and their access to the public transport in the city of Yazd have been studied.

The effective factors of the densification
The effective factors of the optimal densification were extracted by examining the records and accomplished studies as the table 2 shows.

Density in Isfahan city
Isfahan is the third most populous city and one of the biggest industrial poles in the country, so that we could include it as the second largest city in terms of economic, politic and industrial.

 From approving the first executive plan in Isfahan, we observed extensive changes around this city; this indicated the growing trend of horizontal expansion in Isfahan. On the other hand, demand for vertical expansion is also seen in different parts of the city. Total population of Isfahan was 1606557 in 2007, which according to its 17933 hectare area, the gross density of population in this city were 89.59 people per hectare. Also regions 10 and 2 with gross density of 126.43 and 47.53 people per hectare are the most densest and the least densest regions of this city, changes in scope of 78.9 people per hectare which showed the tremendous differences between the gross density in the most densest and the least densest parts, which is due to the unbalanced distribution of population in the different regions of this city. Based on density distribution map (map 1) the population is found in different regions of Isfahan which as we moved from the northeastern to the other regions, the population density was diminished. This phenomenon is due to the constraints of the horizontal expansion in eastern Isfahan. So that in the western regions, the obstacle of urban growth and development were less and the urban development was done horizontally.

The correlation test was done between the indicator of the existing population density in regions and the sold density indicator in recent year. Pearson correlation was 0.467 and p-value was 0.107. In other words, the regions with high population density have shown more tendencies for purchasing density. In other words, they are trying to enhance the differences in existing population density in this region, which in near future will observe high density in regions 10 and 4. These regions followed their increasing trend to more density with more differences.

The policy of increasing density should be carried out only within a comprehensive framework, in which different parts were coordinated with each other and could evaluate the effects of all factors interference in determining density. Any increase in density which accomplished without considering such comprehensive frameworks, would have unsolicited adverse consequences and status. Therefore we should formulate a model which according to the effective factors on density and its effects on the city could be a framework for urban management decision making in determining optimal density. So that the urban management could not venture density increase in every place of city without any justified reason.

Introducing the studied region
Region 5 is located in southern Isfahan and it leads to Zayanderud River to the north. This region is of particular importance due to containing a large part of precious and historical contexture also features such as Madi crossing through some localities and adjoining to Zayanderud River, and any decision related to this region should be made based on these characteristics and neglecting these features lead to many problems. (Atec, 2009)
This region included ten main localities but in this research eight localities are selected as the sample of studying. This area has 8 neighborhoods division (1-Bagh Zereshk 2-Sichan 3-Jolfa 4-Bahar Azadi 5-Hossein abad 6-Vahid 7-Bagh daryache 8-Farah abad).

Effective factors in determining density in region 5 of Isfahan city

Due to the lack of sufficient information and time for data collection, among the above mentioned indicators, the following indicators (in table 3) were selected and were studied in different regions of city. Since the supposed area included precious historical contexture and the rivers such as Madi and Zayanderud crossed this area, the following indicators were intended.

Indicators Scoring

Since the importance of the indicators is not the same, in this stage two matrices is provided to determine the indicators effectiveness in final scoring of localities, in which the importance of each indicator toward the other indicators, and consequently the score of each one are determined. In first matrix (table 4), the importance of four main indicators including: framework, environmental, social and economic, towards one another and finally their score are determined, and in second matrix (table5) the importance of sub-indicators of framework indicator including: traffic, land area, structural density, historical contexture towards one another and finally their score are determined.

Three scores are used for scoring the given indicators (the scores and their importance is determined in the table), in which each score indicated the importance of indicators towards the other ones. After specifying the importance of each indicator toward the others, the score of each one is calculated from the following formula. To standardize scores, the score of each indicator is divided to the total scores.

$$x=\sqrt{(n\&a*b*c*\ldots)}$$

Where X is the score of considered indicator, N is the number of indicators, a, b, c ... are the scores of the considered indicators towards other ones.

Meanwhile, scoring to the indicators is based on the author's view and it was assumed that, due to the uniqueness of the region and sensitivity of historical contexture and Zayanderud and Madi and requisiteness of considering them, high score is given to framework and environmental indicators and also between framework indicators, higher score is given to historical contexture and these scores in the other localities would be certainly different.

Final score of localities

For calculating the final score of studied localities, scores of each locality towards each indicator is multiplied in standardized score of that indicator and get the score of given locality in different indicators, and final score of locality is calculated from total scores of given locality in each indicator (table6). The localities which received higher scores are more appropriate for suggesting density and possibility of density increase in these localities is higher.

Conclusion and suggestions

Several indicators were effective in determining the density; including social-cultural, economic, and framework indicators and neglecting these indicators lead to some problems. Here due to the research limitations, few indicators were studied. In analysis, suitability of the localities for suggesting structural density is considered as final score of locality towards indicators, as it was observed in table 6, Farah Abad and Bagh Daryache with the score of 3.7 and 3.6 received the highest score and after them Bahar Azadi, Bagh Zeresk and Vahid were suitable choices for increase in structural density. Hossein Abad and Jolfa with the scores of 1.3, 1.8 and 2.1 received the lowest scores and are not suitable for increase in density.

Although high density had many characteristics; the amount of density should be based on locality feature, so due to special characteristics of region 5 including valuable and historical contexture of Jolfa, adjacency to historical route of Chahar Bagh Bala and Zayanderud, presence of Madi in majority of localities as well as characteristics such as limitation of the buildings, Low capacity within the contexture of

passages, the structural density should not be more than 5 floors, the trend of increase in density and issuance of building permits with high density should be prevented. The results of each locality have mentioned below separately.

- In approved zone of historical contexture of Jolfa, the density should not increase; since one of the factors which accelerated destruction of monuments and historical contexture of Jolfa was issuance of building permits for destructed monuments with higher density than the existing situation which is a factor for increasing the price of land and demand for destruction, and it has renovating of other parts.

- In approved zone of historical contexture of Jolfa which is located in localities such as Jolfa, Sichan and Hossein Abad, in order to preserve historical contexture and appearance, these localities are not suitable for increase in density. Also because of the limitation of buildings and inadequate passages network in Vahid locality, this locality doesn't have the qualification for increase in density. So density in these regions should not consider more than average.

- Farah Abad is the only locality that Madi doesn't cross and also doesn't have any historical contexture and its score was suitable in the majority of indicators particularly in traffic indicator, so this locality is more suitable than the other one in density increase.

- Bahar Azadi locality could have the possibility of density increase due to regular contexture and suitability of the majority of indicators, With the exception of areas located in frontage of Chahar Bagh Bala route and Madiha.

- Bagh Daryache locality could have the possibility of density increase due to the suitability of the majority of indicators and high structural density towards the other studied localities, except to Zayanderud and its Madiha vicinities.

- Also Bagh Zereshk locality with the characteristics similar to Bagh Daryache could have the possibility of density increase, except to the frontage of historical contexture of Jolfa, Chahar bagh route, Zayanderud route and Madi in it.

- Furthermore, the localities in the frontage of ma-

diha, Zayanderud and the historical route of Chahar Bagh should be determined and due to its sensitive and particular condition, a special density commensurate with them should suggested; but generally density in this area could not be high because these elements are part of the main structure of Isfahan city and any unsystematic changes would have adverse findings.

- Commercial routes including University Street to Simin, Chahar Bagh, Nazar, Simin Street, and boulevard around Zayanderud should determine and density commensurate with these areas should suggest. These routes except to Chahar Bagh and Zayanderud route, due to suitable width, had the possibility of increase in height; of course increase in height should be related to the size of commercial plates.

|  | high density | low density |  |
|---|---|---|---|
| Positive points | - the reduction of the physical distance and multiple urban traffic (increase of availability)<br>- the closeness of essential services to each other<br>- the possibility of repayment and maintenance of the remains of the architectural monuments<br>- optimal protection of the agricultural lands around the cities<br>- the creation of the public Spaces and the reinforcement of the community life<br>-the reduction of the transportation and living costs<br>-the reduction of the costs of infrastructure and the municipal utilities | - the loss of valuable lands of the urban fringe<br>- the increase of the consumption and the energy costs<br>- the increase of the preparation expenses and the service security<br>- the decrease of security for the seclusion of the existing spaces<br>- the increase of the cost of living<br>- endangering the natural the wild life<br>- the dependency of the family members to the cars and personal travels and the reduction of the social relationships | Negative points |
| Negative points | - the increase of the land price<br>- the increase of the noise pollution and the buzz of the residents especially in adjacent units in dense apartments<br>-the reduction of the per capita land and residential space<br>- the reduction of the child safety on the streets and urban spaces<br>-the reduction of the car ownership<br>-the complexity of the crisis management | - the increase of the per capita land, residential space and yet, the availability of more outdoor space<br>- healthy environment and cleaner air for the families<br>- the existence of the safe spaces for the children to play<br>- better and easier management at the time of the unexpected events | Positive points |

Table 1.the positive and negative points of the high and low density

| Physical dimensions | Technical consideration and utilities | Aesthetic aspects | Natural factors | Economic factors | Socio-cultural factors | Indicator |
|---|---|---|---|---|---|---|
| height of building in urban fabric | Capacity and limitation of infrastructure utilities | Harmony and efficiency in sky line and elevations | Climate and weather | Land price | Existing population density | Sub Indicator |

| The dominant width of roads | Zoning of earthquake | Harmony in the urban fabric | Environmental capacities and limitations[1] | Construction price | Education level | |
|---|---|---|---|---|---|---|
| The decayed historic area domain | The slope and topography | Variation in urban space | Verdant space per capita | Municipality budget and the construction funds | Cultural, sports and library services per capita | |
| City development strategy and The expansion direction | Quality of soil[2] | | Natural view and landscape | The tax rate and the urban taxes resulted from the constructions | Normal population growth and the growth of the migration from rural to urban areas | |
| The car ownership rates | Safety issues in the time of crisis (fire and earth-(quake | | | Household income | The cultural tendencies and the intra-urban migrations resulting from it | |
| traffic in the district | | | | Distance between place of residence to occupation | The well – proportioned housing pattern and the dominant housing styles | |
| The access to public transportation | | | | The expenses for the development of the infrastructure installations | Vision and superintendence | |
| The area of the land plots and the occupancy levels | | | | | | |
| Rate of urban sprawl | | | | | | |

1.the river confines, the shortage of land in the area, the mountains, the agricultural lands and gardens
2.Quality of soil ( compressive strength and the natural frequency of earthquake, etc.) and the technical limitations resulting from the height increase

| Adaptability with the upper plans | | | | | |
|---|---|---|---|---|---|
| shadow cast of the buildings and the necessity of the use of ventilation and natural light | | | | | |
| The benefit from the services | | | | | |
| usage diversity and mixed use | | | | | |

Table 2.The effective factors of the densification

| indicators | Social-cultural | economical | environmental | Framework | |
|---|---|---|---|---|---|
| Sub-indicators | Existing population density | Price of land | Proximity to natural phenomenon such as Zayanderud and Madi | Land area | |
| | | | | Floor area ratio | |
| | | | | Historical fabric | |
| | | | | City appearance | |
| | | | | traffic | Area of the existing passages in contexture |
| | | | | | Width of the existing passages in contexture |
| | | | | | Passages capacity |

Table3.the studied indicators

| Standardized score | Score | Economical | Physical | Ecological | Social | Indicator |
|---|---|---|---|---|---|---|
| 0.046. | 0.29 | 1/3 | 1/5 | 1/9 | 1 | Social |
| 0.657. | 4.21 | 7 | 5 | 1 | 9 | Ecological |
| 0.203 | 1.32 | 3 | 1 | 1/5 | 5 | Physical |
| 0.94 | 0.61 | 1 | 1/3 | 1/7 | 3 | Economical |
| 1 | 6.96 | | | | | Sum of scores |

Table4.matrix of indicators scoring
(CR= 0.06)

| Sub indicators of physical indicator | Land area | Traffic | Floor area ratio | Historical fabric | score | Standardized score |
|---|---|---|---|---|---|---|
| Land area | 1 | 3.6 | 6 | 3.6 | 1.1 | 0.088 |
| Traffic | 6 | 1 | 6 | 3.6 | 1.58 | 0.126 |
| Floor area ratio | 3.6 | 3.6 | 1 | 3.6 | 0.6 | 0.047 |
| Historical fabric | 6 | 6 | 6 | 1 | 3.83 | 0.306 |
| Sum of scores | | | | | 12.51 | 1 |

Table5.matrix of sub-indicators scoring of framework indicator
(CR= 0.1)

| | Physical (.203) | | | | Ecological (.657) | Economical (.094) | Social (.046) | Indiciators |
|---|---|---|---|---|---|---|---|---|
| final score | Traffic (.084) | Historical fabric (.699) | Num of floor levels (.043) | Land area (.174) | Proximity to natural phenomenon such as Zayanderud and Madi (1.0) | Price of Land (1.0) | Existing Population Density (1.0) | Locality |
| 2.06 | 6 | 3 | 6 | 6 | 1 | 6 | 1 | Bagh Zereshk |
| 3.02 | 6 | 1 | 6 | 3 | 3 | 6 | 3 | Sichan |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 3.35 | 6 | 3 | 3 | 6 | 3 | 6 | 1 | Bahar Azadi |
| 2.96 | 1 | 1 | 3 | 3 | 3 | 6 | 3 | Jolfa |
| 2.68 | 1 | 1 | 3 | 3 | 3 | 3 | 3 | Hossein abad |
| 3.34 | 6 | 6 | 1 | 1 | 3 | 1 | 6 | Vahid |
| 5.58 | 6 | 6 | 3 | 3 | 6 | 3 | 6 | Farah abad |
| 2.27 | 6 | 6 | 3 | 6 | 1 | 3 | 3 | Bagh daryache |

Table 6- final score of localities in the indicator of effective factor in determining structural density

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