Escola de Camins
Escola Tècnica Superior d'Enginyeria de Camins, Canals i Ports
UPC BARCELONATECH

Assessment of Site Location of Post-Disaster Temporary Housing after Kermanshah Earthquake Applying MIVES for Determining Sustainability Index

Work By:

Mohammadreza Rezaei

Directed By:

Alberto de la Fuente Antequera

S.M. Amin Hosseini

Master In:

Structural and Construction Engineering

Barcelona, October of 2019

TRABAJO FINAL DE MÁSTER

ABSTRACT

Every year, many people all over the world lose their homes due to natural disasters. After a major natural disaster, residential areas are in some way unusable. Displaced population, who lost their homes, need to inevitably to be settled in temporary housing, mostly in other places. The most of displaced people are not dissatisfied with the conditions of temporary accommodations. The late delivery of shelters, non-standard, unhealthy and unsecure accommodations, undesirable weather conditions, and the lack of privacy and safety, are some of the problems, which usually are caused by disasters.

In general, providing the shelter after natural events could not lead to significant progress achievements due to the aforementioned issues. Temporary housing causes several economic, social, and environmental problems. However, temporary housing plays an important role in regulating the disrupted process of normal life. Certainly, temporary housing, it affects the permanent settlement reconstruction program and must have a plan to interact with each other. In this regard, it is required to minimize its problems. One of the factors needs to be considered is selecting a suitable site location of temporary housing. Thus, this master thesis aims to design a model, for selecting the most suitable post-disaster site location of temporary housing based on sustainability goals (from economic, social and environmental perspectives).The case study of this thesis is the post-disaster site location of temporary housing aftermath the earthquake in the Sarpol-e Zahab, which is located in west part of Iran. The earthquake, with a magnitude of 7.3, occurred in November, 2017. Due to the great damage, emergency managers were forced to provide temporary housing for displaced people. 43 sites have been selected to erect temporary housing in the campsite approach.. The sites are located inside and outside of the city.

This research study presents a new model for decision-makers to be enable to select suitable sites of temporary housing. Decision-makers can determine the optimal site location based on the integration of economic, social and environmental aspects by applying this model. The Integrated Value Model for Sustainable Assessment (MIVES), a Multi-Criteria Decision-Making Model (MCDM), has been used to evaluate the sustainability indexes of the alternative sites.

Keywords:

Earthquake, MIVES, MCDM, Natural Disaster, Sarpol-e Zahab, Site Selection, Temporary Housing.

ACKNOWLEDGEMENT

First, I would like to thank my tutors, Alberto de la Fuente Antequera and Seyed Mohammad Amin Hosseini for giving me the opportunity of working on this project. Thanks also for guiding and advising me throughout this work and for having made of this thesis a great personal and professional challenge that has opened me multiple opportunities.

I would like to thank my parents and my brother. As well as to Armin Ajand and Mahdi Shahsavari, for their unconditional support and for being always there to encouraged me to continue and improve myself.

Besides, I appreciate the support received by my love Fatemeh Tafreshi she has aided me on this arduous way and continuously encourage me to improve myself in daily life.

Table of Contents

REFERENCE

FIGURE

TABLE

CHAPTER 1

1. INTRODUCTION AND OBJECTIVE

1.1 INTRODUCTION

Annually 13% people suffer from natural disasters during their lives. In addition, according to the International Co-operation Organization 2008. 18.9% of men and 2.5% of women, over the lifetime, have an individual experience of experiencing natural disasters. Therefore, natural disasters are not rare events (Najaran & Khoram, 2015). Despite the dramatic advances in technology and the achievements of the last century, still is not incapacitated from natural disasters. The world is faced with a variety of natural disasters on a different scale from time to time. In addition to casualties, natural disasters cause displaced population. Annually, an average of 3 million people became homeless after natural disasters (Asefi & Fakhri, 2016).

Of which about 80% who were devastated by the earthquake of their homes has been (Khorma, Najaran, & Naeini, 2014). The earthquake is a natural hazard that, based on its magnitude and low-quality infrastructures, can create a huge catastrophe in a short time. Negative impacts of disasters, such as earthquakes and floods, in developing countries due to the weakness of the structure of the houses is high. This issue causes on increase of displaced population. Will be high impact in these areas.

This impact is not limited to areas affected by disasters, but it has negative social and economic effects on the surrounding areas. After an event on a wide scale, some parts of residential areas are unusable; survivors have to stay in a new place other than their previous home. Affected people by a natural disaster, especially those lost relatives and their properties, have bad mental situations. These people need a safe shelter to return to their normal lives. Indeed, the basic needs of displaced people in the aftermath of natural events, is to have suitable temporary settlements, which plays a critical role in keeping up and saving people's lives and ensuring security in the aftermath of the incident (khorshidiyan, 2006).

Additionally, this issue embraces several factors. In other words, temporary housing issue is a multidisciplinary problem, which need to be considered in short time. In this regard, it is required to apply a robust decision-making method to overcome the aforementioned problems.

To this end, is based on (MIVES) with help (AHP) the Analytical Hierarchical Process. (AHP) is employed for structuring the decision-making process for the selection of a manufacturing system among feasible alternatives based MIVES.

The case study of this master thesis is an affected city of Iran by the earthquake in 2017. The country of Iran, due to its location in the Alpine- Himalayan belt, is one of the five seismic countries in the world (Mohammadzade & Fakhri, 2015). About 17.6% of the earth's devastating earthquakes occur in Iran. The presence of variable climate and instabilities. The earthquake is one of the natural disasters that is known as the most important issue of urban planning and crisis management in Iran (Forghani & Darbandi, 2015).

1.2 GEOGRAPHICAL LOCATION OF THE CASE STUDY

The case study of this dissertation is Sarpol-e Zahab, which is located in the west of Kermanshah, a western province of Iran. The population of Sarpol-e Zahab was 85,342-people (Statistical Center of Iran, 2016). At 21:48 on Sunday 12 /11/2017 an earthquake, with magnitude 7.3, occurred close to Ezgeleh in Kermanshah province. The earthquake was followed by 148 aftershocks until 16:30 on Monday 13/11/2017 (Institute of Geophysics National Seismic Center, 2017). In this earthquake, five-city had been affected. The most damages of the earthquake happened in Ezgeleh, Sarpol-e Zahab, Qasr-e Shirin and Eslamabad-e Gharb. Among all the affected cities, Sarpol-e Zahab was the most breakdown and had higher number of casualties (Road Research Center, 2017). The 123400 buildings were built in Sarpol-e Zahab, of which 35200 were destroyed and 59642 damaged. Aftermath of this earthquake, 738 people died and 9388 people were injured; and 70000 people were displaced (Statistical Center of Iran, 2016).

1.3 OBJECTIVES

This master thesis aims to design a model, for selecting the most suitable post-disaster site location of temporary housing based on sustainability goals (from economic, social and environmental perspectives).

In order to reach the main objective, the following specific questions should be answered:

- Which indicators are required to be assessed for having most suitable sites?
- Which indicators have higher impacts on sustainability indexes?
- How to increase social, economic, and environmental satisfactions values?
- What are differences of site locations are located inside or outside of the city regarding the sustainability perspective
- Where will be the better places for the site location?

1.4 WORK METHODOLOGY

As shown in Figure 1.1, the MIVES method is applied as the main methodology of this dissertation. In general, the required data are collected in order to design a new model based on the MIVES concept and characteristics of the case study. Then, the new model is designed and applied to the case study. In this section, indicators and their weights are determined. Additionally, sustainability indexes of alternatives are evaluated using MIVES formulas. In the last step, the results of the model are analyzed. The aforementioned sections are conducted in the five chapters.

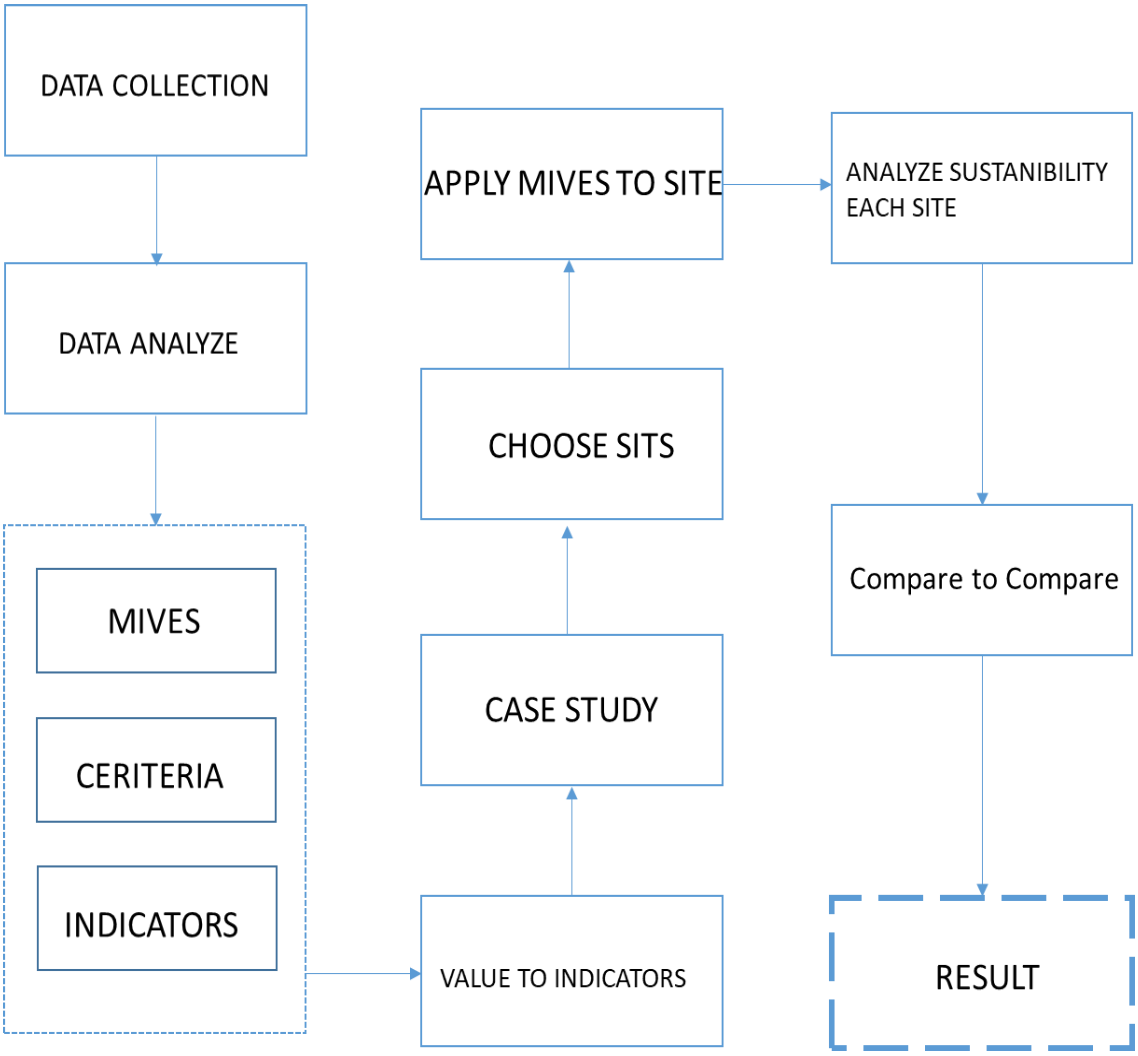


Figure 1.1. The methodology in case study.

In **CHAPTER 1** the introduction section presents a general view of this thesis, including main problems, objectives, case study, and the methodology.

In **CHAPTER 2** the keywords of this research study are explained. Additionally, the previous studies are related to the subject of this master thesis are reviewed.

In **CHAPTER 3** the different natural hazards (earthquake and flood) and the effects of soil, location of the fault and other governing parameters of the decision are identified and discussed as well as characteristics of case study.

In **CHAPTER 4** the main methodology of this thesis, MIVES, and its components (weights, indicators, criteria and requirements) are explained.

In **CHAPTER 5** Apply methodology to the case study and getting the end result.

Finally, in **CHAPTER 6** conclusion, recommendations and future research perspectives are presented.

CHAPTER 2

2. STATE OF THE ART

2.1 TEMPORARY HOUSING

In earthquake-prone areas, the possibility of a natural occurrence of incident is high. However, there is a lack of research on how to provide better services to the affected people. This has caused this, which measures to accommodate and meet the needs of the injured. It usually takes place without proper planning, which reduces the quality of the service. The occurrence of natural disasters in all societies is inevitable. Due to the type and extent of the accident and the location of the incident, it can lead to various consequences. From the level of non-observable damage to the occurrence of various crises and catastrophes. Therefore, after an accident with damage to permanent habitats comes in. People lose their shelter and housing, and since making permanent housing for survivors requires a lot of time and money. That is the short term it is not possible to discuss the temporary settlement and finds a special place. The post-disaster period, it is not a single period at all. Also consists of three the construction period is. These three periods are: (1) Period of life (2) Stabilization of conditions and (3) Resuscitation (Nezhad, 2010).

- Emergency accommodation, which means immediate shelter, which provides the least comfort. Comfort and privacy for the homeless immediately after the accident (Nezhad, 2010).
- Temporary housing, which is a shelter that is at least comfort, for quasi-family situations. Sleeping/sitting/privacy space for fixation family units in the post-traumatic period (Nezhad, 2010).
- Half-permanent settlement means the provision of housing that provides comfortable and comfortable conditions to help restore the proper living conditions to family units. There will be a year after the accident brought up (Nezhad, 2010).

2.2 SUSTAINABILITY

The development of sustainability was determined in 1987 according to the so-called concept "Bundled Report" (United Nations). Whereas the human population grows in geometric progression. While the means of subsistence do so in arithmetical progression. Will be need for a change of trend towards more sustainable solutions. Need to evaluate it because want to achieve sustainability. There are three fundamental aspects that lead us to Sustainable development these pillars are the environmental (usually evaluated through the ACVs), the economic the social. Figure 2.1 is, (1) minimize economic, (2) maximize social, and (3) minimize environmental impacts, based on local conditions (Josa, 2012).

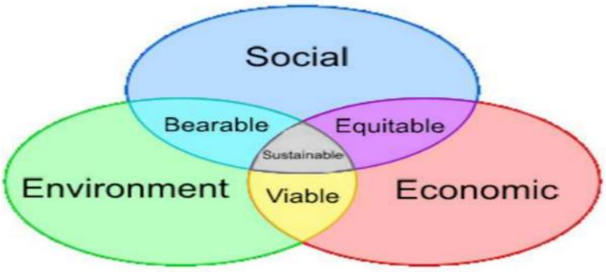


Figure. 2.1. Main requirements of PDH sustainability (Josa, 2012).

2.2.1. Economic

According to (Fuente, Oriol Pons, & Aguado, 2015) the most important criteria in economic requirement is cost and time. It is critical since the disaster happens and after post-disaster, there is a lot of demolition of Structure and Infrastructure. Moreover, after post-disaster should spend many expenditures for repairing and reconstruction the building, rod and, Infrastructure. In fact, aftermath must do the preparation and provide utilities require mobilization treatment health. Therefore, the preparation of these initial needs is essential to spend money. Ought to choose the option of economic do not spend more money in economic and this is inevitable. Therefore, three indicators are (1) land of cost (2) cost of preparation of the sit (3) cost infrastructure of the sit. According to (Lombera & Aprea, 2009) the economic operation should be considered in duration the construction stage and in terms of its maintenance and conservation throughout its useful life. In Construction of industrial is intended to the maximum efficiency and reduce financial costs. Another factor to consider is the cost of land the importance of the final cost of the building. An economic factor is an important part of maximum profit, in every business, it is always looking for an economy.

2.2.2. Social

Stakeholders are the main part of the society who get homeless after the earthquake and need help because they are physically and mentally injured. The social requirements can also include additional indicators that can be reviewed. According to (Pons & Fuente, Integrated sustainability assessment method applied to structural, 2013) the social requirements analyze an alternative effect on society. The social requirements of eliminating discriminatory indicators are lower, the studies on people show. According to (Hosseini S. M., 2016) ergo physical and mental health, well-being, and so on can play a key role as social indicators to evaluate and affect another part of social requirements. Here to take part it and Consider mental and physical aspects, such as risk, health conditions, community participation, infrastructure, etc. Benefits of improving living standard to local communities (Li-Yin Shen, 2010).

2.2.3. Environmental

Although Sustainability is really important, achieving a sustainable environment is very complicated. Insomuch that the population is increasing it leads the environment to damage the ecology. The ecology, that is going to be used in future by the next generation, has six principle indicators,(1) water, (2) Co2 emission, (3) energy, (4)Improving productivity, (5)reducing the generation of pollution, (6) and reducing resource consumption (Li-Yin Shen, 2010).

2.3 LITERATURE REVIEW ABOUT SIT LOCATION CHOOSING FOR TEMPORARY HOUSING

Due to the importance of temporary housing, many articles have been written about it. Below are some of them

1- Providing a new model is able to select an optimized location for TH with economic, social, cultural and environmental assessments. To obtain satisfactory, satisfaction from the interests of the beneficiaries. This model was designed to (1) maximize the welfare of the DP, (2) minimize the negative impact on neighborhood life, (3) minimize the general cost of TH (4) to minimize the negative impact on the environment, and (5) Maximize the welfare of people involved in the construction of TH. This site can be used for emergency shelter and shelter. Used to find the best site location for TH for the probable earthquake Mosha in Tehran, (Iran). The Integrated Value Model for Sustainability Assessment (MIVES), which consists of multiple decision-makers. Multiple Decision Model (MCDM) to assess sustainability (Hosseini, Albert de la Fuente, & and Oriol Pons, 2016) .

This article does not cover the distance between hospitals to sites in the social sector. Indicator the hospital after the earthquake is very important. Additionally, there is a lot of injury after the earthquake it has to be checked.

2- For a proper and regular selection of temporary shelters, pre-earthquake, using a geographic information system and MADM based on the crime of assessing damage after determining the appropriate criteria for selecting a temporary asylum application. For the municipality of Tehran zone 1 the capital of Iran. Purpose of this research was (1) the criteria governing the identification and construction of temporary shelter• (2) the methods that can be employed in site selection• (3) the appropriate means of site selection (Babak Omidvar, 2013) .

This article does not mention the dangerous areas near the flood, fault and hazardous areas. This is a very important issue because there is the possibility of earthquake occurrence after the first earthquake. It may be much worse in the second earthquake. However, did it in my own work to distance from the fault and flood area. Also, the distance from hazardous areas.

3- The purpose of this article is to provide guidance. It can design and build high-quality homes while saving time and money. It discusses economic, social, cultural, environmental, time, and so on. Covering a wide range of issues in terms of qualitative, managerial (etc.) (Abulnour, 2013).

If the topic points to the appropriate place, it was possible to point out the choice of a suitable location and its relation to construction. For example, land prices, land preparation costs and land needed infrastructure.

4- Schools should be resilient in events such as earthquakes, such that their operations will not be affected. Have an important role in the post-disaster activity. A safe school represents a healthy learning place and an appropriate temporary shelter. Vibration has caused considerable damage and has caused many children to die in the world. More than 10,000 schoolchildren and 7,000 seriously injured classrooms in Kashmir 2005.In northern Pakistan, where 17,000 students died, and 10,000 schools was destroyed. The 1990 earthquake crashed into a six-store building in the Philippines (Rizalyn C. Ilumina, 2018).

School buildings have two functional factors. Educational value and emergency value. After the disaster of using the school such as the storage, of relief supplies and the operation center. In the study a methodology of assigning an index corresponding to a school building post-disaster. Functional asset value using the Analytical Hierarchy Process (AHP) and an expert's survey. In addition to a prioritization plan, decision-makers can prioritize buildings with high seismic hazard and high asset value (Rizalyn C. Ilumina, 2018) . However, do not mention to the social sector as well as to the economic sector. If the social sector is taken into consideration, this was a good thing because it has a consistent direct relationship with it.

2.4 LITERATURE REVIEW ABOUT MIVES

These days using MIVES in a plenty form got extensive and universal thus, can see it in different articles and projects, so this decision- making method helped the best option among those opportunities has been chosen. Here is some dissertation in which this method used.

1- The first article is about Multi-Criteria Decision-Making in the sustainability assessment of sewerage pipe systems. That thesis focuses on the analysis of the sustainability of different materials provided for sewage pipes. Using a Multi-Criteria Decision-Making method (MCDM) based on value function concept. Then several attributes of the scientific value-added of that research include the establishment of a method. The subjectivity involved in the measurement and comparison process minimized. Substitute materials for the construction of sewage pipelines. In addition, it has been concluded that concrete solutions are better in terms of stability for wider diameters other substitutes (Fuente, Oriol Pons, & Aguado, 2015).
2- The second article is about a combination of the Knapsack algorithm and MIVES for choosing optimal temporary housing site locations: A case study in Tehran design a new model for choosing a site based on sustainability concepts. The new model combines the Integrated Value Model for Sustainability Assessment (MIVES) and the classical algorithm to identify a subset of the stable among the possible options based on the region (Hosseini, Ponsb, & Fuentea, A combination of the Knapsack algorithm and MIVES for choosing optimal, 2017).
3- The third article is about a system approach to the environmental analysis of industrial buildings, residential and office buildings. However, more attention should give to sustainability in many industrial construction fields. Accordingly, an Integrated Value-for-Sustainability Assessment Model (MIVES) model presented. In this dissertation, which sets out six study areas to define the sustainability criteria for industrial buildings

This system uses the tree to calculate the stability of the tree, (Toma, Lombera, & Aprea, 2009).

4- The fourth article is about integrated value model for sustainable assessment applied to technologies used to build schools in Catalonia, Spain. That article shows that a study to find out that technology has proven that the most sustainable. For building used schools are in a place where there are meaningful these kinds of buildings. The study seeks out that architecture technology the Economic downsizing, environmental and social effect to solve the problem. The Integrated Value Model for Sustainability Assessment (Flexible Model for Value Assessment and MIVES) used in this research to create a dynamic assessment tool. Choose processes to determine which technology should use to create the most sustainable school center (Pons & Aguado, 2012).

5- The fifth article is about multi-criteria decision-making method for assessing the sustainability of post-disaster temporary housing unit's technologies case study in Bam, 2003. This research study offers a new model for choosing an optimized THU based on the concept of sustainability. This model supports decision-makers in selecting a more appropriate type of THU to reduce temporal efficacy (TH) when there is no possibility. MIVES model a sustainable assessment (MIVES) is a multi-criteria decision making (MCDM), which includes the concept of the value of performance, to evaluate the sustainability of the value of each the alternative. THU technology that proposed for the Bam earthquake improvement program proposed by a semi-public organization this method used to achieve two purposes, (1) to determine the technology to users and (2) to test the model (Hosseini, Fuentea, & Pons, 2015).

6- The sixth article is about multi-criteria decision-making method for sustainable site location of post-disaster temporary housing in urban areas. A new model to support decision-makers in choosing site locations for TH. This model can determine the optimal location of the site based on the integration of economic, social and environmental aspects throughout the life cycle of these homes. The integrated value forecasting model (MIVES), the multiple decision model (MCDM), for assessing the sustainability of the above aspects. MIVES includes a concept of the value function that allows the homogeneity index to base on the satisfaction (S. M. Amin Hosseini Albert de la Fuente & Oriol Pons, 2016).

7- The seventh article is about the use of MIVES as a sustainability assessment MCDM method for architecture and civil engineering applications. This article is a synoptic study of the main evaluation of the sustainability of the analysis of methods for the construction sector. The comparison of their strengths and their weaknesses to challenge the Spanish virtual model for sustainability assessment (MIVES). MIVES multi-criteria decision-making methodology based on the concept of value performance and seminars by experts in this thesis, examine the merits of MIVES and the weaknesses through it (Oriol, Fuente, & Aguado, 2016).

8- The eighth article is about multi-criteria decision-making model for assessing the sustainability index of wind-turbine support systems. Application to a new precast concrete alternative. Determining which system is suitable for a set of boundaries (e.g. height, power turbine, and soil conditions), the economic, social and environmental. The model compatibility has proven by assessing the stability index (Fuente, Armengou, Pons, & Aguado, 2016).

9- The ninth article is about sustainability based-approach to determine the concrete type and reinforcement configuration of TBM tunnels linings. Case study, extension line to Barcelona Airport T1. Concrete and reinforcement to cover segment TBM tunnels using MIVES (a multi-functional decision-making method for sustainability assessment). This MCDM approach allows for at least mentality in decision making while integrating economic, environmental and social factors. This model was used to assess the sustainability of the various options presented for its production (Fuente, a, Armengou, & Aguado, 2016).

10- The tenth article is about integrated sustainability assessment method applied to structural concrete columns. This research provides a general model for the stability analysis of columns. This tool evaluation has taken using MIVES, the MCDM decision that has been made. Considers the main sustainability programs (economics, environment and social) and are valuable. The concept of performance to coordinate indicators and match the degree of satisfaction. This is a general tool and can be used to evaluate other components in the building after that (Pons & Fuente, 2013).

11- The eleventh article is about the use of MIVES as a sustainability assessment MCDM method for architecture and civil engineering applications. This article is a synoptic study of the main evaluation of the sustainability of the analysis of methods, for the construction sector. The comparison of their strengths and their weaknesses to challenge the Spanish virtual model for sustainability assessment (MIVES). MIVES multiple criteria decision-making method based on the concept of value performance and seminars from experts in this dissertation. Examine the merits of MIVES and its weaknesses through its methodology and two applications of representation. Finally, the area is using MIVES (Pons, Fuente, & Aguado, 2016).

CHAPTER 3

3. CASE STUDY AND PLACE OF CATEGORY

3.1 DIFFERENT SOIL TYPES IN DIFFERENT AREAS IN SARPOL-E ZAHAB

Examine the various phenomena associated with this earthquake. The geological phenomenon and geotechnical phenomenon have occurred and it is important to study these phenomena. According to (Haghshenas A. , 2017) these factors can play a role in this soil is definite. It is because of much less destruction in the northern heights of the city across the bridge of Zahab, which is heavy rock and poor soil. In Sarpol-e zahab and the north of the boulevard, do not see destruction in that form.However, down the Boulevard "Karbala Road", which is the main boulevard of the city. Destruction is very wide in several neighborhoods.

In terms of appearance when look at the soil, it is fine grains and the upper part of it is agricultural soil. Two hundred the units of Maskan Mehr were in the northern city of SarPol-e Zahab, which had not been seriously damaged and was part of the Cracks. According to (Baitullah, 2018) due to the major damage of the SarPol-e Zahab city in zone of Foladi, the effect of soils was remarkable. Behind the area of Maskan Mehr Shahid Shirodi housing building, it traverses Sarpol-e Zahab and the zone Foladi. Goes to the Alvand River, from the Piran waterfall to the city of SarPol-e Zahab. This route involves soft soil and saturation due to the running water of the Alvand River.

The soft soil of this area has also played a role in increasing the damage to the buildings in this area. Considering serious soil type, construction effect and magnification of earthquake acceleration and increasing the duration of earthquake vibration duration by soft, ash and wet soil. According to (Haghshenas, ashayeri, mosavi, & biglari, 2017) the main boulevard of Sarpol-e Zahab city is the presumption of the existence of manual soil by some citizens in some areas, including the area of zone Foladi. The lower parts of west, of the coastal boulevard in the distance between the beaches Boulevard on the river to the buildings of Maskan Mehr housing complex Shahid Shiroodi.

In addition, drilling of post-war construction spans and construction on them, as well as increasing the size of soils and further degradation also raised. Field observations confirm the existence of a vast area of the village of the soil - a result of the mosquitoes in recent years by the municipality - near the Shahid Shirodi complex. Maskan Mehr housing buildings in Shahid Shiradi Complex also not built on hand soils and built on agricultural land. As shown in figure 3.1, distribution map for damage caused by unitary, the rate of destruction in the south of the city of Sarpol-e zahab.

Figure. 3. 1. Distribution map for damage caused by unitary the rate of destruction in the south of the city (Haghshenas, ashayeri, mosavi, & biglari, 2017).

3.1.1 TYPE OF SOIL IN THE HOSPITAL AREA IN SARPOL-E ZAHAB

In this project, there are (6) drill bits. To drill a machine to dry depth 7.5 and 10 drilling meter. Based on information in the borehole. Soil is a species of clayey fine grains. A borehole at a depth of 8 meters collided with water. Other borehole are not static. The number of (SPT) the result of the standard penetration test, in all boreholes, it is about 30, soil type III. The results of dry soil specific gravity are approximately 1.67 $^{g}/_{cm^3}$, an indication of middling soil density (Salamat, 2017).

3.1.2 TYPE OF SOIL IN THE MASKAN MEHR AREA IN SARPOL-E ZAHAB

In this project, there are (7) drill bits. To drill a machine to dry depth 10 and 20 drilling meter. Based on information in the borehole. Soil is of type, coarse sand with fine clay. The number of (SPT), it is a sign of high soil density above 30 soil type III. A borehole at a depth of 2 meters collided with water. Other borehole are not static (Salamat, 2017).

According to the above-mentioned Sarpol-e zahab area, divide into three parts of the soil type dirt as shown in figure 3.2, in the region of A in the north of the Sarpol-e zahab is rocky soil and high strength. In addition, in area B, soil agricultural and manual soil is from depo time of war, and its soil has very weak resistance. In area, C soil is of clayey fine grains and has a medium resistance.

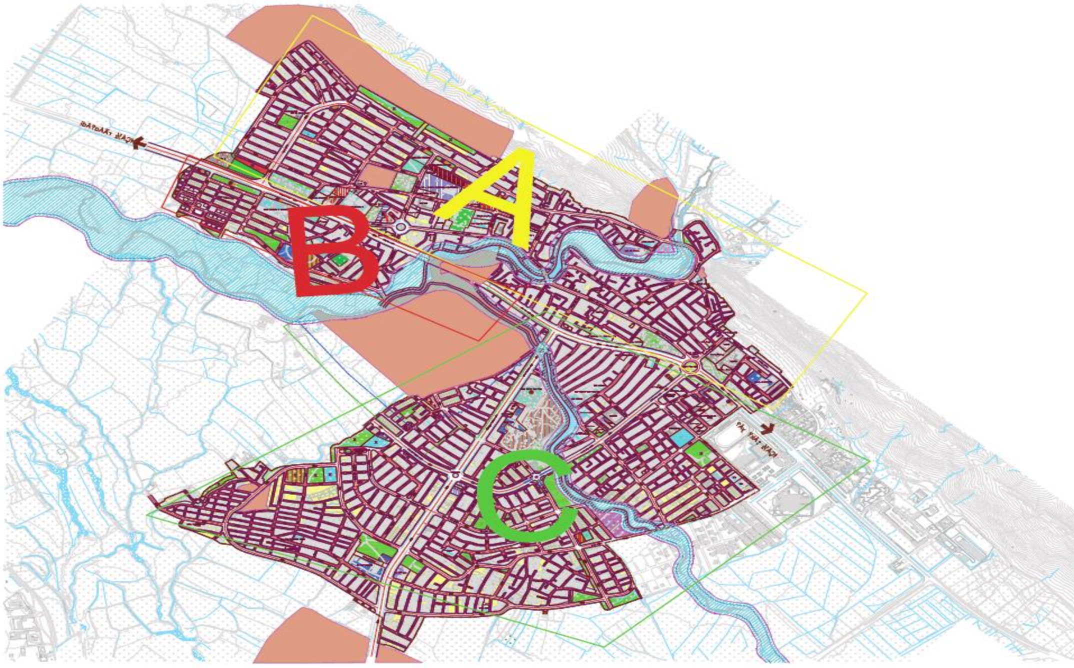


Figure. 3. 2. Split Sarpol-e zahab of soil type.

3.1.3 SOIL ASSOCIATION WITH THE EARTHQUAKE

According to (Behloli, 2017) inappropriate soil and the presence of earthquake-stricken and earthquake-damaged areas could be due to the losses in this earthquake. Which itself indicates that, unfortunately, urban development plans are without comprehensive and realistic studies and inappropriate areas for housing and development of the city.

In the selection of project sites, and especially important projects such as hospitals, buildings with population density. High-risk centers, it is necessary to pay attention to the type of soil and design based on soil behavior in the site. In the construction of the building, excavation of boreholes and geotechnical tests and building design based on the soil characteristics of the land should be mandatory and strictly enforced. So soil should affected, when building on a stone, may not have a problem if design a building with less force. If build on softer and softer soil, because of the strength of the vibrational earthquakes, these buildings must designed and constructed to withstand and sustain

3.2 FAULT AREA IN SARPOL-E ZAHAB

Effects of near field like orientation and localization. Move at the fault page and the rise of the pulse in the speed map in the near range. This dominant frequency of about one second causes the regions to be perpendicular to the fault Placed. Have a stronger movement compared to other cities (Haghshenas, ashayeri, mosavi, & biglari, 2017). As shown figure 3.3 shows the location of the fault in Sarpol-e Zahab. In a part have divide the areas into eastern and western parts as shown in figure 3.4.

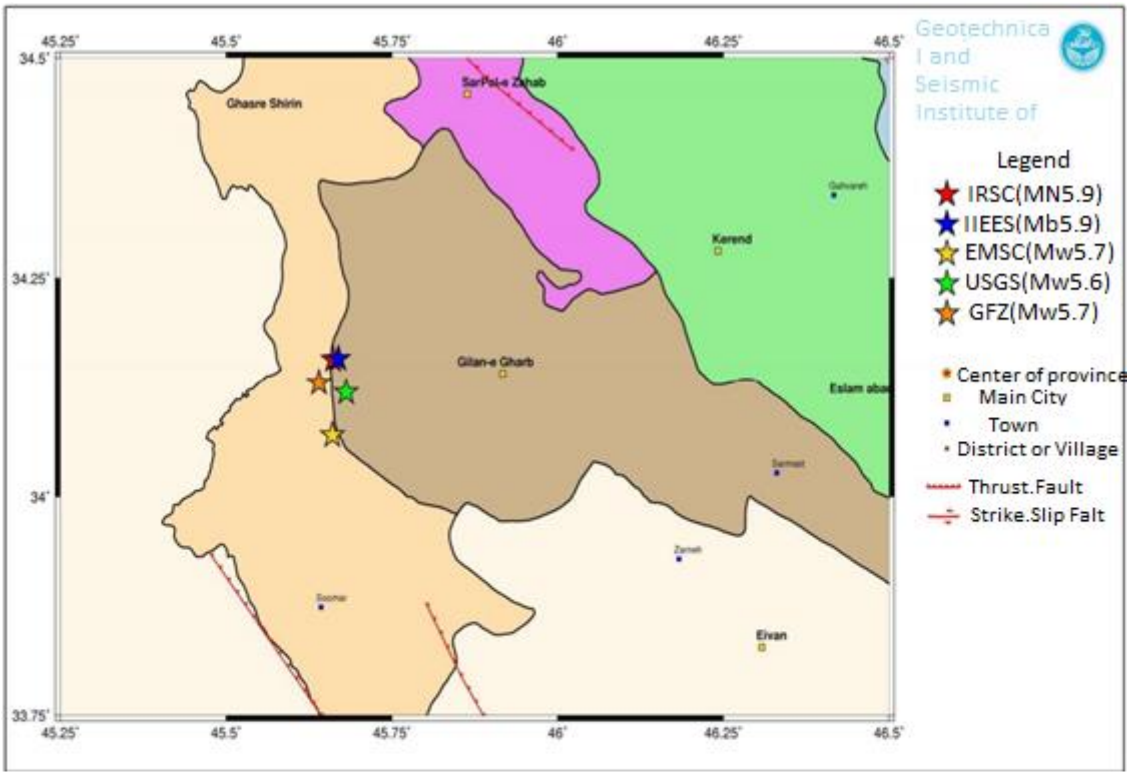


Figure. 3. 3. The map of fault of Sarpol-e zahab (Center, More than 3.7 earthquake reports from Kermanshah, 2017).

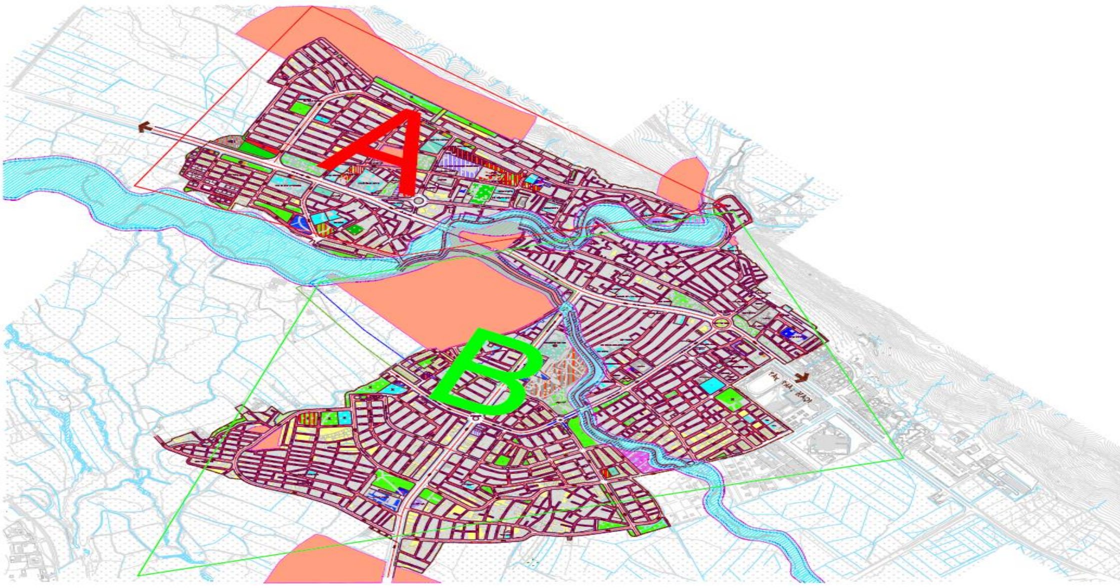


Figure. 3. 4. Split Sarpol-e zahab of fault.

3.3 FLOOD AREA IN SARPOL-E ZAHAB

Do not have a house on the river's edge, because the soil is in trouble. The soil that is next to that river is poor soil. If also want to build a house, it will not built with construction rules. Slope of city from north to south. Another point is about the adjacent areas of the river in the city of SarPol-e Zahab, which should considered. The occurrence of the phenomenon liquefaction and spillage of sand in the riverbed. Especially near Maskan Mehr Shahid Shirodi and neighborhood is a long time. The effects of this phenomenon well seen on the riverbed (Haghshenas, ashayeri, mosavi, & biglari, 2017). In a part, divide the areas into 3 parts as shown in figure 3.5.

Figure. 3. 5. Split Sarpol-e zahab of flood.

3.4 DIFFERENT GROUPINGS OF TEMPORARY HOUSING

According to mention the above, categorized site positions into different groups. G1, Type of soil.G2, Distance from fault .G3 Distance from flood .G4, Residential places.G5, Non-residential places.G6, Center of town. G7, Out of town.

G1, Soil= ($TH_{5,}$ TH_7, TH_{12}, TH_{18}, $TH_{27,}$ $TH_{41,}$ $TH_{43,}$)

G2, Fault= (TH_5, $TH_{7,}$ TH_{12}, $TH_{18,}$)

G3, Flood= (TH_{12}, TH_{18}, $TH_{27,}$ TH_{32}, TH_{41},)

G4, Residential = (TH_7, TH_{12}, TH_{27}, TH_{32}, $TH_{41,}$)

G5, Non-residential = (TH_5, TH_{18}, $TH_{43,}$)

G6, Center of town = (TH_7, TH_{12}, TH_{18}, $TH_{32,}$ $TH_{41,}$)

G7, Out of town = (TH_5, TH_{43}, TH_{27},)

3.5 INFORMATION ABOUT THE EARTHQUAKE OF SARPOL-E ZAHAB

"In the first part will talk about the earthquake, where and it happened. The Kermanshah earthquake occurred on November 12, 2017 with a magnitude of 7.3 M. It occurred in the northwest of Iran, near the border of this country with Iraq in the depth of the average crust of 19 km. The earthquake occurred about 10 kilometers from Ezgeleh and 33 kilometers from Qasr-e Shirin 37 kilometers from Sarpol-e Zahab. The local time was 21 and 18 minutes, which corresponds to world time 18 and 18, with duration of 1/29 s. The earthquake affected 10 cities and 1930 villages (USGS, 2019). In addition, the earthquake occurred near two capitals of the autonomous communities called Sanandaj and Kermanshah with the distances 216 and 174 km. Also reportedly three earthquakes occurred before the earthquake and 526 earthquakes after the earthquake with magnitudes 4/7 M up to 1/8 M, until hour 12am on November 28, 2017, according to (USGS, 2019) then the USGS community internet intensity Map as shown in figure 3.6".

Figure. 3. 6. USGS community internet intensity Map (USGS, 2019).

In april of the year 1150, is another devastating earthquake that occurred in Sarpol-e Zahab area. Based on the reports obtained in Iran, there are earthquakes every 10 years for example the one of August 11, 2012 in Ahar and Varzaghan, previously the one of December 26, 2003 in Bam, and before another earthquake in June 21, 1990 in Rudbar and Manjil, however, in the Kermanshah area, during the past 100 years, large-scale earthquakes had not occurred. Acoording to (Zifan, 2017) the exact location of the earthquake has been shown in figure 3.7.

Figure. 3. 7. Map of the location occurred earthquake *(Zifan, 2017)*.

3.5.1 FINITE FAULT MODE

"The Zagros mountain range, which extends over a length of more than 1500 km from eastern Turkey, through part of Iraq and Iran, to the Gulf of Oman, it is one of the key structural elements in The alpine and recent tectonics of the Middle East. Structurally, it seems to result from the collision of the continental plate of Arabia in the southwest with Central Iran in the northeast as shown in figure 3.8. The seismicity of the region indicates that the tectonic deformations are still in progress (USGS, 2019)".

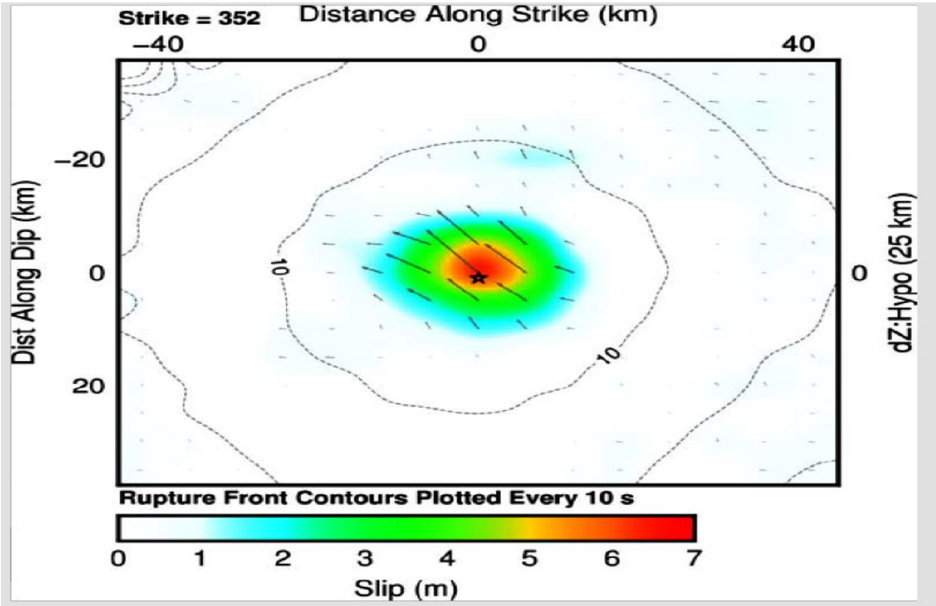


Figure. 3. 8. Cross-section of Slip Distribution (USGS, 2019).

According to USGS reports, the reason for the Kermanshah earthquake was the activity of the Zagros plate. "Distribution of the amplitude and direction of slip for sub fault elements of the fault rupture Model are determined from the inversion of tele seismic body waveforms and long period Surface waves. Arrows indicate the amplitude and direction of slip (of the hanging wall with Respect to the footwall), the slip also colored by magnitude. The view of the rupture plane is above. The strike of the fault rupture plane is 352° and the dip is 16°E. The Dimensions of the sub fault elements are 6 km in the strike direction and 5 km in the dip direction. The rupture surface is approximately 35 km along strike and 20 km along down dip. The seismic moment release based upon this plane is 1.2e+27 dyne.cm" (USGS, 2019). Unit 3:52:54 in date 2017 November 22 recorder 878 Aftershocks (Dr & Beitolahi, 2017) .

This earthquake recorded with 59 station of accelerometer, location of the station of accelerometer showed with color Purple in the map as shown in figure 3.9 (Road Research Center, 2017) .

Figure. 3. 9. Number of recorder stations (Road Research Center, 2017).

In below there is table numbers of change earthquake from 2017 march 21 until 2017 November 12 as shown table 3.1 (Road Research Center, 2017).

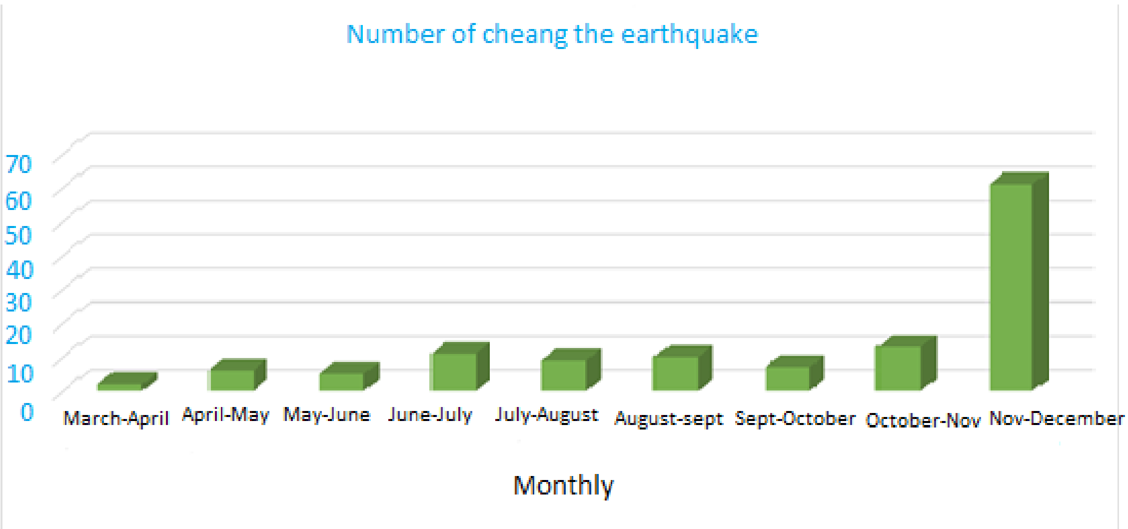


Table 3.1. Numbers of change earthquake (Road Research Center, 2017).

In this earthquake five city had been effect and the most damage of the earthquake is effect to Ezgeleh,Sarpol-e Zahab, Qasr-e Shirin and Eslamabad-e Gharb, in between all city was the most breakdown and dead in Sarpol-e Zahab.

Earthquakes occurring from 21/march /2017 up to 13/nonmember 2017 as shown figure 3.10 it shows the seismicity of this region has been high, all of earthquake from The beginning year until 14/nonmember 2017 were 124 and according to of report (Road Research Center, 2017) in nonmember 2017 were 61 with 2.5 more Richter.

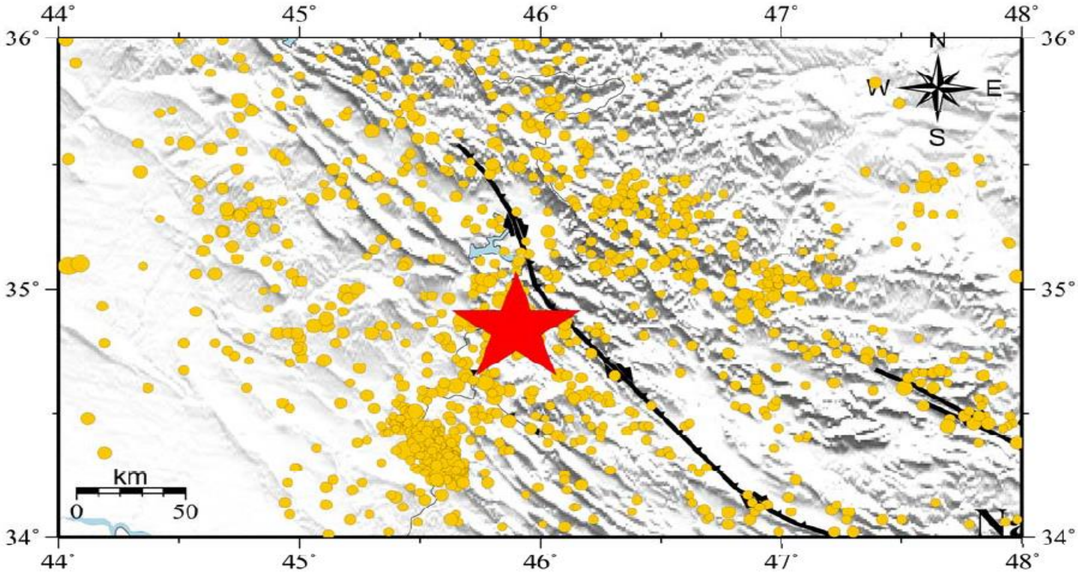


Figure 3.10. Place and turns in near of earthquake, (Road Research Center, 2017).

3.6 POPULATION

In the below there are table of the process of changing the urban population and village population of the affected city in three tens of the near city of the earthquake as shows in table 3.2 ,3.3 . Also as shows in table 3.4 is about increasing the number of cities in Kermanshah province in three decades, and population trends urban village of the province (Road Research Center, 2017).

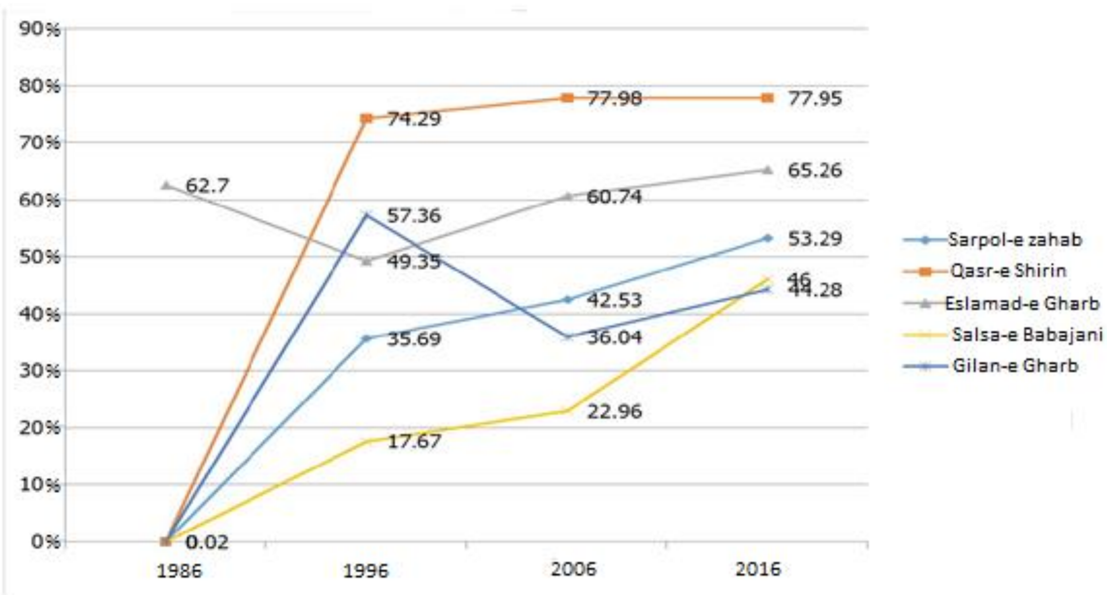


Table 3.2. The process of changing the urban population of the affected city in three tens (Raheb, moghatai, Najafi, & Rafiei, 2017).

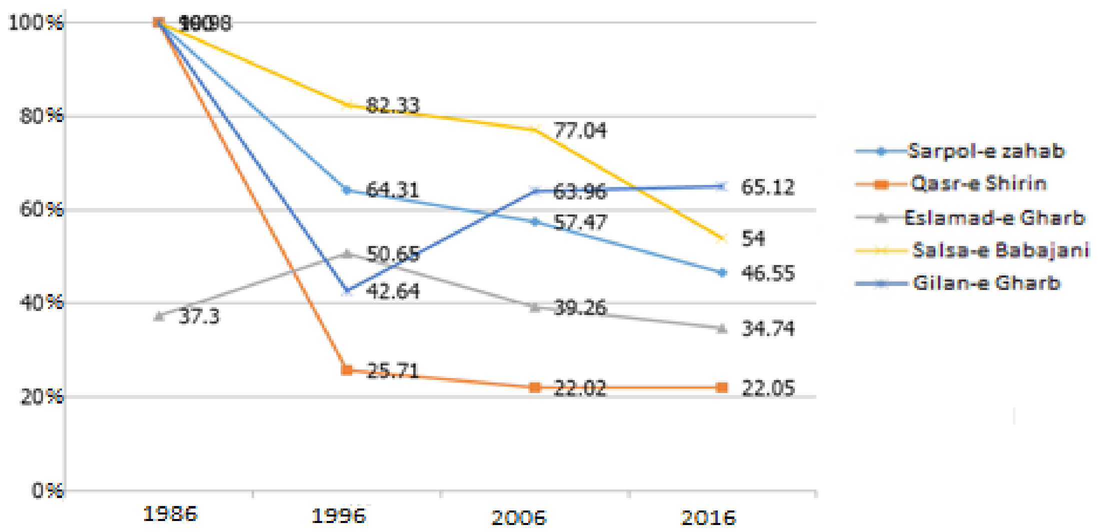
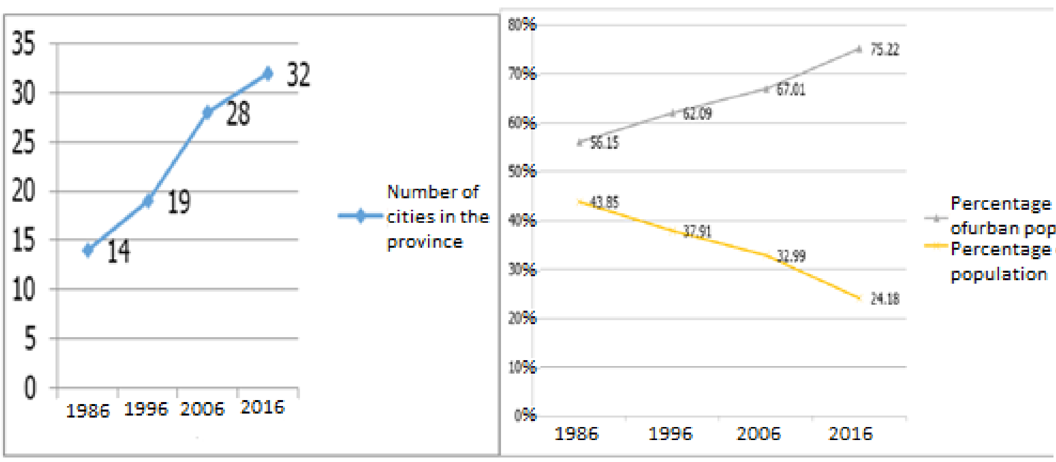


Table 3.3. The process of changing the rural population of the affected city in three tens (Raheb, moghatai, Najafi, & Rafiei, 2017).



Increasing the number of cities in Kermanshah province in three decades

Population trends, Urbanand village of the province

Table 3.4. Increasing the number of cities in Kermanshah province in three decades, population trends urban village of the province, (Raheb, moghatai, Najafi, & Rafiei, 2017).

3.7 INFORMATION OF BUILDING

observed in this figure in province near of kermansha there are 320000 of unit residential without skeleton and 70000 with skeleton, as shown Table 3.5 (Road Research Center, 2017).

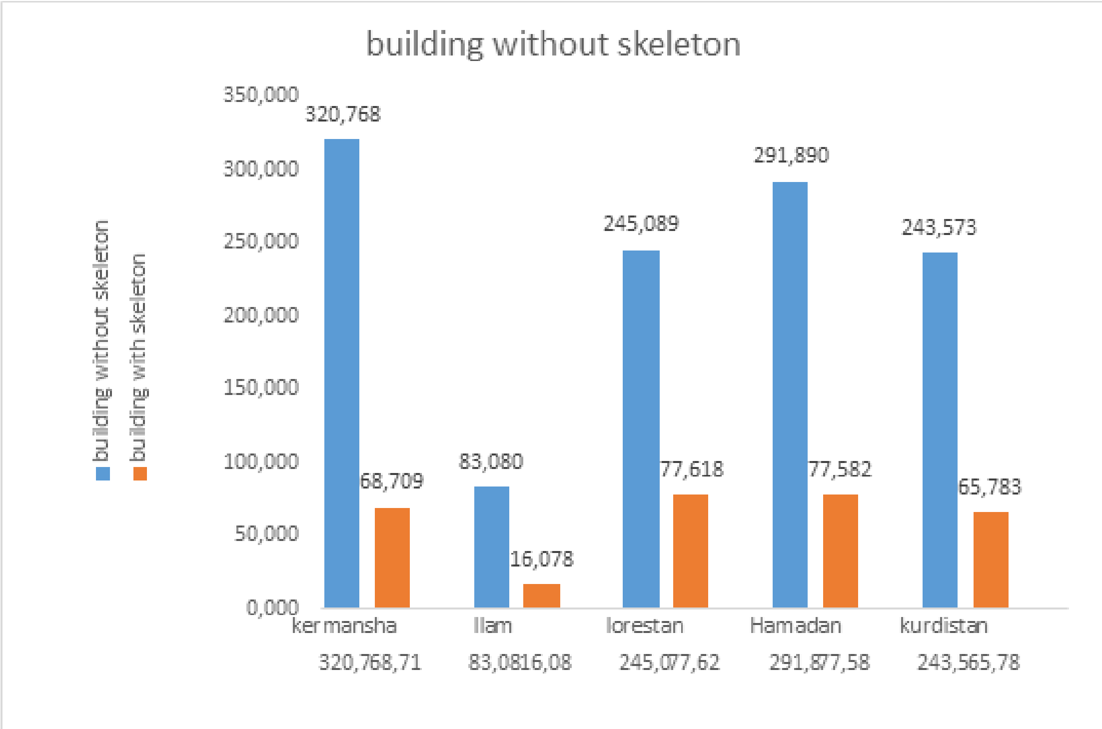


Table 3.5. Numeral of building without skeleton and building with skeleton (Road Research Center, 2017).

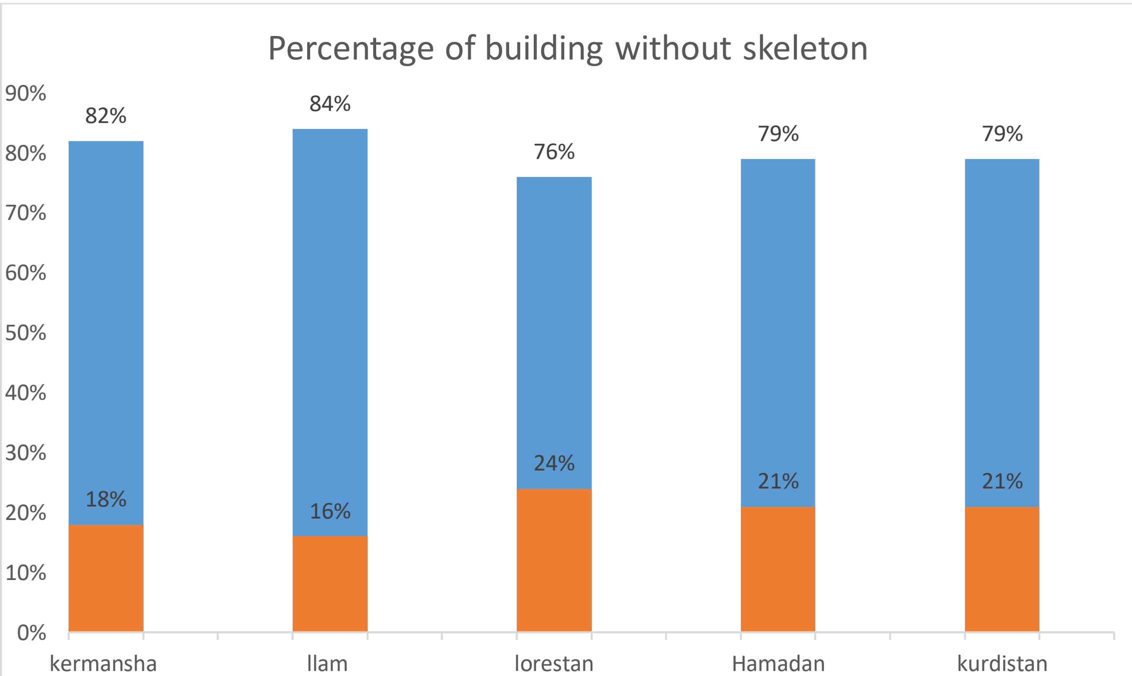


Table 3.6 Percentage of building without skeleton and building with skeleton (Road Research Center, 2017).

The population of living in building without skeleton and building with skeleton in Kermanshah of region urban and rural, as shown table 3.7 (Road Research Center, 2017).

Table 3.7. Percentage of building without skeleton and building with skeleton (Road Research Center).

Population of building without skeleton			Percentage building without skeleton		Rural population	Urban population	Total population	province
Total	Rural	Urban	Rural	Urban				
1,110,707	444,634	1,421,090	93%	78%	478,444	1,468,615	1,952,434	Kermanshah

3.8 AFTER THE EARTHQUAKE

Including 123400 buildings, of which 35200 were destroyed.59642 damaged, 3931 commercial buildings affected in the urban and rural areas. Aftermath of this earthquake, 738 people died and 9388 people were injured, and 70000 people were homeless (Statistical Center of Iran, 2016) . The earthquake, the electricity of three cities of Sar-e-Pul Zahab, Qasr-e Shirin and Tazehabad 100 percent was definitively. The cities of Kerend-e Gharb, Yavanrud, Gilan-e Gharb, Paveh and Kermanshah were 31 to 61 percent definite. There were about 480 villages with electricity failures, according to one of the problem, loss of water resources in 7 cities. This problem continues in about two weeks in the cities of Sarpol-e Zahab and Qasr-e Shirin. More than 511 cases of broken drinking water lines occurred in earthquake cities. The gas company of Kermanshah province cut off the gas network of the three city of Salas-e Babajani, Sarpol-e Zahab and parts of the city of Qasr-e Shirin, (banafshi, 2017).

Red Crescent 16 rapid reaction, team 31 rescue dog, team 41 specially displaced, team 41-immigrant emergency response. Team 9 emergency officers and a total of 591 operational forces as well as 40 ambulance units 9 rescue vehicles. During the transfer of injuries, used 33 Helicopters of the Red Crescent and Police. Heavy traffic was between, Patagh to Sarpol-e Zahabin the early hours after the earthquake occurred. So that injured people cannot be deployed at the right time. Most injured were taken to health centers by private cars. Of course, with the dispatch of several ambulance and buses, these problems became less severe the next morning. Between 33 and 57 thousand households somehow affected by the earthquake (Mansori, 2017).The main building in near the earthquake whereas they didn't full hurt , but couldn't use of them (Raheb, moghatai, Najafi, & Rafiei, 2017). According to Najjar 4,000 tons of forage for livestock in the region will be distributed through agriculture jihad (Hamshahri, 2017).

3.9 EFFECTS ON CITIES

3.9.1 ABOUT LOCATION AND POPULATION OF SARPOL-E ZAHAB

The city of Sarpol-e Zahab, with an area of 90330 hectares, and population density is almost for each persons, 83 persons in hectares, and the quality of the building is for concert structure (2/13%) and steel structure is (4/21%) and masonry structures is (4/65%) (Raheb, moghatai, Najafi, & Rafiei, 2017). Located in the west of the autonomous community of Kermansha. According to the report of the Central Organization of Statistics of Iran in 2017, the population of Sarpol-e Zahab was 85,342-people.The city of Sarpol-e Zahab is north of Salas-e Babajani east of the city of Dalahu, south of the Gilan-e Gharb city, and west to Qasr-e Shirin and Iraq (Statistical Center of Iran, 2016).

3.9.1.1 Sarpol-e Zahab (after the earthquake)

Among all these cities, the greatest number of deaths and damages was in city Sarpol-e Zahab. According to the forensic reports, the death toll is 518 people and according to the reports of the housing foundation, the damage caused by all the buildings is about 30000. In addition, the city had only one hospital, of which the damages generated were very large. The fall of the rock on the path, which led to the collapse of the powerful electric power pole and the blockage of the main road of Kermanshah Sarpol-e Zahab. Eighteen schools destroyed during earthquake (Mansori, 2017) and (Housing Foundation of I.R.Iran, 2017). The influence of rain into the tent and the temporary settlement of the earthquake of Sarpol-e Zahab (Babakhani & Molavi, 2018). According to Governor of province of sarpol-e zahab on the power cable connection in the temporary housing of earthquakes in sarpol-e zahab, 10 the tent in fire burning (zahab, 2017). In below there is figure after of earthquake as shown in figure 3.11 this picture purple color is place of hospital and red color is place of damage and green color is it have been chosen of place for temporary housing (Kiyani, 2017).

Figure. 3. 11. Figure after earthquake in Sarpol-e zahab, (Kiyani, 2017).

3.9.1.2 Hospital of Sarpol-e zahab

Establishment of Sarpol-e Zahab hospital in 1992 by the red cross after the Iran-Iraq war. About 1000 square meters under the building, In the south-east of the city, system foundation is single with tie (Majidi, 2018).

The 119 health houses in hometown of Sarpol-e Zahab, Salas-e Babajani, Dalahu, Ezgeleh, and Eslamabad-e Gharb damage. Below table, hospitals of Imam Khomeini in

Eslamabad-e Gharb, the shahid of Sarpol-e Zahab and have been seriously damaged. According to (Kalantari, 2017) there is in below as shown Table 3.8 the treatment centers visited and the distance to the earthquake center.

Table 3.8. The treatment centers visited and the distance to the earthquake center (Kalantari, 2017).

Distance to center	**Name of the health center**
47.7	Haspital Shohada Sare Pole Zahab
106	Haspital Emam Khomini Eslamabad Gharb
47	Haspital hazrate abplfazl ghasre shirin
83.4	Haspital Zahra Gilan Gharb
51	Haspital Ghodos Pave
61.2	Haspita Hazrate rasol Javan rod
33.7	Clinic in Salase baba jani
75.1	Medical center in Dalaho

Hospital in Sarpol-e Zahab, the building of the hospital saw severe damage from the earthquake, 54 beds were active during the earthquake. The hospital building is a concrete framing frame with a double side roof slab and a floor, building facade made of stone. Another hospital transmitted to the region was a desert hospital in the region of the guard. The hospital consisted of five buses connected to each other, with various equipment from the operation room chamber, radiographs labs (Kalantari, 2017) as shown in figure 3.12.

Figure. 3. 12. Army Field hospital in Sarpol-e Zahab City (Kalantari, 2017).

The main hospital in Sarpol-e Zahab was severely damaged and could not be served as shown in figure 3.13.

Figure. 3.13. Severe injuries to Sarpol-e Zahab martyrs hospital (Kalantari, 2017).

3.9.1.3 Maskan-e mehr of sarpol-e zahab

Maskan-e mehr housing buildings, Mehr Sarpol-e Zahab, Shahid Shiroodi town 41 Block 7th floor residential. Approximate dimensions of these blocks are 18 m at 18 m. kind use material is concrete (Kiyani, Farshchi, & Kykhosro, 2017). The Alvand workers' Mehr housing: 48 blocks of 4 residential floors, buildings steel made of two IPE 140 profiles. In all, all of these 48 building blocks have been damaged (Kiyani, Farshchi, & Kykhosro, 2017). The 12 blocks consisting of 100 residential units 100% destruction (Bitolahi, 2019).The town of Farhangian with the name of Mehr Shokouh 25 blocks of 5 residential floors, approximate dimensions of these blocks are 10 meters at 18 meters, the type of these steel buildings.

3.9.1.4 School of Sarpol-e zahab

In this earthquake, schools do not see much damage. The damage is only in the facade as shown in figure 3.14 (Mohamadi, 2017). School in other city they had good performance in the earthquake and save of the hurt very Serious, and major of the school use instead place of help a people (Raheb, moghatai, Najafi, & Rafiei, 2017).

Figure. 3. 14. School in Sarpol-e zahab (Mohamadi, 2017).

3.9.2 ABOUT LOCATION AND POPULATION OF SALAS-E BABAJANI

The city is north of the city of Pave, from the east to the city of Yavanrud, from the south to the cities of Islamabad and Sarpol-e Zahab, and from the Maghreb to the territory of Iraq, and consists of two parts central and Ezgeleh. Its area is about 1920 square kilometers, It 252 villages.

Population based on the status of the center of the country in the year 95 was 35219, of which 10,000 are urban and 260,000 villages and 8,000 nomads (Statistical Center of Iran, 2016). Due to, exist many free spaces in the margin of the city, develop of city is with Scattered (Raheb, moghatai, Najafi, & Rafiei, 2017).

3.9.2.1 Salas-e Babajani (after the earthquake)

With the 23 dead after the Sarpol-e Zahab, has been killing; one of the main victims was the earthquake. The city suffered 90% damage and displaced 36,000 people, (Statistical Center of Iran, 2016). So thirteen earthquakes with a magnitude greater than five in the Richter scale have been felt, people are afraid of repeating the disaster of the month of November. Losing their loved ones a year in the tent and nightlife of the night in the morning. Before the earthquake, also there was not hospital in this area (MASHREGH NEWS, 2018).

3.9.2.2 Hospital of salas-e babajani

Salas-e Babajani, healthcare system in 1382 started, Has 8 beds for admission of women and men, it has a steel structure. The facade is brick and stone (Kalantari, 2017). In this program, visits to nine centers of the most important centers of treatment in the western province visited at a radius of about 110 km from the earthquake center. Estimates of damage based on the specified indicators (Kalantari, 2017) as shown in Table 3.9.

Table 3.9. Qualitative description of the severity of the damage to the building (Kalantari, 2017).

Qualitative description of the severity of the damage to the building	**Name of the health center**
Very much	Haspital Shohada Sare Pole Zahab
Very much	Haspital Emam Khomini Eslamabad Gharb
Much	Haspital Hazrate Abplfazl Ghasre Shirin
Little	Haspital Zahra Gilan Gharb
Little	Haspital Ghodos Pave
Medium	Haspita Hazrate rasol Javan rod
Little and Medium	Clinic in Salase baba jani
Medium	Medical center in Dalaho

3.9.3 ABOUT LOCATION AND POPULATION OF EZGELEH

The city of ezgeleh is located in the west of Kermanshah province and considered as one of the suburbs of the city of Salas-e Babajani .The distance from Ezgeleh to the center of Kermanshah Province is about 200 km. According to the latest census in 1395, the population of this city is 1502. The nearest city was the earthquake center 5 km (Statistical Center of Iran, 2016).

3.9.3.1 Ezgeleh (after the earthquake)

Slipping Stone, about 15 km south of Ezgeleh near the checkpoint .Causing damage to the office building, cutting off a soldier and causing serious damage to another soldier.6 people killed in this city. Drinking water from the city of Ezgeleh and 18 villages in the city after the earthquake is turbid. Not drinkable. In this earthquake, there were 12 livestock and 3 heavy livestock and 6 livestock units damaged and two livestock units destroyed (Statistical Center of Iran, 2016).

3.9.4 ABOUT LOCATION AND POPULATION OF QASR-E SHIRIN

The city of Qasr-e-Shirin is limited to the north and west to Iraq from the south to Ilam province from the east to the cities of Sarpol-e Zahab and Gilan-e Gharb. In the 2016 census, there are 23,929 people. 5473 households. Qasr-e Shirin is located 166 km west of Kermanshah city. The city is located between 45 ° 35 'east longitude and 34 ° 31' north latitude and 333 meters above sea level. The city of Qasr-e Shirin has 186 kilometers of border with Iraq (Statistical Center of Iran, 2016). The space of the city 976 Hectare and density persons about 18 persons in each Hectare (Raheb, moghatai, Najafi, & Rafiei, 2017).

3.9.4.1 Qasr-e Shirin (after the earthquake)

Qasr-e Shirin with 16 killed. The earthquake destroyed the historic caravanserai of Qasr-e Shirin. Temporary camps show people in theaters in the city of Qasr-e Shirin (MASHREGH NWES, 2017) as shown in figure 3.15.

Figure. 3. 15. The areas marked with green are, related to the cluster camps of the peopl (MASHREGH NWES, 2017).

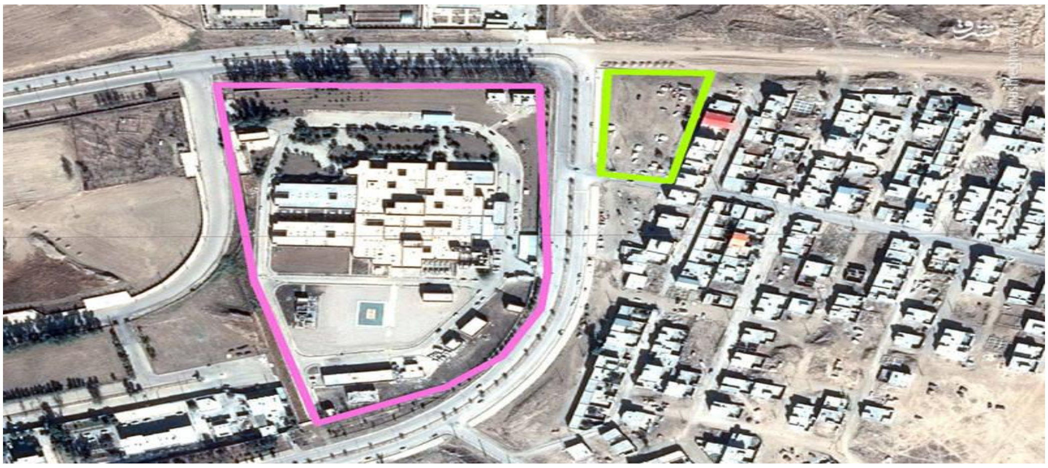


Figure. 3. 16. The area marked with violet color related to one of the hospitals of Qasr-e Shirin city (MASHREGH NWES, 2017).

3.9.4.2 Hospital of Qasr-e Shirin

Abolfazl Hospital, Qasr-e Shirin, The hospital built in 1999 on one floor and with concrete, the hospital capacity 32 beds; the facade of this building is of stone type (Kalantari, 2017).

3.9.5 ABOUT LOCATION AND POPULATION OF ESLAMABAD-E GHARB

Eslamabad-e Gharb is the second most populous city in Kermanshah province. From northern Yavanrud city, east of Kermanshah city, south of Sirvan country and west of the city of Dalahu and Gilan-e Gharb of the west. Population 140876, the language of the people of Eslamabad-e Gharb is Kurdish, kalhori .The total area of 2109 square km. It is 46 degrees, 31 minutes long, and 34 degrees 6 minutes long. General hospital is one. Medical emergency Center are three, Health centers are Nine, Health homes are 58. The factories of this city are the factory of the tile of Kaje and its large factory of sugar factories (Statistical Center of Iran, 2016).

3.9.5.1 Eslamabad-e Gharb (after the earthquake)

Eslamabad-e Gharb killed with 23 person, found a few days old baby around a river in Eslamabad-e Gharb. It was maximum acceleration distribution of the earthquake, in Eslamabad-e Gharb 210. Imam Khomeini hospital in Eslamabad-e Gharb, too damage. In Eslamabad-e Gharb Maskan-e Mehr, most a failure in the walls (Mansori, 2017).

3.9.5.2 Hospital of Eslamabad-e Gharb

Imam Khomeini hospital in Eslamabad-e Gharb. Imam Khomeini hospital consists of two main buildings. (1) Steel building and four floor with a capacity of about 134 beds, building facade made of stone. (2) The second building is a six-floor and 8300 square meters under building reinforced concrete structure. The hospital's capacity was 126 beds, Stone building facade. The construction of a new concrete section began in 2008 and benefited in 2017, hospital Imam Khomeini suffered serious damage and the hospital's electric was completely off (Kalantari, 2017).

3.9.5.3 Maskan Mehr of Eslamabad-e Gharb

Eslamabad-e Gharb, Sharafabad residential complex located in Eslamabad-e Gharb, 99 blocks 5 concrete floors. Each block has twenty residential units, is each floor is 4 unit, the approximate dimensions of the blocks are 25 meters in 13. The three hundred settlements located west of the west coast of Kerend, 4 block building of 5 floors, type of build of the steel,dimensions each 18 in 18 meters (Kiyani, Farshchi, & Kykhosro, 2017). Mehr house Badre, is 20 blocks and has 522 units without damage (Bitolahi, 2019).

3.10 OVERALL STATISTICS OF DEATHS IN EACH CITY

According to reports of management crisis until now, deaths have been 586 as shows in Table 3.10 (Road Research Center, 2017).

Table 4.10. Number of the dead is to Divided of city (Road Research Center, 2017).

Number of dead's	Cities
518	Sarpol-e Zahab
23	Salas-e Babajani
23	Eslamabad-e Gharb
16	Qasr-e Shirin
6	Ezgeleh
586	**TOTAL**

3.11 DAMAGE TO HISTORICAL SITES

Palace Khosro, Four Chapa and Abbasi Caravanserai in the Qasr-e Shirin, Yazdgerd castle in the village of Zarde and Zij Manizhe in the village of Patagh and the Argh Hill in the city of Gilan-e Gharb and temple of Polangard in Eslamabad-e Gharb (Mashregh News, 2018).

3.12 DAMAGE TO INDUSTRIAL STRUCTURES

Sarpol-e Zahab industrial estate, silage damage is almost acceptable but destruction of 100% salon wheat in Qasr-e Shirin flour factory in Sarpol-e Zahab industrial town (Report_Chapter-15_1396-10-05, 2017).

3.13 DAMAGE TO THE ROAD AND BRIDGE

In general, they had a good performance (banafshi, 2017), The roads have a good performance due to their proper width (Raheb, moghatai, Najafi, & Rafiei, 2017) there was not damage of the road a generally.

3.14 DAMAGE TO ALL PLACE NEAR THE EARTHQUAKE

In below there are table of damage of place importance and Infrastructure in near the earthquake as shows Table 3.11 (Road Research Center, 2017).

Table 3.11 Damage to buildings (Road Research Center, 2017).

From the first hours available	Airport
Hospital in llam the damage minor Suffered	Hospitals
Hospital in Sarpol-e Zahab the harm and damage	
Five effect historical, tree in Qasr-e Shirin include of Abbasi Caravanserai, Palace Khosro, Four Chapa and Zij Manizhe in Sarpol-e Zahab and Yazdgerd castle in Dalahu	Places of Cultural
Destroyed a lot of Section of shiravane castle	
Extensive destruction of Maskan-e mehr in Maskan-e mehr Extensive destruction of Maskan-e mehr in Eslamabad-e Gharb	Maskan-e Mehr

CHAPTER 4

4. METHODOLOGY

4.1 MIVES

MIVES (Modelo Integrado de Valor para una Evaluación Sostenible) in Spanish is consisted of a multi-criteria decision-making method (MCDM). There are some indicators in this method, that the related value function for each indicator has been matched. Therefore, this method proceeds with the assessment of the sustainability (Hosseini, Albert de la Fuente, & Oriol Pons, 2016). The MIVES is MCDM based on the use of value functions to assess the satisfaction of the different stakeholders involved in the decision-making process (Oriol, Fuente, & Aguado, 2016). The main initial phases of the MIVES includes a definition of the system boundaries and the decision tree. In the first phase, the temporal axis, the components axis, and the general aspects are determined. In the second phase, all the aspects are organized around the branches of the decision tree.

The first level of the tree contains the most general aspects (requirements) the second level contains the criteria. The third level, the most specific aspects (quantifiable indicators). The definition of the tree also implies setting the value functions to transform the indicators from physical units (kg, hours, $, points,) into value units (from 0 to 1). The weighting and aggregation procedure of the different tree levels. Requirements tree, the construction phase of the decision tree is the most important part of the process. Thus, the coherence, representativeness, and objectivity of the criteria and indicators under consideration will guarantee the goodness and credibility of its results (Fuente, Oriol Pons, & Aguado, 2015) as shown in figure 4.1. This tree has three different hierarchical levels. Part 1 is the economic, environmental and social requirements. Part 2 is the hierarchical level, which has the criteria. Part 3 is the indicators.

MIVES is a methodology that was developed at the beginning of the new Millennium in Barcelona and Basque Country in Spain, in Polytechnic University of Catalonia (UPC) by, Vinolas, Marques, Josa, Aguado, Cortes (2009). According to (Hosseini S. M., 2016) MIVES like other decision-making model has advantages and disadvantages and needs to be modified. Nevertheless, MIVES has selected as the most suitable model, because of positive features. So far, MIVES has already been used for industrial buildings underground infrastructures, hydraulic structures, wind towers, sewage systems, post-disaster sites, and housing selection and construction projects (Oriol, Fuente, & Aguado, 2016).

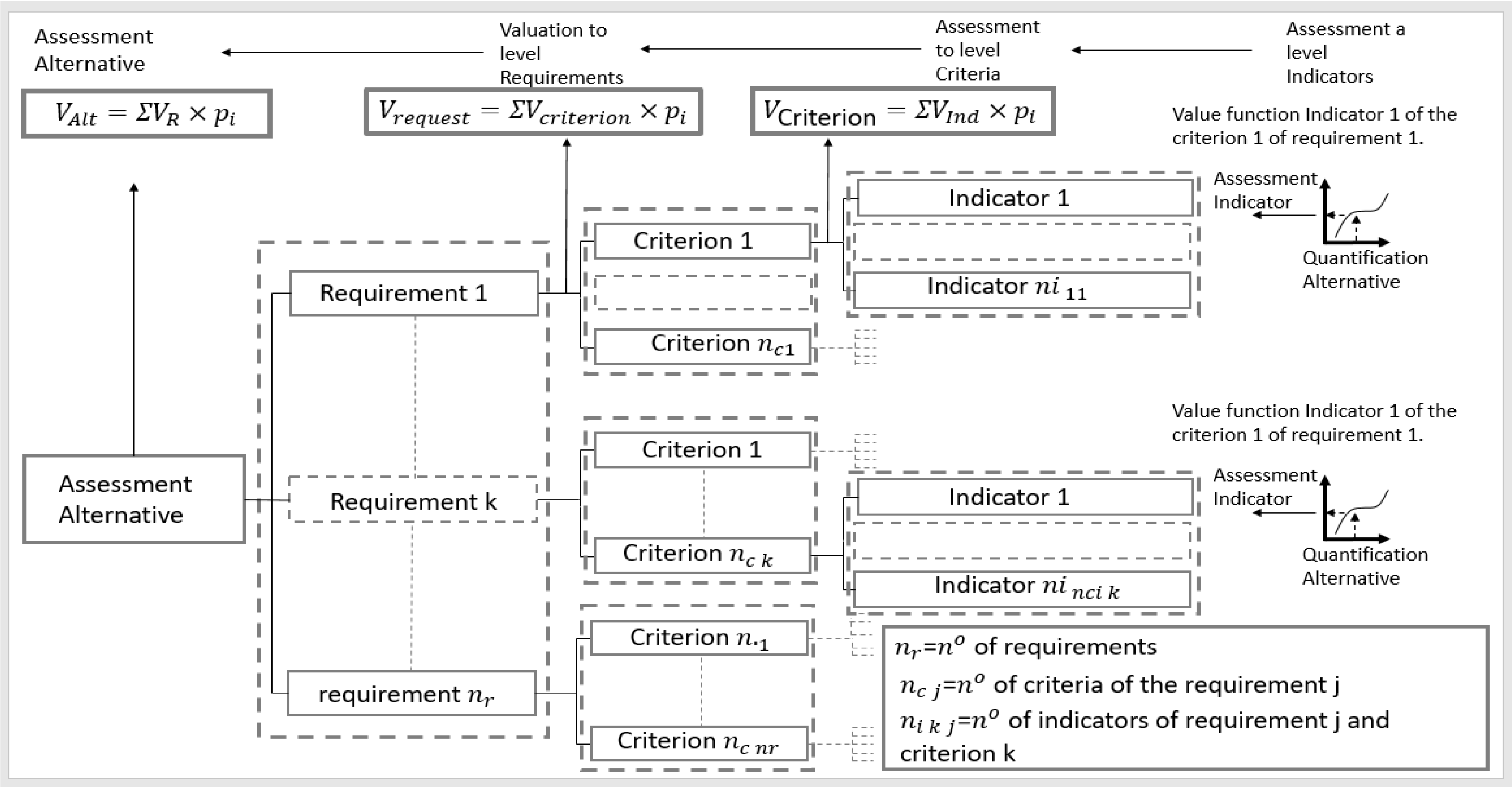


Figure 4.1. Tree of MIVES (Viñolas, Cortés, Marques, Josa, & Aguado, 2009).

4.1.1 WEIGHT ASSIGNMENT

There is weighting of requirements in the decision tree. The weightings assign to the indicators of each criterion. Then the criterion of each requirement is related to three requirements that establish their relative importance. Therefore, these weights determine the assessment of the aspects considered within the system boundaries. Customize the general requirements tree to the specific conditions of the case of study. In this step, the weights of the requirements, criteria, and indicators are assigned by using the analytical hierarchy process (AHP) method (Saaty,1980) it was used to set the weights (Fuente, Oriol Pons, & Aguado, 2015).

Criteria valuation obtained from the valuations of the indicators belonging to that same criterion multiplied by their weights as shown in Eq. 4.1. The requirement is the sum of the valuations of the criteria belonging to that same requirement multiplied by weights as shown in Eq. 4.2. Value index of the alternatives, the evaluation of the alternatives obtained by adding the valuations of the requirements multiplied by weights as shown in Eq. 4.3. In all aspects, the weight of these indicators depends on their importance (Josa, 2012).

$$V_{Criterion} = \sum_{i=1}^{n} V_{indicator} \times \text{Weight}_{indicator}$$

Equation. 4. 1. The formula for Criteria valuation in MIVES.

$$V_{\ Requirement} = \sum_{i=1}^{n} V_{Criterion} \times \text{Weight}_{Criterion}$$

Equation. 4. 2. The formula for requirements valuation in MIVES.

$$V_{\ \text{Alternative}} = \sum_{i=1}^{n} V_{Requirement} \times \text{Weight}_{\ Requirement}$$

Equation. 4. 3. The formula for alternatives valuation in MIVES.

V_{Criterio}: Criteria valuation

$V_{\ \text{Requerimiento}}$: Requirements valuations

$V_{\ \text{Alternativa}}$: Alternatives valuations

4.1.2 FORMULA

The value functions assigned is using the method previously proposed to evaluate the sustainability index (Is) of each alternative solution. The generic form of a value function is as shown in Eq. 4.4. Which allows assessing the sustainability (satisfaction) associated with each indicator (Lind) by transforming the physical units to a dimensionless value between 0 and 1 (Fuente, a, Armengou, & Aguado, 2016). The value function in MIVES is based upon the general exponential. This function permits the simulation of a wide range of responses by properly modifying the constitutive parameters (Hosseini, Albert de la Fuente, & Oriol Pons, 2016).

B is the value of Lind for X_{min} and X_{min} is the minimum abscissa value in the indicator interval assessed. X is the abscissa value for the indicator assessed. Pi is a shape factor which defines whether the curve is concave (Pi < 1), convex (Pi > 1), linear (Pi = 1) or S-shaped (Pi > 1), as shown in figure 4.2. Ci approximates the abscissa at the inflection point. Ki tends towards Lind at the inflection point B. The factor that prevents the function from exceeding the range (0, 1), as shown in Eq. 4.5. X_{max} being the abscissa value of the indicator that gives a response value of (1) for increasing value functions (Fuente, a, Armengou, & Aguado, 2016).

$$V_{ind} = B \cdot \left[1 - e^{-K_i \cdot \left(\frac{|X - X_{min}|}{C_i}\right)^{P_i}}\right]$$

Equation. 4. 4. The formula for valor indicators in MIVES.

$$B = \left[1 - e^{-K_i \cdot \left(\frac{|X_{max} - X_{min}|}{C_i}\right)^{P_i}}\right]^{-1}$$

Equation. 4. 5. The formula for calculating B in MIVES.

Pi: it is a form factor that defines.

Ci: is the approximate value of the abscissa in the point of inflection.

Ki: is the approximate value of the ordinate in the inflection point.

B: is the factor that allows the function to be keep in the value range from (0) to (1).

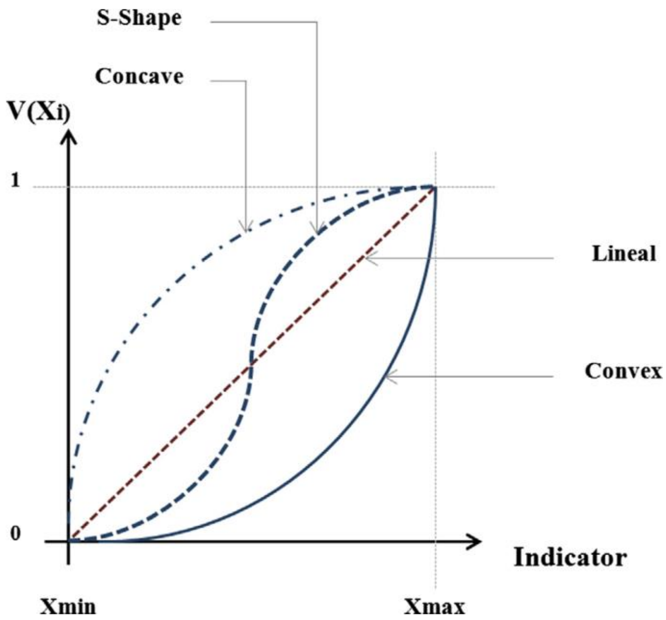


Figure. 4. 2. Possible forms of the value function.

4.1.3 Shape of function

Different models of value function will be shown in this section such as S-shape, convex, concave and linear

4.1.3.1. *Value function in S*

One of the shapes that may appear is a concave-S. When satisfaction increases rapidly or decreases slightly, have this shape. S-shaped functions have a minimum satisfaction that drops to zero for values that are smaller than a defined lower indicator value. The maximum satisfaction that reaches one for values greater than a defined upper indicator value. Increased satisfaction from almost 0 to 1 for values between the defined lower and upper indicator values. This type of conspicuous is contained a combination of concave and convex functions (Hosseini, Albert de la Fuente, & Oriol Pons, 2016).

4.1.3.2 Convex Value Function

While a convex value, function is increasing. The satisfaction (value in ordinates) increases or decreases much more when the increase or decrease of the indicator variable is closer to the values. In the case of decreasing value function just the opposite happens, satisfaction increases or decreases much more when the decrease or increase of the variable of the indicator is closer to the values (MANUAL MIVES, 2009).

4.1.3.3 Concave Value Function

That a function of concave value increases and decreases respectively. For increasing value functions, satisfaction (value in ordinates) increases or decreases much more. When the increase or decrease of the indicator variable is closer to the values in the case of a decreasing value function the opposite happens, satisfaction increases or decreases much more when the decrease or increase of the indicator variable is closer to the values (MANUAL MIVES, 2009).

4.1.3.4 Linear value function

In this type of function, there is a function of increasing and decreasing linear value respectively. So when there is an increase or decrease in the indicator variable, the satisfaction of the decision-maker increases or decreases equally regardless of the point (MANUAL MIVES, 2009).

CHAPTER 5

5. THE METHODOLOGY USED IN THIS CASE STUDY

5.2 THE METHODOLOGY USED IN THIS CASE STUDY

The methodology used in this study is included in the decision made here to create. The requirements, criteria, indicators, and weights that make up the Temporary Housing sustainability assessment method described, with applied MIVES.

The life cycle of a (TH) conditioned by, (1) choose of that (2) it is manufacture (3) the utilization of that; (4) it is deconstruction. There is an example of the decision-making tree with all the value functions and the allocation of weights, the next step is to define it as shown in table 5.1. This case study is in place Sarpol-e zahab of Kermanshah in Iran. The case study in part of requirements has chosen (3) parts.

R1, economic. R2, social. R3, environmental. Then in the second part, have (5) criteria. In part of economic is C1, land cost. C2, construction cost. In addition, in part of social are C3, access. C4, hazardous zone. The final part in environmental is C5, pollution. In addition, in the last part of (13) indicators there. Will weigh it after choosing the tree as shown in table 5.2.

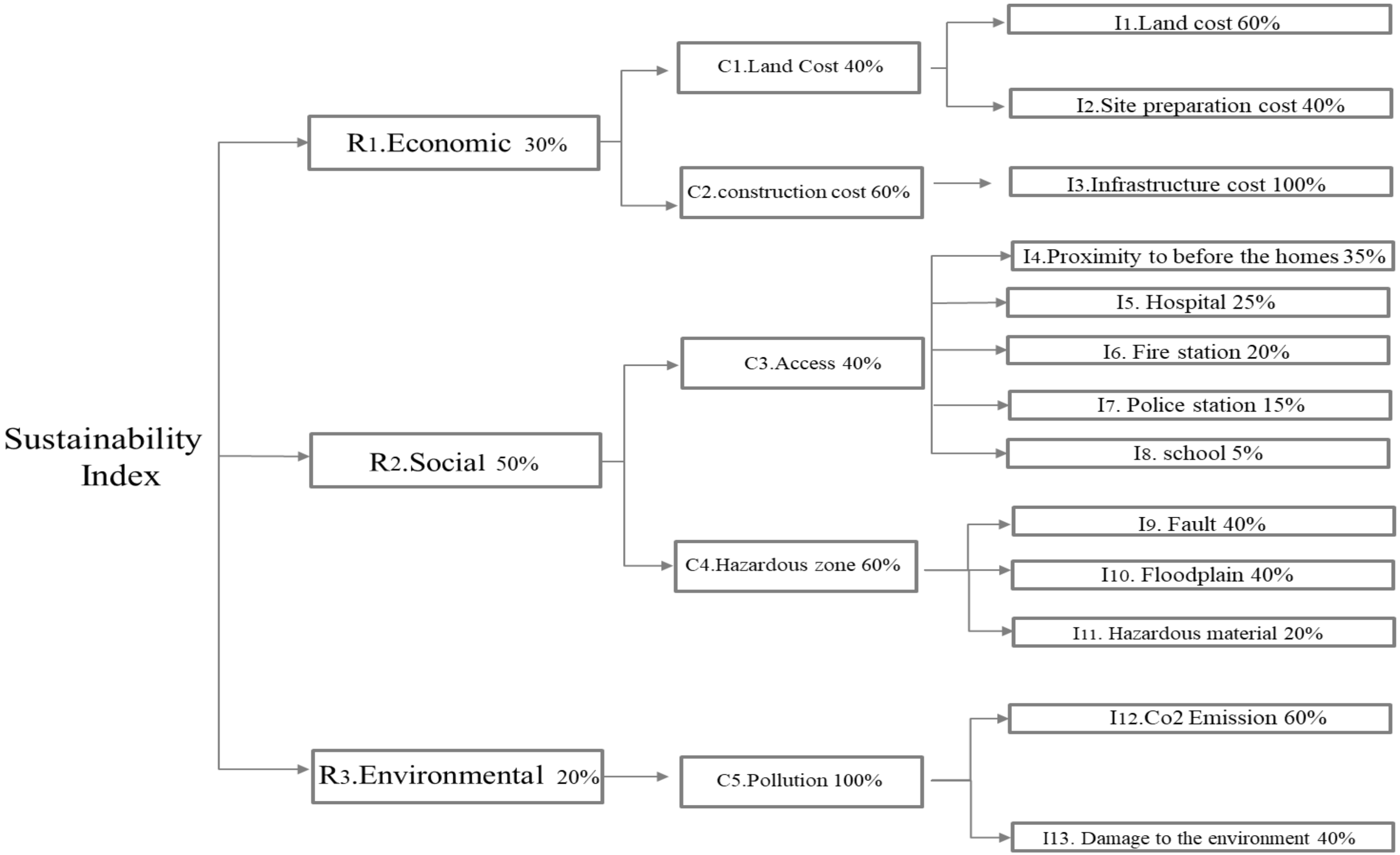


Table 5.1. Sustainability Indexes in this case study for choose temporary housing in Sar-e pol zahab.

Table 5.2. Weighting table.

Requirement	Criteria	indicators	Unit
		I_1.Land cost (60%)	IRR/m^2
	C_1.Land Cost (40%)		
		I_2.CostPreparation (40%)	IRR/m^2
R_1.Economic (30%)			
	C_2.constructioncost (60%)	I_3.Infrastructure cost (100%)	APS
		I_4.proximity to before the house (35%)	KM
		I_5.Distance from Hospital (25%)	KM
		I_6.Distance from Fire station (20%)	KM
		I_7.Distance from Police station (15%)	KM
	C_3.Access (40%)	I_8.Distance from School (5%)	KM
R_2.Social (50%)			
		I_9.Distance from Fault (40%)	KM
		I_{10}.Distance from Floodplain (40%)	KM
	C_4.Hazardous zone (60%)	I_{11}.Distance from Hazardous material (20%)	KM
R_3.Environmental (20%)			
	C_5.Pollution (100%)	I_{12}. Co2 Emission (60%)	KM
		I_{13}. Damage to the environment (40%)	APS

5.2.1 EXPLAIN TO EACH INDICATORS

In this part to explain how each indicators will be given weight. Moreover the measurement of indicators is also in the text below mentioned and it's necessary to know how many valor of each indicators are accepting because, should choose all indicators and have the ability to measure. Here are some indicators affect the sustainability and can give valor, moreover we can measure them. According to (Hosseini S. M., 2016) these indicators are police, hospitals, and fire services of the demanded areas) impacts on host community are assessed.

5.2.1.1 I_1: Land cost

One of the effective fix valor is the land cost, although it is included to two types. Respectively land ownership and land rent, should to spend money for taking land in each way. To take the land, the cost is calculating per square meter (cost=m^2). Also, price each squares meters depends on the space and location of its placement. Moreover, consider that land selection for the project site should protect agricultural land and natural resources. The value of the land after demolition for re-development (Li-Yin Shen, 2010).

X_{max} is 35000000 and X_{min} is 8000000 if we choose land in X_{min}, will have a lot satisfaction also can chose in middle price that is acceptable but when it passes X_{max}, it is not affordable and economic. Because government often should spend a lot of money to repair and reconstruct the buildings and does not like spending more money.

As far as described the land price depends on location and the area of the land. Value function from land price is always decreasing and it is concave. For obtaining the price of land in Sarpol-e zahab, have interviewed somebody were in there.

5.2.1.1. Land cost of Sarpol-e zahab

In below as shown in table 5.3, land cost of Sar-e pol zahab (Statistical Center of Iran, 2016) .

Table 5.3. Land cost of Sarpol-e zahab (Statistical Center of Iran, 2016).

Land cost of Sarpol-e Zahab	Price
35000000 IRR	0.0025
8000000 IRR	0.004
21500000 IRR	0.0055

5.2.1.2 I_2: Cost of preparation

The prerequisite of the construction is the cost of preparing. According to (Hosseini S. M., 2016) assesses the amount of costs required during the site preparation process. Minimum investment for preparation activities is related to the features of the site below consist of dismount bushes and drainage of the land, and implementation of land slop, type of soil etc. the cost of preparation can be obtained with cubic meters, (cost=m^2). In Iran, each type of instruction work has its own price, and there is a price list for instructional work. These prices review and rewrite every year. For example, price for dismount bushes in each square meter in ground is 215 IRR with code 010101 in list price (Organization, 2018). Pay attention to economics, durability and availability for material selection (Li-Yin Shen, 2010).

Note that the value function from the cost of preparation is as the same as the value function from land cost. In the part of economic value function is decreasing but in cost of preparation depend of land sometime there are in land with the least expenditures. Sometime there are land with much expenditures. X_{max} 321015 IRR and X_{min} 0 IRR will have value function with slope slowly and no accept valor when pass of X_{max} also when X 160508 IRR is almost middle valor of cost preparation. As shown in table 5.4. Almost cost preparation in around of Sarpol-e zahab (Organization, 2018).

Table 5.4. Cost preparation of sarpol-e zahab (Organization, 2018).

Subject	Code	Price
shrub exhume	010101	215 IRR (m^2)
Excavation and Embankment	020501	5300 IRR (m^2)
Stone crushing with rubble stone	040103	315500IRR (m^3)
Total price	**-**	**321015 IRR**

5.2.1.3 I_3: Cost of Infrastructure

No matter where has been chosen for construction, the Implementing of the infrastructure is fundamental and essential. The structure will be put for example establishment sewerage and excavation pit latrines as well as landfill, should to spend more expenses later. Therefore the use of infrastructure before constructing the building shouldn't be omitted to avoid extra expenses later. According to (Hosseini, Albert de la Fuente, & Oriol Pons, 2016) the selected site may be located in an area where urban amenities (water and wastewater, cable, gas pipe, etc.) damaged, by natural destruction, prevent the selection of a site in that area. Infrastructure is per square meter (cost=m^2). According to (Li-Yin Shen, 2010) the project should serve both the local economy and the local economy's infrastructure to generate economic benefits.

The part of economic value function is increasing, in cost of infrastructure depends on the distance of equipment and facilities, if near of each both, can spend less.

The value function of cost infrastructure, in the part economic is always great choose because of low price. Also in part of infrastructure is expensive for constriction. For the indicator have chosen methodology (Assign point System) in below there is table 5.5 for valor.

Table 5.5. Valor with (Assign point System).

Excellent	Good	Average	Not bad	Bad
1	0.75	0.5	0.25	0

5.2.1.4 I_4: Proximity to before the homes

According to experience, collections of the temporary housing are foreseen in different parts of the city, near the living place of the injury. Thus, most of people like existing the new sit for temporary housing near their destroyed house. Obviously, their houses are without doors and walls; they do not feel safety and security. Moreover, their home is always stolen, therefore they would like to be closer to their home in order to protect and secure themselves.

In this case, studies show there were many houses that were faced with this problem many times. Recent example of this reaction can be found after the earthquake of 1382 Bam, Pointed out that despite the allocation of a large number of emergency tents in the lands around the city. Finally, people had their emergency and temporary housing near their destroyed houses. They only built that group of homeless people went to camps before the earthquake was a tenant and not a civilian (Nezhad, 2010). In this section, the acceptable distance is between 0.05 and 1 Kilometers (Nojavan, Omidvar, & Salehi, 2011) .

5.2.1.5 I_5: Distains from hospital

Another main issue when a disaster happens is carrying injuries to the hospital. As the losses, injuries and fatalities are numerous after earthquake so the distance from the hospital and the temporary housing site is really important.

Because after earthquake will have a lot injury, will need the health service if we have distance far from a hospital. Need spending too much for reaching injuries to a hospital. In addition, there is gold time for reaching the Heart patient to the hospital in which there is the time for an ambulance to reach to a clinic. In Iran is an average of 8 minutes and 49 seconds, (Kolivand, 2017). Furthermore, the most desirable distance from the small clinics and clinics is 0.7 kilometers and from the hospitals is 1.5 kilometers (Roshti, Jalili, & Zolfi, 2012). Emphasizing on site hygiene, and the provision of health care and safety (Li-Yin Shen, 2010).

X_{max} is 3.4 KM and X_{min} is 0.3 KM m and Ci 1.30 KM, in this part its good value function of decreasing & S shape. Because its acceptor until 1.5 KM when passes of 1.5 KM is very dangerous and takes a lot of time.

5.2.1.6 I_6: Distance from fire station

The proximity of fire station to temporary housing in the earthquake is one of the strengths of temporary housing planning. According to the standards, the best distance from fire stations is about 1 kilometer. A fire truck can travel directly to within 5 minutes of a maximum distance of 2.9 kilometers. Of course, the time of preparation and movement of cars, which is between 1 and 2 minutes, is not included in this time (Roshti, Jalili, & Zolfi, 2012) .

In this part is value function decreasing and when distance is in 0 KM, shape will have the best satisfaction then the best distance is up to 1 km. If the distance passes 1km, we will have low satisfaction.

5.2.1.7 I_7: Distance from police station

After the earthquake happened, there are a lot of people who have vulnerable body and mentality. In this situation, it is necessary to have an organization to support people and bring them security. Because their houses are not safe and they do not have windows, doors and walls.

In this part, its distance is not far or near. It is in the middle distance. In the case of police stations, the best distance in terms of pedestrian access during the crisis is 0.4 km. About the barracks, according to their distribution in the city is 2 km (Roshti, Jalili, & Zolfi, 2012). The assessment should be to identify future safety risks to people and project users. Various measures to protect the site's safety (Li-Yin Shen, 2010). Have chosen value function of decreasing and S shape. In this part, its good function of decreasing and S shape. Because in this case maybe will be police station in each sit. When there are police station in sit took distance 0 m and there is satisfaction in best mode. Until 0.4 KM is, accept then if pass of 2 KM never is not accept because in this zone, there is not security. In below there is map of density of crime of Sarpol-e Zahab depend a place of city as shown in figure 5.1 (Zade, Asadi, & Saraei, 2017).

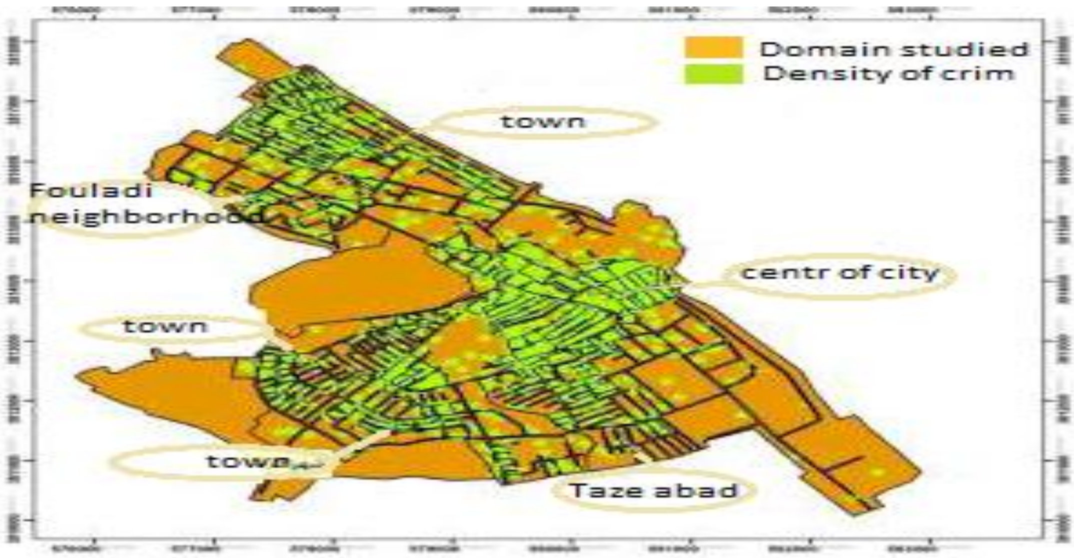


Figure. 5.1. Density of crime in Sarpol-e zahab (Zade, Asadi, & Saraei, 2017).

5.2.1.8 I_8: Distance from school

In this case, study had a few damage of the school. Tow week after the earthquake and then primer service to homeless and injury, will Conditions normal of place. Children need to education because with this work can help and motivation to they again. For to have Conditions normal of life moreover they need to learn and education. According to (Roshti, Jalili, & Zolfi, 2012) for ease of movement and for the continued motivation of education and education for children. Adolescents should locate the affected area in such a way as to minimize the distance of primary education schools. In accordance with urban planning criteria that have a functional radius, the Centers considered to 0.5 kilometers. In times of crisis, due to the importance of the initial education, 0.7 accesses of children and adolescents to such centers seems such a reasonable distance. Providing amenities to synchronize new town and local communities (Li-Yin Shen, 2010).

5.2.1.9 I_9: Distance from fault

Distance from the fault is another factor that have chosen this indicator. Because after 1 year again occurred the earthquake in Kermanshah and its normal after each earthquake to happen again, aftershocks or again happen new earthquake. That is why should choose the site far distance from the fault moreover could give value an indictor kilometer or danger of fault. The distance from the fault is well over 0.1 kilometers and acceptable (Nojavan, Omidvar, & Salehi, 2011).

The 100% value function of part distance from fault is increasing & S shape. The reason for choosing this shape. For example in this case study happened center of earthquake in ezgle but there are a lot of damage in Sarpol-e zahab, center of earthquake from Sarpol-e zahab is almost far. In below as shown in figure 5.2 is Fault of the city Sarpol-e zahab (Institute of Geophysics, 2019). Other figure for fault near of city Sarpol-e zahab (Zare, Kamranzad, Parcharidis, & Tsironi, 2019).

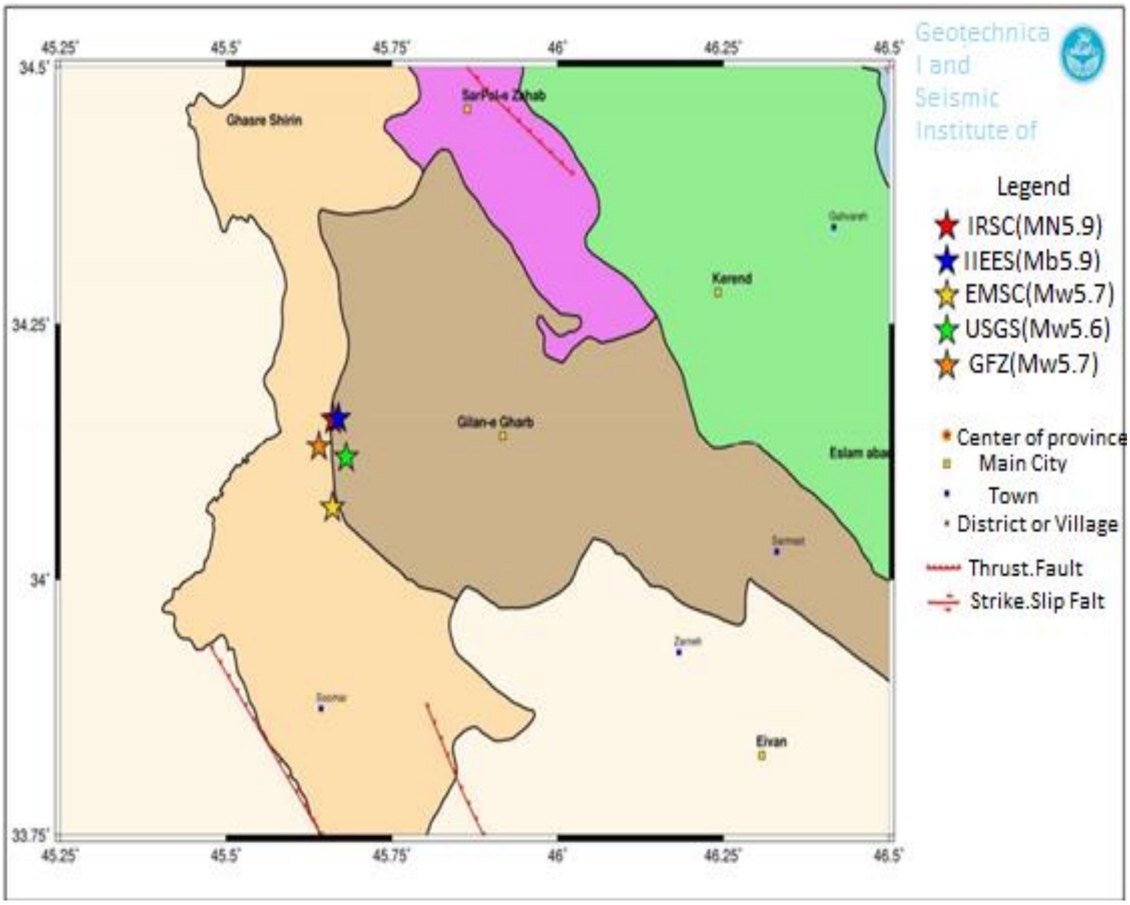


Figure.5. 2. Fault of city Sarpol-e zahab (Institute of Geophysics, 2019).

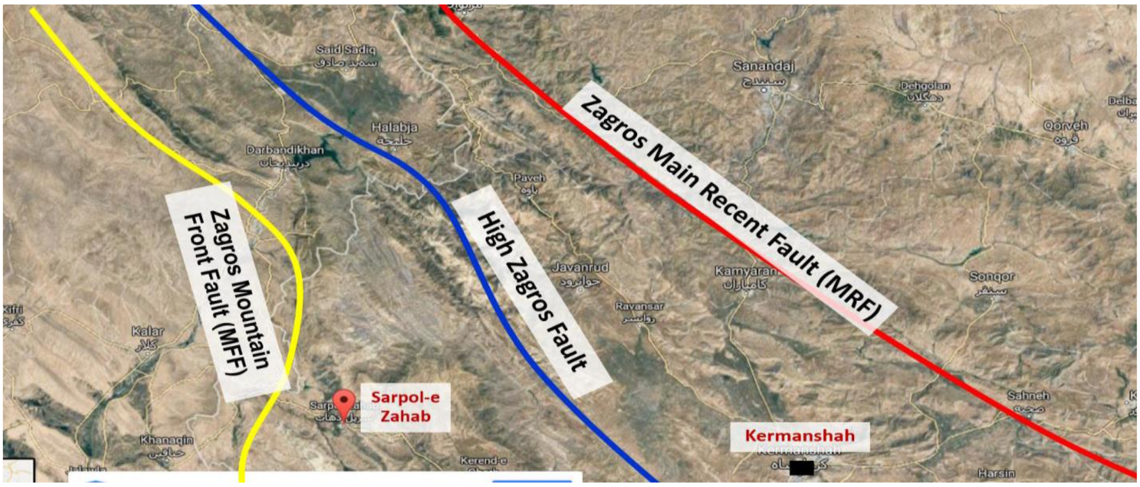


Figure. 5. 3. Location of different faults in the Zagros Mountains near the affected area of the earthquake (Zare, Kamranzad, Parcharidis, & Tsironi, 2019).

5.2.1.10 I_{10}: Distance from floodplain

When the earthquake happens, there are a lot of parts getting under water if they are not far away the floodplain. This reason makes us to consider it as an important factor. Thus, have to obey the limitations.

In our case study, there is one river in the center of city and the possibility of flood is a lot. So the limitation from the riverside plain is a width of two to 0.02 kilometers in width on both sides of the river basin, is consider for full access to the riverbed (Rahimi, 2019) . Investigation of the potential environmental risks and benefits associated with the proposed project (Li-Yin Shen, 2010).

5.2.1.11 I_{11}:Distance from hazardous material

In issue, there is hazardous material in hospital or factory and gas station. When the earthquake happens then it damages those places in the factory, hospital and gas stations. Obviously hazardous materials are moving and causing all types of pollination consisting of air, water, earth, etc. for example in the gas station may have the explosion. It means the logical distance from hazardous materials should be kept because of the health of citizens. Temporary locations should be at least 0.2 kilometers (Nojavan, Omidvar, & Salehi, 2011). Adequate demolition plan on hazard materials and waste reduction or recycle (Li-Yin Shen, 2010).

5.2.1.12 I_{12}: CO_2 emissions

According to (Fuente, Oriol Pons, & Aguado, 2015) as far as science proved, the reduction of CO_2 brings about a lot of problems such as hot climate and melting ice which it itself brings the water higher and higher.

The goal of the benchmarks is to minimize the amount of consumption. According to (Hosseini, Albert de la Fuente, & Oriol Pons, 2016) CO_2 emissions are based on two aspects (1) preparation activities for each site during construction phase and (2) the transportation required for each site during the construction and demolition phase. Amount of CO_2 emissions due to preparation activities is not considered. Therefore, only the CO_2 emissions from transportation for each alternative assessed. The indicator for take valor is kilometer and for measure is X_{max} 27 km and X_{min} 0 km. Reducing the release of chlorofluorocarbons and hydro-chlorofluorocarbons thus protecting the ozone layer (Li-Yin Shen, 2010). Building construction results in high-energy consumption and CO_2 emissions during construction, use and degradation. Therefore, indicators should estimate to assess the impact of the temporary housing on the environment in terms of CO_2 emissions and energy consumption (Hosseini, Albert de la Fuente, & Oriol Pons, 2016).

5.2.1.13 I_{13}: Damage to the environment

In this indicator, some of temporary housings are directly damaging the environment for example site 7 there was on the lawn moreover the site 18 there was in the park. These two sites have a lot of damages to the environment. So choose this indicator for measuring, use with methodology assign point system there are in below as shown in table 5.6.

Table 5.6. Valor with (Assign point System).

Excellent	Good	Average	Not bad	Bad
1	0.75	0.5	0.25	0

After choose tree of MIVES, In addition, are indicators as shown in table 5.7, there are total indicators and mention reference.

Table 5.7. Index *sustainability* and factors.

	Factors	Reference
Economic	❖ Land of cost ❖ Cost of preparation of the Sit ❖ Cost Infrastructure of the Sit	(Nojavan, Omidvar, & Salehi, 2011) (Nojavan, Omidvar, & Salehi, 2011) (Nojavan, Omidvar, & Salehi, 2011)
Social	❖ Proximity to before the homes ❖ Distance from Hospital ❖ Distance from Fire station ❖ Distance from Police station ❖ Distance from School ❖ Distance from Fault ❖ Distance from Floodplain ❖ Distance from Hazardous material	(Najaran & Khoram, 2015) (Nojavan, Omidvar, & Salehi, 2011) (Roshti, Jalili, & Zolfi, 2012) (Roshti, Jalili, & Zolfi, 2012) (Roshti, Jalili, & Zolfi, 2012) (Nojavan, Omidvar, & Salehi, 2011) (Raheb, moghatai, Najafi, & Rafiei, 2017) (Roshti, Jalili, & Zolfi, 2012)
Environmental	❖ CO_2 Emission ❖ Damage to the environment	(Hosseini, Albert de la Fuente, & Oriol Pons, Multicriteria Decision-Making Method for Sustainable, 2016)

Below is a table, which shows the units of measurement of each indicator. Also, graph the shape of each index. Furthermore, there are the X_{MAX}, X_{MIN} of each index, as shown in table 5.8.

Table 5.8. Value function parameters for each indicator.

Indicator	**Unit**	**X_{max}**	**X_{min}**	**C**	**K**	**P**	**Shape**	**Ref.**
I_1. Land cost	IRR/m2	30000000	8000000	18000000	0.4	1.5	DC_V	(Statistical Center of Iran, 2016)
I_2. Cost preparation	IRR/m3	321015	0	160507	0.2	1.20	DC_V	(Organization, 2018)
I_3. Cost infrastructure I_4: Proximity to before the homes	APS KM	1 1	0 0	0.5 0.5	0.1 0.4	1.2 1.4	IC_V DS	(Organization, 2018) (Nojavan, Omidvar, & Salehi, 2011)
I_5. Hospital	KM	3.4	0.3	1.3	0.08	3	DS	(Roshti, Jalili, & Zolfi, 2012)
I_6. Fire station	KM	3.7	0.9	0.95	0.01	3	DC_V	(Roshti, Jalili, & Zolfi, 2012)
I_7. Police station	KM	3.4	0.4	1.3	0.2	3.20	DS	(Roshti, Jalili, & Zolfi, 2012)
I_8. School	KM	1	0	0.50	2.5	1	DC_X	(Roshti, Jalili, & Zolfi, 2012)
I_9. Fault	KM	2.9	0	1	0.8	2.2	IS	(Nojavan, Omidvar, & Salehi, 2011)
I_{10}. Floodplain	KM	2	0	0.9	2.8	0.99	IC_X	(Rahimi, 2019)
I_{11}. Hazardous material	KM	1.5	0	1.4	3	0.99	IC_X	(Nojavan, Omidvar, & Salehi, 2011)
I_{12}. CO_2 emission I_{13}.Damage to the environment	Km APS	3.6 1	0 0	1.75 0.5	0.1 1	2 1	DC_V IC_X	(Hosseini, Albert de la Fuente, & Oriol Pons, 2016)

Decrease concavely (DC_v), decrease convexly (DC_x), decrease linearly (DL) or have other shape

This table is all result of this case study, shown result each of criteria, requirement and total sustainability, as shown in table 5.9.

5.3 RESULT

Table 5.9. Table of all result of this case study.

Sites	Site5	Site7	Site12	Site18	Site27	Site32	Site41	Site43
Vc_1	0,5543	0,9373	0,6038	0,4752	0,7066	0,6437	0,4219	0,3808
Vc_2	0	0.4356	0.4356	0.1896	0.1896	0.7083	1	0.4356
Vc_3	0,5807	0,7072	0,7291	0,8107	0,6260	0,7405	0,6966	0,2860
Vc_4	0,3714	0,4238	0,3787	0,4069	0,8670	0,5462	0,9372	0,8196
Vc_5	0,2810	0,0101	0,3200	0,1060	0,2560	0,4015	0,6190	0,7828
Sites	Site5	Site7	Site12	Site18	Site27	Site32	Site41	Site43
VR_1	0,2217	0,6363	0,5029	0,3038	0,3964	0,6825	0,7688	0,4137
VR_2	0,4551	0,5372	0,5189	0,5684	0,7706	0,6239	0,8410	0,6062
VR_3	0,2810	0,0101	0,3200	0,1060	0,2560	0,4015	0,6190	0,7828
Sites	Site5	Site7	Site12	Site18	Site27	Site32	Site41	Site43
VS_I	**0,3503**	**0,4615**	**0,4743**	**0,3966**	**0,5554**	**0,5970**	**0,7749**	**0,5837**

5.3.1 MAIN RESULT

Main result, according to in the table above site number 41 was the most stable site selected, shown with green color in the table. Moreover, the most unstable site is 5 shown with red color

5.3.2 THE SUBSET OF THE RESULT

- Sites with numbers 41, 32, 43 respectively are first to third. Sites one and two are located inside the city. However, site number three is outside the city and this indicates that the city sites are performing better.
- The best category is the social part, because you will have the most impact on the process for the best site.
- In the section, the economic is the best site number 41, as well as is the most bad site number 5.

- In the section, the social is the best site number 41, as well as is the most bad site number 5.
- In the section, the environmental is the best site number 43, as well as is the most bad site number 7.

CHAPTER 6

6. CONCLUSIONS

6.1 GENERAL CONCLUSIONS

This master thesis presents a new model for selecting site location of temporary housing based on sustainability index using MIVES. This model enables decision-makers to increase social aspect of site locations and to minimize economic and environmental impacts of alternative sites. This model is applied especially for the Sarpol-e zahab case. However, this model could be an appropriate tool for selecting site locations of post-disaster housing of other cases. For this purpose, some indicators and their weights should be adjusted to the specifications and requirements of the new case. Additionally, the majority of indicators of this model can be applied for selecting site locations of other public functions, such as public facilities, educational services, health services, and more. Nevertheless, the model should be developed based on each specific case, as it carried out in this research study. Furthermore, this model assists decision makers to identify the weaknesses of a particular site and then overcome these weaknesses.

From (43) sites of post-disaster temporary housing in the Sarpol-e zahab, 8 site have been assessed by the new designed model. These eight sites have been selected based on the seven categorization of all 43 sites., These sites have been categorized based on distance to floodplains and faults, type of soil, residential areas, and locating inside or outside of the city.

It should be noted, temporary shelter plays an important role in restoring the interrupted process of normal life in the economic and social context.

6.2 SPECIFIC CONCLUSIONS

1. The results of the model demonstrate that sites, which are located close to floodplain and faults obtain lower sustainability indexes.
2. The second one is careful selection of sites in places with poor soil, which has considerable economic, environmental, and social negative impacts.
3. Site locations of post-disaster temporary housing that are located close to the city center and inside city have higher sustainability indexes.

- The most important issue in site selection is selection of appropriate criteria for location. Currently, unfortunately temporary housing is only available on a limited of criteria. They are include land ownership and land per capita. That usually ends with wasteland choice of land.
- Considering indicators of this model shows that, there is a robust correlations between site location process of post-disaster temporary housing and reconstruction program.
- As it is required to apply the new designed model or other same models, which are based on several input data, the city's geographic information and layers should be at the municipal crisis management center. Additionally, the government should make the necessary plans for resettlement of the affected area beforehand.
- Sites are spread out in the city obtain higher social values. However, these sites have lower economic and environmental satisfactions values.
- This model is very applicable in some cases. From there, several combinations of potential sites emerge with associated sustainability.
- Sites, which had other functions before selecting, do not need to be prepared. These sites lead to minimum economic and environmental impacts and short delivery times that could conclude to higher social satisfaction value.
- Having highly disaster resistant public buildings, such as hospital and schools, are spread out in the city could increase sustainability index considerably.

6.4 FUTURE PERSPECTIVES

The covers a specific part of post-disaster TH management. There is no doubt that the results of this study can be used to improve the site location sustainability. Despite the previously reported achievement, several issues regarding this master's thesis have yet to be discovered. Although the model presented here reports the exact results, future research should continue to validate it. The information obtained could be the basis for further research in this area. Do elsewhere and in other countries.

In the area of temporary housing management both in terms of sustainability and decision-making, very good progress has been made. However, there are still many aspects that need to be covered in future research lines. For instance, the weighting of indicators has considerable impacts on sustainability indexes of alternatives. In this regard, the weight assigned by different techniques need to be applied for achieving more accurate results. Additionally, it is required to find an approach for considering all stakeholders' concerns about index priorities with the involvement of all experts in the process.

REFERENCES

[1] Abulnour, A. H. (2013, june 04). The post-disaster temporary dwelling: Fundamentals. *Production and hosting by Elsevier*, 1-2. doi:http://dx.doi.org/10.1016/j.hbrcj.2013.06.001

[2] Asefi, M., & Fakhri, S. (2016, February 21). Evaluation of temporary post-earthquake resettlement and its quality improvement strategies tailored to the needs of the affected. pp. 55-88. Retrieved 08 24, 2019

[3] Babak Omidvar, M. B.-S. (2013). Temporary site selection and decisionmaking. pp. 536-537. doi:doi:10.1111/disa.12007

[4] Babakhani, N., & Molavi, A. (2018). *Kermanshah earthquake problems in the aftermath of rain persistence.* TEHRAN. Retrieved 05 12, 2019, from http://www.irna.ir/kermanshah/fa/News/82834529

[5] Baitullah, D. A. (2018, November 13). Retrieved 06 18, 2019, from https://www.mrud.ir

[6] banafshi, M. b. (2017, 12 26). Retrieved from http://www.iiees.ac.ir

[7] Behloli, A. (2017, 11 16). Kermanshah, Sarpol-e Zahab earthquake analysis and analysis article. Retrieved 06 17, 2019, from http://www.arbcrete.com

[8] Bitolahi, D. B. (2019, 03 13). *Research Center for Roads, Housing and urbanism.* Retrieved from https://www.bhrc.ac.ir

[9] Center, I. o. (2017, november 13). More than 3.7 earthquake reports from Kermanshah. p. 5. Retrieved 06 28, 2019, from https://ut.ac.ir/file/download/news/1510651899-report-1-1-2-.pdf

[10] Dr, & Beitolahi, A. (2017). *Management of the earthquake crisis in Kermanshah-Sar-e-Pol Zahab.* Retrieved 04 07, 2019

[11] Forghani, M. A., & Darbandi, S. (2015, MAY 10). Evaluation of Factors Affecting Temporary Post-Earthquake Settlement Selection Using GIS and AHP Techniques. *Rescue Scientific Journal, Seventh Year, Issue*, p. 54. Retrieved 08 27, 2019

[12] Fuente, A. d., a, A. B., Armengou, J., & Aguado, A. (2016, october 19). Sustainability based-approach to determine the concrete type and. *Tunnelling and Underground Space Technology*, 1. Retrieved 06 23, 2019, from www.elsevier.com/ locate/tust

[13] Fuente, A. d., Armengou, J., Pons, O., & Aguado, A. (2016, jun 23). Multi-criteria decision-making model for assessing. 1. Retrieved 06 23, 2019, from http://dx.doi.org/10.3846/13923730.2015.1023347

[14] Fuente, A. d., Oriol Pons, A. J., & Aguado, A. (2015, july 1). Multi-Criteria Decision Making in the sustainability assessment of. *Journal of Cleaner Production*, 4. Retrieved 05 12, 2019, from www.elsevier.com/ locate/jclepro

[15] Haghshenas, A. (2017, december 12). *Evening of Iran.* Retrieved 06 17, 2019, from https://www.asriran.com

[16] Haghshenas, E., ashayeri, i., mosavi, s. m., & biglari, m. (2017). *Earthquake report 12/ NOVEMBER /2017*. TEHRAN: International Institute of Seismology and Earthquake Engineering. Retrieved 06 19, 2019, from http://www.iiees.ac.ir

[17] Hamshahri. (2017). *Announcement of details of temporary settlement of earthquake victims in Kermanshah.* tehran. Retrieved 05 12, 2019, from http://www.hamshahrionline.ir/news/

[18] Hosseini, S. A., Fuentea, A. d., & Pons, O. (2015, 09 25). Multi-criteria decision-making method for assessing thesustainability of post-disaster temporary housing units technologies:A case study in Bam, 2003. *Sustainable Cities and Society*, 1. Retrieved 06 23, 2019, from www.elsevier.com/locate/scs

[19] Hosseini, S. A., Ponsb, O., & Fuentea, A. d. (2017, 10 13). A combination of the Knapsack algorithm and MIVES for choosing optimal. *International Journal of Disaster Risk Reduction*, 1. Retrieved 06 22, 2019, from www.elsevier.com/locate/ijdrr

[20] Hosseini, S. M. (2016, 09 1). Sustainability in the Post-Disaster Temporary Housing Management for Urban Areas. Retrieved 05 06, 2019

[21] Hosseini, S. M., Albert de la Fuente, P., & and Oriol Pons, P. (2016, August 07). Multicriteria Decision-Making Method for Sustainable. pp. 1-2. doi:10.1061/(ASCE)CO.1943-7862.0001137.

[22] Hosseini, S. M., Albert de la Fuente, P., & Oriol Pons, P. (2016, 1 1). Multicriteria Decision-Making Method for Sustainable. p. 2. Retrieved 04 28, 2019

[23] Housing Foundation of I.R.Iran. (2017, NOV 23). *Islamic Revolution Housing Foundation*. Retrieved 03 22, 2019, from http://www.bonyadmaskan.ir/Pages/Home.aspx

[24] ICSMM, M. I. (2009). B. Viñolas, F. Cortés2, A. Marques3, A. Josa4, A. Aguado5. Retrieved 06 13, 2019

[25] Institute of Geophysics National Seismic Center. (2017). *Earthquake Report 7.3 Richter from Kermanshah Flock.* tehran: University of Tehran. Retrieved 08 27, 2019

[26] Institute of Geophysics, S. S. (2019). *Earthquake report 5/9 of gilane garb in kermansha.* Tehran. Retrieved 05 26, 2019, from http://irsc.ut.ac.ir/reports/GilaneGharb5.9.pdf

[27] Josa, A. (2012). *Introduction to MIVESI multicriteria multicriteria analysis.* bilbao. Retrieved 05 05, 2019, from https://www.tecnalia.com/images/stories/Noticias/1_Introducion_a_MIVES_AlejandroJosa.pdf

[28] Kalantari, S. a. (2017, 12 26). Retrieved from http://www.iiees.ac.ir

[29] Khorma, M., Najaran, M. T., & Naeini, H. S. (2014, August 27). Skills of Designing the temporary housing with approach of earthquake Case study Khorasan Razavi. *Research Journal of Iranian Association of Architecture and Urban Planning*, pp. 95-106. Retrieved 08 25, 2019

[30] khorshidiyan, A. m. (2006, March 21). Post-traumatic temporary shelter; review of supply policies. p. 1. Retrieved 07 19, 2019, from :/Users/caminstech/Downloads/20352-45167-1-SM.pdf

[31] Kiyani. (2017, NOVEMBER 20). *GEONEWS*. Retrieved 05 21, 2019, from http://geonews.blogfa.com/post/526

[32] Kiyani, B. H., Farshchi, H., & Kykhosro, B. (2017, 12 26). Retrieved from http://www.iiees.ac.ir

[33] Kolivand. (2017, agust 02). *Young Journalist Club*. Retrieved 05 28, 2019, from https://www.yjc.ir

[34] Li-Yin Shen, J. L.-Y. (2010, october 14). A checklist for assessing sustainability. *Journal of Civil Engineering and Management*, 4. Retrieved 06 04, 2019, from https://doi.org/10.1080/13923730.2007.9636447

[35] Lombera, J. -T.-J., & Aprea, I. G. (2009, aguste 8). A system approach to the environmental analysis of industrial buildings. *Building and Environment*, 675. Retrieved 05 12, 2019, from www.elsevier.com/locate/buildenv

[36] Majidi, s. (2018, 1). MASHHAD. Retrieved from Investigating the Importance of Urban Structures in Earthquake in 2017 november 12 in the sare pole zahab

[37] Mansori, k. a. (2017, 12 26). Retrieved from http://www.iiees.ac.ir

[38] (2009). *MANUAL MIVES*. Retrieved 05 06, 2019, from https://deca.upc.edu/es/proyectos/mives/ficheros/aplicacion-v1/mivesmanual.pdf

[39] Mashregh News. (2018, April 30). *Mashregh*. Retrieved 03 23, 2019, from https://www.mashreghnews.ir

[40] MASHREGH NEWS. (2018, 11 12). *MASHREGH*. Retrieved 03 22, 2019, from www.mashreghnews.ir

[41] MASHREGH NWES. (2017, 11 20). *MASHREGH*. Retrieved 03 22, 2019, from https://www.mashreghnews.ir

[42] Mohamadi, M. (2017, 12 26). Retrieved from http://www.iiees.ac.ir

[43] Mohammadzade, R., & Fakhri, S. (2015, January 7). Phenomenological Assessment of Temporary Housing Status from the Viewpoint of Women in the Chobanlar Sardakloo Quake Village. *Housing and Rural Environment*, pp. 69-84.

[44] Najaran, M. T., & Khoram, M. (2015, nov 11). Modular temporary shelter design based on user-centric approach. Retrieved 03 18, 2019

[45] Nezhad, Z. h. (2010). *shiraz.* Retrieved 06 15, 2019, from https://shiraz.ir/bundles/FileRepository/278/cat2343/55ee553644a61.pdf

[46] Nojavan, M., Omidvar, B., & Salehi, E. (2011, JULY 10). Locating a temporary settlement using Phase algorithms. p. 210. Retrieved 3 18, 2019

[47] O. P., Fuente, A. d., & Aguado, A. (2016, may 9). The Use of MIVES as a Sustainability Assessment. *https://www.mdpi.com/journal/sustainability*, 1. doi:10.3390/su8050460

[48] Organization, C. P. (2018, MARCH 18). *Country Planning and Budget Organization.* Retrieved 05 26, 2019, from https://www.mporg.ir/home

[49] Organization, C. P. (2018, march 18). *Presidency of the Planning and Budget Organization of the country*. Retrieved 5 21, 2019, from https://www.mporg.ir/home

[50] Pons, O., & Aguado, A. (2012, 01 14). Integrated value model for sustainable assessment applied to technologies used to build schools in Catalonia, Spain. *Building and Environment*, 1. Retrieved 06 22, 2019, from www.elsevier.com/locate/buildenv

[51] Pons, O., & Fuente, A. d. (2013, september 032). Integrated sustainability assessment method applied to structural. 882-893. Retrieved 05 15, 2019, from www.elsevier.com/locate/conbuildmat

[52] Pons, O., & Fuente, A. d. (2013, 09 03). Integrated sustainability assessment method applied to structural. *Construction and Building Materials*, 1. Retrieved 06 23, 2019, from www.elsevier.com/locate/conbuildmat

[53] Pons, O., Fuente, A. d., & Aguado, A. (2016, MAY 09). The Use of MIVES as a Sustainability Assessment. *mdpi*, 1. doi:10.3390/su8050460

[54] Raheb, G., moghatai, M. M., Najafi, M., & Rafiei, M. (2017). report of Scrolling Settlements., (p. 16). Retrieved 04 07, 2019

[55] Rahimi, Z. (2019, APRIL 23). *ISNA.* Retrieved 05 30, 2019, from https://www.isna.ir

[56] (2017). *Report_Chapter-15_1396-10-05.* Tehran.

[57] Rizalyn C. Ilumina, A. W. (2018, 01 30). A Post-Disaster Functional Asset Value Index for School Buildings. *ScienceDirect*, 231-232. Retrieved 07 26, 2019, from www.sciencedirect.com

[58] Road Research Center, H. a. (2017). *Report Urgent preliminary of earthquake 2017 Novambre 12 Kermansha-Sarpol-e Zahab.* Tehran. Retrieved 04 07, 2019

[59] Roshti, M. a., Jalili, K., & Zolfi, A. (2012, 01 11). Optimal location of the temporary accommodation of earthquake victims in Case study of GIS urban areas using multi criteria and. pp. 51-56. Retrieved 05 27, 2019, from Downloaded from jgs.khu.ac.ir at 19:43 IRST on Monday March 4th 2019

[60] S. M. Amin Hosseini Albert de la Fuente, P., & Oriol Pons, P. (2016, march 7). Multicriteria Decision-Making Method for Sustainable. *Construction Engineering*, 1. doi:10.1061/(ASCE)CO.1943-7862.0001137.

[61] Salamat, A. S. (2017). *Findings Geotechnical earthquake of kermanshah -sarpol-e zahab*. Tehran: Ministry of Roads and Urban Development Research Center for Housing and Everything. Retrieved from https://www.bhrc.ac.ir

[62] Statistical Center of Iran. (2016, 1 1). *Dargahe meli amar*. Retrieved 03 22, 2019, from https://www.amar.org.ir

[63] Sussie C. Morrisha, R. J. (2019, march 23). Post-disaster business recovery: An entrepreneurial marketing perspective. *Journal of Business Research*, 1. doi:https://doi.org/10.1016/j.jbusres.2019.03.041

[64] Toma, J., Lombera, S. J., & Aprea, I. G. (2009, 8 8). A system approach to the environmental analysis of industrial buildings. *Building and Environment*, 1. Retrieved 06 22, 2019, from www.elsevier.com/locate/buildenv

[65] USGS. (2019, 01 06). *Servicio Geológico de los Estados Unidos*. Retrieved 03 22, 2019, from https://earthquake.usgs.gov/earthquakes/eventpage/us2000bmcg/dyfi/intensity

[66] Zade, S. A., Asadi, A., & Saraei, M. h. (2017, February 06). p. 84. Retrieved 05 29, 2019

[67] zahab, G. S.-e. (2017). *Chain fire in the tent of the temporary of the earthquake.* kermansha. Retrieved 05 12, 2019, from http://ravansar.ostan-ks.ir/sarpolezahab

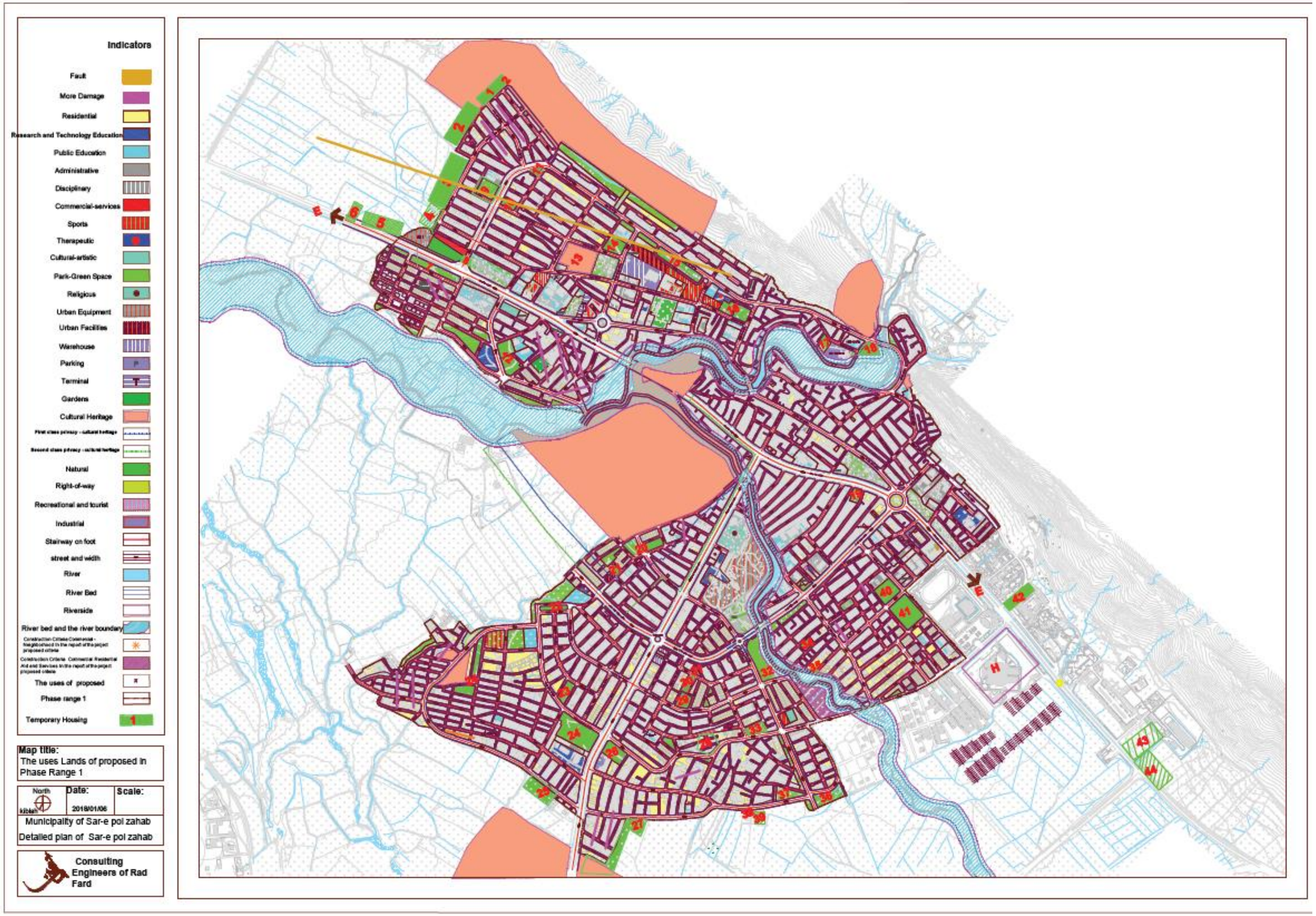
[68] Zare, M., Kamranzad, F., Parcharidis, I., & Tsironi, V. (2019). *Preliminary report of Mw7.3 Sarpol-e Zahab, Iran earthquake on November 12, 2017.* Tehran. Retrieved 05 26, 2019, from https://www.emsc-csem.org/Files/news/Earthquakes_reports/Preliminary_report_M7.3_20171112_v3.pdf

[69] Zifan, A. (2017, may 18). *google*. Retrieved 03 22, 2019, from https://commons.wikimedia.org/wiki/File:Kermanshah.svg

Annex

Sites	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10	I11	I12	I13
Site5	22000000IRR	5300 IRR	Bad	0.085km	3.3 km	1.56 km	1 km	0.7 km	0.261 km	0.43 km	0.15 km	3.5 km	Not bad
Site7	10000000IRR	215 IRR	Average	0	2.9 km	1.15 km	0.65km	0.22km	0.392km	0.615km	0.105km	3.177km	Bad
Site12	8000000 IRR	315500 IRR	Average	0	2.9 km	0.96 km	0.49km	0	0.83 km	0.099km	0.325km	2.9 km	Average
Site18	25000000IRR	5515 IRR	Not bad	0.1 km	1.4 km	1.405km	1.4 km	0	0.964km	0	1.4 km	2.212km	Bad
Site27	17000000IRR	5300 IRR	Not bad	0.01 km	1.5 km	3.66 km	3.3 km	0.225km	2.527km	1.137km	0.217km	2.229km	Not bad
Site32	19000000IRR	5300 IRR	Good	0	1.3 km	2.66 km	2.3 km	0.22 km	1.737km	0	0. 825 km	2.192km	Average
Site41	20000000IRR	-	excellent	0	0.3 km	2.475km	2.115	0	1.724km	0.97km	1 km	1.375km	Good
Site43	15000000IRR	315500 IRR	Average	0.9 km	0.7 km	3.1 km	3 km	0.95 km	2.794km	1.973km	0.045 km	0.415km	Average

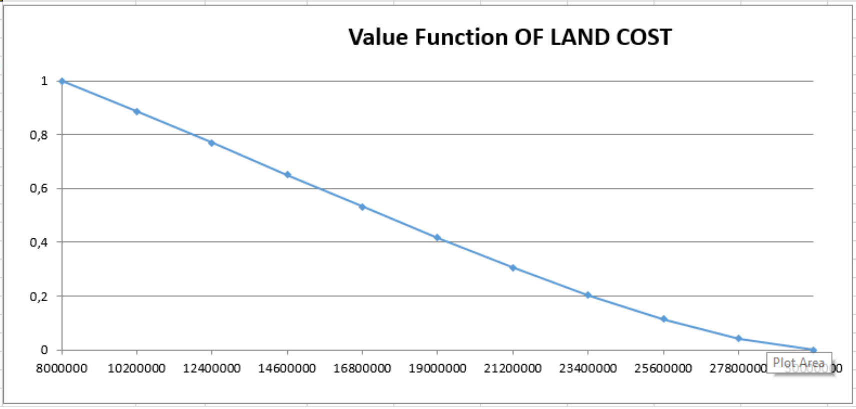
Sites	Site5	Site7	Site12	Site18	Site27	Site32	Site41	Site43
VI1	0.2677	0.8959	1	0.1362	0.5214	0.4166	0.03656	0.6283
VI2	0.9842	0.9994	0.0095	0.9837	0.9843	0.9843	1	0.0095
VI3	0	0.4356	0.4356	0.1896	0.1896	0.7083	1	0.4356
VI4	0.9299	1	1	0.9169	0.9921	1	1	0.0631
VI5	0.0004	0.0445	0.0445	0.9457	0.9177	0.8329	1	0.9992
VI6	0.4782	0.7785	0.9443	0.5821	0	0.0577	0.0939	0.0111
VI7	0.8029	0.9406	0.9821	0.5796	0.0001	0.1170	0.1854	0.0049
VI8	0.7821	0.9864	0.6364	1	0.9859	0.9864	1	0.2227
VI9	0.0408	0.0969	0.4121	0.5221	0.9981	0.9327	0.9297	0.9998
VI10	0.7417	0.8553	0.2707	0	0.9727	0	0.9530	0.9998
VI11	0.2919	0.2148	0.5280	0.9901	0.3932	0.8658	0.9206	0.0990
VI12	0.0009	0.0169	0.0460	0.1767	0.1725	0.1817	0.4326	0.8172
VI13	0.5674	0	0.7311	0	0.3813	0.7311	0.8985	0.7311


Indicators
Fault
More Damage
Residential
Research and Technology Education
Public Education
Administrative
Disciplinary
Commercial-services
Sports
Therapeutic
Cultural-artistic
Park-Green Space
Religious
Urban Equipment
Urban Facilities
Warehouse
Parking
Terminal
Gardens
Cultural Heritage
Natural
Right-of-way
Recreational and tourist
Industrial
Stairway on foot
street and width
River
River Bed
Riverside
River bed and the river boundary
The uses of proposed
Phase range 1
Temporary Housing
Map title:
The uses Lands of proposed in Phase Range 1
North
Date:
2018/01/06
Scale:
Municipality of Sar-e pol zahab
Detailed plan of Sar-e pol zahab
Consulting Engineers of Rad Fard

1.

Xmax	30.000.000	
Xmin	8.000.000	
Valor de Ci	18.000.000	Valor de X en el punto de inflexión
Valor de Ki	0,400	Valor de Y en el punto de inflexión
Valor de Pi	1,50	Factor de forma

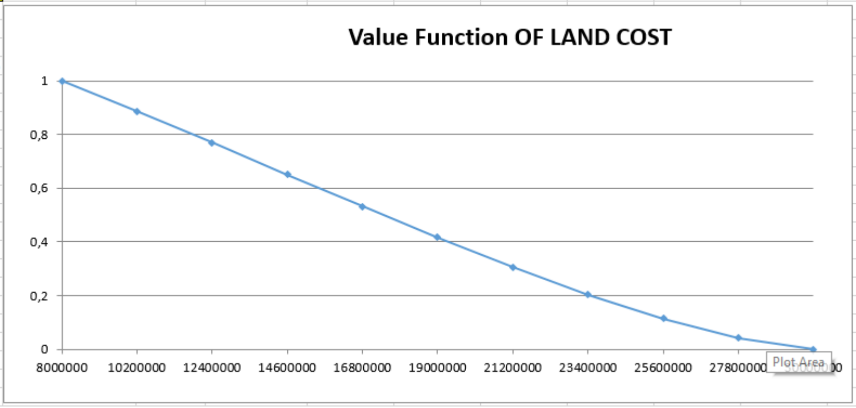
Valor de Bi	2,395006055
Función de valor	
X	Y
30000000	0
27800000	0,040586887
25600000	0,113026866
23400000	0,203531386
21200000	0,306075663
19000000	0,416593573
16800000	0,532002314
14600000	0,649851626
12400000	0,7681575
10200000	0,885307701
8000000	1



2.

Xmax	30.000.000	
Xmin	8.000.000	
Valor de Ci	18.000.000	Valor de X en el punto de inflexión
Valor de Ki	0,400	Valor de Y en el punto de inflexión
Valor de Pi	1,50	Factor de forma

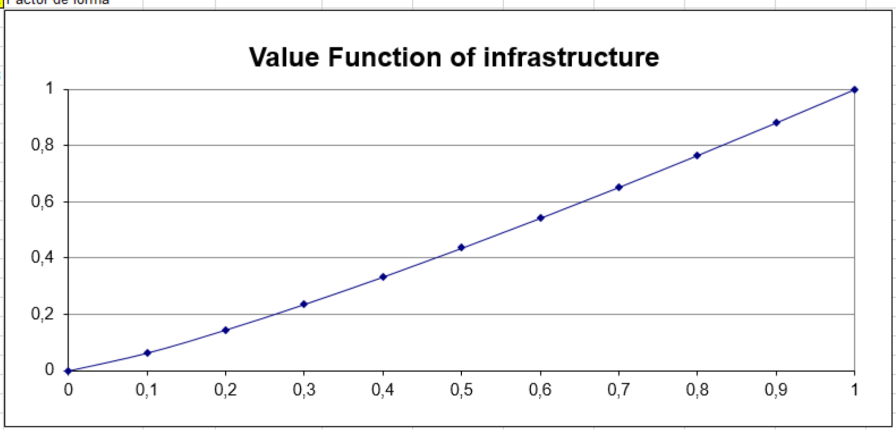
Valor de Bi	2,395006055
Función de valor	
X	Y
30000000	0
27800000	0,040586887
25600000	0,113026866
23400000	0,203531386
21200000	0,306075663
19000000	0,416593573
16800000	0,532002314
14600000	0,649851626
12400000	0,7681575
10200000	0,885307701
8000000	1



3.

Xmax	1	
Xmin	0	
Valor de Ci	0,5	Valor de X en el punto de inflexión
Valor de Ki	0,001	Valor de Y en el punto de inflexión
Valor de Pi	1,2	Factor de forma

Valor de Bi	435,775473
Value Function	
X	Y
1	1
0,9	0,88135371
0,8	0,76528842
0,7	0,65206561
0,6	0,54201344
0,5	0,43555766
0,4	0,33327646
0,3	0,23600796
0,2	0,14509835
0,1	0,06316366
0	0



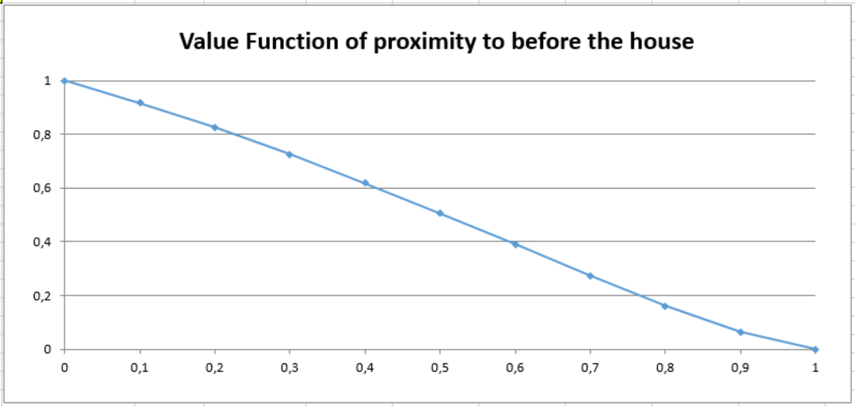
4.

Xmax	1,0	
Xmin	-	
Valor de Ci	0,5	Valor de X en el punto de inflexión
Valor de Ki	0,400	Valor de Y en el punto de inflexión
Valor de Pi	1,40	Factor de forma

Valor de Bi	1,533698513

Función de valor

X	Y
1	0
0,9	0,063117305
0,8	0,160999379
0,7	0,272533634
0,6	0,389153816
0,5	0,505629655
0,4	0,6185159
0,3	0,725538345
0,2	0,825260295
0,1	0,916865295
0	1



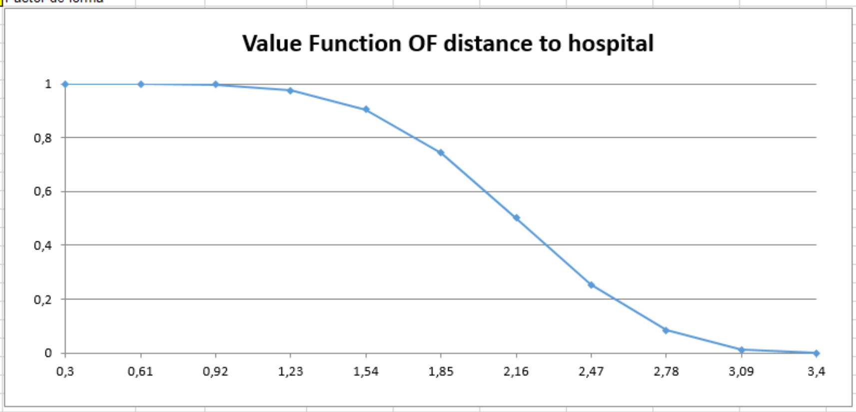
5.

Xmax	3,4	
Xmin	0,3	
Valor de Ci	1,30	Valor de X en el punto de inflexión
Valor de Ki	0,800	Valor de Y en el punto de inflexión
Valor de Pi	3,00	Factor de forma

Valor de Bi	1,000019446

Función de valor

X	Y
3,4	0
3,09	0,010789467
2,78	0,083125643
2,47	0,253902859
2,16	0,500568103
1,85	0,742321206
1,54	0,903992207
1,23	0,975804969
0,92	0,996147883
0,61	0,999651689
0,3	1



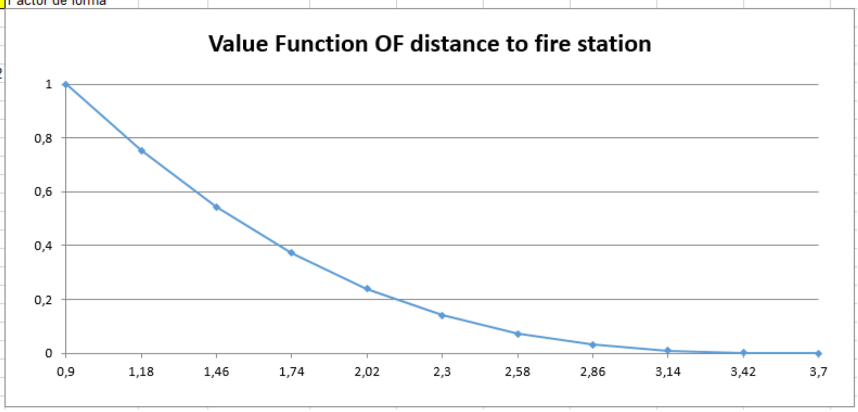
6.

Xmax	3,7	
Xmin	0,9	
Valor de Ci	0,95	Valor de X en el punto de inflexión
Valor de Ki	0,010	Valor de Y en el punto de inflexión
Valor de Pi	3,00	Factor de forma

Valor de Bi	4,426993742

Función de valor

X	Y
3,7	0
3,42	0,001133331
3,14	0,009058525
2,86	0,030498303
2,58	0,071951319
2,3	0,139441167
2,02	0,238183766
1,74	0,372199525
1,46	0,543909947
1,18	0,753770547
0,9	1



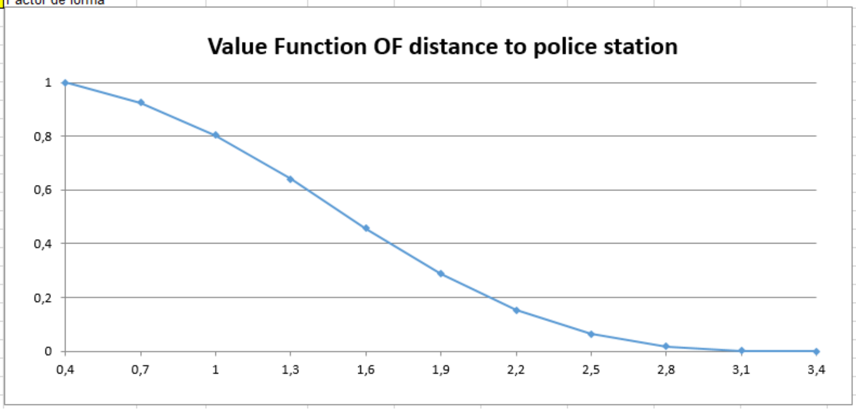
7.

Xmax	3,4	
Xmin	0,4	
Valor de Ci	1,30	Valor de X en el punto de inflexión
Valor de Ki	0,200	Valor de Y en el punto de inflexión
Valor de Pi	3,20	Factor de forma

Valor de Bi	1,057898051

Función de valor

X	Y
3,4	0
3,1	0,001937515
2,8	0,017672019
2,5	0,063257367
2,2	0,151723443
1,9	0,286748838
1,6	0,457597477
1,3	0,639633572
1	0,80285695
0,7	0,924918026
0,4	1



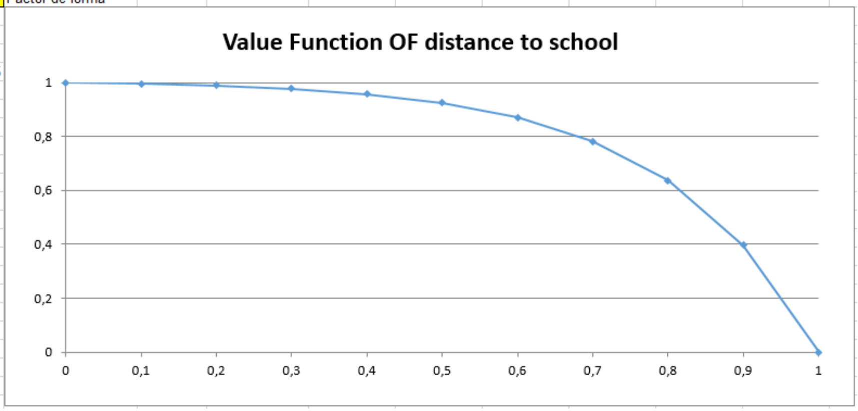
8.

Xmax	1,00	
Xmin	-	
Valor de Ci	0,50	Valor de X en el punto de inflexión
Valor de Ki	2,500	Valor de Y en el punto de inflexión
Valor de Pi	1,00	Factor de forma

Valor de Bi	1,006783655

Función de valor

X	Y
1	0
0,9	0,396138501
0,8	0,636408647
0,7	0,782139857
0,6	0,870530304
0,5	0,92414182
0,4	0,956658848
0,3	0,976381423
0,2	0,988343769
0,1	0,995599299
0	1



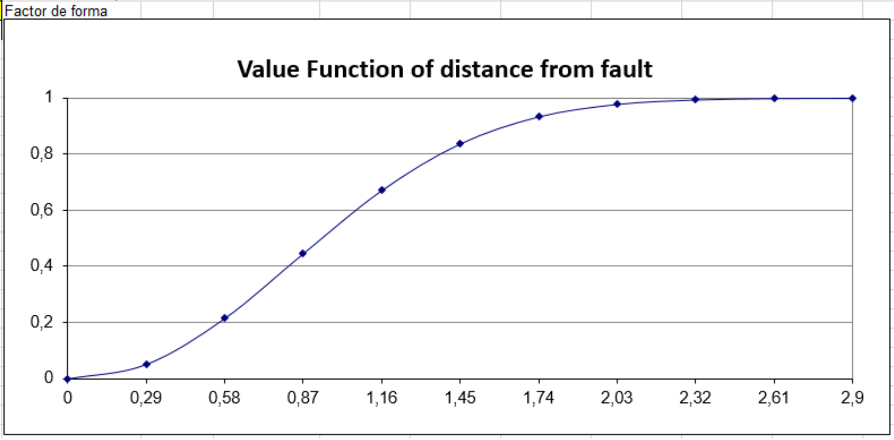
9.

Xmax	2,9	
Xmin	0	
Valor de Ci	1	Valor de X en el punto de inflexión
Valor de Ki	0,8	Valor de Y en el punto de inflexión
Valor de Pi	2,2	Factor de forma

Valor de Bi	1,00024253

Value Function

X	Y
2,9	1
2,61	0,99888503
2,32	0,99411513
2,03	0,97782669
1,74	0,93341057
1,45	0,83683581
1,16	0,6702452
0,87	0,44516363
0,58	0,21447851
0,29	0,05118176
0	0



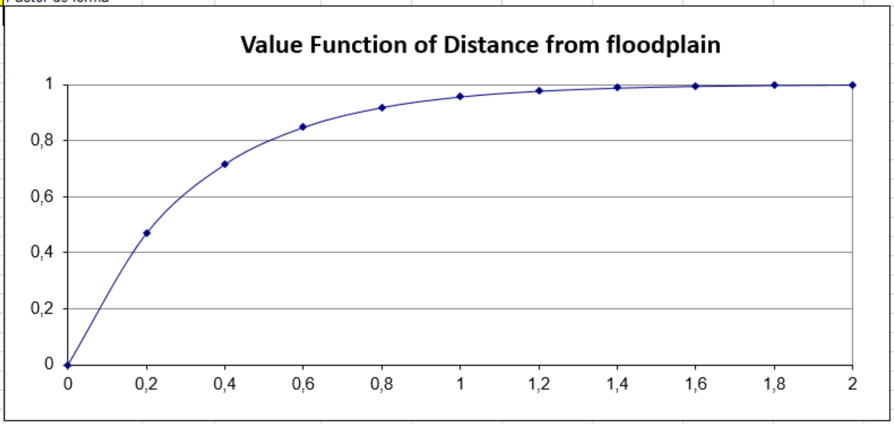
10.

Xmax	2	
Xmin	0	
Valor de Ci	0,9	Valor de X en el punto de inflexión
Valor de Ki	2,8	Valor de Y en el punto de inflexión
Valor de Pi	0,99	Factor de forma

Valor de Bi	1,00208988

Value Function

X	Y
2	1
1,8	0,99823814
1,6	0,99498613
1,4	0,98897839
1,2	0,97786854
1	0,95729885
0,8	0,91915789
0,6	0,84829923
0,4	0,71629741
0,2	0,4692658
0	0



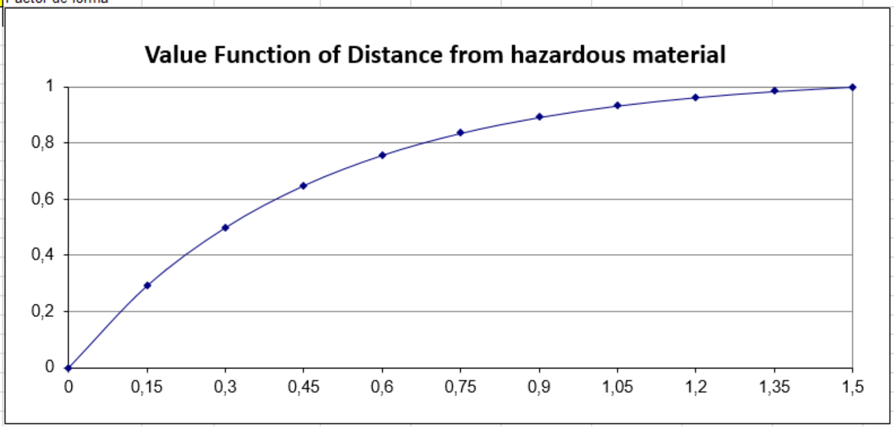
11.

Xmax	1,5	
Xmin	0	
Valor de Ci	1,4	Valor de X en el punto de inflexión
Valor de Ki	3	Valor de Y en el punto de inflexión
Valor de Pi	0,99	Factor de forma

Valor de Bi	1,0419632

Value Function

X	Y
1,5	1
1,35	0,98428078
1,2	0,9626451
1,05	0,93285067
0,9	0,89179582
0,75	0,83518295
0,6	0,75704347
0,45	0,64905759
0,3	0,49955154
0,15	0,29188824
0	0



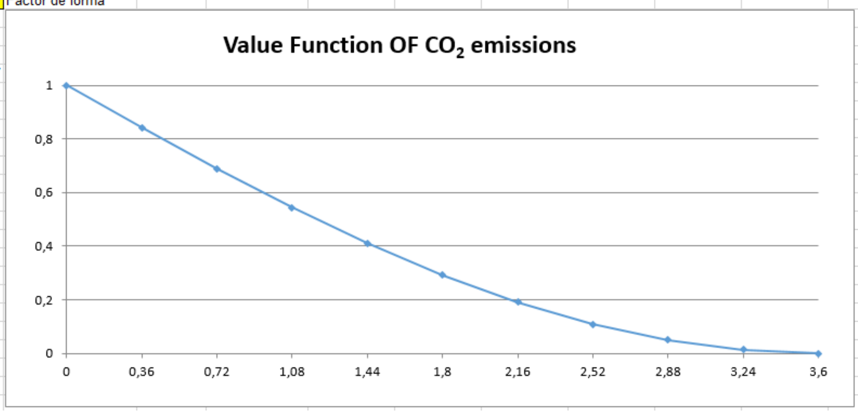
12.

Xmax	3,60	
Xmin	-	
Valor de Ci	1,75	Valor de X en el punto de inflexión
Valor de Ki	0,100	Valor de Y en el punto de inflexión
Valor de Pi	2,00	Factor de forma

Valor de Bi	2,898200617

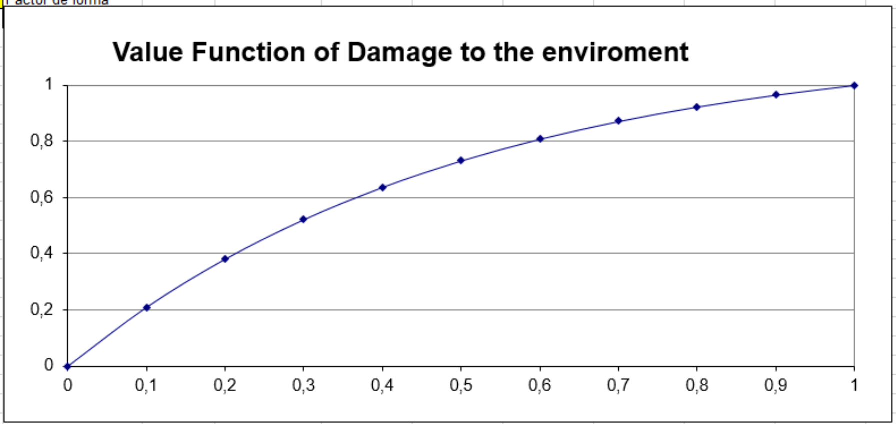
Función de valor

X	Y
3,6	0
3,24	0,012238797
2,88	0,048645962
2,52	0,108306799
2,16	0,189739339
1,8	0,290955511
1,44	0,409541782
1,08	0,542754679
0,72	0,687625941
0,36	0,841071678
0	1



13.

Xmax	1	
Xmin	0	
Valor de Ci	0,5	Valor de X en el punto de inflexión
Valor de Ki	1	Valor de Y en el punto de inflexión
Valor de Pi	1	Factor de forma
Valor de Bi	1,15651764	
Value Function		
X	Y	
1	1	
0,9	0,96534656	
0,8	0,92302076	
0,7	0,8713239	
0,6	0,80818122	
0,5	0,73105858	
0,4	0,63686077	
0,3	0,5218073	
0,2	0,38128068	
0,1	0,20964108	
0	0	



NOTATION

A = response value of X_{min} (indicator abscissa), generally A ¼ 0;

B = factor that prevents the function from leaving the range (0.00, 1.00);

Ck = criterion k;

Dai→Rm = distance from the gravity center of the alternative site I to the gravity center of the region m;

DCv = decrease concavely;

DCx = decrease convexly;

DS = decrease S-shape;

I = sustainability index;

ICx = increase convexly;

Ik = indicator k;

IS = increase S-shape;

Ki = factor that defines the response value to Ci;

PCi = population covering parameter for alternative site i;

Pi = shape factor that determines whether the curve is concave or convex or whether is linear or S-shaped;

Rk = requirement k;

Smax = maximum satisfaction;

Smin = minimum satisfaction;

V = value;

Xind = considered indicator abscissa that generates a value Vi;

Xmax = maximum value indicator;

Xmin = minimum value indicator;

W = considering the weights assigned to the indicators;