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Evaluation of Noise Pollution in the Architectural Site Analysis Process based on the Environmental Impact Assessment Matrix

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Abstract

Site analysis is evaluated based on numerous factors in the process of architectural design, the achievement of which requires a complete evaluation system and an accurate understanding of it. The present study investigated the factor of noise pollution as one of the significant and influential parameters in the process of architectural site plan analysis. The present study mainly aims for a parametric simulation and evaluation of the noise pollution factor using l impact assessment matrix. The study is quantitative and has been varied out using modeling and simulation techniques. Reputable architectural software such as Grasshopper and Rhino have been used for an accurate evaluation of the parameters. According to the results and based on the simulations conducted in software, determination of the obstacles, and specification of the noise pollution sources, the number of noise pollution production houses through a source is more influential than the intensity of the noise pollution by the same source. Besides, the noise pollution received at each point of a design's context depends on the height of the noise source besides the direct distance from it. Eventually, the environmental assessment matrix was used to specify the suitable and favorable ranges for design based on the impact of noise pollution . The analytical components of the site such as noise pollution can be more effectively and directly taken into account in the design process using algorithms and parametric methods so that the analysis and design phases are integrated unlike in traditional methods.

Keywords: Assessment; Environmental assessment; Noise pollution; Noise; Simulation

1. Introduction

Although the Environmental Impact Assessment (EIA) approach became prevalent in the 70s, no unified method has yet been proposed for it, so each community has adopted its specific strategy based on their conditions. Besides, few studies have examined the use of this method in integration with other methods despite the computer facilities. Meanwhile, a project's success depends on its relationship with the site and surrounding environment. Furthermore, increased environmental risks have highlighted the necessity of adopting this approach with accuracy and speed in communities. Thus, a systematic method must be used to identify and apply the main variables in the field of design analysis with a good speed. After site selection, further analysis on accessibility, site area, vegetation, local texture, noise pollution, vision and landscape, and similar items help improve the initial conclusions.

Site analysis is among the most imperative stages in the architectural design process , which comprises the evaluation of an existing potential site regarding the development plan. The impact of environmental risks, the influences on the community, and the features in the proximity, scheduling, site analysis, and the environmental features identify the opportunity and limitation plan. A good and correctly conducted site analysis based on the essential needs is highly cost-effective for a sensitive environment and is considered a rational approach for project development. Plan analysis of a building and a site's capacities and capabilities alongside the evaluation of political, regulatory, and environmental issues demonstrate the value of developing a piece of land (Haye, 2014).

A glance at physical planning and building and architectural designs in many modern urban developments and mass housing construction or large-scale commercial complexes inside and outside of the cities reveals that most of them suffer from the lack of a close connection with the specifications of the site and their context. In this regard, the site design and analysis process is considered a key step in a well-designed project in any construction and development project. the complete analysis of a site and its surrounding context can lead to better-proposed plans, better and more coordinated execution, and eventually, a built environment with higher quality (James & Lagro, 2013). Considering the land as an influential factor in the formation of architecture and urban planning projects is not a new phenomenon or method, it is rather an old method that had been neglected or forgotten over time (Abedi & Iravani, 2015). Buildings cannot be imagined as separate from their environment since each

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building impacts and are impacted by its environment and the two are in interaction (Mehrabi, 2016).

The auditory system is undoubtedly the most important sense to perceive the environment after vision. People are generally notified of others' needs and transmit their messages through this sense. Awareness of some dangers occurs through hearing. People perceive the presence of other people, birds, and animals through their sense of hearing. Individuals reach a high level of awareness of the natural environment by hearing the sounds of wind moving through plants and the sound of water flowing. It is through hearing that they can notice the hustle and bustle of life or the irritating noises of traffic and industries. However, sounds can be categorized into pleasant, unpleasant, upsetting, and unbearable experiences (Bear & Higgins, 2002). Urban noise is a permanent problem in the modern world, which is why there is an increasingly pressing need for quiet and calm areas for urban populations. Special attention should be given to quiet areas and their relationship to human health and environmental health. The acoustic quality of a city depends not only on the absence of noise but also on the presence of quietness and liveliness.(Zannin, Diniz, 2002). The accelerating increase in population is accompanied by problems such as noise pollution due to human artifacts, automobiles, and industrial activities. Noise pollution leaves terrible impacts on humans, among which one can mention sleep and focus disorders. Research made by environmental experts indicates that green spaces have a significant impact on reducing noise pollution in the urban environment and can prevent its negative impacts on human health. Green spaces have yet to find a suitable position in Iranian urban planning and design, and are not yet considered seriously (Pishdar & Daman Darya, 2015). Of course, various factors such as the surrounding buildings, the building landscape, color conflicts, weather, air pollution, and fixed and moving non-structural physical elements such as cars, trees, signs, etc. play parts in noise pollution assessment and its degree of influence. Environmental impact assessment has is always used as a necessary measure in various types of development or activities that fall into the jurisdiction of other laws as well as the activities that will improve the land (Landscape Institute, 2002). The present study discusses noise pollution and its parametric analysis in a site located in the urban fabric, and the changes in sound considering the surroundings and the density of the studied area. The study of noise pollution is of great significance in the design context in valuing the various points of the site for design. Besides, the present study could help professors, students, and architecture offices by providing them with information on the three-dimensional urban space and building landscapes in the urban fabric.

So far, the quality of the presentation and map drawing techniques have only increased using computers. A broad and expanding spectrum of techniques used for visualizing landscapes is available, and contemporary computer and multimedia technologies can provide landscape experts with the best opportunities. Assessment from various development aspects and any point of vision inside the model area was made possible when three-dimensional modeling emerged. These techniques have wide capabilities, especially regarding linear developments such as roads and transmission lines. Diverse design alternatives can be easily developed and compared when the main location and structure are modeled (Norouzizadeh & Seidaii, 2016). So far, the potentials and capacities in the field of design context have not been used much as a productive parameter in creating ideas and designing various projects. The further use of these factors would create diverse concepts consistent with the design context. Thus, the important point is how to take advantage of these new computational approaches and assess the impacts of vision and landscape in site plan analysis in the form of a parametric model. The present study seeks to investigate the impacts of noise pollution in the design context and its changes in the process of architectural design, and is also considered as a part of the process of achieving ideas in the current context for design. No study has yet been conducted on the process of architectural site analysis using this method, the previous research has mainly focused on explaining and describing the process of site analysis and determining its various phases.

2. Methodology

To investigate and measure noise pollution factor and its impacts on the improvement of the site analysis and design process, the present study has first identified and categorized the various aspects and variables of acoustic analysis. Then, expert opinions on the variables influencing noise pollution have been taken into account in this categorization. These opinions have been analyzed to clarify the effective themes and place them in the right categories. Then, the themes were studied to identify the quantitative criteria for noise pollution assessment. The research method in this section is quantitative, and the techniques of modeling and simulation are used. Simulation processes used in architecture research can be categorized into groups such as architecture design processes, modeling, and design. Depending on the virtual needs of the project condition, the processes can be equipped with various programs. In this regard, various software can be used for simulation and assessment that are capable of parametric investigation and data analysis. For this purpose and to this end, software such as Rhino and Grasshopper have been used.

3. Literature Review

The progress and advancement in technology made itself more evident after the Second World War and the industrial revolution in Europe. These types of advancements alongside the emergence of facilities for a comfortable and modern life brought about disadvantages such as environmental risks as well. These risks include the five main categories of air, water, soil, heat, and noise pollution (Arana, et al: 1998). Among the environmental pollution, noise pollutions are of special significance due to the adverse psychological and physiological impacts

they leave on humans (Bahreini et al., 2005). Although noise has unfavorable social, psychological, and physical impacts and there is consensus over the fact that it must be prevented and controlled, it is inevitably produced and emitted in the workplace and the environment, so that noise pollution is still one of the main environmental management issues even in developed industrial countries. Noise pollution threatens human health as a harmful factor, especially in developing countries. The impacts of noise exposure should not be underestimated. Not only does noise exposure leave an adverse influence on human auditory system, but it can also disrupt the performance of other vital systems. Although some of the impacts mentioned above can be more confidently attributed to noise, the direct influence of psycho-physiological, social, professional, personal, etc. factors have led to some ambiguities in some cases, so that the results of previous studies are not as consistent as expected (Ilka, 2019: 1). One of the simplest and most tangible complications that noise results in is the loss of auditory power in humans. Constant and even non-irritating noise is harmful to humans and decreases the sensitivity of the ear to various types of sounds. Regarding the adverse impacts of noise pollution, it would be enough to mention that human needs a resting time of 18 minutes in a completely quiet room after being exposed to noise with an intensity of 288Db for around 28 minutes just to compensate for the noise (Akhtarshenas, 2020).

Noise pollution in large cities leads to irreparable damages on the area's residents such as hearing loss, clinical impacts, emotional and psychological effects, disruption in speech, and the loss of auditory power (Belojevic, et al, 1997). Among the factors creating noise pollution such as traffic, construction, the community, and industries, the noise emitted from the traffic has gained more attention since it disrupts the peace of large city dwellers (El-Fadel, et al, 2002) it was assumed in the past that most of the noise pollution is due to the traffic in large cities and most of the studies in this regard have been conducted in metropolises. However, studies indicate that small cities are also polluted in terms of noise and vibration since they suffer from a disproportionate number of motorcycles considering their population (Oveysi et al., 2006). Studies conducted since the 90s in various districts of Tehran metropolis indicate that noise and noise pollution figures over the standard amounts in various districts, so most of the citizens have assessed the level of noise pollution in the city to be annoying (Izaddustradr, 1995). Studies conducted outside of Iran also show that the Noise levels are beyond the standards of environmental sounds in most countries, which is traced back to improper urban development, poor management, and cultural issues (Zanmin, et al, 2002). The results of Han et al. in their study focused on analyzing the relationship between environmental noise and urban morphology in Shenzhen, China, revealed that the noise of the area's environment was positively correlated with the light intensity at night and the temperature of the land. Traffic noise was significantly correlated to small and large to moderate vehicle currents, and in terms of areas with various land uses, high-traffic lands and residential-commercial land uses had the highest shares in environmental noise, respectively (Han et al., 2018). High noise levels can have abundant impacts on public health, and previous research indicates that most of the studies on noise pollution resulting from vehicle traffic have been carried in metropolises such as Tehran (High noise levels can have a great impact on public health and research history shows that most studies on noise pollution caused by vehicle traffic have been conducted in metropolitan areas, including Tehran. (Sayadi & Movafagh, 2012). The noises resulting from road traffic make up a major part of the environmental noise that often harms the dwellers of large cities and their suburban areas. The increased production of vehicles and their uncontrolled entrance to the urban transportation network and the increased noisy hours during the night can undoubtedly be considered among the most influential factors in the increased exposure to noise (Saremi, Rezapour, 2013). Recent studies have revealed that over 30% of European citizens are exposed to noises higher than 55dB, and 20% of them are exposed to noises over 65dB during the day which leads them to complain about complications such as sleep disorders (Muzet 2007). On the other hand, the increasing expansion of cities and their industrial centers and the exponential increase in the percentage of vehicles and other noise pollution resources highlight the importance of conducting the present study. Thus, the issue that is the most important in the present study and makes up its main goal is the parametric investigation and analysis of noise pollution in a site in the urban fabric, and the changes in this factor will be examined considering the surrounding environment and the density of the studied area. The study of noise pollution is of great significance in the context of design in valuing the various points of the site for design. Besides, the present study could help professors, students, and architecture offices by providing them with information on the three-dimensional urban space and building landscapes in the urban fabric. From this perspective, awareness of the special qualities of each environment that have the potential to influence the audience's mind plays an essential part in favorable urban design and the improvement of its components. The present study will investigate noise pollution considering different variables such as the centers and sources of noise pollution, noise pollution intensity of the sources, and the number of the house in a day that the sources can produce noise pollution.

3.1 The definition of noise pollution

Noise pollution is the unwanted waves that influence the activity of living organisms –especially humans- under specific spatial and temporal circumstances and can lead to numerous physical and psychological complications, especially in auditory nerves. The unit for measuring noise pollution is a decibel and the human ear's tolerance

threshold is around 130db. Sound propagation shows different behaviors depending on whether the noise pollution is being propagated in an enclosed or open environment. Soundwaves in an open environment continue their propagation until to the point of depreciation without colliding into an obstacle. The environmental conditions play an inevitable role in how the sound is propagated. Although humans are used to noise, noise pollution is in fact a factor for exhaustion and reduces the working capacity of a person whether in physical or mental jobs. Noise pollutions impact the mental and psychological estate of the exposed person and create issues in their compatibility with the workplace and even the community and the family, the result of which reduces work productivity. Increased time of exposure to noise pollution can reduce the auditory power (Ilka, 2019).

3.1.1 Noise pollution assessment

Quantitative noise pollution assessment methods are focused on the measurement and assessment of the indices influential on environmental preservation and provide a tool for decision-makers to make policies based on. In fact, environmental impact assessment –as the most important quantitative method for the evaluation of environmental impacts- is an effort to reduce the harmful impacts of human activities and their projects on the environment are influenced by a set of sustainable assessment methods and frameworks, and sees the physical environment from a completely quantitative perspective. The physical environment and its quantitative and tangible impacts make up the most important criteria for environment evaluation in these methods. The methods mentioned earlier develop quantitative and computable indices that usually provide key information on natural systems (Mahan & Mansouri, 2017). The physical level of a sound is measured on the scale of decibels which is determined based on the change in the pressure made as a result of the soundwave. For instance, if a sound gets louder by 10db, it means that the intensity of the perceived sound is doubled, and if it decreases by 10db, it means that the perceived sound intensity declines to half the original sound (Mardomi et al., 2012). Noise pollution is defined as unwanted sounds that have harmful impacts on the quality of human life environment. In some cases, noise pollution is merely considered as the sounds that are harmful to human health. However, according to the World Health Organization's definition of health which considered not only the absence of suffering but also spiritual and social peace to be necessary for health, all disturbing sounds must be considered noise pollution. Most of the noises in urban areas are due to the three sources of vehicles, production and industrial units, and socio-cultural factors (Ahmadi Afzadi & Enayati, 2020). The following table demonstrates the noise pollution at 70db and over which reaches the painfulness threshold at jet airplane takeoff.

Table 1
The noise pollution index based on various components (Own, 1985)

Type of noise	Decibels	Characteristic
Searing threshold, normal breathing	0-10	Hearable
The shaking of leaves in the breeze	20-30	Very soft
Library, quiet restaurant	40-50	Soft
Reading loudly, the vacuum cleaner	60-70	Moderate
Mixer, heavy traffic	80-90	Very loud
Train, gunshot in the proximity	100-120	Annoying sound
Jet airplane taking off	150	Painful

3.2 Environmental impacts

Environmental impacts assessment is a method through which the impacts of a project or operations on the environment are investigated and predicted so that the operations are carried out in a way that leaves the most minimal impacts on the environment based on the understanding of the current condition and the type of the impacts. This assessment is generally a process through which the key environmental identification prediction and assessment of the impacts resulting from the development are identified and followed up on, and the collected data are used to reduce the harmful impacts in project design and contribute to an informed decision-making process (Lema, 2013). This assessment method can make a linear connection between the building and its environmental impacts by assessing the environmental impacts.

3.2.1 Environmental impact evaluation methods

Various measures must be taken to study the environmental impacts including the identification of impacts, preparing a report of the damaged environment, impact prediction and assessment, and selection of the proposed action from a set of assessed alternatives to deal with the identified needs. The purpose of various activities varies, based on which the respective methods are adopted. The following table demonstrates some of the methods prepared for the study of environmental impact assessment. The mark × in the table indicates which activities the mentioned method suits. Of course, the lack of this sign does not indicate that the method does not suit the respective activity. the method might be connected to it indirectly (Canter, 1999).

Table 2
various EIA analysis methods (Canter, 1999)

Various EIA methods	Items determining the goals	Impact identification	Impacted environment description	Impact prediction	Impact assessment	Decision-making	The relationship between the results
Comparable topics (case studies)	x	x		x	x		
Checklists focused on decision					x	x	x
Expert opinions (expert judgment, Adaptive environmental assessment, modeling, and simulation)		x		x	x		
Expert systems (impact identification, prediction, assessment, and decision-making)	x	x	x	x	x	x	
Laboratory tests and scaled models		x		x			
Matrix (simple, stepwise, calculated)	x	x		x	x	x	x
Supervision (basic)			x		x		
Supervision Ifield study of similar cases)				x	x		
Networks (chain and tree impacts)		x	x	x			
Overlap maps			x	x	x		x
Images and photomontage			x	x			x

The selected alternatives are evaluated and the superior alternative is chosen with the help of one of the methods mentioned above. Method selection can vary depending on the type and vastness of the project and expert opinions. Sometimes more than one method can be selected and used to choose and evaluate the superior alternative to make sure. After the impacts of the alternatives are assessed and the top alternative is selected, methods must be presented to eliminate, reduce, or control the harmful environmental impacts and rehabilitate, revive, and compensate the damages imposed on the environment since each alternative eventually leaves negative environmental impacts. These measures are mentioned as remedial or mitigation actions, are a necessity in assessment reports, and project executives must adhere to them in their plans.

3.2.1.1 The matrix method

In this method, the environmental factors and activities of the project are placed in rows and columns, respectively. This method was first introduced by Leopold in 1972. Leopold proposed that importance and magnitude must be determined to specify the impact of each factor. In Leopold's matrix, scores of one to ten are appointed based on the impact of each environmental factor and project activity and are registered as negative or positive figures depending on the negative or positive impact. The contents of each cell are used to highlight the intensity of the impact or other characteristics relevant to the nature of the impact. The advantages of the matrix method in environmental impact evaluation include being systematic, simple, affordable, fast, and comprehensive.
The strength of the matrix approach is that it is quite beneficial in the design of future studies and is inherently affordable and comprehensive. When too many variables are included in the matrix, restrictions emerge that could make the matrix incapable of dealing with indirect impacts and temporary aspects and create a sort of

inflexibility in various types of impacts that will make the general examination of the matrix difficult (the basis of these impacts appears to be greater than other components). Thus, many matrices provide less and lower-quality information than what they appear to at the first glance.

3.3. The noise pollution matrix using a three-dimensional model of the design context

Since the traditional techniques used in Iran for preparing noise pollution maps provide us only with information from a specific elevation, these maps do not suit the noise assessment process. Thus, the presentation of a method that can demonstrate the noise changes in proportion to noise pollution sources and height in a three-dimensional simulated model of the studied area appears to be necessary. Simulation of the noise pollution matrix in each design context is carried out in four general phases after the noise production centers are identified by dividing the site into assessable cells:

1. Gridding the site into analysis cells
2. Determining the distance of each cell to the noise center
3. Determining the noise production intensity of each noise pollution source
4. Determining the hours of noise pollution produced by the sources
5. Discussion and analysis

4. Discussion

4.1. Simulation

The parameters, rules, and description of the assessment model are discussed in this section. Considering that the present research topic is a subset of the positivism paradigm and takes advantage of this paradigm's computational and simulation techniques, efforts have been paid to provide a brief explanation of its stages and results and to suffice to the most concise explanations in discussing the primary presumptions and theories. Thus, the desired parameters are categorized and defined. The rules and relationships between the parameters are determined and the parametric model is created. The set of required answers are then extracted based on the primary conditions and relationships. Then, the selected outputs and the reason for their selection are introduced, and the nest section will assess and analyze them.

4.1.1 *Classification of the parameters*

The present study seeks to investigate the influence of environmental parameters on the factor of noise pollution, through which the relationship and impact of the parameters can be identified. The architect can develop a better understanding of the subject and develop more efficient and optimal forms by knowing about these impacts. For this purpose, the desired parameters are first identified and classified. Then, the rules between them are specified and the parametric model is built accordingly. Of course, it must be borne in mind that a limited number of parameters out of all environmental parameters influencing noise pollution have been selected based on the conducted pretests and interviews with the experts of this field.

4.1.2 Parameter evaluation

At this stage, the parameters are determined based on not any given rule and formula, but rather a formula obtained using the rules of optimization and artificial intelligence. This means that the rules are determined based on what was on the designer's mind and as the design rules, and the optimal state is calculated by the computer considering the specific conditions of the project as the inputs. These values are assigned to the parameters to obtain the form that is optimal concerning various parameters. The present study seeks to take advantage of this level of the parametric method to obtain the values for the parameters. Thus, aside from the capability of determining the values manually, the architect will also be able to take advantage of computer capabilities in the rational processes of this part of the architecture to obtain the values of the parameters.

4.1.3 Data collection

The site grid algorithm must first be investigated to create the noise pollution algorithm and its analytic outputs. Four variables have been considered for this algorithm including the main mesh of the site, the number of levels, the number of analysis cells, and the size of analysis cells. We have created an algorithm capable of investigating and analyzing the main site mesh for this purpose using Grasshopper software and considering the variables influencing this parameter, and the mentioned algorithm can be used to extract two-dimensional cells, three-dimensional cells, and site analysis points.

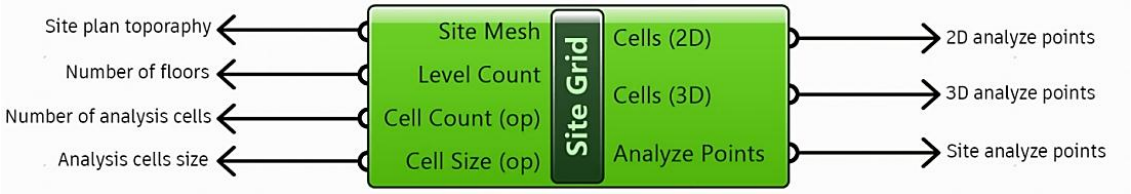


Fig. 1. the algorithm of creating cells and site analysis points based on the received main site mesh and input dependent and independent variables

This algorithm has a great significance and priority since the user would not be able to design and create the noise pollution algorithm to assess the physical and environmental parameters of the design context of this

algorithm was not designed and produced, because this algorithm will be the basis of all analyses and the main algorithm will receive its sells and analysis points from it. as observed in the figure above, we need four main variables to create this algorithm, among which the first and most important variable is the site mesh since we would not be able to start the work without this input. The second variable is the number of levels authorized for design, which is determined by the user based on the detailed plan and the area's density . The third input is the number of analysis cells[i], and the final input is the size of the cells for analysis. It is evident that the smaller these cells are, the more accurate but time-consuming the analysis will be.

4.2 The studied area

The case study was selected based on inductive reasoning and thought, and for better generalizability of the research. Shams Tabrizi's shrine in Khoy was selected as the case study given the accessibility of similar analysis documents. This site was selected and assessed since it had high potentials and all of the factors influencing noise pollution such as the presence of landscapes around the site, the presence of a historical and valuable element in the site, distinct green spaces, and the author's complete knowledge on the site. Moreover, this site had many other characteristics that made it a suitable choice for the case study, including:

- A special form in the site that is different from the conventional square or rectangle geometries
- Being historical
- The presence of the historical element of a minaret could prove influential in the assessment and analysis
- The presence of fabric around the site with a minimum height of three floors
- The presence of suitable vegetation around the site and in the distant landscape
- The presence of various visions and accessibilities around the site
- The presence of various axes and passageways around the site ranging from dead ends to two-way streets

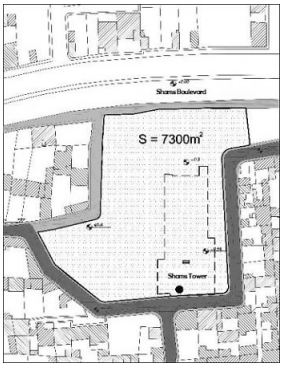


Fig. 2. the site and context selected for environmental impact assessment. Shams Tabrizi Shrine, city of Khoy

As can be seen in the above image, the Site does not have a regular geometric shape, and this will bring many challenges in the design and production of the site's arena algorithm. In addition to this, the existence of the historical element of Manar is a factor that is influential in several cases of analysis.

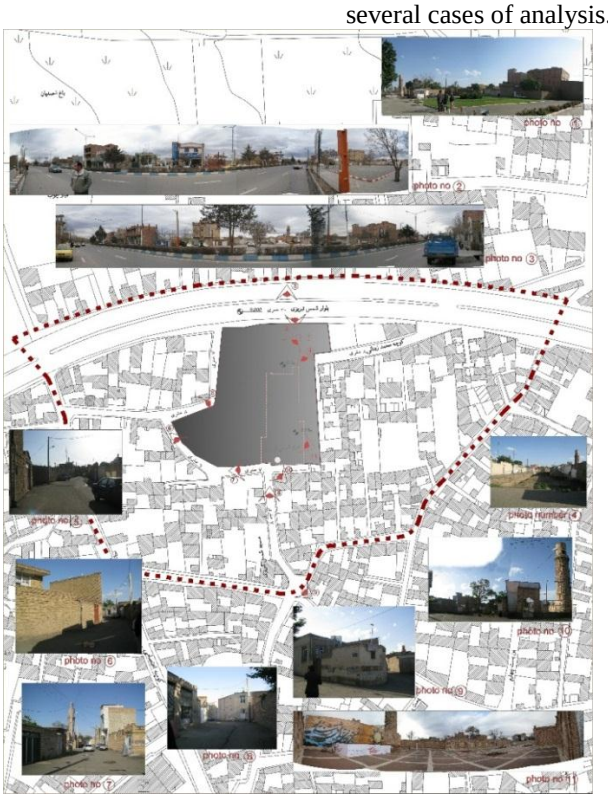


Fig. 3. Views of the site. Shams Tabrizi Shrine, city of Khoy

In the above image, there are different views from different angles of the site; which shows the surrounding area of this site. The maximum density in this site is three floors, which will have an impact on the design and production of the constructability algorithm.

4.3 Site survey and acoustic zoning

Protection against pollution can be a part of environmental protection. Residential, educational and office buildings should be built in a site with a maximum noise level of 65 dB per day in terms of specific acoustic requirements. To achieve the correct acoustic design, The noise pollution of the outside environment should be evaluated. If the environment's noise is more than 65 decibels in some places, it can be reduced to the necessary level with suitable distance shields or sound barriers. (Ministry of Road and Urban Planning, 2017) The sources of external pollution that should be investigated are as follows: Traffic Noise Pollution, Surrounding Area Noise Pollution .to reduce environmental pollution, especially traffic, the following Items can be used:

- Create a suitable distance from the sound sources
- Use of sound barriers

4.4 The noise pollution factor

Noise is defined as "unwanted sounds". Noise is a dangerous factor present in various human activities, in daily social life, at home, and most of all, in professional processes. Being exposed to high levels of sound for a long while generally damages the human ear. These sounds are measured in a unit called decibel (dB) that tells you how loud something is, and it could hurt your hearing if it is loud enough. Most of the people frequently exposed to voices higher than 85dB or even auditory shock (sudden hearing loss) at levels higher than 137dB go through hearing damage (Barkokebas, 2014). The noise is small and large communities influence each of us. Among the many forms of pollution, noise pollution could have the greatest impact on our daily productivity, mood, and comfort. Noise control is the main factor in the planning, design, and construction of transportation carriers. The challenge is to achieve the desired level of noise while maintaining or improving the visual environment. Thus, addressing noise pollution and calculating its influence on the architectural design process and the design context can be quite influential in the emergence of a more optimal form in terms of noise pollution's influence on the environment. Therefore, the noise pollution factor has been selected as one of the influential factors in parametric environmental impact assessment, and the following variables have been classified for it based on its features.

Table 3
The variables used in the assessment of the noise pollution factor in the design context alongside the inputs and output

Variables parameter	Inputs	Outputs
Noise pollution	Site analysis points Noise pollution intensity Noise pollution emission hours Noise pollution factor Noise pollution emission centers	Emitted noise pollution

The study of noise pollution in the design context comprises identifying the key points of the site in terms of receiving noise. The project architect conducts the required investigation to measure the noise pollution received from noise sources in each part of the design context and determines the location of the significant points in the architectural plan accordingly. Noise pollution was examined based on various variables in this study including noise emission sources around the site, the noise pollution emission intensity of each source, noise pollution emission intensity of each source, and the noise pollution factor that might vary for each source. To this end, we used Grasshopper[ii] software and considered the variables influencing this parameter to create an algorithm capable of analyzing and studying noise pollution at every point of the design context.

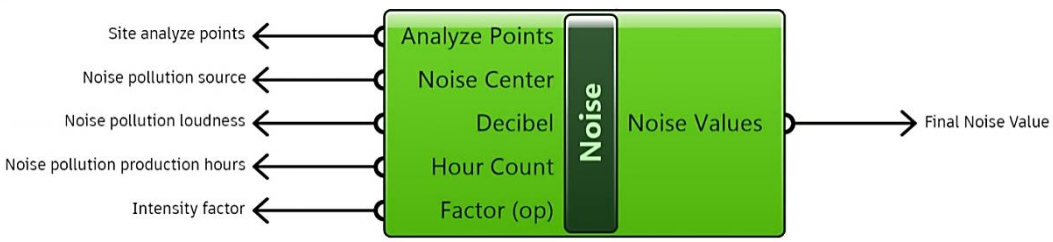
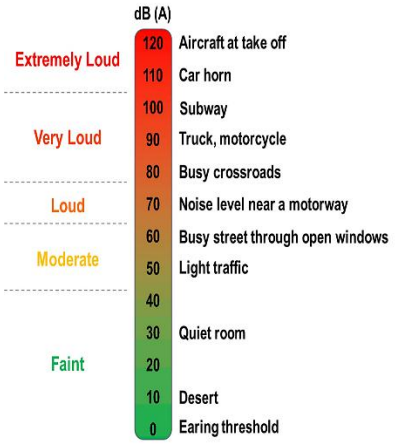


Fig. 4. the algorithm for investigating noise pollution in the site based on dependent and independent input variables

Table 4
dependent and independent input variables of the noise pollution algorithm

Variables	Definition		Description
Site analysis points	Are used as points of analysis and visual demonstration.		All algorithm calculations and analyses are conducted based on these points' placement.
Noise emission centers	Noise emission centers are exactly the centers around the design context that result in noise pollution with various intensities around the sire. The Accurately identifying of these centers can lead to a more accurate assessment in the design context and assessment of this parameter's impact on various parts of the project.		A noise pollution center can be a street, alley, school, hospital, or anything whose presence around the design site results in noise pollution. To determine noise pollution centers and points based on the designed algorithm, it would be enough to determine the desired points in the design context and select them in the software. The noteworthy point is that these points could be above the ground level as well.
Noise pollution intensity	This parameter works based on the noise center's power of noise emission in dB units and is calculated exactly based on the amount of noise pollution in the noise pollution center in dB.	Any level of noise pollution emitted from each of the noise centers can be easily and accurately measured using the respective devices. of course, it must be mentioned that the noise production power varies depending on the type of the noise center. For instance, the level of noise pollution created by a school is completely different from the level created by vehicle traffic.	
Noise pollution hour count	This parameter is related to the noise centers and determines how many hours a day each of these centers emits noise pollution on average.		For instance, the noise pollution hour count of a school is different from a mosque or a street. Thus, we considered a range of zero to 24 hours in this section of the algorithm, and the number of hours registered by the user is the average number of hours the noise center emits noise.
Noise pollution factor	In this part of the algorithm which revolves around the calculation of the noise pollution, we considered a factor based on which the user can obtain the intensity of the noise pollution centers' impact.		For instance, the impact and disturbance of noise pollution such as a school might be less than a street in a given area or vice versa. The user can enter a coefficient between zero and one to reduce or increase the impact intensity of the noise pollution center in the calculation.

Considering those mentioned above and the specification of the noise pollution intensity of various noise centers around a design context, the limitations, maximum, and minimum for the input of noise analysis algorithm's emission intensity were considered (a minimum emission intensity of 30db and a maximum of 150), indicating that the user cannot work outside of this range. It must be mentioned limitations other than this range have been mentioned for the inputs of the algorithm so that if the user accidentally enters numbers smaller than 30 or larger than 150, the algorithm automatically considers the maximum or minimum number defined for it. Based on the explanations given earlier on this algorithm's inputs, starting to work with the algorithm would require the input of site analysis points and the points specifying noise pollution centers. After determining these two components, the algorithm starts its calculations after entering the noise pollution emission intensity of these centers. The calculation of the noise emission intensity of noise pollutions is as follows: the corresponding relationship between decibels and milliwatts (10% ((dB - 30) / 10)) * h * f) is used to convert the algorithm inputs from decibels to milliwatts.

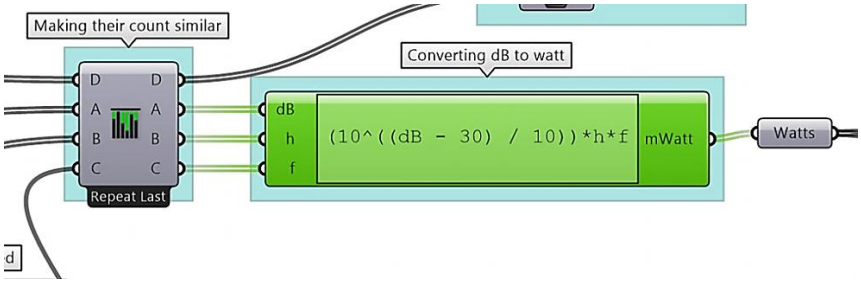


Fig. 5. the inputs of noise pollution emission intensity, hour count, and factor as values involved in the relationship that are converted to output in milliwatts

It must be mentioned that since the sound energy propagates on a spherical surface, the produced sound energy must be divided by the sphere surface. Thus, the distance of the analysis points to the noise centers was considered the sphere diameter, and the equation of (w / (4 * pi * (r^2)) was used to calculate the amount of energy received by each of the analysis points in the site. Eventually, the sum of the energies absorbed by a point or analysis cell must be calculated, and the equation of ((10 * (Log10 (MW)) + 30) should be sued to convert the absorbed energies by each cell into decibels to get the output. Now, we can observe the output of noise pollution analysis on each of the analysis cells and points on the site.

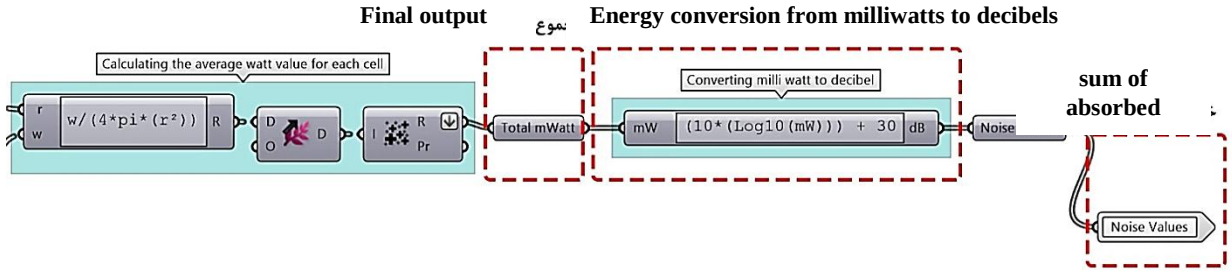


Fig. 6. conversion of the sum of energies absorbed by analysis points from milliwatts to decibels and preparation of the final output

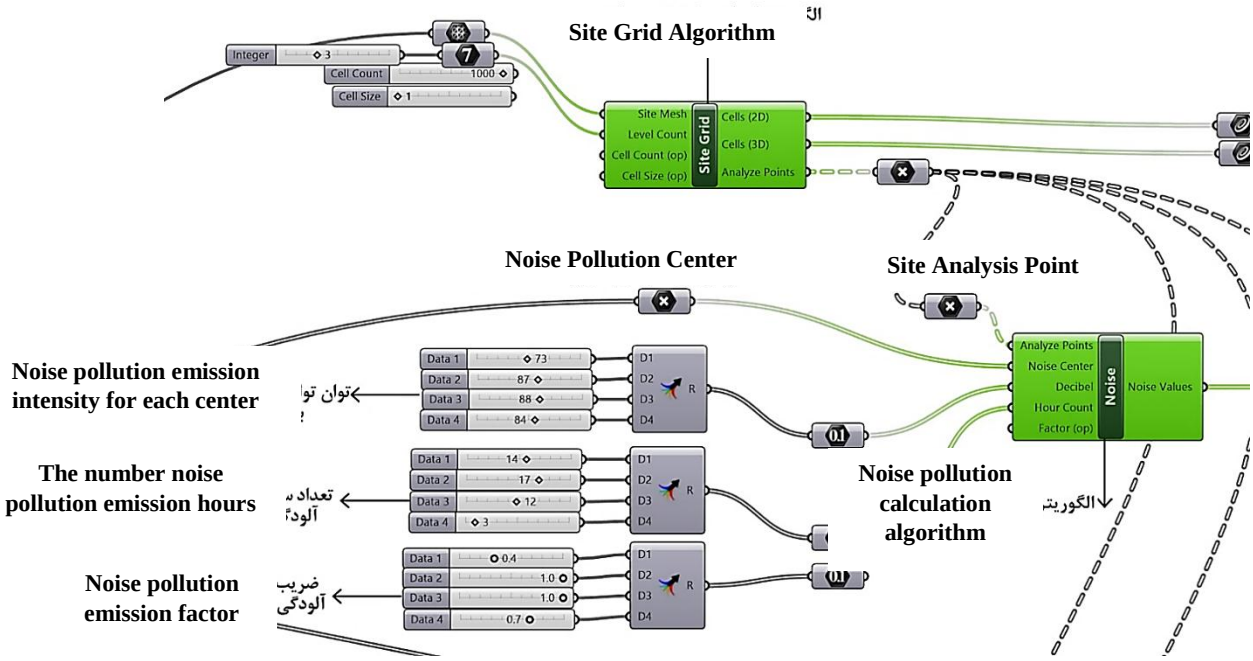


Fig. 7. the inputs and outputs of the noise pollution calculation algorithm in one glance

The impact of noise pollution on different points of the site is directly related to the distance of each point from the centers of noise pollution. Also, the impact of noise pollution produced by a source depends on the distance of the source to the analysis points and the height of the source of pollution from the ground. It is also necessary to mention; According to the detailed design path of this algorithm, the variable influence of the number of hours of noise pollution production has been observed more than the noise pollution production capacity of a source.

5. Results

In order to calculate and display the final matrix, in addition to the noise pollution matrix, two other algorithms and matrices are also needed. One of these algorithms is the matrix calculation algorithm point by point in the desired site, and the other is the matrix display algorithm in the form of numerical and color data. These two algorithms along with all the inputs and outputs are shown in the figure below.

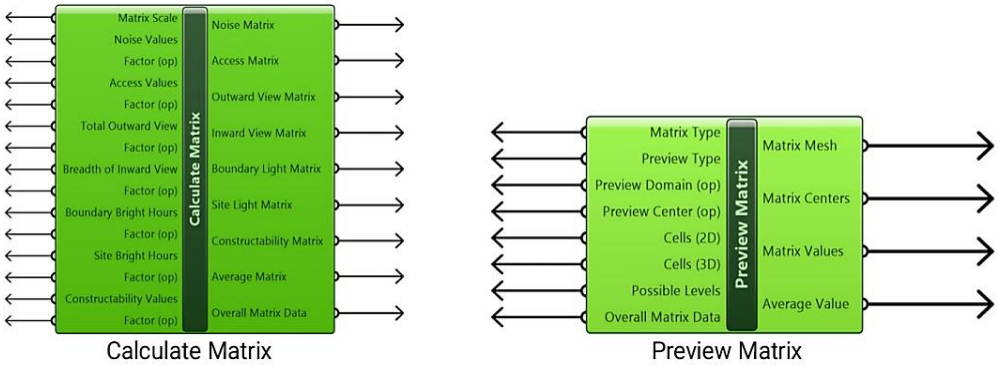


Fig 8 Calculate and Preview Matrices

Considering that in the process of designing and producing different algorithms in site analysis, different algorithms have been produced separately, hence each of the algorithms can be selected separately as an input for the type of matrix and the matrix of Environmental impact elements was outputted separately in site analysis.

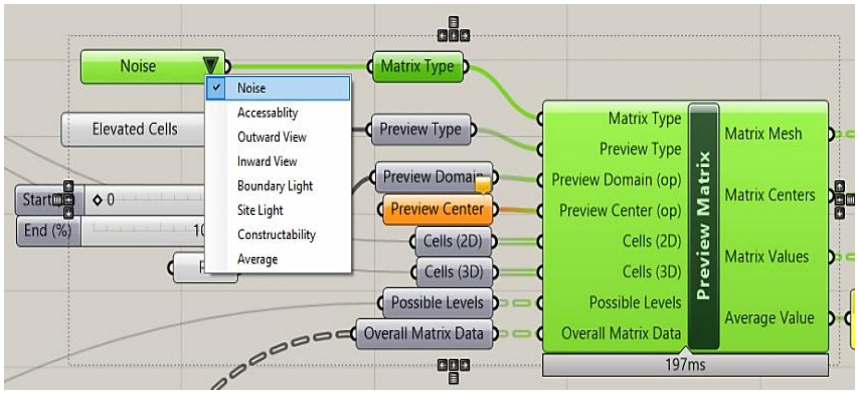


Fig. 9. Selection of site analysis algorithms in order to prepare evaluation matrices

The site was gridded using analysis cells, and each cell in the grid has its respective score. This gridding was classified in a range of extremely favorable to unacceptable for construction so that the scores in the range of zero to two are considered unacceptable, values between two and four are considered unsuitable, values between four and six are considered acceptable, values between six and eight are considered favorable, and values between eight and ten are considered extremely favorable.

Table 5
The scoring range of the analysis points and their assessment to determine the points suitable for design and construction based on Leopold's matrix[iii]

The assigned value	Design and construction priority
0-2	Unacceptable
2-4	Unsuitable
4-6	Acceptable
6-8	favorable
8-10	Extremely favorable

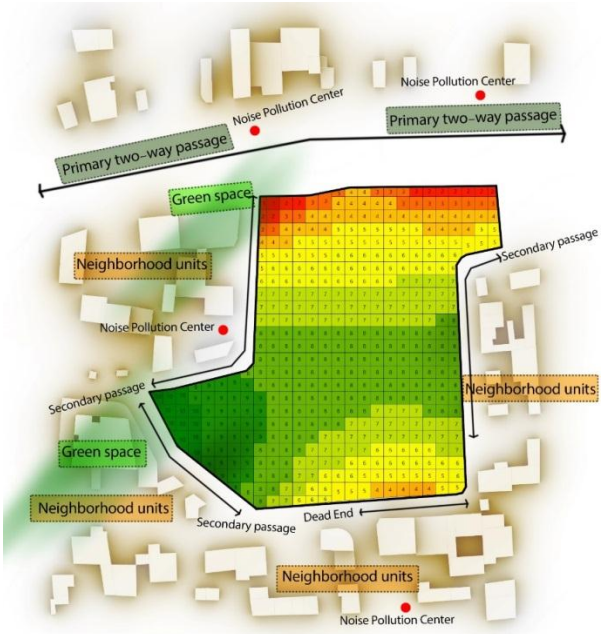


Fig. 10. noise pollution assessment matric based on noise pollution centers and conducted analyses

The noise pollution centers observed in the figures above could be any element or factor capable of emitting noise pollution such as two-way streets and passages, schools, streets, one-way local passage, small neighborhood center, park, or any other element present in urban space and atmosphere around the design context. The number of noise centers in this assessment can be increased or reduced, and the assessment can be conducted based on the features of other design contexts in any fabric and climate. Since this assessment is completely valid and credible, designers can use it as a guide for optimal design in all fields. The matrix can even help the designer as a guide and initial idea and concept creator to start their design.

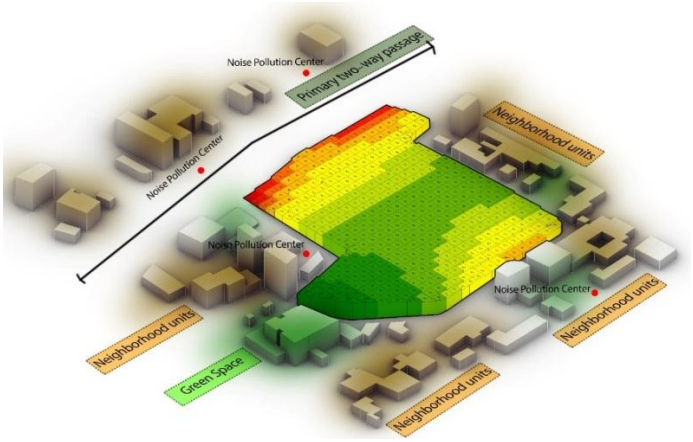


Fig. 11. the three-dimensional matrix of noise pollution assessment and analysis

1. Conclusion

Environmental impact assessment can be considered a suitable strategy to minimize the negative impacts and risks for the environment and provide the designer with suitable alternatives and solutions for decision-making and the generation of primary ideas. Parametric quantitative assessment of the environmental impact matrix and simulation methods were used in the present study to identify and assess the noise pollution factor and analyze it at every point of the site, contrary to other studies that have used qualitative methods. Thus, the points that were assigned scores of five or higher (the spectrum of light to dark green) were identified to be suitable for design and construction, while the points that got scores lower than 5 (the spectrum of yellow to red) were not favorable in terms of noise pollution and would not be suitable for design and construction. Besides, it was revealed that the impact of noise pollution on any point of the design context is related not only to the distance of the noise pollution center from that point but also to its height and distance from the ground level. On the other hand, the analyses and algorithms, and codes generated for this research indicate that the number of noise pollution emission hours of a noise source is

significantly more influential and important than the noise pollution emission intensity of the same noise pollution source. Noise pollution assessment and analysis were investigated in the present study, but other factors influencing the process of site analysis and design such as favorable accessibility, vision and landscape, sunlight, and shading can also be evaluated completely parametrically using the environmental impact assessment matrix[iv]. More variables can also be included in the analyses in each component. Aside from site analysis before design, this method can also be used to assess and analyze designed and constructed sites, and determine to what extent the desired project has been designed optimally based on the environmentally influential factors in the design context. Thus, aside from its higher speed and accuracy in design, the obtained parametric assessment and analysis method can integrate the analysis stage and other sages such as idea generation, design change dynamics, standard assessment, and subsequent implementations.

References

Abedi. S, Iravani. H, (2015), *Analysis of the Contextual Architecture and its Effect on the Structure of the Residential places in Dardasht Neighborhood of Isfahan*, European Online Journal of Natural and Social Sciences, Vol 3; p.3

Akhtarshenasan, Sasan, 2020, *Noise pollution, and its control methods*, the first national conference on a healthy environment and sustainable development in the light of citizenship rights, Shiraz; p.3

Ahmadi Afzadi. Haniyeh, Enayati. Ali, 2020, *Study of Noise Pollution in Residential Areas and Strategies to Reduce It*, 7th National Conference on Applied Research in Civil Engineering, Architecture and Urban Management, Tehran; p.5

Arana, M., A., Garcia .1998. *A Social Survey on the Effects of Environmental Noise on the Residents of Pamplona*, Applied Acoustics, (53), pp. 245–253.

Barkokebas, Jr & Others, (2012), *Analysis of noise on construction sites of high-rise buildings*, IOS Press; p.4

Bear Anne. R. & Katherine Higgins, 2002, *Environmental Planning for Land Development, Guidelines for Sustainable Local Planning and Design*, translated by Dr. Hossein Bahreini and Dr. Keyvan Karimi, University of Tehran Press, Tehran

Belojevic,G., B., Jakovlevic, O.,Aleksic .1997. *Subjective Reactions for Traffic Noise concerning some personality traits*, Environmental International

Canter, L. (1999). *Environmental Impact Assessment*. Florida: CRC Press LLC.

El-Fadel, M., et al .2002. *Parametric Sensitivity Analysis of Noise Impact of Multihighways in Urban Areas, Environmental Impact Assessment*, (22), pp. 145–162.

Han X, Huang X, Liang H, Ma S, Gong J. *Analysis of the relationships between environmental noise and urban morphology*. Environmental Pollution. 2018; p.233

Haye, R. L. *The Architect's Handbook of Professional Practice*, (2014), The American Institute of Architects. John Wiley & Sons, Canada; p.1

Ilka, Nabi, 2019, *Investigation of noise pollution impacts and environmental protection strategies*, the 4th International Conference on Tourism, Geography and Clean Environment; p.5

Izaddustdar, A. 1995. *Investigation of Traffic Noise Pollution in Modares Highway from the beginning of Vali-e-Asr Street to Imam Khomeini Square*, Tehran. M.Sc. Thesis, Department of Environment, Azad University; p.82

Lagro. Jr, James. A, (2013) *Site Analysis Informing Context-Sensitive and Sustainable Site Planning and Design*, Third Edition, John Wiley & Sons, Canada; p.13

Landscape Institute, I.E.M.A. (2013). *Guidelines for Landscape and Visual Impact Assessment*. New York: Routledge Publishing; p.3

Mahan. Amin, Mansouri. Amir, 2017, *Development of a landscape evaluation model* (with a review of current methods and approaches to landscape evaluation), Bagh-e Nazar Magazine, Tehran. 14 (56); p.36

Mardomi. Karim, Hashem Nejad. Hashem, Bagheri. Malihe, Hassanpour. Kasra, 2012, *Architectural Design Considerations in Reducing Noise Pollution in Medical Environment*, Journal of Environmental Studies, (4); p.143

Mehrabi, M. (2016), *Consideration of Climate Impact on Contextual Architecture in Arid Region*, The Turkish Online Journal of Design, Art, and Communication; p.3

Ministry of Road and Urban Plannig, (2017), Iranian national building codes (Code 18), p.85

Muzet A. Environmental noise, sleep, and health. Sleep Med Rev 2007; 11(2): 135–42.

Own, O, S.(1985), *Natural Resource Conservation: An Ecological Approach* ,Macmillan Publishing, Co INC; p.506

Mohammadzadeh, Rahmat, 2010, *the role of physical planning in reducing noise pollution*, Journal of Human and Environment, Volume 8, No. Two

Nowruzizadeh, Sahar. Saidai, Kaveh. 2016, *Analytical Tools in Landscape Architecture*, Bagh-e Nazar Magazine 14, (47); p.68

Oveysi, A. Ismaili Sari, A. Qasempuri, M. 2006. *Investigation and measurement of noise pollution caused by traffic in Yazd*, Faculty Journal. Natural Resources, Volume 59, No. 4

Pishdar, Mahsa & Daman Darya. Mostafa, 2015, *noise pollution Control and reduction using green space design in Bandar Abbas urban spaces*, International Conference on Sustainable Architecture and Urban Planning, Dubai; pp.1-2

Rofe, Y. (2019), Mobility, *Accessibility and Urban Form*, Ben-Gurion University of the Negev

Soltani, Bahram. 1995, *Application of sound comfort criteria in urban planning and design*, Publications of Iran Urban Planning and Architecture Studies and Research Center Publications

Saremi, Mahnaz, Rezapour Tara, 2013, *Non-auditory effects of environmental noise pollution, Journal of Kerman University of Medical Sciences*, 20 (3); p.314

Sayadi, M. H., Movafagh, A., Kargar, R. 2012a. *Evaluation of Noise pollution in the schools of Birjand city and its administrative solutions*, in 2011. Journal of Occupational Health & Epidemiology, Autumn (13); p.694

Zannin, P.H., Diniz, F.B., Barbosa, W.A. 2002. *Environmental noise pollution in the city of Curitiba in Brazil.* J Appl Acoust. 63(4). 351-358.

[i] To set up the algorithms and perform accurate evaluation, the design context must be gridded and provided to the user in the form of a grid. This is done with the help of the Site Grid algorithm. Analysis cells are provided to the user after dividing the design platform . They are responsible for receiving input data from the user and analyzing and evaluating them.

[ii] Grasshopper is a plugin that runs on the Rhino software. This plugin can model and simulate in all areas related to architecture and can be used in various fields such as energy simulation, structure, site evaluation, optimization, etc.

[iii] In this method, a matrix is formed in which the detailed activities of the project in the construction phase are written in the columns and various environmental factors (biological, socio-economic, physio-chemical, cultural, and strategic) are written in the rows. The cells predict and evaluate the impact of each environmental activity that will be affected by the intensity and extent of the effect. In the impact summary, the average of positive and negative effects for each activity and each environmental factor is calculated, the scores of magnitude and importance of the effects are multiplied, and the results of the sum are algebraic and according to the result, are summed up. The best option is selected based on the results, and ranking is conducted in the Leopold matrix.

[iv] For further information on parametric analysis and evaluation of other environmental impact components in plan site analysis, refer to the author's doctoral dissertation on parametric environmental impact assessment for plan site analysis in architecture.