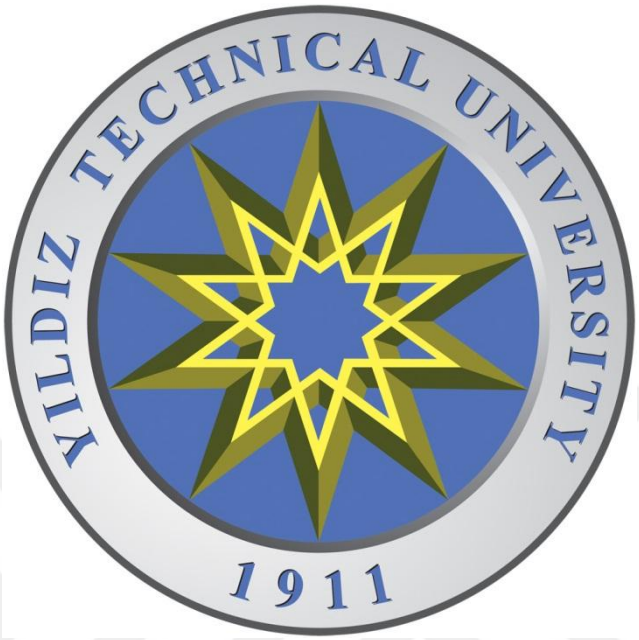


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POST-DISASTER RECONSTRUCTION AND THE ROLE OF COMPUTATIONAL METHODS IN ARCHITECTURE

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Lina ALKHODARI

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LIST OF ABBREVIATIONS

BBB	Build Back Better
BoQ	Bill of Quantities
CAD	Computer Aided Design
CRED	Center of Research on Epidemiology of Disasters
DRR	Disaster Risk Reduction
EAA	Emergency Architects Australia
EM-DAT	Emergency Event Database
NGOs	Non-Governmental Organizations
NN	Neural Networks
UNSIDR	The United Nation Office of Disaster Risk Reduction
VIP	Ventilated Improved Pit

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ABSTRACT

POST-DISASTER RECONSTRUCTION AND THE ROLE OF COMPUTATIONAL METHODS IN ARCHITECTURE

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Department of Architecture

MSc. Thesis

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The subject of post disaster reconstruction is considered one of the hot research topics in architecture. The importance of this topic is due to the increasing number of disasters in the last years, and also related to the impact of disasters on communities and physical construction. The impact of disaster can be minimized by setting up legislation in the design and building phases which can reduce the vulnerability to disaster in advance as a precaution. Also, by implementing the (Build Back Better) concept to improve the physical and social structure of the community in the rebuilding after the disaster. There are a lot of studies which have tried to handle this subject efficiently by employing the parametric and computational methods of architecture, in order to overcome the constrains regarded to the design and implementing of temporary houses. Some of these researches have focused on the design requirements which can be translated into parameters to produce different variations of the temporary house units. However, the suggested methods of design still need an intervention of experienced architects who are able to translate the data from the disaster area into convenient parameters which can be introduced to the intended algorithmic modeling application. According to some researches, most of the users of the temporary houses have committed changes to the designed units due to being unsuitable for their requirements.

In this study, guidelines for designing a temporary house is provided. Also, the process in which the algorithmic design proceeds is presented. Accordingly, the parametric temporary house design process is defined , one of the steps is translating the statics collected from the site of disasters (by people who are not necessary architects) into parameters in an automatic classification method. In this method the different user requirements is taken into account. The neural network system is used for classification. Moreover, the K-means is used to generate pairs of inputs and their related outputs that

are large enough to train the Neural network. For the purpose of checking the efficiency of the automated method of selecting parameters for the design, data is collected about various countries from around the world (with taking into account the diversity of the characteristics defining each country). After this, the design properties in shape of numerical values for the selected countries is manually determined. And finally, the selected countries was tested in the Neural network automated system and the system is proved to be very efficient. This system have the advantage of giving accurate results in a short period of time, which makes it more efficient as a whole system. Additionally, the number of design requirements can be increased and the parameters and design properties will be increased respectively. This is a step to achieve more designs convenient to different user requirements. Comparatively, determining the design properties for different regions according to increased number of design requirements manually would make the job of the architect more complicated, more time consuming and less accurate in term of results.

Key words: Post-disaster reconstruction, temporary house, parametric architecture, neural networks.

ÖZET

AFET SONRASI İMAR VE MİMARLIK HESAPLAMA YÖNTEMLERİN ROLÜ

Lina ALKHODARI

Mimarlık Anabilim Dalı

Yüksek Lisans Tezi

Tez Danışmanı: Yrd. Doç. Dr. TOGAN TONG

Afet sonrası yeniden yapılanma konusu mimarlıkta sıcak araştırma konularından biri olarak kabul edilir. Bu konunun önemi, son yıllarda afet sayısının artış göstermesine bağlı olup ve aynı zamanda toplum ve fiziksel inşaat afetlerin etkisiyle ilgilidir. Afetin etkisi, önceden tedbir alınmış afet savunmasızlığını azaltabili rtasarım ve inşaat aşamalarında, mevzuatı kurarak minimuma indirilebilir. Ayrıca, afet sonrası yeniden yapılanmada toplumun fiziksel ve sosyal yapısını geliştirmek için kavram uygulaması yapılabilir. Bu konuyu, geçici evlerin tasarımı ve uygulanmasında kabul kısıtlamalarının üstesinden gelmek için, mimari parametrik ve hesaplama yöntemleri kullanılarak etkin şekilde ele almayı deneyen birçok çalışma var. Bu araştırmaların bazıları geçici ev birimlerinin farklı varyasyonlarını oluşturmak için parametreler tercüme edilebilir tasarım gereksinimleri üzerine yoğunlaşmıştır. Bununla birlikte, tasarıma önerilmiş metotlar,verileri afet bölgesinden amaçlanan algoritmik modelleme uygulamasına tanıtılmış elverişli parametrelere çevirebilen deneyimli mimarların müdahalelisinehala ihtiyaç duymaktadır. Bazı araştırmalara göre, geçici evlerin kullanıcılarının çoğunluğu kendi gereksinimleri için uygun olması nedeniyle belirlenen birimlere değişikliği onaylamış. Bu çalışmada, geçici bir ev tasarımı için yönergeler sağlanmaktadır. Ayrıca, algoritmik tasarım getirisindeki süreç sunulmuştur. Buna doğrultuda, parametrik geçici ev tasarım süreci tanımlanmış, adımlardan biri (mimar olması gerekli olmayan insanlar tarafından) toplanan istatistiklerin, afet alanlarındanotomatik sınıflandırma yöntemi parametrelerineçevrilmesidir. Bu yöntemde farklı kullanıcı gereksinimleri dikkate alınır. Nöral ağ sistemi sınıflandırma için kullanılır. Ayrıca, K-ortalama girdilerin çiftleri ve Nöral ağı eğitmek için yeterince büyük ilgili çıkışların oluşturulmasında kullanılır.Tasarım parametreleri için seçilenotomatik yöntemin verimliliğini kontrol etmek amacıyla, dünya genelinde (her ülkenin farklı karakteristik özelliğini hesaba dahil

ederek) çeşitli ülkelerden veri toplanmıştır. Bundan sonra, seçilmiş ülkeler için tasarım özellikleri sayısal değerler şeklinde manuel olarak belirlenir. Ve en sonunda, seçilmiş ülkeler Nöral ağ otomatik sisteminde test edilmiş ve sistemin çok verimli olduğu ispat edilmiştir. Bu sistemkısa bir zaman diliminde kesin sonuçlar veriyor olması avantajına sahiptir ve bu onu bütün bir sistem olarak daha verimli hale getirir. Buna ek olarak, tasarım gereksinimleri sayısı arttırılabilir ve parametreler ve tasarım özellikleri sırası ile artacaktır. Bu, farklı kullanıcı gereksinimlerini karşılamak için uygun tasarımlar elde etmenin ilk adımıdır. Nispeten, tasarım ihtiyaçlarının artış sayısına bağlı olarak, farklı bölgeler için tasarım özelliklerini belirlemek mimarın işini daha karmaşıklaştırmakta, daha fazla zaman almakta ve yeterli zamanda daha az kesin sonuç tanımlanmaktadır.

Anahtar Kelimeler: Afet sonrası yeniden yapılanma, geçici ev, parametrik mimari, nöral ağlar.

CHAPTER 1

INTRODUCTION

Among ages and generations, there have been many destruction actions that happened around the world. Many regions have witnessed certain actions which have resulted in major disasters causing total change to both people and architecture of these regions. Therefore, these disasters are often classified according to their cause: natural or human induced.

a) **Human induced disasters:** The human induced destructive actions or disasters are directly and principally caused by one or more identifiable human actions for multiple reasons, these reasons could be economical, social, religious, political, ideological, etc. These actions can be classified into: 1) wars. 2) Armed conflicts. 3) Genocides.

b) **Natural disasters:** The natural disasters are major adverse events resulting from natural processes of the earth. These events are either geological, such as earthquakes, or climatic, such as floods and tornados. They also tempt to cause wide destruction to the regions it happens in.

However, this study is concerned about disasters taking place on earth as well as their effects on architecture. As architects, we have a duty to help human being in all their needs. These needs maybe either to build the dream house, or to build a shelter after destruction in post disaster regions in order to help people in having a place to start their normal life again.

Around the whole world, disasters are affecting more and more of lives and livelihoods. Recently, the world has been witnessing a lot of political and economic changes side by side with the physical climate changes. These factors have affected both people's lives and environments. According to the Center of Research on the Epidemiology of Disasters

(CRED)[1], the number of natural disasters has been showing a significant increase in the last thirty years in compare with the last seventy years before that.

According to EM-DAT[1], during the period between 1994 and 2013, an average of 218 million people were affected by natural disasters every year, also the EM-DAT has recorded 6,873 disasters, which caused a total of 1.35 million deaths, which means an average of almost 68,000 deaths per year. Note that in order to record an event as a natural disaster in EM-DAT, it should meet at least one of the following criteria:

- Ten or more people are reported as killed.
- 100 or more people reported as affected.
- Declaration of a state of emergency.
- Call for international assistance.

During the human history, there were many events that affected the human societies. Some of these events caused massive destructions in some areas, and therefore, an urgent need for housing and shelters for people in these areas is found. Recently, and with the advances in the construction technology fields, many specifications are defined for the post-disaster constructions and shelters, such as safety, availability, cost efficiency, etc. The priorities of satisfying these specifications are affected by the aim of building these constructions. For example, being in a safe shelter is one of the basic and urgent needs for human in any case, while urgent availability is a priority in temporary shelters after disasters. Therefore, post-disaster reconstruction and shelters are classified into two classes as follows:

a) **Short term reconstructions:** Designing urgent housing types by utilizing smart systems, new construction technologies, etc., in order to be a temporary solution until the ongoing actions can find a way to be ended.
b) **Long term reconstructions:** Re-planning and constructing the destroyed areas by utilizing the previous experiences in building the typical areas and avoiding the disadvantages in the previous constructions and plans.

Parametric architecture and generative methods are considerably new methods in the architecture practice field. By the mid of 1990, using graphic software had become a very popular method in practicing architecture, even a necessity. The parametric methods enable the architects to have a full use of advanced computing capabilities which can

make their work easier and a less time consuming job. Also, having the ability to a better understanding of problems and presenting multiple solutions.

Parametric systems are based on parameters (usually created by the designer after having a good understanding of the intended design and its circumstance) and having algorithms implemented on these variants to obtain various options for the design product, then using computerized selection methods to obtain the best result due to efficiency.

The parametric design has witnessed a lot of evolution since it had been first used. This evolution came from simple models generated by computer scripts. These scripts generate design variations every time they are run with different parametric values. Nowadays, the CAD systems do offer sophisticated three-dimensional interactive interfaces which are able to perform variations in real time. These properties make it very helpful to have more control and immediate feedback when a parameter is changed. Furthermore, the implementation of parametric models can provide structures which show the historical evolution of the model. This enables the designer to go back to previous stages of the design and be able to apply any needed changes. These changes are in all the stages of the design, which means that the designer can easily go back and changes the value of the parameters and reconstruct the model. The parametric model either executes the changes through the structure and reshape the model according to the new values, or just inform the designer if these changes will create a problem in the solution.

The term “humanitarian” is defined in the dictionary as “having concern for or helping to improve the welfare and happiness of people”[2]. Accordingly, the humanitarian architecture can be defined as the architecture which is basically designed to help the people who are in need for. Moreover, it can be further described as finding architectural solutions to humanitarian crises and trying to get to a professional design which is able to help communities in need. Since architecture is more than just designing and drawing, it is described as a method of problem solving. Humanitarian architects works directly with communities on site in order to find practical solutions for current issues no matter how big or small are they. For example, it could be the building or a rainwater collecting system for a city after witnessing a natural disaster, or building urgent shelters for people left with no place to stay in after an earthquake.

Building shelters after the disaster is a process which must be executed as fast as possible to help people. Due to the urgent implementation of the shelter designs, they are usually

not responsive to special standards regarded to the area of disaster, which is considered as one of the challenges in the urgent shelter design for post-disaster state.

In this study, the parametrical methods are discussed and considered as a helpful solution in order to find a design which comes as a response to people's needs and their special circumstances. Recovering from disasters would be as easy and fast as possible. Also giving people designs which are suitable to their needs, not another problem to deal with.

1.1 Literature Review

The post-disaster reconstruction is a versatile research topic. Many studies in different aspects have been conducted in this field. Some have studied the evaluation of community participation in housing reconstruction projects. Hakan and Alper[3] have conducted a study concerning the community participation after Duzce earthquake. That paper examines the housing reconstruction process carried out in Duzce city that was heavily damaged by the Marmara Earthquake of 17 August 1999 and latterly Duzce Earthquake on November 12, 1999. Other researchers studied the reconstruction process from a psychological point of view. For example, Lee has provided a study on the psychological rehabilitation process of 921 earthquake victims in a temporary shelter[4]. The study is based on a clinical psychologist's works in a temporary shelter with victims of the 1999 Chi-Chi, Taiwan, earthquake. Three themes have been discussed: the worlds of the victims, the reflections of the psychologist, and the victim-psychologist relation. The findings and reflections in the rehabilitation process have been described, and the procedure and meaning of "post-traumatic psychological rehabilitation" have been reconsidered. Yüksel and Hasırci[5] also have studied physical and psychological expectations of earthquake victims from temporary shelters and have presented a design proposal. The proposal was made according to interviews conducted with earthquake victims in the city of Kocaeli in Turkey, and needs were identified. They also have presented the design requirements for a temporary house unit according to the results from previous studies conducted after August 17th earthquake in1999. Other studies were mostly concerned about the phase before the disaster, researchers studies how in this phase countries can be less vulnerable to disasters through constructing a disaster risk reduction framework. Mercer et al.[6] studied the high risks of witnessing disasters in SIDS (Small Islands Developing States) due to loss of knowledge to provide disaster risk reduction framework, so the article describes a guided discovery learning activity by which indigenous communities in SIDS can use a Process Framework for integrating

indigenous and scientific knowledge to reduce their vulnerability to environmental hazards. According to Arslan and Unlu[7], providing the shelter after the disaster is generally carried out in four overlapping phases which are; spontaneous shelter (first 72 hours), emergency shelter (first 60 days), interim housing (first year and beyond) and permanent housing. This means that the temporary shelter need to serve up to one year until the permanent houses are built. Accordingly the temporary house is supposed to fulfill the people needs rapidly with minimum cost and maximum convince. Johnson[8] proposes a framework for strategic planning for temporary housing that identifies organizational designs and available resources for temporary housing before the disaster, and also allows modifications to fit the specific post-disaster situation. This study is more concerned about post-disaster state and how to employ the parametric and generative computational methods in designing shelters for the emergency state after a disaster. According to what have been noticed from previous studies, there is a shortage in the studies conducted in computational design and related to humanitarian field. The study of Yeung and Harkins[9] have focused on the application of digital architecture in the reconstruction of the Solomon Islands. In this study, the tools needed to start with building a latrine were previewed by identifying the appropriate parameters. Another study in this field was conducted by Benros and Granadeiro[10]. This study provide a case study of a post-earthquake in Haiti. It focuses on a set of construction drawings as the resulting documentation. Another study focused on the use of digital tools[11]. In this study, a unique coupling of interactive 3D virtual environment with parametric designing in order to manage disaster relief project more efficiently. They have also focused on the use of digital tools and a game 3D virtual environment engine for decision-making support system for human needs. Sener and Altun[12] presented a detailed survey about the earthquake victims who had lived in the temporary shelter settlement in Yeniköy. It showed that the victims were not satisfied with the shelters, and that they needed modifications for a better shelter unit, this study was also concerned about developing design and evaluation criteria for shelters. Torus and Şener[13] provided a library for shelter housing in both unit and neighborhood scale. These models were created according to different criteria in order to design these shelters, the selection of these criteria depends on evaluations made from previous earthquake experiences. These models are considered important project because of the container based modules and computer based generation, as the modular system enable rapidness in implementation and the computer based generation makes it easy to design and create alternatives

according to desired criteria. Furthermore, Johnson[14] puts the light on an important subject which is the second life of shelter, and states that this must be planned for from the outset of the program. Also she offers five major options to consider as a second life of the temporary house.

1.2 Objective of the Thesis

The study aims to put the light on the importance of reconstruction in the disaster areas. Also to think about a framework for disaster risk reduction by the government as an essential step for decreasing the vulnerability of disasters, which is considered an important method to reduce the disaster effect on communities and make the recovery phase more quick and easy to start.

In addition, the study points out the necessity of setting out main guidelines for designing a temporary houses in post disaster areas. Temporary house is one of the first needs that comes directly after the disaster. It is defined as the place in which disaster victims can live in and start recovering from the disaster. The temporary shelter has to be built fast without being over budget, and also should be suitable for victim's needs which are considered changeable in term of person and place.

Therefore, to obtain a better result according to the aforementioned constrains, the computational methods of design are previewed as a useful solution for rapidness, cost and adaptability. Since these methods are proved to require less time in production and assembly, as well as the feature obtained from parametric methods of being modular, a thing that makes it fast generated, easy to change and adaptable for different users. Furthermore, the advantage of obtaining a range of variant models from a set of parameters to select the best solution. The value of each parameter can be easily changed according to the user needs and the country in which the disaster take place.

Additionally, in the context of being sustainable, thinking about the second life of the temporary shelter is considered very important. Therefore, computational methods which include using transformable and precast methods are considered very useful to achieve this goal.

Finally, the study suggests an automated framework for the process of designing a temporary house unit. The aim of the technique is to minimize the role of architects in the stage of deciding the best design parameters to be used in generating the temporary house unit. However, the automated trained system of the technique is ought to do this job

instead. This step is considered essential when trying to make rapid design in the post disaster state, which can also be more efficient when thinking about different user requirements that is changeable between cultures and persons.

1.3 Hypotheses

Destructive actions causes' large scale damages on the built environment which requires reconstruction. The reconstruction of housing units is considered difficult when thinking about different user needs in different societies, as the housing units must be adaptable and responsive to these changeable needs. Accordingly, obtaining a rapid and adaptable design solution for temporary housing units in post disaster is considered essential.

1.4 Methodology of the Study

The method in which the study proceeded mainly depends on starting from the basic definition of destructive actions to their causes, types and the impact they have caused on population and physical structure of a city, then go ahead with the notion of post-disaster reconstruction as an after coming stage of disasters. Types of reconstruction and their implantation mechanism, also providing guidelines for purchasing a smart method of reconstruction in which previous problems have been obviated. After this, the study goes on with explaining the parametric and generative methods of architecture design as perfect solutions to bypass all the constrains regarded to the reconstruction process. Finally, an automated selection process is provided and tested as a useful method of selecting the best design properties and parameters of the disaster area.

- **Chapter1:** In this chapter an introduction about disasters and their types has been explained, also their occurrence in recent years. After that, some definitions of important expressions had been introduced. With also a review of the previous studies in the field in which the study has been constructed and the aim of it have been explained.
- **Chapter2:** In this chapter the types of destructive actions have been mentioned as well as their impact on people and built environment. These impacts are shown for both human induced (armed conflicts and wars) also for natural disasters in shape of numbers and rates to express their effects on people and built environment. Afterwards, the vulnerability of disasters and the facts leading to a society with higher risks of witnessing disasters has been fully explained. Furthermore, in this part the impact of disasters on the society in all its parts have

been mentioned together with the damages caused to infrastructure and housing to proceed with explaining the urge need for the upcoming post disaster stage which is "reconstruction" and showing the need for thinking about designing buildings which are less affected by disasters in state of occurrence. As a result, the term Build Back Better (BBB) is a very helpful method to be adopted to achieve this target while thinking about reconstruction.

- **Chapter3:** The study proceeds with third chapter in which reconstruction is defined as well as the involved parties in this process from local society to international organizations. Furthermore, the damages assessment process is widely explained in its both shapes Preliminary and the detailed assessment, side by side with assessment tools. Additionally, the three methodologies of disaster assessment to be followed have been provided. In the light of reconstruction, the study proceeds with explaining the types of reconstruction according to their emergency following the disaster action; short-term and long-term reconstruction. Afterwards, some main and general guidelines regarded to properties of the reconstruction process has been explained, with also providing the notion of Disaster Risk Reduction (DRR) which is a method that intended to maximize the gain from development consequence to disaster. At the end of the chapter, a guideline for designing a temporary shelter is previewed, with ensuring that a special methodology and standards for designing temporary shelters is highly required from researchers in this field.
- **Chapter4:** This chapter starts with providing a definition of parametric architecture and explaining the method of workability; parameters, rules, generating variants, selection of the best. After this, the humanitarian field in architecture is mentioned in light of parametric architecture, which can be considered very helpful in response to the demands of this field, due to the features of being a time reducing method and also can be customized for conservation of resources as well as safety and cost requirements. The constrains regarded to reconstruction process such as limited funding, materials, time, foreign expertise and accessibility of the sites, also the main obstacle of not being able to follow up on site in case of problems in implementation can take long time, and impeding the speed needed in states of emergency, all are problems which can find a solution in parametric methods of design and its smart systems of construction on field. Furthermore, smart systems in architecture such as; sustainable buildings,

transformable buildings and pre-cast methods are explained to clarify them as helpful methods when thinking about a prototype for temporary shelter (for the short-term reconstruction) as well as the reconstruction and planning of the whole city (for the long-term reconstruction), these techniques can be used in shape of parameters in design due to being helpful in both time saving and cost management. Eventually, a case study was selected to explain the methodology and workability of parametric modeling to show the conducted procedures from the assessment requirement stage in which all parameters are set for the design, to design stage and obtaining the prototype also the evaluation and feedback to commit needed changes until final stage of documentation.

- **Chapter5:** In this chapter a suggested automated mainframe for the process of designing temporary house units is provided. The suggested technique takes advantage of the automatic classification methods in order to minimize the role of architects in the stage of the decision making in the process. The decision making is useful in providing the best parameters for the design according to the design requirements and the different properties of the disaster area. The aim of this suggested technique is to ensure rapidness in the process of reconstruction and designing temporary houses for post disaster. Furthermore, it can meet the different user requirements and provide the best design which can suit their needs. The chapter proceeds with describing the technique, with giving details about the steps in which it is implemented as well as an evaluation of the system by testing it on real data.

CHAPTER 2

DESTRUCTIVE ACTIONS AND DISASTERS

In the world there are two main reasons for built environment destruction, the human induced type of destruction and the natural disasters. Whether it is human induced or natural the result is huge negative effect on both built environment and people's life.

2.1 Wars and Armed Conflicts

Architecture is very connected to people. All the activities they perform are included in an architectural space which they became related to. Accordingly, people would be highly affected by the destruction of their built environment. Among ages, the history of mankind have witnessed a lot of armed conflicts which have caused wide destruction to the social and physical construction of countries. This study is concerned about the reconstruction process following to these actions. Such famous destructive action is the WWI and WWII which have resulted in series of new and bitter wars; civil, ethnic and religious. From 1946 to 2001 there were 225 armed conflicts[15]. The period from 1989 to 1999 was the most intensive, producing 110 armed conflicts in 73 locations[16]. Some countries have cities which were totally destroyed (Grozny), or suffered years of urban warfare (Beirut) and prolonged siege (Sarajevo), with entire populations rapidly displaced (Kosovo). Some have been ethnically cleansed and witnessed genocide and the houses were made uninhabitable (Bosnia and Herzegovina), or using famine as a mean of war (Mogadishu), or bought back to early middle ages (Afghanistan). The following stage of these actions should be the reconstruction. This process needs all parties to be involved, from international organizations to community members.

2.1.1 The World's Most Known Destructive Wars

Wars in the world is as old as human. The Oxford dictionary describes the act of war as "a state of armed conflict between different countries or different groups within a

country." Wars are usually committed by human to prove their dominance over other. These destructive actions were instruments to mold the future of the world. It have affected the spread of culture, civilization, and religion. Also, they have introduced weapons, tactics, and leaders who dominated future conflicts.

Wars ranking is made according to two specifications. Table 2. 1 and Table 2. 2 show the world's top 10 wars according to their influence on history of specific countries in the world, and their sizes and bloodiness, respectively[17].

Table 2. 1 World top 10 wars according to their influence on history (cont'd)

No:	**War/battle name**	**Start/end date**	**Combatants**	**Influence on history**
1	Yorktown (Virginia-America)	28th Sep. to 19th Oct. 1781	Americans and French against the British	It was the climax of the American Revolution and directly led to the independence of the United States of America.
2	Hastings (England)	14 October 1066	Norman-French army and English army	Decisive Norman victory.
3	Stalingrad (world war II)	1942-1943	Germany and Axis – soviet union	It is considered by many historian to have been the turning point of World War II in the European theatre
4	Leipzig (Napoleonic Wars)	16–19 October 1813	First French empire- sixth coalition	Leipzig led to the fall of Paris and the abdication of Napoleon.
5	Antietam (Washington-America)	September 17, 1862	United states-CSA confederacy	Stopped the first Confederate invasion of the North. It also ensured that European countries would not recognize the Confederacy or provide them with much-needed war supplies.

Table 2. 1 World top 10 wars according to their influence on history (cont'd)

6	Cajamarca (Peru)	November 16, 1532	Spanish empire and Conquistadors- Inca empire	Pizarro's victory opened the way for Spain to claim most of South America and its tremendous riches, as well as imprint the continent with its language, culture, and religion.
7	Atomic Bombing of Japan	August 6 and August 9, 1945	United states and united kingdom- Japan	The end of World War II in the Pacific.
8	Huai-Hai (china)	6 November 1948 – 10 January 1949	Republic of china- Communist Party	It was the final major fight between the combatants.
9	Waterloo	18 June 1815	France- seventh coalition	It brought an end to French domination of Europe and began a period of peace on the continent that lasted for nearly half a century.
10	Vienna	11 and 12 September 1683	Holy Roman empire- Ottoman empire	The Ottoman Turks' unsuccessful siege of Vienna in 1529 marked the beginning of the long decline of their empire. It also stopped the advance of Islam into central and western Europe, and ensured that the Christian rather than the Muslim religion and culture would dominate the region.

Table 2. 2 World's top 10 wars according to bloodiness in history (cont'd)

No:	War/battle name	Start/end date	Combatants	Number of death
1	World War II	1939-1945	Fought between the vast majority of the world's nations	Over 70 million fatalities and is believed to be the deadliest, bloodiest war ever in history
2	Mongol Conquests	1206-1368	It was held by Mongol empire on several regions.	More than 60 million killings.
3	World War I	1914-1918	Between the countries in Europe	Around a staggering 50 million plus.
4	Conquests by the Empire of Japan	1894-1945	Japan and a lot of other countries	Over 20 million deaths.
5	Russian Civil War	1917-1922	Bolshevik Red Army and the White Army	7 million people.
6	Napoleonic Wars	1803-1815	It was led by Emperor Napoleon I-against an array of European power	Over six and a half million people.
7	Thirty Year's War	1618-1648	Anti-Habsburg States and Allies-Habsburg States and Allies	The death toll of well above 5 million people.
8	Vietnam War	1955-1975	Anti-communist forces (supported by	Over a million civilians were killed in addition to the

Table 2. 2 World's top 10 wars according to bloodiness in history (cont'd)

			several countries)-communist forces	hundreds of thousands participants in the war.
9	Soviet War in Afghanistan	1979-1989	Soviet-led Afghan forces and the multi-national insurgent groups called the Mujahedeen	Over a million Afghan civilians and those that were participants in the war.
10	American Civil War	1861-1865	'North' or the 'Union' and the South also known as the 'Confederacy'	More than 800,000 people were killed in the war.

2.1.2 The Cost of Conflicts

Since 1970s, the number of countries which were involved in conflicts has reached 42 countries, which represent 44% of the world total population. Staggering numbers of lives have been lost in these regions that have reached 12 million, and by 1944 the world saw 15 million refugees and 20 million displaced within the borders of their home countries as a result of WWII[18]. Until these days, the number of countries hosting wars and conflicts is considerable and increasing according to the accelerating events going in the world as shown in Figure 2. 1[1]. Since WWII the Balkans have witnessed the most rapid, forced movement of population (refugees, displaced, ousted/cleansed and migrants). The tiny central African country of Rwanda have witnessed the most intensive genocide and killing campaigns in the history of humans and armed conflicts. Also the conflict happened in Caucasus, in particular Chechnya, has caused the most destruction recorded in physical infrastructure since the 1940s. Furthermore, the long term and even ongoing conflict in Palestine is still creating constant suffering and destruction to people's all aspects of life there. Figure 2.2[19] shows the increasing in numbers of fatalities recorded in deadliest countries from 2013 to 2014 in the same countries, according to the figure it is increasing with large rates in just one year.

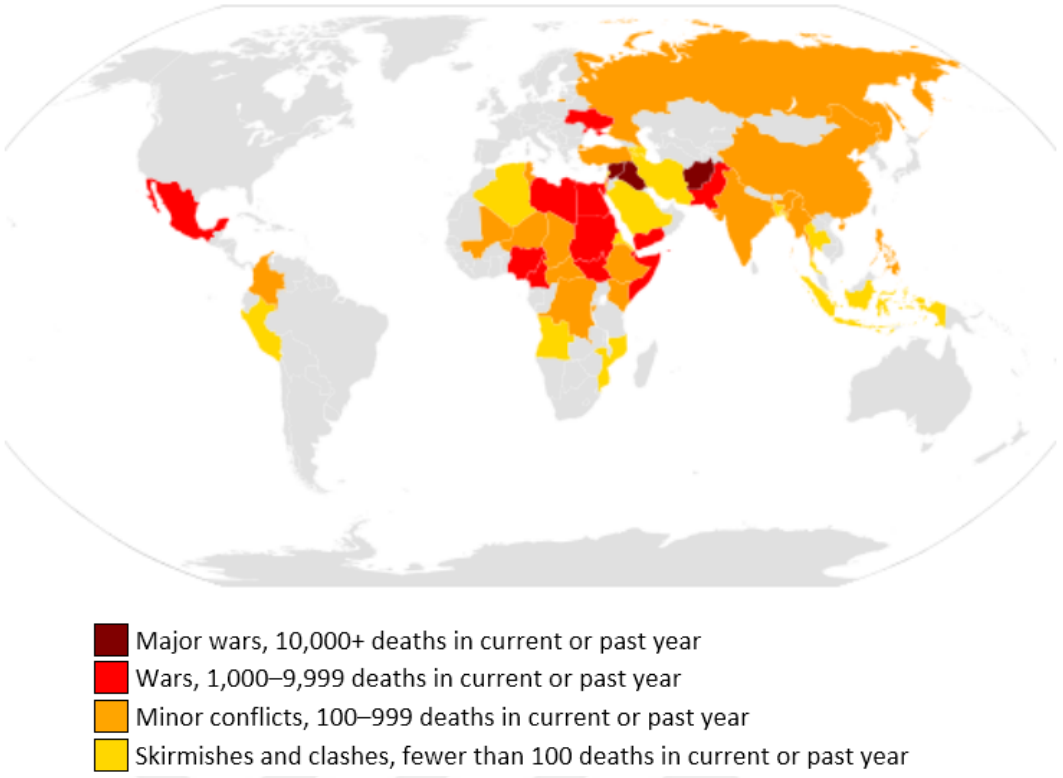


Figure 2. 1 Locations of ongoing conflicts worldwide, January 2016

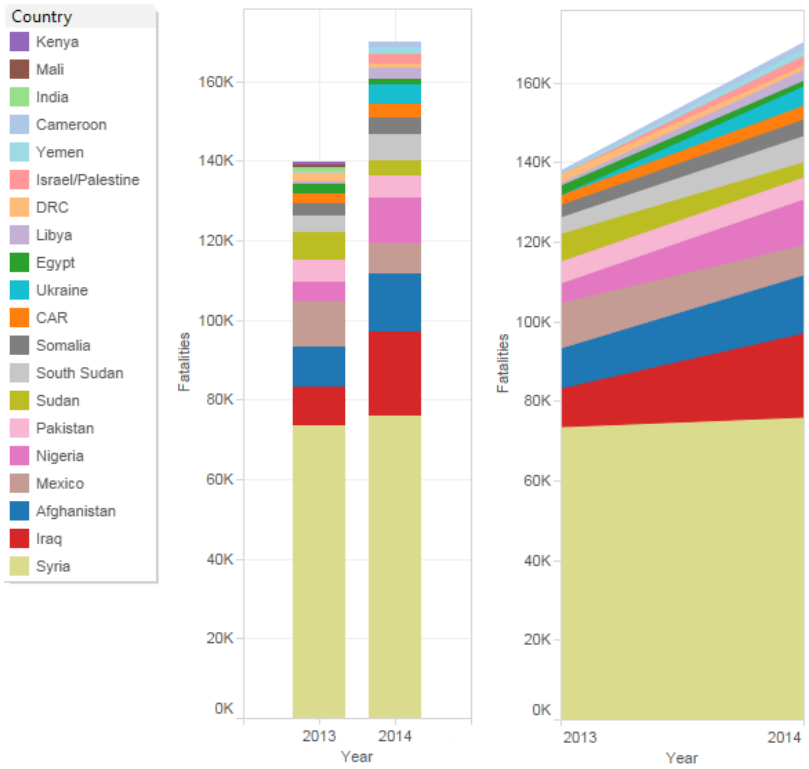


Figure 2. 2 The number of fatalities in the deadliest countries in 2013 and 2014

2.2 Natural Disasters

2.2.1 Definitions and Natural Disasters in Numbers

Studying disasters and their impact on environment and communities has gained prominence due to the rising number of disaster events in the world which are being reported to happen at an unimaginable rate.

Disasters have been defined in different ways from the organizations operating the sector of disaster management. For example, The United Nations Office for Disaster Risk Reduction (UNISDR) defined disasters as "A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources". The Centre for Research on the Epidemiology of Disasters (CRED) defined it as "An unforeseen and often sudden event that causes great damage, destruction and human suffering" or, "a situation or event which overwhelms local capacity"[20]. They also classified the natural disasters as:

1. Geophysical: earthquake, mass movement (dry), volcanic activity.
2. Hydrological: flood, landslide, wave actions.
3. Meteorological: storm, extreme temperatures, fog.
4. Climatological: drought, glacial outburst, wild fire.
5. Biological: animal accident, epidemic, insect infestation.
6. Extra terrestrial: impact and space weather.

American Geological Institute defined the disaster as "A naturally occurring or human induced geological condition or phenomenon that presents a risk or is a potential danger to life or property"[1]. They also elated the occurence of a disaster to two factors:

1. The first one is: the hazard factor which is the risk of potential disaster occurring.
2. The second one is: the vulnerability factor which means the number of people who are at risk of being harmed due to the occurrence of the hazard.

The overwhelming majority of natural disasters with a (91%) percentage is the climate-related events according to stated disasters from 1994 to 2013. Floods and storms having a 71% of the total global disasters. Figure 2.3 shows the occurrence percentage of natural

disasters by disaster type in 1994 and 2013. Figures 2.4 and 2.5 show the numbers of stated disasters and victims in the world between 1994-2013, respectively. They also show the countries in which these disasters have happened[21].

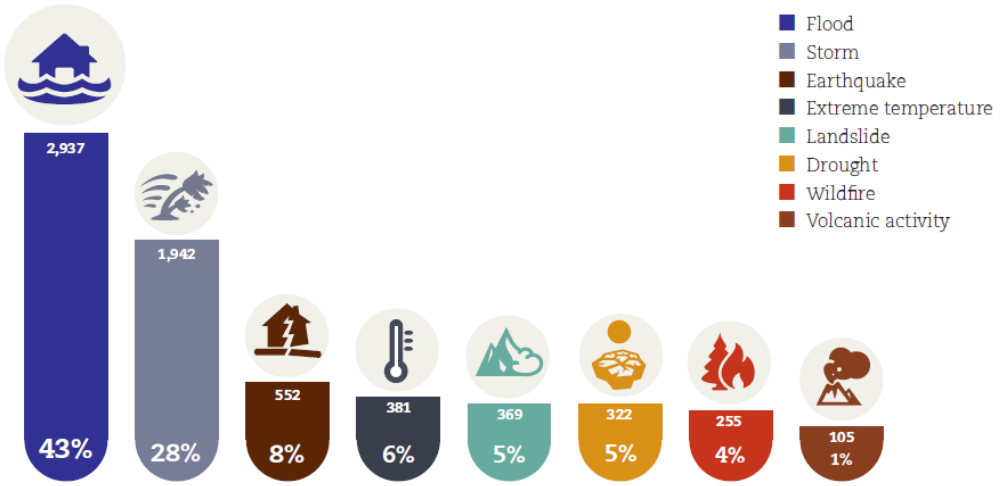


Figure 2. 3 The occurrence of natural disasters (1994-2013)

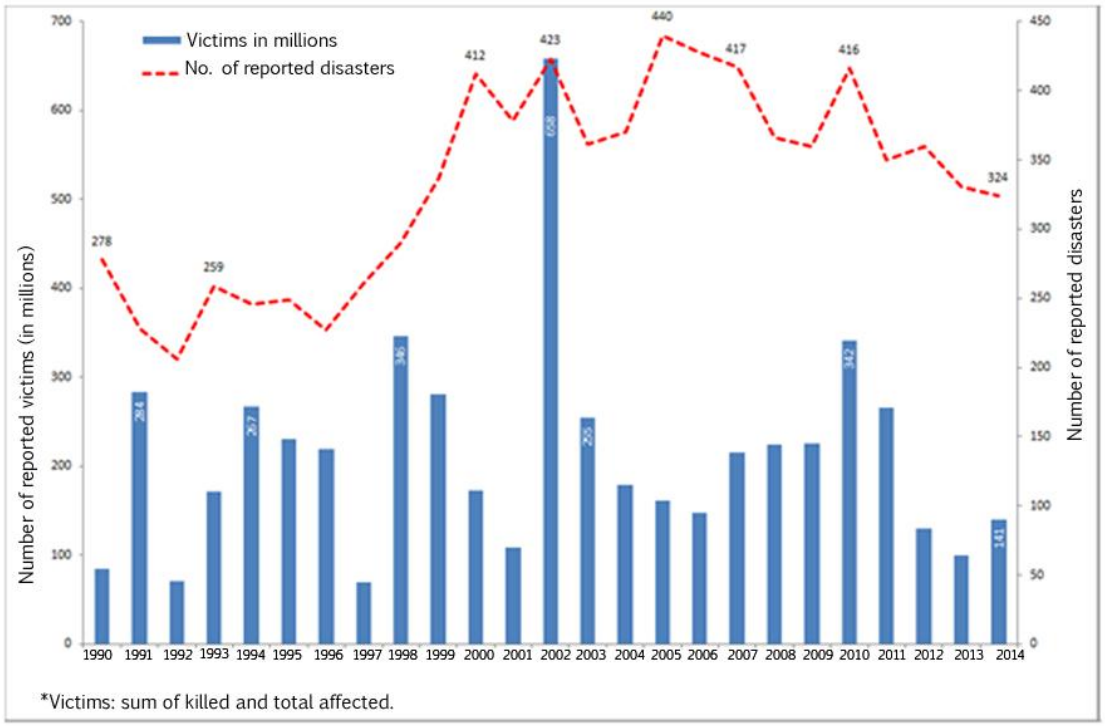


Figure 2. 4 The number of reported disasters and victims (1990-2014)

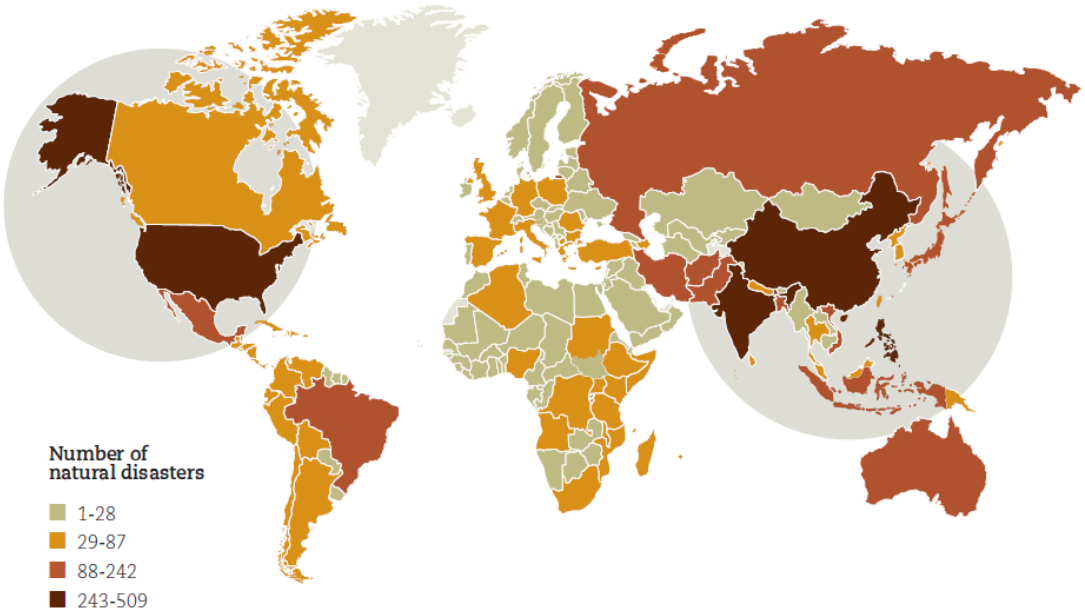


Figure 2. 5 The number of natural disasters in the world (1994-2013)

2.2.2 Disasters and Vulnerabilities

Vulnerability is defined as a function of the degree of risk, susceptibility, resistance and resilience of a community to a disaster[1]. Another expression which is not totally different in defining disaster vulnerability, as "the interactive component of the exposure, sensitivity, reliance, reliability and resilience of any system that is experiencing a hazard event"[22]. The degree of exposure to disasters or hazards is related to three main themes according to vulnerability studies: The first is the pre-existing disaster conditions. The second is vulnerability as a social response. The third is vulnerability of places[23]. Disasters are a widespread phenomenon for human in urban areas and have higher potential danger in areas with higher risks of being impacted by hazards. The situation of disasters is more prevalent in developing countries as the settlements and residential are usually located in hilly regions and industrial zones[24]. Further reasons is related to lifestyle properties such as living in coastal areas. So in order to reduce disaster vulnerability and trying to reduce the potential contribution of such actions to hazards, it is suggested to consider thinking about development planning process and disaster risk management activities integrally.

2.3 The Impact of Destructive Actions

As described previously, the effect of disasters due to its vulnerability is large on both individuals and groups. The form of these effects usually varies and comes typically in the form of a rolling series of repercussions (secondary and ripple effects). The impact of disaster can be direct or indirect, positive or negative[25]. The direct impacts of disaster comes in the form of death or injuries in term of human population, and or in the form of destruction for built environment (buildings, infrastructure and services). The other indirect impacts of disaster is on life districts such as political systems, social structure, economy and other systems related to the community. The amount of impact caused by a hazard usually depends on the precautions and preparations taken by the government, as countries with disaster recovery policies are usually more rapid to recover and can be less affected by disaster or catastrophe. Whereas after event, as much as the programs of emergency and recovery are effective and efficient as much as the community can get back to normal with no need to mention the role of external community assistance. There are several factors that contribute to the amount of destruction after any kind of disaster[26], these factors are:

- The state of economy of the country before the disaster, normally the countries with weak economy situation are more likely to face greater damages than the developed ones.
- The amount, scale and shape of destruction is related to the disaster type, different type of disasters can cause different impacts.
- The timing and duration, the time in which the disaster take place can affect the amount of destruction, for example the damages caused after the 2007 Gisborne earthquake happened in New Zealand were low due to its timing, as it happened after the normal working hours.
- The community efforts, as the degree of social participation and the degree of organization can affect the impact of disaster on people.
- The political role in helping to overcome the situation in line with the local institution.
- The international community response is usually according to shape in which the government is affected by the disaster.

One of the most important fields which are directly affected by disasters is the development in the community, whereas disasters can cause loss in resources input which can cause shortening in the life time of development investments, or it can cause the diversion of the budget indented for developmental projects for the unplanned disaster management programs, furthermore disasters can cause obstacles for development such as unemployment and loss of income, and political instability.

To sum up, the impacts of disaster is relatively large on the community with all its aspects, from the social and political to economical aspects. This is why it is important for any post disaster recovery and management programs to consider a holistic approach which can cater for all these different aspects.

2.4 Disaster Damages to Houses and Infrastructure

The economic situation of a country is considered one of the key factors to determine the impact a disaster can cause, as building facilities with poor income resources and the lack of following building regulation can make the damage due to disaster more intense, and can cause more life losses. For example, thousands of school children were killed after earthquakes in their schools due to poor built school buildings. Further, the bad influence on people when forced to leave their houses due to damage after disasters. Also another major obstacle for starting recovery after disaster is the potential damage to hospitals and health facilities which can reduce the ability for a country to respond to disaster at the first instance. It is like what happened at Iran in 2003 after the Bam earthquake when all the health facilitates were damaged and patients and staff were killed[27]. As a result, international efforts for reconstruction are highly required for situations in which a country faces damages to vital infrastructure more than it can handle with their economy, otherwise this country would be in a very critical situation, with years to get life back to normal, a thing that can slow the economic and educational development for generations. This is why it is highly recommended to consider programs for safe schools and hospitals, especially in areas with high chances of floods and earthquakes to reduce death and physical damages. A good example for making schools and hospitals earthquake-proof is Turkey, which has given commitment to make it done by 2017[1].

2.5 Post Disaster State: The Importance of Reconstruction and Start Thinking About Recovery

According to Rubin[1], the disaster management process usually can be represented by four phases: mitigation, preparedness, response and recovery. These phases have been recognized under different names in various countries. For example, these phases have been stated in New Zealand by the (Ministry of Civil Defense and Emergency Management) as the (four R's): reduction, readiness, response and recovery. According to Haas et al.[28] the last two phases (response phase and recovery phases) are broken down into four periods:

1. The Emergency Period: this period is the first days after the hazard, this period can range from a few hours up to few days. Usually the basic community functions are disrupted, and the stage of cleaning –up is initiated.
2. Restoration Period: the process of restoring the important services, communication and transportation. This period takes from several weeks up to few months.
3. Replacement Reconstruction Period: in this period the built environment is returned more to levels prior to disaster, also the social and economic activities are returned to pre-disaster levels or even higher.
4. Commemorative, Betterment and Developmental Reconstruction: in this period the disaster is overcame and the works of memorials takes place. Moreover, activities of major construction and development works for a better future are initiated.

Next is to think about the stage after the first post-disaster response activities (which are made during the emergency and restoration periods) which is reconstruction, and to start getting the community to normal life as soon as possible. With the huge number of existing post-disaster reconstruction experiences still a lack of well managed experiences and there is an urge need for further studies to improve this field. The reconstruction of a community after a disaster or hazard usually means to repair the physical damage which has been induced due to disaster. While some authors such as Kennedy et al.[29] and Lyons[30] believe that the method of rebuilding the damaged buildings in the exact pre-disaster state often make these building face the same levels of vulnerability which have existed earlier. As a result, the buildings restored to pre-disaster standards are highly

suspected to face the same difficulties in case of potential disaster events in the future. According to this fact of possibly re-facing the same difficulties and impacts of disaster if a restore method of reconstruction is followed, a new concept is starting to emerge. In this concept, the post-disaster reconstruction would be considered as an opportunity to not only restore what was damaged and return the community affected by disaster to its pre-disaster state, but also to create a methodology of reconstruction in which a community would have a more "resilient" state of normalcy[31], [32], [33].

In the context, the pre-mentioned term "resilience" has been defined in many ways by different authors. For example it was discussed as a property of an adaptive cycle which can be used to understand complex systems. In an adaptive cycle where "potential sets limits to what is possible" and "connectedness determines the degree to which a system can control its own destiny". Gunderson and Holling[34] state that "resilience determines how vulnerable a system is to unexpected disturbances and surprises that can exceed or break that control". UNISDR defines resilience as "The ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including the preservation and restoration of its essential basic structures and functions". In terms of psychology Luthar et al.[35] describe resilience as "A dynamic process encompassing positive adaptation within the context of significant adversity". Twigg[20] uses the term resilience where resilience is defined as "the capacity to absorb stress or destructive forces through resistance or adaptation"; or "the capacity to manage, or maintain certain basic functions and structures during disastrous events;" or "the capacity to recover or 'bounce back' after an event". While Haimes[36] defines vulnerability and resilience as "two sides of the same coin" and says that both terms express how a system is able to withstand threats. Vulnerability represents the states that can be adversely affected by specific magnitudes of threats, whilst resilience represents the ability of the system to recover in an acceptable period of time from the threats encountered[37].

CHAPTER 3

POST-DISASTERS RECONSTRUCTION

Reconstruction is defined as the urgent reaction must happen after destructive actions and disasters in order to get people's life gradually come back to normal, post- disaster reconstruction scenarios includes a long list of activities in order to meet basic human needs, physical restoration and reconstruction, political restructuring, economic regenerating, and trying to establish foundations for sustainable development. When a disaster take place in a specific area it would cause wide devastation, not only on the physical structure of the community such as built environment, houses and institutions, but also to the whole structure of the community such as economic, political, social and all aspects of life. Therefore, the post disaster reconstruction process has to be integrated and comprehensive in order to satisfy all needs of the society. As a result the reconstruction process is considered complicated, and a lot of parties in the society must participate to promote the best shape of recovery to the community, these parties are not only from the community which have witnessed the disaster but also include international institutions which are usually more specified and well experienced in such situations. The post disaster recovery has three distinct but interrelated meanings. Recovery is a goal, a phase and a process. First, recovery is considered a goal which involves the restoration of the community's life back to the normal shape it was pre to disaster. Second it is a phase in the cycle of emergency management which starts by stabilization of the disaster conditions, and ends with having the community back to its normal routine. Third, it is a process by which the community can achieve the purpose of returning to normal life. The recovery process involves both activities: The ones which were planned before disaster impact, and those that were improvised after disaster impact.

3.1 Assessing Damage and Needs for Reconstruction

The disaster assessment refers to the process of surveying and information collection activities which are accomplished in order to determine the impact of disaster on the affected population and to determine their resulting needs. The assessment of damage is needed to start thinking about reconstruction method, also to show how the statistics required in Chapter 5 can be obtained. The process of disaster assessment is usually carried out at two distinct stages of a disaster:

- **Preliminary assessment:** Sometimes also called rapid assessment or situation assessment. This assessment is conducted immediately after disaster and in order to obtain a full vision of geographical extent of the disaster, the number, categories, location, and circumstances of the disaster-affected population. The result of this assessment is a picture of people's conditions and their needs after the disaster. This assessment is considered as an initial reconnaissance, which can help the relief and rescue operations. It is considered as a valuable baseline data to control the post-disaster situation and to determine whether it is improving or deteriorating over time.
- **Detailed assessment:** A later stage of assessment which is conducted to obtain more specific information about the nature, location, and extent of losses and damages, and the resulting needs of the affected populations. These information are considered useful for planning and implementing reconstruction programs.

3.1.1 Types of Disaster Assessment

After the disaster comes the reconstruction and recovery phases, for this purpose the disaster assessment is required and two types of detailed assessment are relevant:

- **Damage assessment:** in this type the information to be collected are for the purpose of re-planning the city and reconstruct its physical construction such as buildings and infrastructure. The required information are as follow:
    - Damage to housing and buildings.
    - Damage to livelihood (e.g., shops of small traders, industrial units).
    - Damage to agriculture and animal husbandry (crops, fruit trees, livestock).
    - Damage to services (educational, health, recreational facilities) and government buildings

- Damage to infrastructure and utilities (water supply, sewerage, roads, bridges, electricity, telecommunications, etc.)

In each of the pre-mentioned sectors, specialists are required to determine the level of damages. For example, civil engineers are required to give a detailed report about the damages in the housing in the commercial and public buildings, physical infrastructure, and utilities. While agronomists and agricultural specialists are supposed to determine losses to crops and forests, among others, also economists must determine losses in the local economy. In the assessment process, the community and local families participation is essential to help specialists in the damage assessment surveys involving their housing units and other sectors affected from the disaster.

- **Needs assessment:** In this type, the level and types of needs from the affected population is determined, by asking people about their priorities and also about the best strategies to meet these needs. Common needs of population are usually housing needs, livelihood needs and needs for services (water supply and sanitation, electricity, schools, health centers, etc.). According to the collected information from this assessment specialists can identify and prioritize the needs in order to obtain an appropriate types of assistance and inputs for reconstruction process.

3.1.2 Methodology of Disaster Assessment

The post-disaster assessment is accomplished through three main tasks:

1. **Technical evaluation of structural damage:** In this task of assessment the main objective is to precisely determine the nature and extent of damage to all buildings in disaster affected areas, by the use of pre-defined categories in which the structural damage can be classified, as different categories represent different degrees of damage. Judgments concerning damage categories are made on the basis of direct onsite visual evaluation of building exteriors, taking into account damage to the foundation, load bearing walls, ceilings, or roofs of the structure. This can be accomplished by a street by street and house by house survey in the disaster affected area. In this survey it is essential for the surveyor to evaluate all the existing structures even if the structure is not affected. This is meant to ensure that all the buildings are identified and recorded, also can help finding the specific

cause of damage to those that are affected. According to the collected information, the level of assistance allocated for the affected families will be decided, the house holders must be informed about the results from the damage assessment and must be provided with interpretation of the assessment findings and its financial assistance implications.

2. **Inventory of Affected Assets:** This assessment include a detailed survey of losses due to the disaster, including loss of assets and income. Important inventory categories include such assets as shops, workshops or work sheds, stalls, tools/ equipment, livestock, etc. According to this assessment special financial provisions are given to the affected people.
3. **Sample survey:** In this type of survey more detailed information are obtained from interviewing samples of the affected population and collecting statistical information from them. These surveys are usually made for the needs assessment and for trying to determine the most appropriate type of assistance and intervention.

There are many methods for selecting the sample to survey in order to conduct needs assessment:

- **Simple random sampling:** In which every one of the targeted population is considered equal in the chance of being selected.
- **Systematic random sampling:** In which Every fifth or tenth member on a numbered list is chosen.
- **Stratified random sampling:** The population are divided into categories, then members from each category are then selected by simple or systematic random sampling; then combined to give an overall sample.
- **Cluster sampling:** The sample is restricted to a limited number of geographical areas "clusters"; for each of the clusters chosen, a sample is selected by simple or random sampling. Subsamples are then combined to get an overall sample.

3.1.3 Assessment Tools

The tools to be used are Checklists or Worksheets which are considered the simplest and maybe the first tools used for disaster assessment. These tools are generally an abbreviated list which can provide the assessor with a comprehensive, yet flexible guide to the type of information to be collected. Also these tools are formatted in a shape which

can remind the surveyors of the key points to ask about and the questions that must be fell out. The standardization of the checklists is considered essential as well as being simple as much as possible to facilitate the process of collecting and analyzing information. It is also important to have common understanding of the terminology used and consistency in spelling names, e.g., of the affected villages or towns so that to avoid any possible confusion and also to make sure that the collected information can be presented to the user in most helpful shapes. For the damage assessment, formatted checklists are usually used, and for the needs assessment, questionnaires are more commonly used. These questionnaires are simply a list of questions to be asked to the affected populations for the survey assessment. The purpose of the questionnaires is to have detailed information about the needs of the affected population and for vital statistical information of the post-disaster conditions. Questionnaires are considered a good way of obtaining detailed information for planning purposes, but are not good tool for rapid assessments in the immediate aftermath of the disaster.

3.2 Types of Post-Disaster Reconstruction

In order to be subjective, accurate and more productive when thinking about post disaster reconstruction, a decisions concerning the type of reconstruction must be taken. Generally, there are two types of post disaster reconstruction:

1. Short term relief and rescue.
2. And long term reconstruction.

The first type is more considered as a relief or urgent rescue for affected population, in this rescue the basic needs must be provided, and comes in shapes of providing temporary shelters to stay in as well as food and medicine. While the second type is more complicated and needs international efforts to provide experience and sufficient budget to the purpose of reconstruction and planning of the affected community. When thinking about long/ short term of reconstruction some differences in design methodology are found and will be changeable according to the two types, while some other basic and general measurements are still stable for them, in Table 3.1 a comparison between the two types will show the differences.

Table 3. 1 A comparison between the two types of post-disaster reconstruction

	Short term post disaster reconstruction	**Long term post disaster reconstruction**
Emergency	Urgent and rapid, should be ready within days after the disaster.	Not urgent, the starting of this types depends on how fast the short term reconstruction have been provided and also on previous planning.
The age considered for the buildings	Serve people for few years 1-2 years until the country or city can come back to life again.	Serve for a life time, so it is considered as a type of city planning.
Period of design and establish process	Has to be ready to use as soon as possible, so the period of design and establish is considered short.	It can take long time or the normal period considered for designing complex buildings.
Type of buildings	Basic purpose type of building such as houses, schools, hospitals, governmental buildings, food and clothes distribution and commercial buildings.	All type of building needed in a city from the simple purpose type of buildings to the most complicated ones.
Design strategies	The rapid strategies of design are considered fundamental, such as prefabricated, transformable, recyclable, re- used type of buildings. Also green and sustainable methods are considered important.	All the latest and newest strategies are important to achieve the best designs serving the region.

The first comparing factor is emergency, as short term rescue is considered the first solution needed in the first day comes after the disaster, it has to be urgent and rapid as much as possible to satisfy the basic life needs of human, while the other type (the long term) is not considered as urgent as the short one, because that it is a large scale one when considering size of area and services it has to satisfy. The second is the age considered for the buildings, the age of the resulted building in short term is short as it serves people

for limited period of time until life can come back to the normal shape it used to be, the period for the short term relief depends on the efforts and budget intended from the government to start the long term one, while the long term buildings have to be durable as well as the normal procedures for designing the city for long life time buildings. Period of design and establish process is the third factor of the comparison between the two methods, and this factor is related to the first one "Emergency", as the period of designing the architectural product need to satisfy this requirements and works as much rapid as possible for the short term one, while being not limited to a specified period of time in the long term reconstruction. However, there is no need to mention that bringing the city to normal life again is considered a priory in this type and the period to satisfy this purpose should be considerable, furthermore this reconstruction must take into consideration how to develop the community and thinking about modernism and latest technologies, and also trying to undo pre-disaster mistakes to avoid having same difficulties resulted from any possible disaster in the future. The forth is type of buildings, in short term relief basic buildings which can satisfy basic human needs are needed, the type of buildings which people can't proceed their life's without such as shelters, hospitals, schools, food supply stores and depots, governmental and administrative buildings. On the other hand, the long term reconstruction will cover all type of building should exist in a normal city from the simplest to most complicated. The fifth is design strategies, by the time short term relief is requiring rapidness and minimum time to be in the use by people in post-disaster areas, a method of finding systems and strategies which are able to be smart enough to satisfy the purpose, the use of prefabricated architectural members, transformable and re-used, recycled methods would be considered practical for the foundation of these building as rapid as possible. Whereas comes the methods of flexible, smart and easy to commit changes in the factors -parameters, variants- shaping a certain design. In this manner, the parametric design and algorithmic thinking are considered as helpful methods of design beside the pre-mentioned methods of fabrication.

3.3 Main Principles Help in providing a Bitter Reconstruction Process

In order to obtain better results from the reconstruction process and also to minimize the disaster vulnerabilities, two main princples are discussed: Build Back Better (BBB), and Disaster Risk Reduction (DRR).

3.3.1 The Concept of "Build Back Better"

Since reconstruction and recovery following a disaster requires carful thinking of requirements and successful implementation, the recovery activities should consider minimizing the disaster effects on communities, with also providing development. The Build Back Better (BBB) can be defined as "a way to utilize the reconstruction process to improve a community's physical, social, environmental and economic conditions to create a more resilient community". The term Build Back Better (BBB) is used to represent the ideal process of recovery, in which all the aspects of community are discussed and developed to achieve the state of normalcy which is more resilient than the pre-disaster setting[38]. The features of BBB is to make communities stronger and more resilient following a disaster event. Accordingly, the BBB requires the efficient implementation of recovery activities to avoid the delays and to ensure the best results intended from the BBB based approach. According to Mannakkara and Wilkinson[38], three categories are required for BBB; (1) Risk Reduction, which looks at the improvement of structural resilience in the built environment through improved structural designs and land-use planning; (2) Community Recovery, which works on the social recovery of affected people and regeneration of the local economy; and (3) Implementation, which is the means by which (1) and (2) can be put in place efficiently and effectively. The implementation of BBB often whiteness failure in practice, which shows a gap in knowledge according to understanding the BBB, also a problem related to finding a practical manner to make the implementation more easy. And accordingly, a more successful reconstruction and recovery can be achieved. Two critical issues which have to be addressed:

1. The Build Back Better concept mainly focuses on improving the resilience of the community after the disaster, and underline what is considered essential to obtain a successful recovery and reconstruction. However, the limitation in knowledge, experience and an organized and practical procedures to follow prohibits the implementation of BBB in the post disaster situation.
2. Also another reason in not having enough understanding of what prevents the implementation of BBB, and how its components can be resolved, and how they interact, also not having a framework for the best practice of BBB to follow in order to enable a practical application of the theory.

3.3.1.1 Guidelines for Build Back Better

The earliest known formal official document to be published which tries to provide a guideline for implementing BBB in post disaster areas is provided by the former US President Bill Clinton's "Key Propositions for Building Back Better"[30] where:

- Proposition 1: Governments, donors and aid agencies must recognize that families and communities drive their own recovery.
- Proposition 2: Recovery must promote fairness and equity.
- Proposition 3: Governments must enhance preparedness for future disasters.
- Proposition 4: Local governments must be empowered to manage recovery efforts, and donors must devote greater resources to strengthening government recovery institutions, especially at the local level.
- Proposition 5: Good recovery planning and effective coordination depend on good information.
- Proposition 6: The UN, World Bank, and other multilateral agencies must clarify their roles and relationships, especially in addressing the early stages of a recovery process.
- Proposition 7: The expanding role of NGOs and the Red Cross/Red Crescent Movement carries greater responsibilities for quality in recovery efforts.
- Proposition 8: From the start of recovery operations, governments and aid agencies must create the conditions for entrepreneurs to flourish.
- Proposition 9: Beneficiaries deserve the kind of agency partnerships that move beyond rivalry and unhealthy competition.
- Proposition 10: Good recovery must leave communities safer by reducing risks and building resilience.

Despite having some proposed guidelines for the BBB, the implementation of BBB in recent disasters such as the 2009 Victorian Bushfires and the 2010 Haiti Earthquake have had shortfalls. Therefore, there still a need to balance the extent of improvement made to structural designs and land-use plans for risk reduction with affordability, time constraints, preferences and traditions of the local community is a common problem. With also a shortage in coordination and communication between the numerous stakeholders involved which creates duplication of activities. Also another problem exists in

facilitating reconstruction and recovery activities to be accomplished fast without compromising quality. As a result, a comprehensive framework for BBB is needed to address this shortage and provide solutions.

3.3.1.2 Recommendations to Improve Post-Disaster Structural Changes

According to Mannakkara[39] and Wilkinson, from the experiences of post-disaster reconstruction worldwide, some lessons can be adopted when implementing structural changes in order to build back better. These recommendations can be categorized under building codes and regulations, cost & time, and Quality.

- **Building Codes and Regulations:** The regulations for hazard based building regulations must be created using multi-hazard assessments in areas chosen for redevelopment and reconstruction. To ensure that structural changes improve the built environment, consistent regulations and a strong legal framework is considered helpful in the adoption of building codes and regulations. Furthermore, the community and stakeholders should be educated about adopting community-inclusive risk reduction/building practices and changed regulations.
- **Cost and Time:** Long-term funding needs to be made available to cover extra costs for structural improvements. Also the building regulations must be promoted using appropriate incentives such as tax reductions. To reduce the time of planning and preparation, a pre-planned strategies for structural changes to deal with post-disaster environments must exist.
- **Quality:** To provide a better reconstruction, inspection from the local governmental authorities during the construction must insure the quality as a priority. This requires training the stakeholders on new design and construction information required for the rebuild.

3.3.2 Promoting Disaster Risk Reduction (DRR) Policy in the Reconstruction Process

According to what have been discussed in Sub-Section 2.2.2, it has been noticed that poor or less developed countries are more and highly vulnerable to disasters, due to their poor infrastructure or having unstable housing in earthquak prone areas. The disaster risk

reduction framework is a plan generated from the collaboration of academics in climate change, disaster response and development.

Development policy and disaster response are intricately linked. Development affects the capacity of individuals, communities and governments to prevent, cope and rebuild from natural disasters[40]. Accordingly, when the disaster prevention methods are ignored, the gains from development is reduced, and in order to maximize the benefits from development plans, disaster risk reduction must be taken into consideration. Global warming in recent years have made a lot of changes in weather causing climate changes and rise in sea levels which have contributed to increased vulnerability to environmental disasters. The existing problem in the relationship between development and disaster reduction is further complicated by climate changes which further involves global governance and economic organizations. The disaster risk reduction framework (DRRF) is concerned about both disaster mitigation and reducing any activities leading to climate changes by merging the risk reduction framework into the development policies and practices. A disaster risk reduction framework suggested by Jessica Mercer et al.[39] proposes to integrate the scientific knowledge with local communities to reduce the vulnerability to disaster, in this framework a new knowledge is not composed, but a method of identifying how existing knowledge can be integrated to achieve the best results of reducing vulnerability levels to environmental hazards. The outcome of the proposed framework consists of:

1. Reduced vulnerability to environmental hazards.
2. Increased collaboration among stakeholders.
3. Organized disaster risk reduction planning.

In order to obtain this outcome, the process framework from Jessica Mercer et al. involves a series of steps. These are briefly outlined below:

- Step One: Engaging the community in discussions surrounding their vulnerability to environmental hazards and the benefits of indigenous and scientific knowledge.
- Step Two: Identification of underlying vulnerability factors and the contribution of each factor to a community's current vulnerability to environmental hazards.
- Step Three: Identifying indigenous and scientific strategies used both past and present for disaster risk reduction.

- Step Four: Draws together the information from the previous three steps to develop an integrated strategy for disaster risk reduction. The expected impact upon vulnerability levels can then be considered in relation to previous exposure, thereby determining the likely impact of an integrated strategy.

3.4 Guidelines for Designing a Temporary Shelter

Temporary housing comes as a solution for the short term reconstruction discussed in Section 3.2 provided to affected families after disaster, which are in a very intense need to recover their livelihoods as soon as possible. As generally noticed from the reconstruction actions for post disaster, the reconstruction process of permanent housing usually takes several months to even start and probably a number of years to complete. Accordingly, it becomes too important to find a rapid method for thinking about temporary sheltering to families in order to start resuming their lives.

Temporary housing comes in different shapes; from simple wooden shacks to more complex prefabricated buildings. So, it is thought that providing a design methodology and providing dedicated standards for designing temporary shelters is very essential and widely needed due to the lack of such standards and also according to the increasing number of hazards and disasters in the last decades.

3.4.1 Temporary housing

So, to find a design methodology, it is essential to know what temporary housing is. The housing recovery includes various stages; these stages may overlap, and not all affected families will pass through each stage. Quarantelli defined the housing recovery stages as follows: 1) In the (brief) period during the height of the emergency, affected families are in the **emergency sheltering stage**; once the height of the emergency has passed. 2) **Temporary sheltering** is employed in the initial days after the disaster and is usually accompanied by provision of food and medical attention. 3) **Temporary housing**, where families can hopefully return to a semblance of normal daily living, albeit in a temporary place. 4) **Permanent housing**, which may follow several months to several years later[41].

According to C. Johnson[6], temporary housing can be defined in two senses; social sense and physical sense. In the social sense, a temporary housing is a house where people can resume on their lives, temporary housing helps people more to recover their lives, as it

can quickly enable them to start again even when permanent houses reconstruction might barely be underway. In temporary housing people usually have their own private spaces so that they will be able to resume the activities of normal daily life. While temporary housing in the physical sense can take on many different shapes, depending on the particular country or whether it is in a rural or urban context. For example, a temporary house may be a prefabricated house, a mobile trailer, a shipping container, a rented apartment or a self-built shack. Not all temporary houses are the same in terms of cost, level of comfort and accompanying services. Although, it has to be comfortable and provides all the people's needs in a house without being over budget for the provider of the house, whether it's the family itself, the government or NGOs. Also according to C. Johnson, a typology for building a temporary shelter can be considered, some of the housing shelter types requires constructing new units, and some do not. While it is considered more cost-efficient to use the existing building, it can have a lot of social drawbacks. So, there are two types of temporary shelters; ones that require new construction, and one that do not require, as follows:

- Types of temporary housing that do not require new construction include:
    - Staying with family or friends.
    - Rented apartments.
    - Public facilities.
- Types of temporary housing that do require new construction include:
    - Self-build shelters.
    - Tents.
    - Shipping containers or mobile homes.
    - Temporary housing units.

Due to the fact that the third stage of housing recovery (temporary housing) is the longest stage before moving to permanent houses, and in this stage the units will be provided to each family separately, the design of these units must be responsive to people's requirements and needs. Accordingly, this study is considered about the temporary housing unit which require design and construction. A model for the design process, and the properties of the temporary housing unit shape according to different countries and different user requirements is fully explained in Chapter 5.

3.4.2 Importance of Temporary Housing

According to experts, it is agreed that considerable investment in temporary housing is a priority not wise, because it will be considered as a twice rebuilding cost expenses when building a temporary housing and then permanent housing[14], [42], [43]. However, reality is contradictory to the opinion of these experts, as the temporary housing has been used in almost every major disaster in the last century. The most recent examples of temporary housing programs are in the United States after Hurricane Katrina (2005), in Pakistan after the Kashmir earthquake (2005), in Thailand after the South-Asian tsunami (2004) and in Iran after the Bam earthquake (2003)[44]. The permanent reconstruction process usually faces many constrains from the demand for building materials, contractors or even building permits to disputes over land rights, urban planning issues and obtaining adequate financing which make it a long time taking process, at least several months up to a couple of year. And even if the government or the NGOs didn't provide a policy for temporary housing people will often take it upon themselves to build a temporary house. For example, in Colombia after the 1999 earthquakes in Armenia, the government was slow in building temporary housing, favoring instead an accelerated permanent reconstruction program; however, within months, the hillsides were full of small wooden shacks that families had erected for themselves as temporary housing.

3.4.3 The Need for Strategic Planning

There is a major misunderstanding in the definition of temporary housing, as it may will turn out not to be temporary at all. By the time these temporary houses are made to be temporary units for post disasters, there physical construction of these units will become a permanent part of the community. Accordingly, it is very important to think about the spectrum of temporary housing in the long-term perspective of the society.

According to the empirical research in this field, strategic planning is considered very helpful in thinking about the job of temporary houses in both the post-disaster period and the long-term planning of the community[45]. This strategic planning is considered highly important, as the decisions taken in the post-disaster period are made extremely quickly and time in this period is very limited, so there is a higher risk of having problematic choices in the future term. As these temporary decisions will be a permanent impact on the future development. If strategic planning is conducted by government it would help in having a better investment of resources, also it could give the benefit of

having the temporary housing as quickly as possible after disasters with a better meeting of people needs. Table 3.2 shows important keys for making a good temporary house program and what is needed to be planned in advance. According to Figure 3.1[14], some main concerns must be considered in the strategic planning for temporary housing such as:

- Types of temporary housing.
- Number of people in the house.
- Estimated time for permanent reconstruction.
- Climate.
- The sites availability.

These are major concerns which are considered as parameters changing from a community to another, and after making the best understanding of these concerns a plan can be made and kept ready in case of a disaster striking. Accordingly, this plan can be updated tactically to meet the needs according to the situation. A strategic planning requires providing temporary housing units ready to use in case of disasters. As an application for the discussed strategic planning, this study suggest a model based on different user requirements (as shown in Chapter 5). This model can be constructed rapidly and can be updated according to changes easily.

Table 3. 2 Key concerns for planning temporary housing (cont'd)

What makes a good temporary house program?	**What need to be planned in advance?**
Quickly available	Delegate responsibilities in advance Procurement agreements with suppliers Identify sites
Comfortable units	Appropriate design for the environment and culture Safe from dangerous materials
Not too expensive	Uses existing facilities if possible Offers basic accommodation; not overbuilt Possibility to recycle units into second use
Reuse	Identify potential reuses Integrate reuse potential into unit design and settlement layout Identify necessary policies, e.g. for donation
Maintains social networks	Locate as close as possible to damaged homes

Table 3. 2 Key concerns for planning temporary housing (cont'd)

Convenient location	Identify possible sites ahead of time and make arrangements for their use
Provision of services	Match with location; may be possible to use nearby existing services Include frequent, inexpensive bus service
Top-down provision of houses when necessary, while enabling residents to help themselves when possible	Consult people about needs and plan accordingly Decide what needs to be provided quickly, in a top down manner Identify what could be managed by residents
Integrated within overall reconstruction strategy	Figure out how long temporary housing will be needed for Estimate a budget for temporary housing, including land, units, infrastructure and services

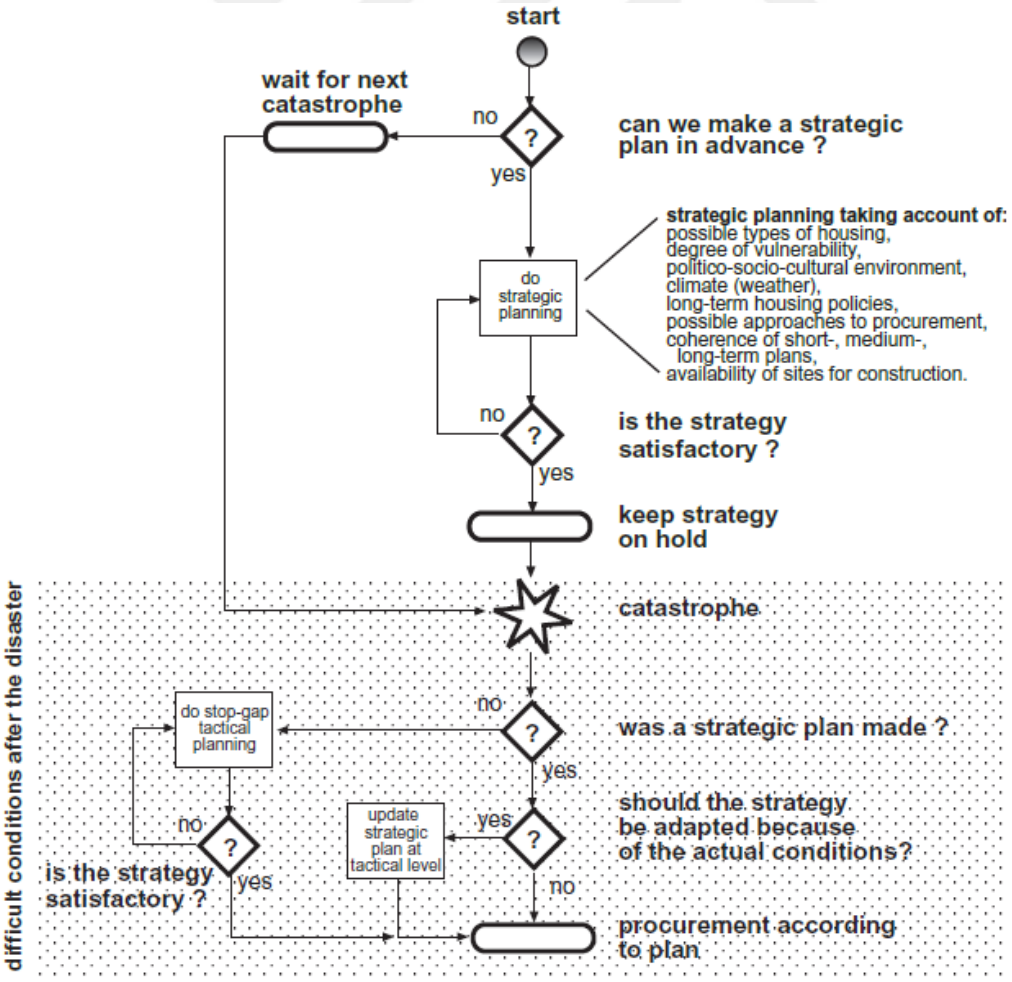


Figure 3. 1 Strategic planning for temporary housing before disaster

3.4.4 Promotion of the Overall Reconstruction Strategy

A strategy which support an accelerated reconstruction of permanent housing is advocated by Ian Davis in his book “Shelter after Disaster”, in order to reduce the need for temporary housing[8]. This proposition is also supported by Cassidy Johnson as she claims that temporary housing disproportionate the amount of financial resources and it also could lead to limiting in the permanent housing resources[8]. However, it is often not possible to accelerate the permanent reconstruction in the reality due to the complications regarded to permanent reconstruction. These complications happens often in the reconstruction process which makes the permanent reconstruction take several years to be built. . For example, after the South-Asian tsunami, it took many months just to come to an agreement about how far permanent housing had to be set back from the shore. According to the empirical researches in the field of temporary housing programs, two different models were revealed for an overall reconstruction strategy:

1. Relatively small investments in temporary: in this model the basic structures and little services are provided, also the financing from governmental and organizational will directly go into the permanent reconstruction[43].
2. Large investments in temporary housing: in this model all needed services with high quality housing is provided, this housing is meant to last for at least three years before starting the permanent reconstruction.

The first model was implemented in Mexico City after the 1985 earthquake and in Colombia after the 1999 earthquake. In Mexico City, temporary housing were very simple and rudimentary with a location next to the destroyed houses on the roadway. While in Colombia the temporary houses were built by the families themselves with some support from NGOs. According to the small budget used in these temporary housing, the financial supports were all allocated for permanent housing and temporary housing were considered as transitional level while permanent reconstruction were in process. The previous cases are unlike what happened in Turkey after the 1999 earthquakes. Their decision was to set large investment for the temporary housing (estimated at 225 million USD) so people were worried that no budget will be left for investments of the permanent reconstruction. According to the large scale of damages, the government expected that permanent reconstruction would take at least two years to start, as a result loans were sought from the World Bank and the European Development

Bank to help finance the permanent housing. As a fact, people stayed in the temporary housing for three years and some case have stayed for even longer. Therefore, from what have been mentioned previously, a strategy for the overall reconstruction is necessary at the outset, and then planning for temporary housing can work within this strategy[14]. Accordingly, permanent houses will start to be built as soon as possible (within several months) with a few complications regarded to land rights or urban planning, and the investments for temporary housing can be set to minimum levels for the sake of permanent housing. Although, the level of destruction is very important, as if it is considered severe and the permanent reconstruction is estimated to take long time to start then the temporary housing has to be comfortable and well serviced as for long occupancy.

3.4.5 The Second Life of Temporary Housing

From the fact that temporary housing is designed for a short period of time estimated to be between a few months up to few year, a method of thinking about the second life of these houses in considered necessary, and in order to obtain the maximum efficiency, this must be thought of from the beginning of the outset of the reconstruction program and its implementing methodology. According to Cassidy Johnson there are five option to select from for the second life of temporary housing: 1) Rental housing; 2) Reuse; 3) Recycling parts; 4) Temporary houses as 'cores' for permanent houses; and 5) Refurbishment of the units and storage for the next disaster.

1. Rental housing: From previous cases of disasters situations, there is a shortage in finding an affordable rental housing, and the cost of renting a house usually increases. As a result, temporary housings can be used as rental housing in their second life especially if their quality is decent and the situation is good. Accordingly, the ownership of the houses can be transferred from government to private sector, or even the landholders can use it as houses for their own. For example, in Turkey many temporary housing located at the center of the city were reused by people to live in, hence they have improved them and added gardens.
2. Reuse: The designed temporary houses can be designed in a method which can make it possible to be disassemble and transported to be used in another place with another purpose. For example, in Turkey one temporary housing project was de-attached and transported to be used as additional classroom in a school, this

unit was designed for the purpose of reuse as it was made of steel structure with prefabricated sandwich panels. In another project a temporary housing unit was purchased by a university to be used as a dormitory for students inside the university. Accordingly, the temporary housing must be designed to have flexibility in the interior spaces and strong structure to withstand transporting.

3. Recycling the parts of temporary housing: Some parts of the temporary housing can be recycled, if the temporary housings were made for example from wooden structure and cannot be reused as a whole. Some parts such as windows and doors can be used in permanent houses or can be donated to families or sold with symbolic prices. Although, this cannot be done sometimes if the temporary housing were owned by the government like what happened in Colombia after 1999 earthquake.
4. Core houses: This method is considered very smart and sustainable, in this method the unit is designed to be used a temporary house for families in emergency states and then as a core for the permanent house. This unit may contain the plumbing and electrical services and a small amount of living space. Afterwards, in case of permanent housing, all wanted parts can be added such as living room, entrance or storage rooms. This model can be used most in places in which people own the land where the unit is meant t be established, so they can add the extra parts according to their needs and budgets. In Düzce in Turkey, there was no formal program that used this approach. However, people some land owner families did it by themselves, they obtained the temporary unites and placed it on their land, and built a permanent house around the basic unit.
5. Refurbishment and storage: Normally the temporary housing units are designed to be collected, refurbished and stored to be used in case of another disaster in the future. But the storage cost is actually considered extremely expensive as it is expected to be stored in a place for many years. However, the storage manner could be considered more reasonable if the government has its own facilities of storage. Similar to what happened in Turkey as the government collected all the units after 1999 earthquake back to the producing facility in Ankara, as it was refurbished and renovated, even some of these units were sent to Bam after the 2003 earthquake.

CHAPTER 4

PARAMETRIC ARCHITECTURE AND COMPUTATIONAL THINKING, A NEW METHOD TO THINK RECONSTRUCTION

During the last decades thinking and practicing architecture have witnessed significant changes due to the evolving of computer science. By the mid of 1990's practicing architectural work had become unimaginable without the use of graphic software. Nowadays parametric and computational algorithmic thinking in architecture and design is becoming more and more dominating, As a result, it have made architecture also take a place in the "intellectual revolution" similar to all the aspects around us. Parametric design is not unfamiliar territory for architects. From ancient pyramids to contemporary institutions, buildings have been designed and constructed in relationship to a variety of changing forces, including climate, technology, use, character, setting, culture, and mood. The computer did not invent parametric design, nor did it redefine architecture or the profession, it did provide a valuable tool that has enabled architects to design and construct innovative buildings with more exacting qualitative and quantitative conditions.

In the domain of architecture, computational design has emerged as a sub-discipline of architecture which is multidisciplinary in nature, this method uses advanced computing capabilities to have a better understanding and presenting solutions to complex problems in the architectural design. Furthermore, by the integration between the computer's abilities and physics these digital technologies have enabled new methods of design, which has led to the rethinking of currently used design theories and educational concepts. Generally, form in parametrical design method is shaped by values of parameters and equations which are used to define the relationships between the forms. Hence, interdependencies between forms can be established and their behavior under transformation can be descried (mathematically and geometrically)[43]. "Parametric

systems are principally based on algorithmic principles" since "an algorithm takes one value or a set of values as input, executes a series of computational steps that transform the input, and finally produces one value or a set of values as output"[14]. Thus the scripting interfaces accessible in most software packages which are innately predisposed to creating parametric models. In parametric tools, the advantages of being adaptable and responsive to changing design criteria and requirements makes the generated parametric models more suitable to user requirements.

4.1 The Process of Parametric Design

The process of generative formation in parametrical thinking requires four elements:

- The start conditions and parameters (input).
- Finding a generative mechanism (rules, algorithms etc.)
- The act of generation of the variants (output).
- And the last is the selection of the best variant.

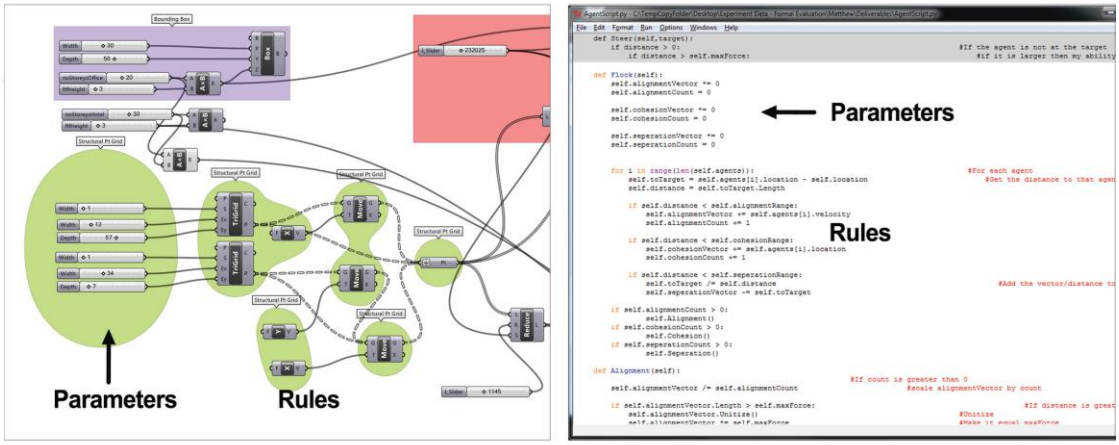
The design artifact does not come out as a product until the fourth step, therefore a generative system is considered as a production system instead of a representational construct[46].

4.1.1 Parameters

In the design process of generative systems parameters refers to variations in the design domain, parameters can offer multiple variations that generate various ideas, the designer changes the parameters in the parametric model to search for different alternative solutions to the intended design. The diversity of parameters is the leading method for creativity as well as extending the boundaries of knowledge, the design can become unique from one designer to another due to their selected parameter. Therefore, a rigorous thinking is required to build a sophisticated geometrical structure embedded in a complex model in order to make it flexible enough for doing variations. Thus, a designer is required to anticipate which kinds of variations he wants to explore in order to expect the shape of transformations the parametric model should do. This is considered a very difficult task due to the nature of the design process which is known to be unpredictable.

4.1.2 Rules/Algorithms

When considering creativity, the process of converging knowledge comes as an important step, rules are the way to define the relations between geometric elements, also configure the parameter attributes, having a wide base of knowledge in the design program can provide a new way of design thinking and exploration also drawing on architectural expertise beside being an important factor in eliciting both personal and design creativity. Rule-based design as a computational design method has been foundational in the practice and research of design computing. Figure 4.1 shows parameters and rules in two different design environments (Grasshopper and Python in Rhino)[47].



(a) Graphical algorithm editor (Grasshopper)

(b) Text-based algorithm editor (Python)

Figure 4. 1 An example for parameters and rules in two different designs

4.1.3 Generating Variants (Output)

From the given parameters and the rules executed on them, diverse number of designs are shown as a result which is considered the output of the design process, these variants are different according to changes made to the value of the different parameters suggested by the designer, the number of these variants is changeable according to the number of parameters, and this is considered as one of the most important features of parametric design, and an element of creativity, this shows how the selection of efficient variations could help in having personality and creativity. Figure 4.2 shows the number of different generated variants in the exterior envelope of The Hangzhou Olympic Sports Center in China[47].

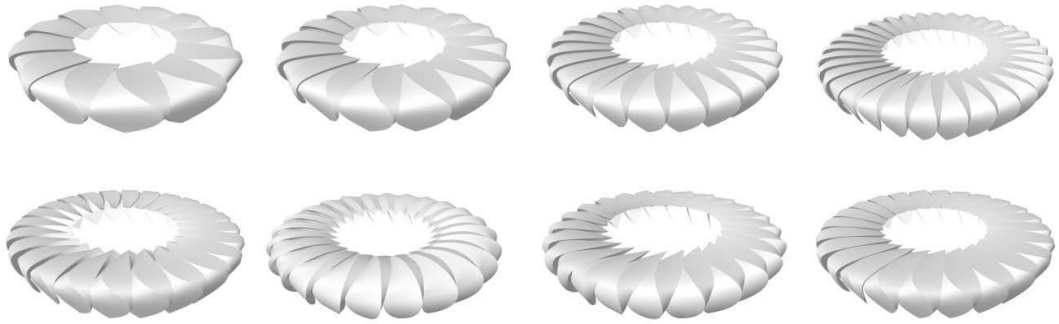


Figure 4. 2 Different variants in the exterior envelop while designing The Hangzhou Olympic Sports Center, China

4.1.4 The Selection of the Best Variant

An evaluation process is attended to be implemented in this stage through a computerized process that evaluate all of the given features of each of the variants and then to select the best results which can help giving the best design due to efficiency.

4.2 The Efficiency of Parametric Architecture

To understand how parametric architecture works, a simple example will be motioned; when using the CAD applications such as AutoCAD a lot of tools are used to do the work we need, these tools can do the job of drawing a kind of a complex shape by including some certain values (generally asked by the program itself), and with the use of these values a shape will be drawn, the built in system of the programs that enable the user to use these tools and helps him a lot to do the job he need with minimum time, such of these tools is the "array" tool (Figure 4.3) that is found in most CAD software, it is a way to repeatedly move and copy elements. Instead of doing it manually and take time in drawing, erasing and redoing, a user can benefit from the abilities of computer to work with algorithms.

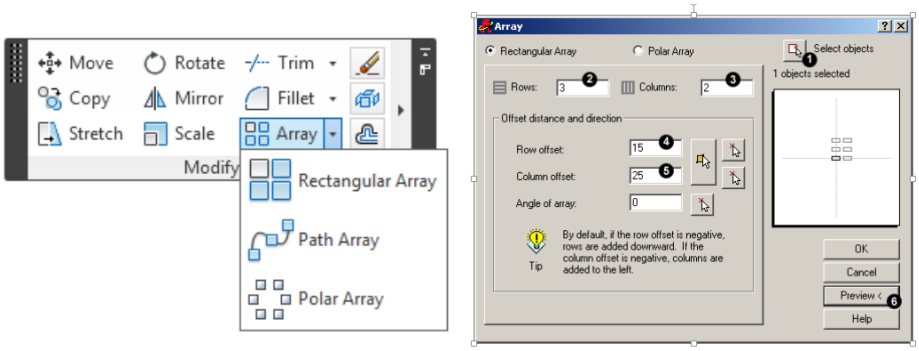


Figure 4. 3 Array tool works in AutoCAD

Another example which explains the workability and the speediness of parametric thinking can be shown by thinking about drawing a simple façade of a building; when drawing the façade of a skyscraper which has eight windows in each floor, divided evenly along the length of the façade, it is simple, but after finish drawing it, you find out that you need to do some changes of the design, bigger windows are needed, and maybe the position of each of these windows will change a bit according to the new design, which means extra time and cost. Therefore, parametric design algorithms makes the computer do the calculations and draw the geometry.

4.3 Parametric Architecture and Humanitarian Field

The need for shelters is the first significant need that comes up directly after the disaster. Thus, thinking about a shelter design must consider both (technical, sociological) constrains, in this process a method which does not only take the physical parameters such as (gross area, height or structure) but also the contextual and climatic parameters (e.g. site conditions, culture of inhabitants, tradition, climate, etc.) Providing a humanitarian shelter design is usually limited by resources and also by the standard solutions which is not responsive to site or user specific requirements. Normally in building shelters the priority is speed and safety, this is where the standardized, prefabricated solution is often seen as the most appropriate. However, these methods includes importing some high-tech equipment and expensive components which are considered foreign and hard to find in developing countries. The underlying theorem is that the more the recovery relies upon local resource, the quicker the community will be able to move to self-sustainability, and thus from recovery to normalcy[4]. Accordingly, to consider a successful building, the design must be build according to parameters that encompass those psychological and social needs.

To obtain the optimum design through the interrelation of these parameters, the use of parametric tools come so helpful. There are only few applications of the computational design field which have taken care about the humanitarian design field. However, the use of the parametric design strategies would be considered as an optimum solution for the humanitarian field.

4.4 Parametric Architecture as a Method for Post Disaster Reconstruction

With all of these changes in the way of thinking, designing and drawing architecture, a new method of re-thinking reconstruction in post disaster is needed, applying parametric architecture method in humanitarian design is an under research topic. Having priories in post disaster reconstruction design such as time reduction, resources conservation, safety and cost should also be taken into consideration. Also with constrains as the unpredictability and diversity of cases, moreover different locations with also the culture and tradition of each region, the response of all these matters is becoming more complicated. However, the use of generative algorithms is considered particularly useful in humanitarian design and post disaster reconstruction for the following reasons:

1. Having extreme conditions in these states would generate a lot of constrains which can be considered as variants and form the base for a parametric design.
2. Enabling optimal use of limited resources, the integration of the interrelated performance requirements is needed.
3. Defining an affordable robust model through parametric modeling would have the property of enabling a mass customized design to adjust for different site and user requirements, and the most important feature is that it allows improvements in subsequent design based on community evaluation.

In such cases of architectural design there is an urgent need for time reduction, resources conservation, also taking safety and cost into consideration. Therefore, parametric modeling is considered an ideal solution for such requirements[48].

4.5 Smart Technologies in the Parametric Design Process for Post-Disaster Reconstruction

To create a parametric design model for post-disaster reconstruction and finding an optimum design solution in the paradigm, considering all the latest architectural design strategies is considered helpful, such strategies are; transformable buildings, multipurpose buildings, green and sustainable building methods, prefabricated and pre-cast technologies, and all the methods which can help satisfying the requirements of post-disaster reconstruction such as; urgent, rapid, cheap, easy to construct and multipurpose if possible.

4.5.1 Sustainable Architecture

When humanitarian architecture is a method of thinking about human and how to find solutions to their problems, also when thinking about parametric architecture with versatile parameters, the need of being environmentally friendly and working to save earth resources is an efficient way of thinking about humanitarian architecture. Furthermore, it is not only thinking about finding a solution but also a method of not causing problems at the first place, also sustainable architecture helps in being more subjective when thinking about the parameters needed to be satisfied for any design.

The passive and active techniques of saving energy, also the selection of recyclable and local building materials are general techniques to take advantage of while doing the design of post-disaster architecture for both long term and short term architecture, and also can be considered as an important parameter while thinking a parametric temporary house prototype for post-disaster architecture mainframe.

4.5.2 Transformable Buildings

The method of designing transformable structures includes a designing approach in which time is considered mandatorily from the early stages of conception in the design process. The design is considered transformable over its life time also have many other features of being re-locatable, reusable, demountable; its building components can be reconfigurable, removable, replaceable, etc. Moreover, these structures can adapt their shape or function according to changing circumstances, to rapidly cover their intended evolving needs required by the society. Accordingly, these features highly embraces the concept of sustainable design according to the working method of these structures that make them not designed for an end state or to be ended in landfills, but in transition state[41]. Further, the transformable designed buildings can be easily modified to meet the demands of changing users or standers. According to how this transformation is understood, two groups of structures can be distinguished. The transformation state of the structure is basically made either by incorporating a mechanism or by designing the structure as a demountable kit-of parts.

4.5.2.1 Structural Mechanism

By considering this mechanism, the transformable structures are provided with a certain mobility system so it can deploy from a compact shape -for the favor of easily transporting the structure- then to a larger shape in which it can provide its intended architectural function (e.g. providing shelter) as shown in Figure 4.4[9].



Figure 4. 4 Mobile deployable bar structure

4.5.2.2 Demountable Kit-of-Parts

When designing a structure as a kit-of-parts with dry, reversible connections between the constitutive components, it becomes possible design for disassemble (DFD), with the advantage of having all these components reconfigurable, replaced or reused (Figure 4.5).

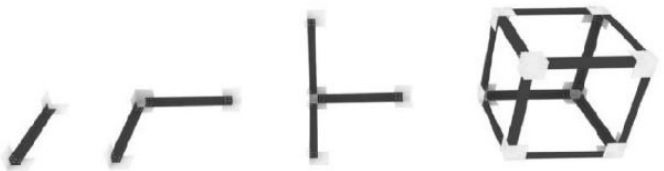


Figure 4. 5 An example for demountable kit-of-part system

4.5.3 Precast Buildings Technology

The precast construction method is the method in which prefabricated molds are used to produce concrete members that can be transferred and lifted at the site then attached to each other using special methods to form building. The main feature for this building system:

- The division and specialization of the human workforce.
- The use of tools, machinery, and other equipment, usually automated, in the production of standard, interchangeable parts and products.

Other effective characteristics of such a method is that it is considered so rapid in the production of members, and the quality control for the produced members are

considerably high, also the molds can be used hundreds or thousands of times to reproduce the members, which also make the structure affordable and cheaper when implemented on large scale. Also when having extreme weather situation the fabrication of structures is considered very efficient and fast due to fabrication made inside the factory, so it is fast that the fabrication does not have to wait until weather is convenient like normal building methods are. Figure 4.6 shows some statistics for the benefits of the Precast technology.

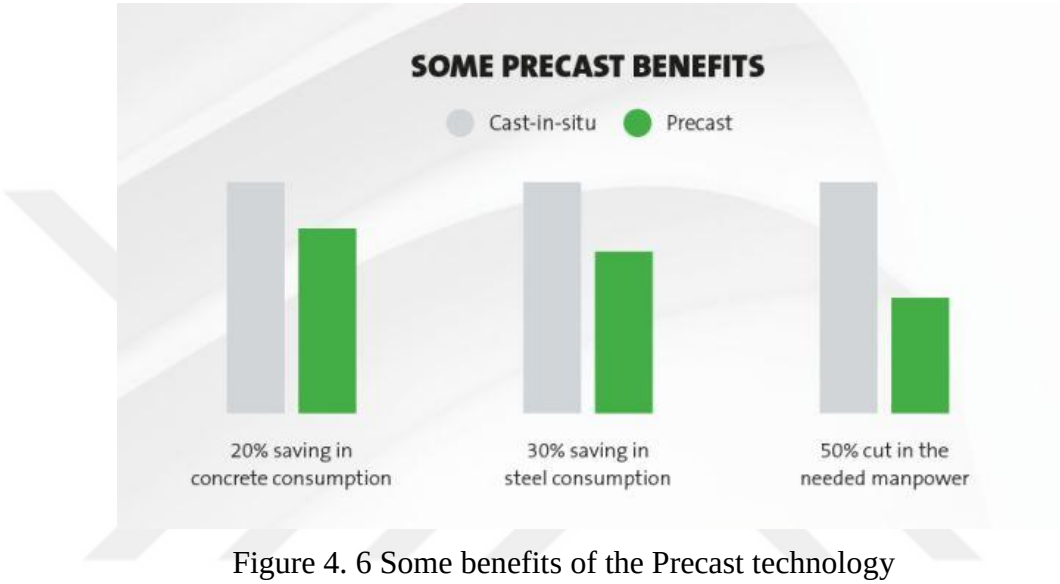


Figure 4. 6 Some benefits of the Precast technology

4.6 A Case Study for Parametric Post-Disaster Reconstruction in Solomon Islands

The case study conducted by Wendy K.Yeung and Jeremy Harkins in[49] descries the parametric model made in Ranongga- Solomon Islands after the earthquake and tsunami which had happened in Solomon Islands in 2007. Ranongga is a 28 kilometer long, narrow island situated amongst the New Georgia Islands group of Western Province, Solomon Islands (Figure 4.7[49]). A huge devastation has been experienced by Ranongga in April 2007 due to the earthquake and tsunami happened to this area. The permanent rebuilding in Ranongga has been delayed for a few years after the disaster with communities living in the temporary tents of UNHCR. With making visits and trying to engage the community of Ranonggo, the Emergency Architects Australia (EAA) coordinated the rebuilding process and tried to establish a number of ongoing projects as a step to address community resilience[9].

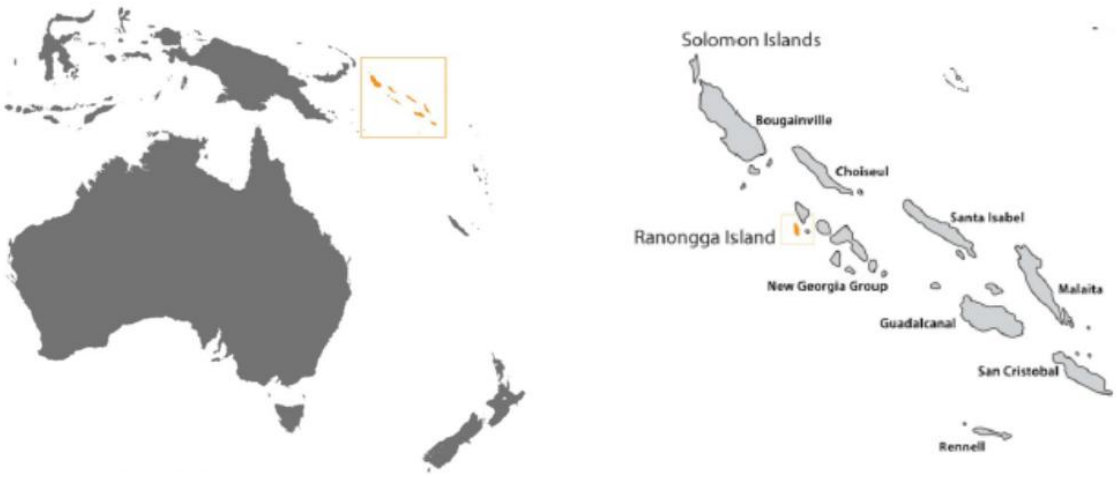


Figure 4. 7 The map of Ranongga island

4.6.1 The Designing Association and the Parametric Model

The Sanitation and Wash Project in Ranongga for the Ministry of Education and Human Resources Development and World Vision is the selected project for the case-study. An exemplar Ventilated Improved Pit (VIP) latrine had been designed by Emergency Architects Australia (EAA) (Figures 4.8 and 4.9[9]). Also this model was made for an evaluation processes, as data was indented to be gathered to feedback the sequential design on a consistent and comparable basis for advance modeling. EAA had completed the site and requirement assessment and the BOQ (Bill of Quantities) for four schools[50]. The methodology for implementing the project includes[9]:

1. Preparing and digging of the latrine pit.
2. The sourcing and the building materials retrieval to site (timber, stone and sand).
3. Concrete preparation for latrine slab and footings (mixing, pouring and curing).
4. Assembling the timber structure.
5. The cutting and fixing of cladding and roof sheeting.
6. Earthworks, leveling, improvement of site, drainage.



Figure 4. 8 VIP latrine project in the village of Keigold, Ranongga. From left to right: (a) delivering roof sheets by dugout canoe; (b) one of the twenty VIP latrine during construction; (c) finished VIP latrine



Figure 4. 9 The finial project (VIP) latrine

4.6.2 Between Constraints, User Requirements, Model of Delivery and the Parametric Design Process as a Useful Solution

The reconstruction of Solomon Islands from Tsunami 2007 was constrained in many ways. The human habitation on the island is geographically spread out with almost no infrastructure, causing problem in material transportation due to habitation spread shape. Another constrain regarding material is the selection which was considered limited in choices, also being sporadic; as it was not available all the time. As well as a very basic method of building which depended on simple tools like handsaws and hammers. The building, designing and supervision processes was led by foreign experts which is considered costly, until providing a sufficient local capacity. A step of making a local depending system and alleviate reliance on foreign experiences would ensure both continuity of the project for as long as possible, also would allow for funds to be spend more on direct construction, with no need to mention the feature of transferring

knowledge to local staff members and providing a successful field workers for further projects. At the meantime, the most successful delivery model involves having international aid from agencies which design and build prototypes as a method of transferring experience and knowledge to local communities. However, these prototypes usually requires a lot of modification in order to suit new site and project specific requirements. Due to this the field architects and site engineers are required to repeat the calculation and documentation manually which is a time consuming process. From above stated, it is concluded that a successful design would require:

- The economical use of local materials which can be built easily and quickly with basic skills and tools.
- The participation of community to ensure knowledge transfer and low cost.
- Building a system which is able to adapt site and user requirements, and also to be flexible to absorb the unexpected circumstances such as material shortage.
- To ensure a long term viability of the project, the designs are supposed to be easily replicable by local communities with minimum need of external aid.

As a result, parametric design method is considered as an innovative solution for such constrains and user requirements. Furthermore, when the post disaster reconstruction and development usually includes replicating hundreds of building units from one prototype in different sites, this is a great chance for evaluating the design and construction process and making use of the user's feedback to improve subsequent sets of designs. However, applying the parametric design modeling process has a problem of lacking building examples, also the few existing built works are considered expensive and requires long time to design and construct. Consequently, there is a major constrain of shortage in lessons learnt from previous projects to design new ones. Accordingly, developing work from a prototype is considered very useful in giving the potential to test these technologies and improve it by comparable basis over time.

4.6.3 The Design Process of the VIP Latrine

From the built of VIP latrine in Ranongga, it was identified in which areas the digital technologies can significantly be used through the whole process. The urge need for aid works made the way of approaching the problem in this case study woks by introducing

a number of small packages of digital tools, while having the intention of improving and adding more divert tools over time as shown in Figure 4.10[9].

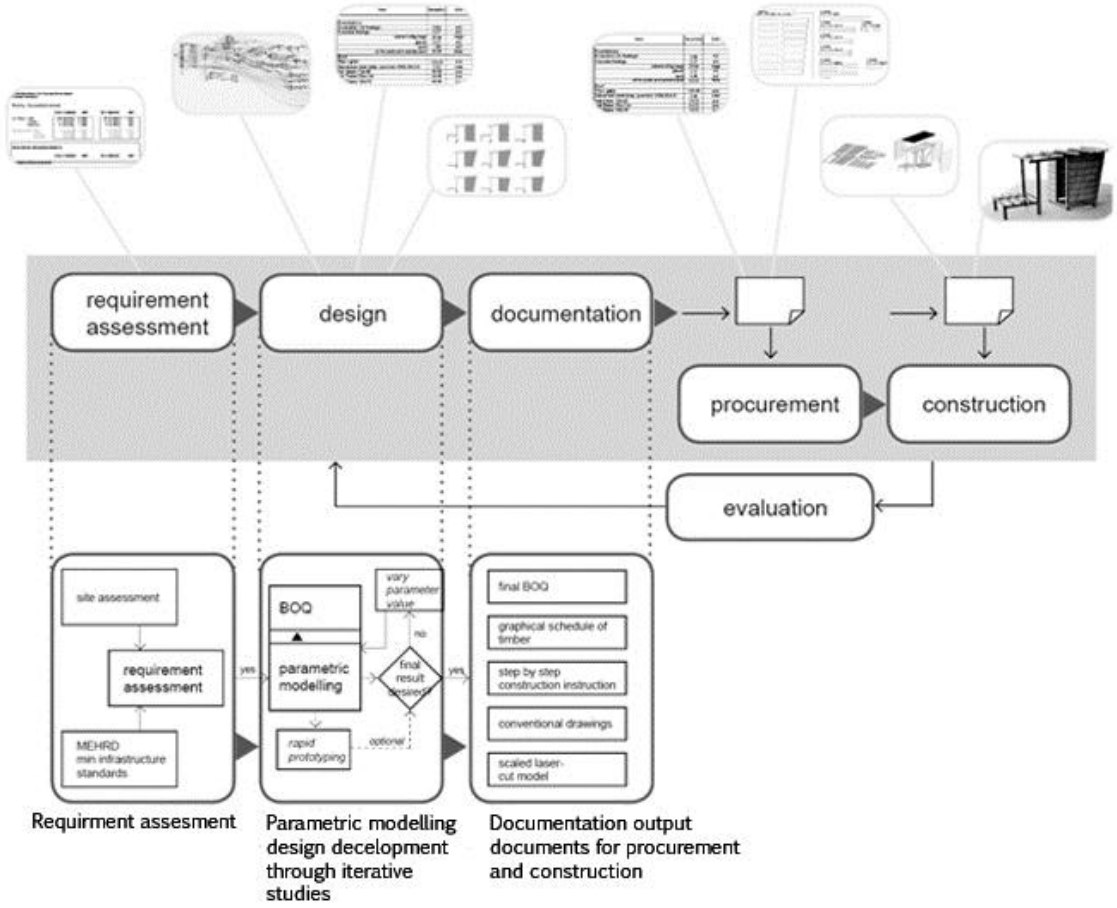


Figure 4. 10 Digital acupuncture-flowchart summarizing the VIP latrine system and its components

4.6.3.1 Assessment of Requirements in Parametric Modeling

After doing the site analysis the concluded data was fed into a Microsoft Excel spreadsheet in order to calculate the additional water and sanitation requirements for the schools. These values from calculation spreadsheet were fed into the design parameter spreadsheet which stores all the parametric values for the digital model in Rhinoceros. Then these values was directly linked with Grasshopper so the model can be controlled according to the values taken from the spreadsheet or with direct sliders in Grasshopper. Linking these values is considered helpful for making a direct update to the quantity and cost of needed material and fuel, and describe how many delivery is needed to transport all material as shown in the BOQ. This method of studying the model and the ability to do adjustments to the parameters can give the user the opportunity to obtain the intended

outcome through informed decisions. Furthermore, this method enable variety of options for rapid prototyping, providing future study and comparison between prototypes in reality. Another benefit from the model is enabling the user to know the areas for potential cost saving, also the chance for raising the design features with a very low increase in cost, as seen in Figure 4.11[50].

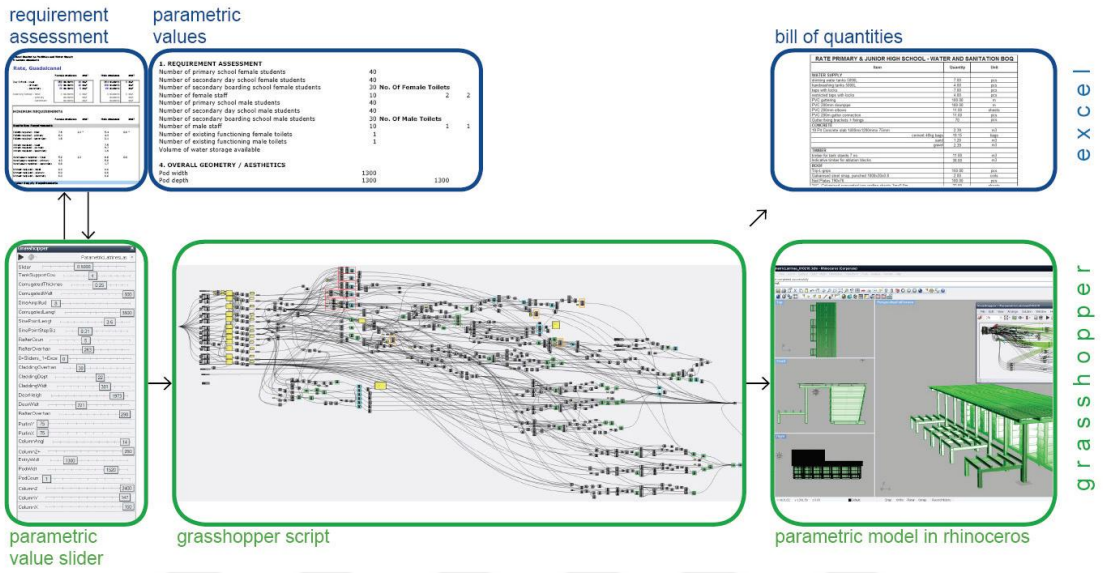


Figure 4. 11 Flowchart summarizing the parametric description of the VIP latrine system. Top row from left to right: (a) requirement assessment; (b) parametric values in Excel spreadsheet; (c) BOQ generated by the parametric model. Bottom row from left to right: (d) slider for selected parametric values in grasshopper; (e) grasshopper script; (f) parametric model interface

4.6.3.2 Design and Design Parameters

In the design process of the VIP latrine there were many parameters and constrains in the Grasshopper script. But the main inputs were the number of intended users; male/ female students and staff (in order to estimate the required capacity), the size of the modules, availability or selection of material, and slope of the roof and inclined wall. These parameters are considered interrelated but can be classified into five categories:

1. Capacity: includes the number of toilets and water storage required.
2. The overall geometry to determine the form of the building.
3. The available material and how to select one.
4. The funding of the project and the time constrains.
5. Constraints, tolerance, miscellaneous.

Furthermore, from VIP latrine feedback from post-occupancy, areas for improvements and essential parameters for modeling were found. The availability of vent pipe diameters and the roof sheets thicknesses fluctuates, are examples of parameters which were considered while writing the Grasshopper script. Also another example is while digging for the pit by the community members it was found that the slab ended up too small, so in the net revision of the design another alternative was introduced. Figure 4.12 shows some of the adjustments[9].

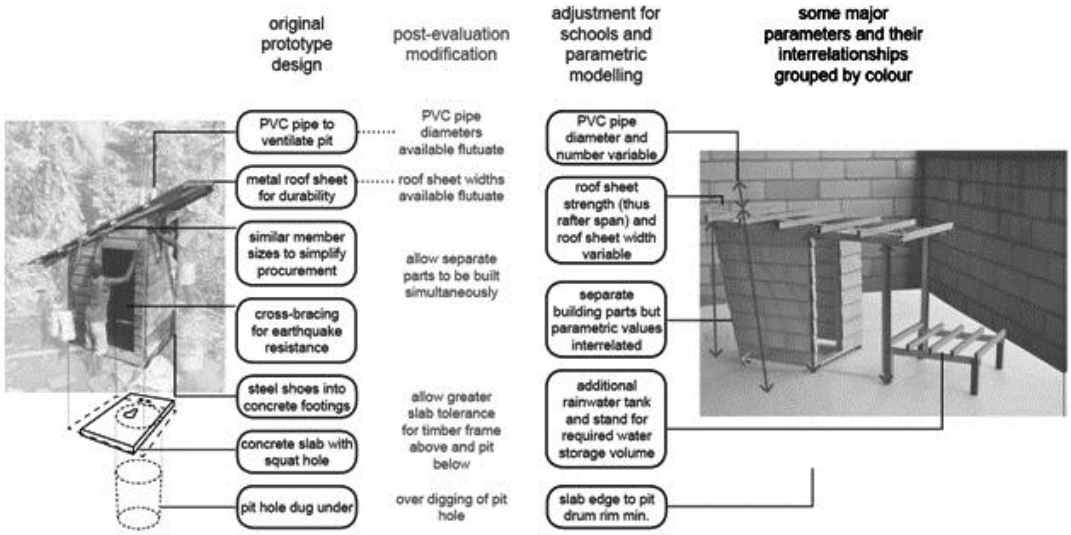


Figure 4. 12 The translation of feedbacks from post-occupancy to do the modification and adjustments for parametric modeling

4.6.3.3 Output: Documents for Procurement and Construction

After the desired designed is obtained, the data from the model generates the following documents for procurement and construction:

- Final bill of quantity: which is according to the main elements in their known dimensions.
- Graphical tables for the timber members: listing dimensions, quantities and description for all the needed timber members for the milling and cutting works to be done in the site.
- Graphical step-by step instruction: this step is needed for the construction process with a 3d graphical method to show the building (quit similar to IKEA instructions for their products).

- Conventional construction documentation: this is usually for skilled carpenters and community members who want to understand the construction drawings.
- 1:1 paper/plastic templates: for further understanding of the elements which need notching or trimming in special shapes.
- A file for the laser cutting: for all the main elements in a 1:10 model. This model helps understanding how the elements of the building will be assembled.

CHAPTER 5

AUTOMATIC SELECTION OF DESIGN PARAMETERS

5.1 Introduction

According to pervious chapters, in order to make a parametric design for temporary house in post disaster, the designer should provide the selected algorithmic modeling application, e.g., Grasshopper, with the parameters of the intended design in shape of numerical values, the ranges of these numerical values ought to result a number of variations to select the best option. However, there still an intense need for trained professional architects in this field who are able to first, find the suitable design parameters, then translate these parameters into numerical values (input) to provide to the algorithmic modeling applications. This is considered essential to overcome the constrains that permeates the design process of a parametric temporary house unit, such as rapidness, cost and adaptability.

Due to the fact that the reconstruction process is usually implemented by NGO's, thus comes the intense need for trained architects who are considered as a link between; the team doing statics from the disaster field and the designer team in their offices. However, this is considered a long time consuming process which can postponed the design process as well as the production of the unit. As a result, a smart method for making this step automated and more controlled by computational methods to achieve the intended results in minimum time with less errors, is considered essential. Furthermore, there is also a lack in the design criteria which can be considered as standards to be set as parameters

for the design, these standards are very helpful to generate different variants of temporary house units which can satisfy the different needs of all communities and individuals.

Accordingly, the foundation of an automated system that can select the best parameters (in shape of numerical values) according to the given statics from the disaster site is very essential and a problem solving step in order to be rapid and responsive to different design requirements. Furthermore, this automated system is ought to work according to simple data (in shape of statics) with no need for professional trained architects to translate the data into parameters and then into numerical values.

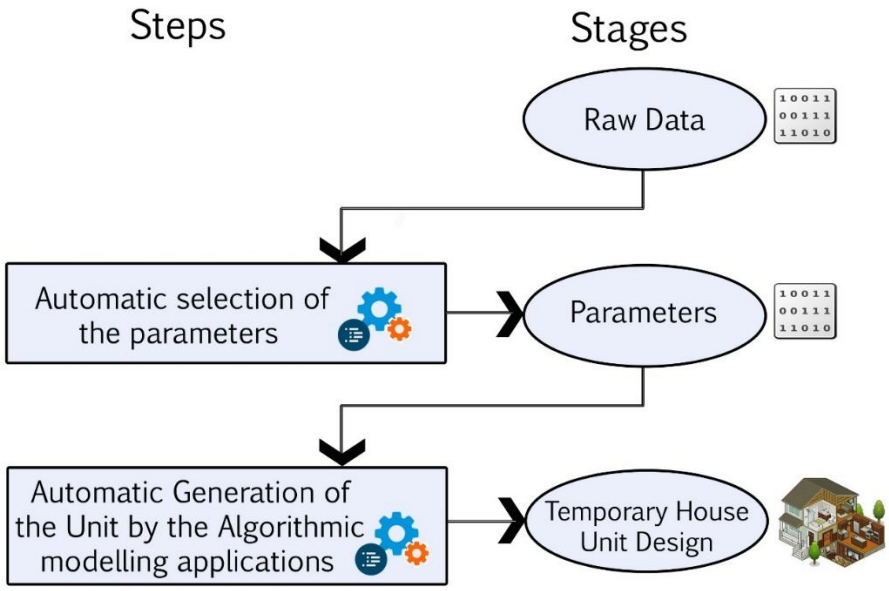


Figure 5. 1 The considered model for parametric temporary house design process

5.2 Considered Model for Parametric Temporary House Design Process

The considered model consists of two main steps and three stages of data, as shown in Figure 5.1. The first stage of data is called Raw Data which is the statistical information collected from the disaster area, these Data will be as input for the first step of the process which is Automatic Selection of Parameters, in this step a smart trained system is supposed to select the design parameters according to the given input. So, the output of this system will be design parameters which will be provided as input to the selected algorithmic modeling application, e.g. Grasshopper. The second step is the Automatic Generation of the Units in the algorithmic modeling application according to the given parameters. Then, the output from this step will be in shape of Temporary House Design

Unit which will be used in post disaster areas. The considered automated process will provide suitable designs to the intended area in minimum time with best adaptability to both site and community.

5.3 Problem Statement

In the aforementioned process, the first step is usually implemented by trained architects who are supposed to understand the Raw Data from the site and translate it into the best parameters shaping the design. However, this is a long time consuming job which should be avoided in the post disaster state.

Accordingly, it is essential to find a smart technique which can solve the problem in step one. Therefore, in this study a smart technique will be explained, the technique depends on using the Neural Network automated classification method. Neural networks are a computational approach which is based on a large collection of neural units that resemble to the way the human brain solves problems with large clusters of biological neurons. The neural network (NN) is a classifier which can assort objects into classes. The neural network accepts a number of inputs (which describe an item to be classified) and outputs the class it believes the item belongs to. The neural network must be trained to provide correct results. The NN must be fed with examples of all possible classes. Meaning that the NN must be provided with the input and the output class to be classified in. Given many such training inputs and outputs, the NN will be able to do the classification according to the provided training. For further information about the NN and their working method and their application check[9]. The Neural Network is a trained system which is similar to human thinking method that can classify a particular element according to a set of features (input data). Therefore, in order to use this method, there must be enough pairs of input and their related output which are large enough to train the Neural Network in order to do the classification process in the intended shape.

Therefore, the contribution of this study is as follows (Figure 5.2):

1. Select the feature vectors _design requirements- needed to design a temporary house which will be as input for the Neural Network system.
2. Design the Neural network system.

3. Generating large numbers of pairs of inputs and their related outputs in order to train the Neural Network, the number of these pairs should be large enough to train it.
4. Setting the parameters of each class in shape of design properties according to the characteristics of each class resulted from the neural network.
5. Collect real Data to be tested by the Neural Network system in order to verify its efficiency.
6. Evaluate the results.

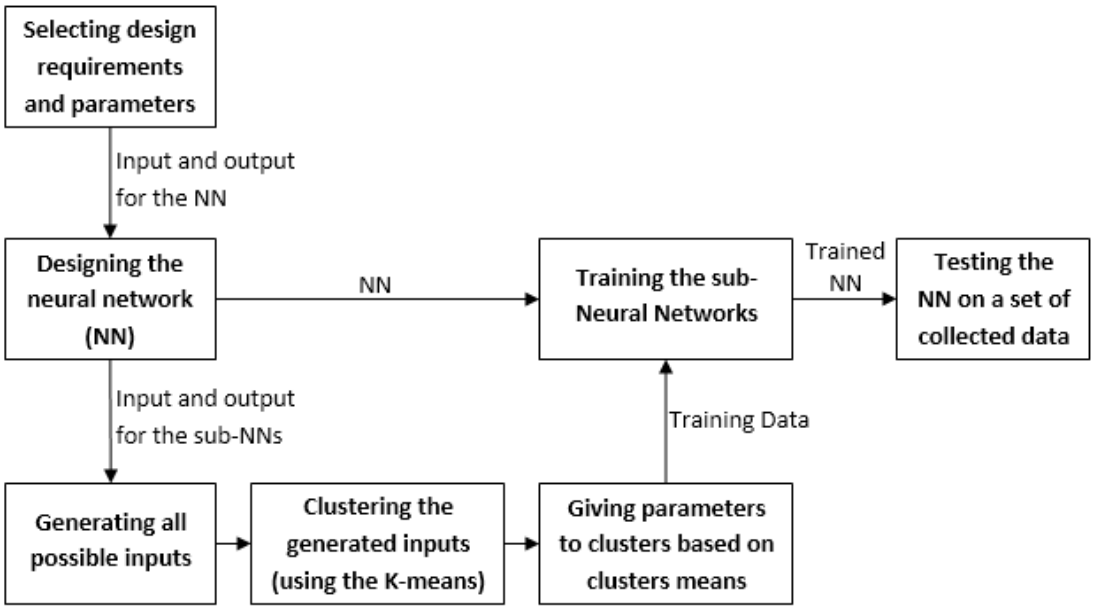


Figure 5. 2 The Automatic selection process of the suitable design parameters

5.4 Model design process

In this part, the process in which the experimental model was implemented will be explained. The six stages of the process will be explained in details, from finding the design requirement, to finding the input data, then setting up the intended system, after this comes the stage of training and experimenting the system, and finally the evaluation of the system.

5.4.1 Selecting the feature vectors design requirements

The first step of constructing any architectural project is to find the design requirements, these requirements will be expressed as feature vectors in the system of Neural Network.

According to S. Sener and M. C. ALTUN 2009[9], the disaster survivors have not used some of the temporary houses which were constructed due to their defects. Also, after the 1999 Marmara Earthquake, In the Yenikoy - Kocaeli temporary shelter settlement, it was observed that 48% of the users have made modifications both indoors and outdoors of their shelter unit, 30% of the users have made modifications only outdoors, 3% of the users have made modifications only indoors. Only19% of the users have not made any modifications to their shelter units. Indoor modifications are related to user requirements like space partitions and privacy needs. Accordingly, it is too important to fully understand the people's needs in order to set all the needed design requirements. Therefore, the resulted design of the temporary house will be a helpful solution to people after the disaster.

Consequently, the design requirements must be responsive to all people needs, the people needs are a changeable factor between countries and cultures. Furthermore, the design requirements does not only include climate and size, but also need to include special requirements which can be termed as "privacy" requirements that can affect the shape of the resulted design according to the user preferences.

S. Sener and M. C. ALTUN 2009[51], provides main design and evaluation criteria considered for temporary shelters, these criteria are classified under seven main categories:

1. Technology, Construction and Materials.
2. Ecology.
3. Cost.
4. Building Physics.
5. Spatial Organization.
6. Sociology.
7. Aesthetics.

These are the main categories, in each one the related design criteria are mentioned.

According to REZOUG 2013[12], the design requirements of temporary housing design are defined under five headings: size, section, climate, ground, plan scheme and paneling.

The design requirements in this study are categorized in six main categories, each category defines the main determinants to consider in designing a temporary house unit. These requirements are Physical, Ecology, Sociological, Building physics and technology, Cost and Safety.

1. **The physical requirements** where the main considerations shaping the temporary house unit are defined as:

    - The size of the unit.
    - Type of foundations.
    - The size of windows.
    - The section of the unit.
    - Walls and paneling size and type.

2. **The ecological requirements** determines how to produce a temporary house unit which is sustainable and does not form a problem to the natural environment, in order to achieve a sustainable design the following considerations must be followed**:**

    - Using local building materials which can make the design more cost efficient and reduce the transportation of the material from other regions.
    - Depending on community efforts and using the local expertise which can make them more aware of the building methods and is also a solution for reducing cost.
    - Using materials which can be recycled or using transformable building technologies that can allow for disassembling the unit and using them again or for other purpose.
    - Making units which are designed to convert the solar energy into heating and electrical energy.
    - Thinking about the second life of the unit, this have been fully explained in sub-section 3.4.5.

3. **The social requirements** are the type of requirements which are defined to produce temporary house units that are more suitable for the user requirements

and more adaptable to their changing needs according to culture and privacy determines, in this study two criteria have been considered:

- Privacy determines inside the house and out -side the house, these determines can affect the number and size of rooms inside the house, also the size of windows.
- The nature of life; rural or urban. These two determines will be further explained in this chapter.

4. **Building physics and technology requirements** which refers to determines affecting the method of building the unit:

   - Construction system.
   - Building methods and using technology, such as using pre-cast methods of building or transformable buildings.

5. **Cost requirements** which describes how the temporary house unit should be cost efficient with minimum use of the budget considered for reconstruction in order to make the start of permanent housing stage more quick and rapid.
6. **Safety requirements** which should ensure building temporary housing unit that are less vulnerable to disaster by undoing the previous mistakes and taking pre-cautions that ensure a better and more safe housing unit:

   - Studying if the region is known for high levels of witnessing a type of disaster and providing special measurements in building regulations to the design in order to be resistant to this action and less vulnerable to destruction in case of potential disaster in the future. Accordingly the location of the temporary houses should be selected carefully.

7. **Special requirements:** according to geographical situation meaning; the region in which the country is situated requires special details in the housing units, as some regions are considered high vulnerable to disaster such as being in a region which is known for witnessing earthquakes such as Japan, or in areas known for repeated hurricane such as China and United States of America. Accordingly, the temporary houses designed in these areas should be responsive to these site special

requirements in order to decrease destruction in case of potential disaster, also to design houses which are not at the same levels of risk for disaster. In order to insure the cost efficiency requirements in building, adding these special requirements in building details is considered in the permanent housing level due to the potential duration of use in the temporary housing level which is assumed to be two years in maximum. Table 5.1 shows the special requirement in building details according to the disaster type.

Table 5. 1 The special requirement in building details according to the disaster type

Disaster type	**Special requirements in building details**
Earthquake	Making foundations resistant to disaster.
Fluids	Buildings should preferably be built on high ground in order to avoid waves. If waves can reach the building site, the building ought to be elevated on steel, concrete, or wooden pilings or anchored to solid rock.
Hurricane	
Storms	Adding a basement under the housing units to be as a shelter for people to hide in case of potential storms. Also, Trees must be used to reduce the wind velocity.
Fire	Building with a type of concert which is resistant to fire.
Landslide	Retaining wall must be provided to support very steep cut slope.

In this study, the design requirements are considered as four main categories which can affect the design of the temporary house, these requirements are:

1- Location.
2- Size.
3- Climate.
4- Ground characteristic.
5- Privacy.

5.4.1.1 Location

Selecting the location of the temporary house unit is considered a very critical job, as it contributes to either decrease the vulnerability to potential disasters if selected correctly,

or it can increase it if a wrong location is selected. Accordingly, knowing the type of disaster is the first step to select the location of the temporary house units, from the type of disaster the effect on the environment can be evaluated, so a decision of selecting a location near or far from the disaster site can be made. Some types of disasters are considered very effective on the built environment and can cause a long term damage to it, which makes the disaster site and the areas next to it dangerous for people, such as the nuclear and chemical disasters, so the temporary house units must be very far from the disaster site. Also, in case of landslides and fluids, the location must be far to increase the safety in case of other potential disaster. However, in case of earthquakes temporary houses can be near the disaster site. Accordingly, the selection of the location of the temporary house units is decided due to the impact of disaster on site and the degree of effectiveness upon the environment. Also, the location of both temporary and permanent houses should be selected in areas which are less vulnerable to disasters and avoiding the potential disaster areas, such as in fluids and hurricanes areas, coastal areas must be avoided, also in the volcanic eruption areas, location must be far from the effective circle assumed for the volcano. Considering that the location must be always selected in the safe nearest site next to the disaster site to insure a quick recovery and to accelerate the reconstruction process and the start of the permanent house level. Table 5.2 shows the location selection of the temporary housing units according to the disaster type and the degree of effectiveness on the environment.

Table 5. 2 The location of temporary housing units from the disaster site (cont'd)

Disaster type	**Degree of effectiveness**	**Location of temporary housing units**
Chemical or nuclear	Intense	Far from the disaster site due to long lasting dangerous effect on the environment.
landslide	Intense	Far from the disaster site
	Average	Near the disaster site
	Mild	
Hurricane	Intense	Near the disaster site
	Average	

Table 5. 2 The location of temporary housing units from the disaster site (cont'd)

	Mild	
Earthquake	Intense	Near the disaster site
	Average	
	Mild	
Flood	Intense	Near the disaster site
	Average	
	Mild	
Wars and conflicts	Intense	Far from the conflict site due to potential bombs and explosive materials.
	Average	Near the conflict site but after the it is officially ended.
	Mild	

5.4.1.2 Size

The size is considered according to the average number of people per household in each county, also it will be affected by other factors such as the privacy considerations and the nature of life (the privacy and nature of life are explained in the fourth requirement) ,accordingly the number of rooms in each house will be determined. In figure 5.3 the plan of the temporary house is shown in term of number of rooms (this is an illustrative diagram not a design). In this study statics about the average number of people per household in the selected countries is found.

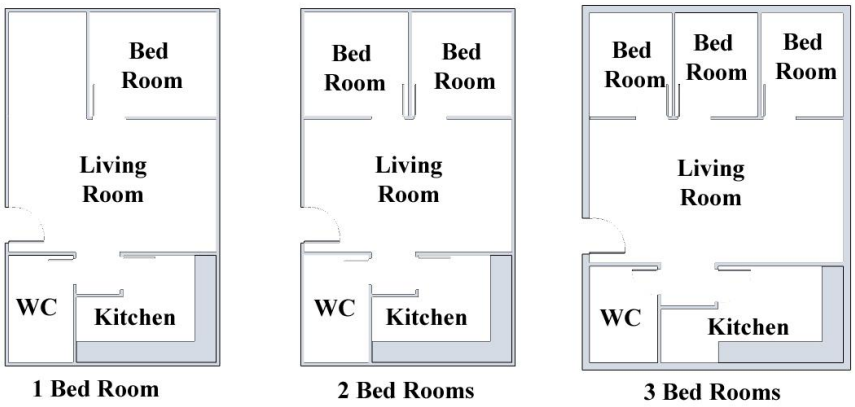


Figure 5. 3 The possible number of rooms in the temporary house unit

5.4.1.3 Climate

Climate consists of two parameters:

a) The average high and low temperatures of the selected county. This expresses the climate of the country in order to determine the thickness of the walls of the temporary house unit which can be:

- Thick (20cm) in both hot and cold regions to provide isolation.
- Thin (12cm) in the mild areas were isolation is not need to minimize the cost.

b) Weather: The average rain percentage is studied and according to it the selected countries are classified in five categories; snowy, extremely rainy, very rainy, rainy, dry. The result of this parameter affects the shape of the roof, which can be flat or sloping.

Figure 5.4 shows the shape of roof.

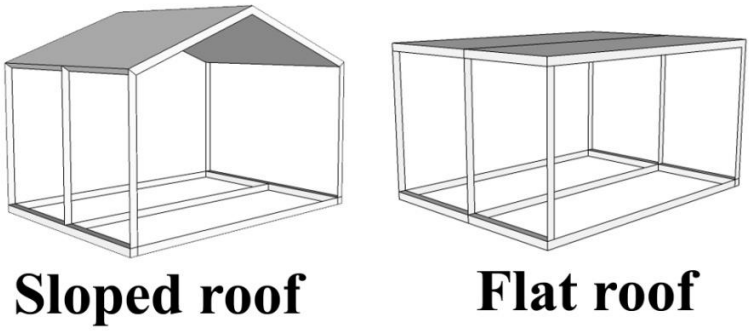


Figure 5. 4 The possible resulted shape according to the climate specifications

5.4.1.4 Ground Characteristics

The type of ground and the topology of each of the selected countries is considered in this parameter. The type of the ground can be sandy, sandy-muddy, muddy, or rocky. The topology also can be flat or multi-level. The result of this parameter determines the type of foundations that can be used in the temporary house unit. The type of foundations that can be used are piers, linear stem wall,or full stem wall. Pier is a better solution in stabilizing different ground levels, while linear and full stem walls are better solutions in distributing the load[12]. Figure 5.5 shows the shape of foundations.

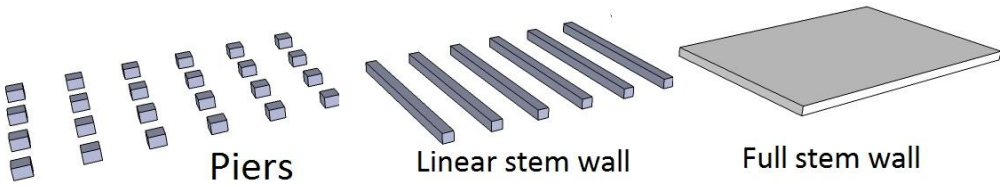


Figure 5. 5 The types of foundation

5.4.1.5 Privacy

Privacy is considered essential to define the special user requirements that affect the design, these special requirements are:

a) The size of windows which is affected by both the weather and user preferences. Figure 5.6 shows the size of windows in the temporary house unit.

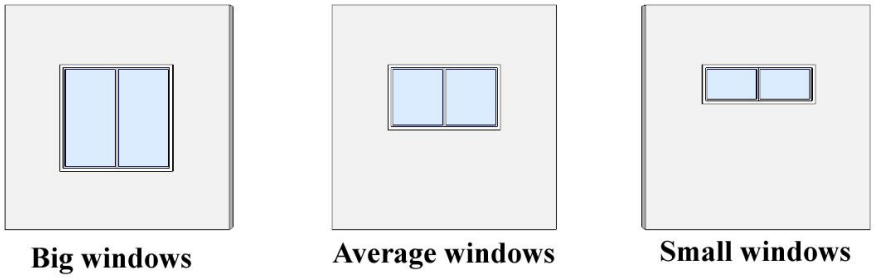


Figure 5. 6 The shape of windows

b) The relation with the outside of the house, as some civilizations are used to have an outdoor space related to their houses.

c) The nature of living in a community (by being urban or rural society) would affect the distribution of space inside the house; as in rural areas people are used to have big room with less number of rooms. However, in urban areas the people are used have more rooms which are small in size. These privacy requirements are introduced as two parameters with scales from 1-4: The privacy inside the house and privacy outside the house.

d) Privacy inside the house:

1: small bed-rooms, more bed-rooms, small living.
2: small bed-rooms, more bed-rooms, average living.
3: big bed-rooms, less bed-rooms, average living.
4: big bed-rooms, less bed-rooms, big living.

e) Privacy outside the house:

1: big windows, cloudy.
2: average windows, sunny.
3: average windows, cloudy.
4: small windows, sunny.

Table 5.3 shows the design requirements for a post disaster building.

Table 5. 3 Design requirements

Category of design requirements	**The design requirements**		**The expressing data**	**The affected parameter of the design**	**The result in shape properties**
Physical	1. Size		Average number of household	The number of needed rooms	• 1 room • 2 rooms • 3 rooms
Ecological	Climate	2. Average Temperature	Average temperatures	The thickness of the walls and the size of windows	• 12cm • 20cm • Small windows • Average windows • Big windows
		3. Weather	The rainfall percentage (snowy, extremely rainy, very rainy, rainy, dry)	The shape of roof	• Flat • Sloping
Physical	Ground characteristics	4. Soil	Sandy, muddy-sandy, muddy, rocky	The type of foundation	• Piers, • Linear stem wall • Full stem wall
		5. Topology	Flat, multi-level		
Social	Privacy	6. Privacy inside	Scale from 1-4	The number of needed rooms	• 1 room • 2 rooms • 3 rooms
		7. Privacy outside	Scale from 1-4	The size of windows	• Small windows • Average windows • Big windows
		8. Nature of life	Urban, rural	The number of needed rooms and the size of windows	• 1 room • 2 rooms • 3 rooms • Small windows • Average windows • Big windows

5.4.2 Design the Neural network system

The used neural network has 8 inputs and 5 outputs. The inputs are noted as In1, In2, …, and In8 in the rest of this chapter, where:

- In1 = Average number of household.
- In2 = Average temperature.
- In3 = The rainfall percentage.
- In4 = The soil type.
- In5 = The topology.
- In6 = Privacy inside the house.
- In7 = Privacy outside the house.
- In8 = The nature of life.

The outputs are noted as Out1, Out2, …, and Out5, where:

- Out1 = The number of needed rooms.
- Out2 = The thickness of the exterior walls.
- Out3 = The shape of the roof.
- Out4 = The type of foundations.
- Out5 = The size of windows.

The value of each output is affected by different number of inputs. Therefore, the neural network is composed of 5 sub-neural networks (NN1, NN2, …, NN5) as shown in Figure 5.7. Figures 5.8 to 5.12 shows the internal design of the sub-neural networks NN1 to NN5 respectively. Note that *Wxy* refers to the weight of the *y*th neuron of the *x*th sub-neural network. These weights are adjusted during the training of the neural network. The trained neural network is used later to classify the disaster areas (based on their input values) to get the most suitable parameters for the algorithmic modeling applications.

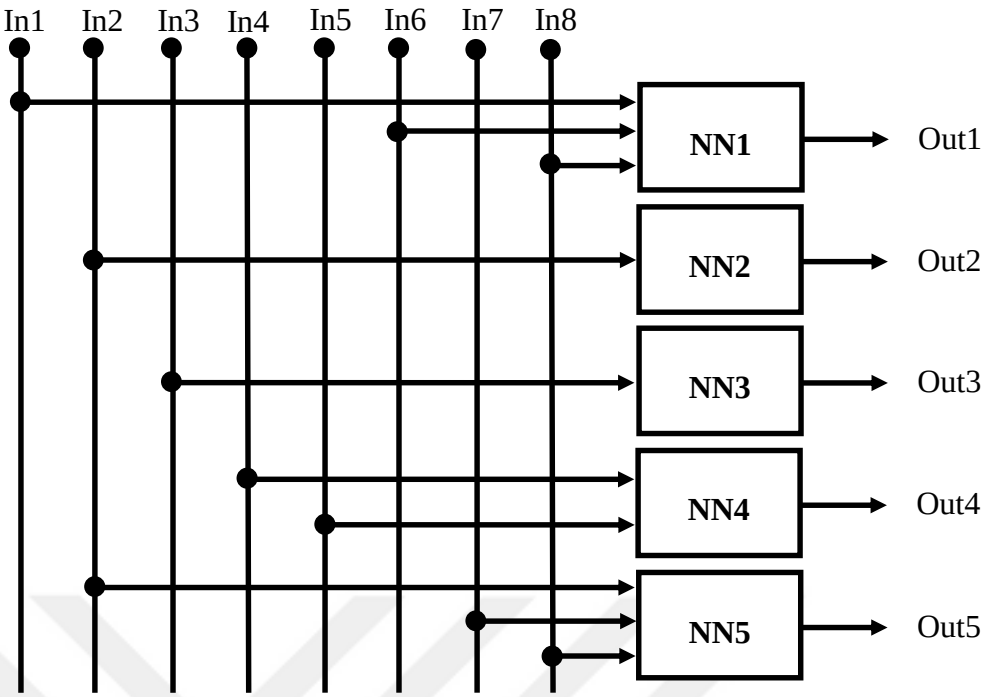


Figure 5. 7 Designed neural network

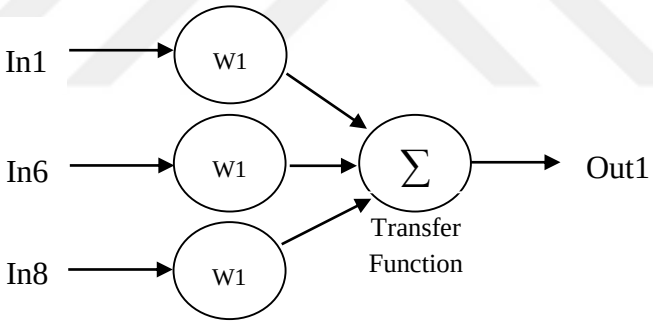


Figure 5. 8 NN1 internal design

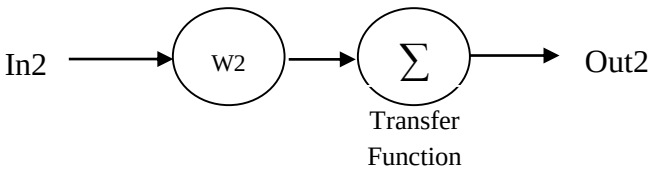


Figure 5. 9 NN2 internal design

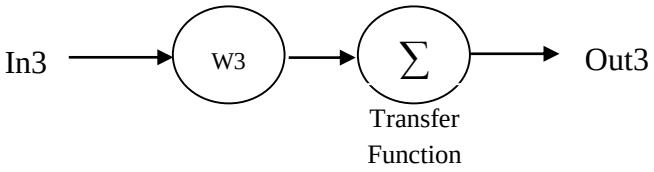


Figure 5. 10 NN3 internal design

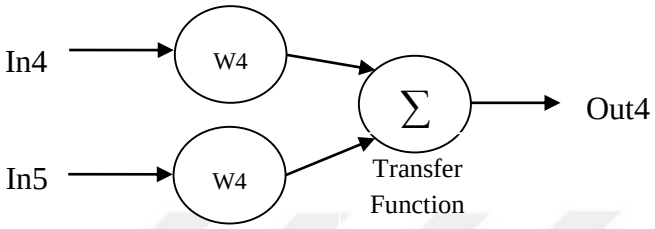


Figure 5. 11 NN4 internal design

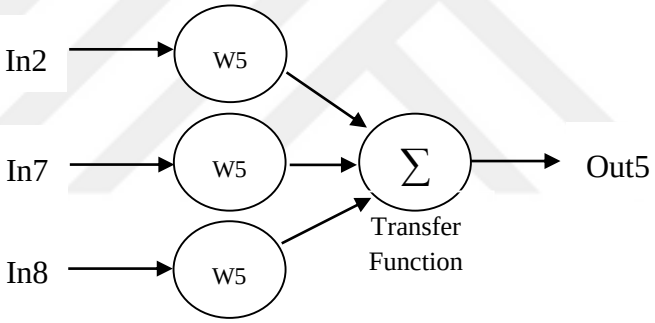


Figure 5. 12 NN5 internal design

5.4.3 Training the Neural Network

Training a neural network requires a training dataset with large number of input-output pairs. A neural network is trained by entering the inputs, one by one, and check the difference between the actual and expected outputs (expected outputs are the ones coming from the training dataset). Then, the network modifies the weights of the neurons to give outputs similar to the expected ones. Therefore, finding a large, and diversified, dataset for the proposed neural network forms a big challenge.

Following, a technique is used to generate a large number of diversified inputs together with their related outputs. The technique is implemented in two steps:

1. Generating the set of all possible inputs and outputs.

2. Clustering these inputs into a number of clusters, equal to the number of possible outputs, using k-means clustering. k-means is a clustering (grouping) method which cluster items in k groups (where k is the number of pre-chosen group). The K-means algorithm does this by calculating the distance between a point and the current group average of each feature. Unlike NN the k-means algorithm does not require training, the grouping in k-means depends on similarities between objects. For further information about the NN and their working method and their application check[52].

For example, NN4 has two inputs (the soil type and the topology) and one output (the type of foundations). The soil has four types: sandy, muddy-sandy, muddy, and rocky. The topology can also be flat or multi-level. On the other side, the total number of possible outputs is 3. These outputs are: piers, linear stem wall, and full stem wall.

Step 1: The total number of possible inputs 4×2=8. These possible inputs are:

1. Sandy and flat.
2. Sandy and multi-level.
3. Muddy-sandy and flat.
4. Muddy-sandy and multi-level.
5. Muddy and flat.
6. Muddy and multi-level.
7. Rocky and flat.
8. Rocky and multi-level.

The inputs and outputs are expressed as normalized numbers between 0 and 100. Therefore, the possible inputs become:

1. Sandy, flat → 0, 0
2. Sandy, multi-level → 0, 100
3. Muddy-sandy, flat → 33, 0
4. Muddy-sandy, multi-level → 33, 100
5. Muddy, flat → 66, 0
6. Muddy, multi-level → 66, 100
7. Rocky, flat → 99, 0

8. Rocky, multi-level → 99, 100

Similarly, the normalized possible outputs become:

1. Piers → 0
2. Linear stem wall → 50
3. Full stem wall → 100

Step 2: Clustering the inputs, using the k-mean clustering, into 3 clusters. The result is:

- **Cluster 1:** inputs 2, 4, 6, and 8.
- **Cluster 2:** inputs 1, and 3.
- **Cluster 3:** inputs 5, and 7.

Finally, both the inputs and their related outputs are used to train the neural network.

The training datasets for the sub-neural networks NN1, NN2, NN3, NN4, and NN5 are generated as shown above. The Matlab Neural Network Toolbox is used to train the sub-neural networks in the experiments.

5.4.4 Setting the Parameters (Design Properties) for the Neural Network Outputs

Setting the parameters for the neural network outputs requires the knowledge of the common properties of each cluster of the inputs. Since the k-means clustering is used, then, the mean of each cluster can be used as the common properties of that cluster, and the parameters for that cluster can be adjusted based on it. Tables A-1, A-2, A-3, A-4, and A-5 in Appendix-A shows the numerical parameters given to Out1, Out2, Out3, Out4, and Out5, respectively. In these tables, the Cluster column represents the cluster of each mean vector resulted from the k-mean clustering. The Mean Vector columns represents the mean value for each input in each cluster. In other words, to classify an input vector, the similarities between that input vector and the mean vectors of the clusters are calculated. Then, the vector is classified in the cluster that has the highest similarity value. Based on this fact, the parameters are given manually for each cluster according to the mean vector in the Given Parameter column. These given parameters are presented as numerical values in the Numerical Parameter column. These numerical parameters are used in the training of the sub-neural networks.

5.4.5 Collecting Real Data and Setting their outputs

To test the efficiency of the proposed technique, real data about different cities is collected. The set of data is tried to be diversified as much as possible. Table A-6 in Appendix-A shows the real collected data while Table A-7 in Appendix-A shows their normalized numerical values. Moreover, the parameters of elements in the collected dataset are set manually by architects to suits the users needs based on the collected data. These parameters are shown in Table A-8 in Appendix-A.

5.4.6 Evaluating the results

Table A-9 in Appendix-A shows the selected parameters represented as normalized numerical values. On the other side Table A-10 in Appendix-A shows the parameters generated by the trained neural network for the collected inputs.

The manual results and the system results are found to have some differences, for example; Table 5.4 and 5.5 shows a comparison between these two results in Istanbul city (Turkey) and Gaza city (Palestine), respectively. The results are expressed in an illustrative plan and model for the two cities as shown in Figures 5.13, 5.14, 5.15 and 5.16.

Table 5. 4 A comparison between the manual and system results for Istanbul city

Results from	**City**	**No. of rooms**	**Thickness of the exterior wall**	**The roof shape**	**Type of foundations**	**The size of window**
Manual	Istanbul	2	20	slopped	Piers	Big
System		2	20	slopped	Piers	Average

Table 5. 5 A comparison between the manual and system results for Gaza city

Results from	**City**	**No. of rooms**	**Thickness of the exterior wall**	**The roof shape**	**Type of foundations**	**The size of window**
Manual	Gaza	3	12	flat	Linear stem walls	average
System		3	12	flat	Full stem walls	small

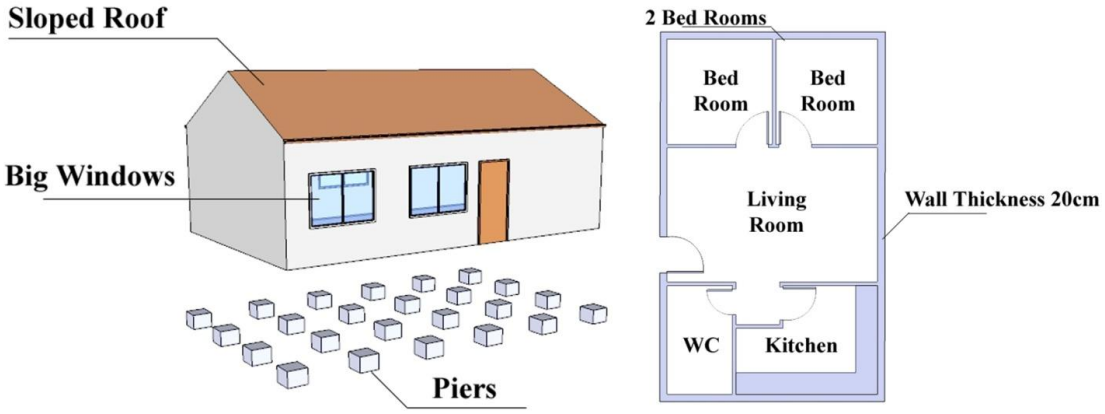


Figure 5. 13 An illustrative plan and model for the manual resulted temporary house unit in Istanbul city

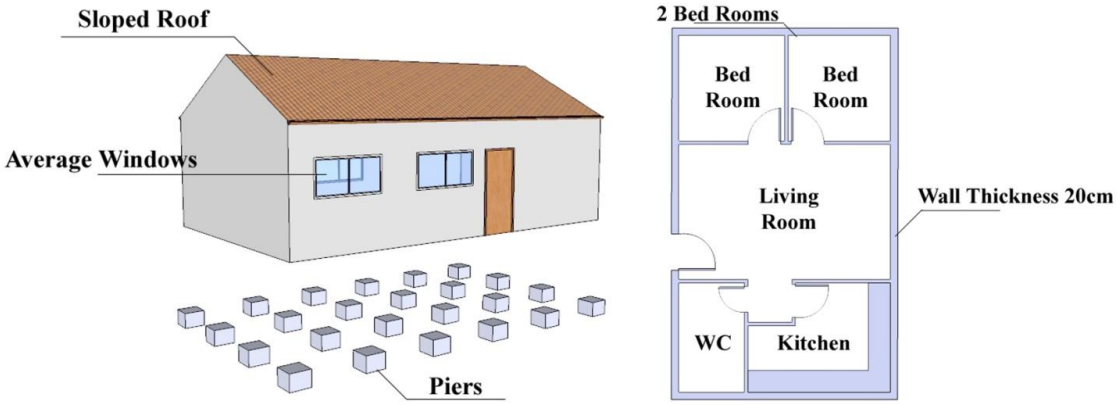


Figure 5. 14 An illustrative plan and model for the system resulted temporary house unit in Istanbul city

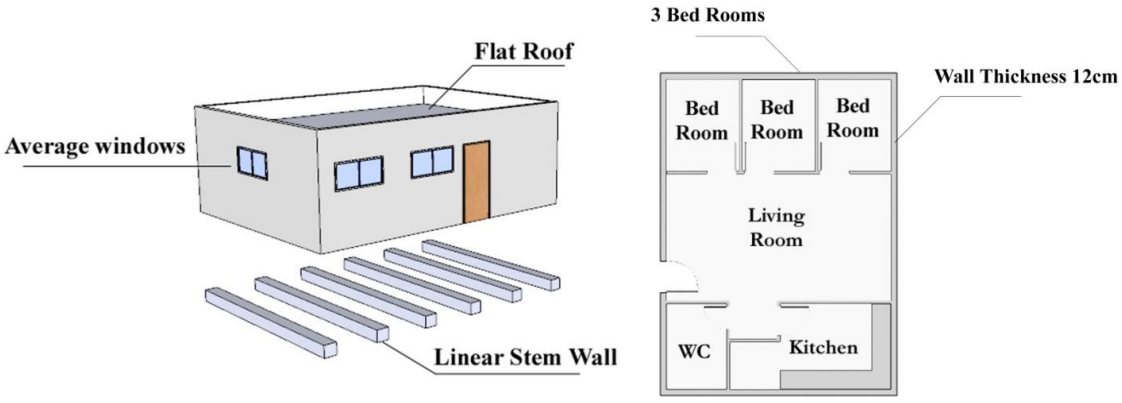


Figure 5. 15 An illustrative plan and model for the manual resulted temporary house unit in Istanbul city

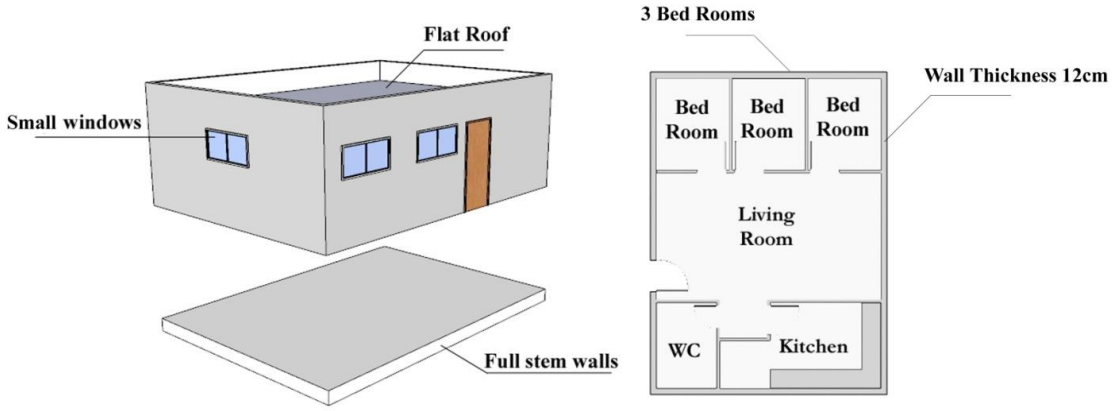


Figure 5. 16 An illustrative plan and model for the system resulted temporary house unit in Gaza city

Table 5.6 shows the match percentages for the five outputs, as well as the total match percentage, between the manually selected parameters and the generated ones using the neural network. Results shows high match between them which proves the efficiency of using neural networks in the automatic selection of parameters for the next step (Algorithmic Modeling Applications). However, the difference between the selected and the automatically generated parameters can be justified by:

1. The different perspectives of the architects in selecting the parameters.
2. The number of design requirements (input of the neural network) as well as their ranges.
3. The architecture of the used neural networks.
4. The generation of the training data (inputs and expected outputs).

These variables open the way for further researches to study their effects as well as improving the techniques of selecting and generating them.

Table 5. 6 Matching Percentages between the manually selected and the automatically generated parameters

Variable	Match Percentage
Out1	76,47%
Out2	82,35%
Out3	82,35%
Out4	74,50%
Out5	66,66%
Total	76,47%

Finally figure 5.17 shows the process of using the system by the interested parties, the system is used in four steps, starting by providing statics and information about the disaster area, until generating the unit by the algorithmic modeling applications. While in this study, the second step is fully discussed.

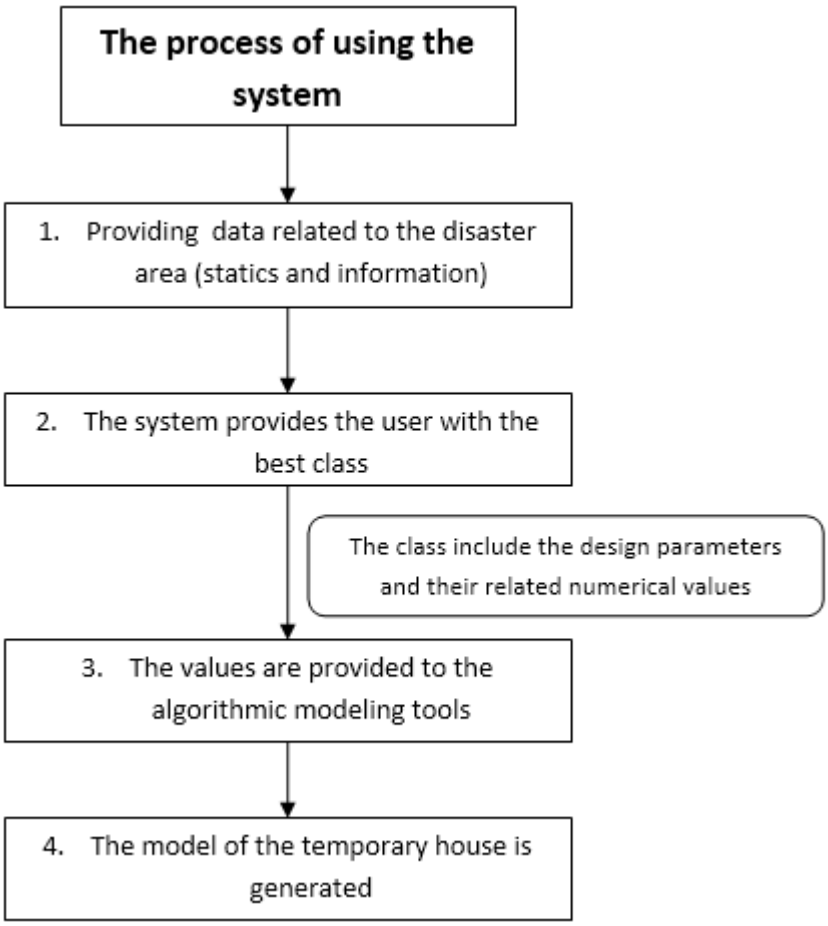


Figure 5. 17 The process of using the system

CHAPTER 6

SUMMARY

This study points out the importance of a critical topic in architecture, the disasters all around the world with its different shapes. Also, the amount of destruction caused by disaster upon physical structure and communities. Hence, finding effective solutions in light of parametric and algorithmic architectural methods. These methods are ought to provide efficient solutions in term of rapidness, cost and adaptability for all different communities.

The study suggests an automated framework for the design process of temporary houses for post disaster. In this process, the role of architects is minimized in the decision making of the most suitable parameters affecting the shape of the temporary house unit. On the other hand, the automated methods are trained and used for implementing this stage of the process. The use of automated method is considered very helpful in term of time management, and thinking of all design requirements that include different user preferences to provide the most suitable design parameters, and generating temporary house units which are suitable and does not require changes from the user. The results provided from experiencing a selected number of cities around the world, showed that the system is very efficient in providing very good results when compared with the manually decided ones. The suggested technique in the study is open for further studies and improvements, by increasing the number of considered design requirements, which means more inputs to the system in order to make the output more accurate, or to provide more number of outputs needed in the design of temporary houses.

The technique can be used in other different fields of automated architectural design. The fields which requires human decision making according to different affecting factors.

This is considered very useful for making rapid and more accurate decisions in the intended field of design.

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APPENDIX-A

NUMERICAL VALUES

Table A.1 Parameters of Out1

Cluster	Mean Vector			Given Parameter for Out1	Numerical Parameter for Out1
	In1	In6	In8		
1	50	82,5	100	2 rooms	33
2	22,72727	52,5	0	1 rooms	0
3	50	16,5	100	3 rooms	66
4	77,27273	46,5	0	4 rooms	99

Table A.2 Parameters of Out2

Cluster	Mean Vector	Given Parameter for Out2	Numerical Parameter for Out2
	In2		
1	50,5	Thin	0
2	84	Thick	50
3	16,5	Thick	100

Table A.3 Parameters of Out3

Cluster	Mean Vector	Given Parameter for Out3	Numerical Parameter for Out3
	In3		
1	16,5	Flat	0
2	82,5	Sloping	100

Table A.4 Parameters of Out4

Cluster	Mean Vector		Given Parameter for Out4	Numerical Parameter for Out4
	In4	In5		
1	49,5	100	Piers	0
2	82,5	0	Linear Stem Wall	50
3	16,5	0	Full Stem Wall	100

Table A.5 Parameters of Out5

Cluster	Mean Vector			Given Parameter for Out5	Numerical Parameter for Out5
	In2	In7	In8		
1	49,5	82,5	100	Average	50
2	49,5	49,5	0	Small	0
3	49,5	16,5	100	Big	100

Table A.6 Collected dataset of inputs (cont'd)

Country	**City**	**Average of family**	**Type of ground**	**Topology**	**Average temperature**	**weather**	**privacy inside the house**	**privacy outside the house**	**Rural/urban**
Turkey	Istanbul	3	muddy	Multi-level	15	Very rainy	2	3	urban
	Erzurum	5	muddy	Multi-level	6	Very rainy	3	3	rural
	Mardin	7	muddy	Multi-level	7	rainy	4	3	rural
Iraq	Al Mosel	6	muddy	flat	21	rainy	4	4	urban
	Bagdad	7	sandy	flat	23	dry	4	4	urban
	Al Nassriya	6	sandy	flat	21	dry	4	4	rural

Table A.6 Collected dataset of inputs (cont'd)

Indonesia	Jakarta	5	muddy	flat	13	Very rainy	2	3	urban
India	Mumbai	5	muddy	flat	28	Very rainy	3	3	rural
	Delhi	5	muddy	flat	25	Very rainy	3	3	rural
China	Harbin	3	Muddy /sandy	Multi-level	5	snowy	2	1	urban
	Beijing	2	Muddy /sandy	Multi-level	13	rainy	1	1	urban
	Kunming	3	Muddy /sandy	Multi-level	16	rainy	2	1	rural
Palestine	Al Quds	5	Muddy /sandy	Multi-level	18	rainy	4	2	urban
	Gaza	6	Muddy /sandy	flat	20	rainy	4	2	urban
Iran	Shiraz	6	Muddy /sandy	flat	18	rainy	4	2	Rural
	Tehran	5	Muddy /sandy	Multi-level	16	rainy	3	2	Urban
	Tabriz	5	muddy	Multi-level	16	rainy	3	3	urban
Japan	Tokyo	2	muddy	Multi-level	7	rainy	1	1	urban
	Asahikawa	2	Muddy /sandy	flat	9	snowy	1	1	rural
Kazakhstan	Kostanay	5	Muddy /sandy	flat	2	snowy	3	1	Rural
	Aktobe	3	muddy	flat	6	snowy	3	1	rural
	Almaty	3	muddy	flat	11	rainy	2	1	urban
Kenya	Nairobi	5	Muddy /sandy	flat	18	Very rainy	2	4	urban

Table A.6 Collected dataset of inputs (cont'd)

	Marsabit	5	Muddy /sandy	flat	20	Very rainy	3	4	rural
Cameroon	Garoua	6	Muddy /sandy	flat	29	Very rainy	3	4	rural
	Yaoundé	5	Muddy /sandy	flat	25	Very rainy	3	4	urban
Libya	Zawilah	5	sandy	flat	27	dry	3	4	rural
	Sirte	6	Muddy /sandy	flat	23	rainy	4	4	urban
Bosnia	Sarajevo	3	muddy	Multi-level	11	Very rainy	1	1	urban
	Bileća	3	muddy	Multi-level	13	Very rainy	4	1	rural
	Derventa	3	muddy	Multi-level	2	Very rainy	3	1	rural
Belarus	Pinsk	2	muddy	flat	3	Very rainy	2	1	rural
	Minsk	2	muddy	Multi-level	7	Very rainy	1	1	urban
	Polotsk	2	muddy	flat	5	Very rainy	2	1	rural
Finland	Inari	2	muddy	flat	-1	snowy	3	1	rural
	Kajaani	2	muddy	flat	2	snowy	3	1	rural
	Helsinki	2	muddy	flat	6	Very rainy	1	1	urban
Brazil	Manaus	3	muddy	Multi-level	27	Very rainy	2	3	urban
	Rondonia	3	Muddy /sandy	flat	26	Very rainy	3	3	rural
	Rio De Janiero	3	muddy	Multi-level	24	Very rainy	1	1	urban

Table A.6 Collected dataset of inputs (cont'd)

Mexico	Monterrey	3	muddy	flat	22	Very rainy	3	1	rural
	Hermosillo	3	Muddy /sandy	flat	25	rainy	3	4	rural
	Mexico	3	Muddy /sandy	Multi-level	18	Very rainy	1	2	urban
Canada	Nunavut	2	muddy	flat	-11	snowy	1	1	rural
	Edmonton	3	muddy	flat	4	snowy	1	1	urban
	Quebec	2	muddy	flat	2	snowy	1	1	urban
America	Arizona	2	sandy	Multi-level	26	dry	2	4	rural
	Montana	2	muddy	Multi-level	14	Very rainy	2	1	rural
	Wisconsin	2	muddy	flat	9	Very rainy	1	1	urban
	Kentucky	2	muddy	flat	12	Very rainy	1	1	urban
	Pennsylvania	2	muddy	flat	13	Very rainy	1	1	urban

Table A.7 Normalized numerical values of the collected dataset of inputs (cont'd)

Country	**City**	**Average of family members**	**Type of ground**	**topology**	**Average temperature**	**weather**	**privacy inside the**	**privacy outside the**	**Rural/urban**
Turkey	Istanbul	30	66	100	60	66	33	66	0
	Erzurum	50	66	100	42	66	66	66	100
	Mardin	70	66	100	44	33	99	66	100
Iraq	Al Mosel	60	66	0	72	33	99	99	0

Table A.7 Normalized numerical values of the collected dataset of inputs (cont'd)

	Bagdad	70	0	0	76	0	99	99	0
	Al nassriya	60	0	0	72	0	99	99	100
Indonesia	Jakarta	50	66	0	56	66	33	66	0
India	Mumbai	50	66	0	86	66	66	66	100
	Delhi	50	66	0	80	66	66	66	100
china	Harbin	30	33	100	40	99	33	0	0
	Beijing	20	33	100	56	33	0	0	0
	Kunming	30	33	100	62	33	33	0	100
Palestine	Al Quds	50	33	100	66	33	99	33	0
	Gaza	60	33	0	70	33	99	33	0
Iran	shiraz	60	33	0	66	33	99	33	100
	Tehran	50	33	100	62	33	66	33	0
	Tabriz	50	66	100	62	33	66	66	0
Japan	Tokyo	20	66	100	44	33	0	0	0
	Asahikawa	20	33	0	48	99	0	0	100
Kazakhstan	Kostanay	50	33	0	34	99	66	0	100
	Aktobe	30	66	0	42	99	66	0	100
	Almaty	30	66	0	52	33	33	0	0
Kenya	Nairobi	50	33	0	66	66	33	99	0
	Marsabit	50	33	0	70	66	66	99	100
Cameroon	Garoua	60	33	0	88	66	66	99	100
	Yaoundé	50	33	0	80	66	66	99	0
Libya	Zawilah	50	0	0	84	0	66	99	100
	Sirte	60	33	0	76	33	99	99	0
Bosnia	Sarajevo	30	66	100	52	66	0	0	0

Table A.7 Normalized numerical values of the collected dataset of inputs (cont'd)

	Bileća	30	66	100	56	66	99	0	100
	Derventa	30	66	100	34	66	66	0	100
Belarus	Pinsk	20	66	0	36	66	33	0	100
	Minsk	20	66	100	44	66	0	0	0
	Polotsk	20	66	0	40	66	33	0	100
Finland	Inari	20	66	0	28	99	66	0	100
	Kajaani	20	66	0	34	99	66	0	100
	Helsinki	20	66	0	42	66	0	0	0
Brazil	Manaus	30	66	100	84	66	33	66	0
	Rondonia	30	33	0	82	66	66	66	100
	Rio de janiero	30	66	100	78	66	0	0	0
Mexico	Monterrey	30	66	0	74	66	66	0	100
	Hermosillo	30	33	0	80	33	66	99	100
	Mexico	30	33	100	66	66	0	33	0
Canada	Nunavut	20	66	0	8	99	0	0	100
	Edmonton	30	66	0	38	99	0	0	0
	Quebec	20	66	0	34	99	0	0	0
America	Arizona	20	0	100	82	0	33	99	100
	Montana	20	66	100	58	66	33	0	100
	Wisconsin	20	66	0	48	66	0	0	0
	Kentucky	20	66	0	54	66	0	0	0
	Pennsylvania	20	66	0	56	66	0	0	0

Table A.8 Selected parameters for the input dataset (cont'd)

Country	City	No. of rooms	Thickness of the exterior wall	The roof shape	Type of foundations	The size of window
Turkey	Istanbul	2	20	Slopped	Piers	Big
	Erzurum	2	20	Slopped	Piers	Big
	Mardin	3	12	Flat	Piers	Average
Iraq	Al Mosel	3	20	Flat	Linear Stem Wall	Small
	Bagdad	3	20	Flat	Full Stem Wall	Small
	Al Nassriya	3	20	Flat	Full Stem Wall	Small
Indonesia	Jakarta	2	20	Slopped	Linear Stem Wall	Average
India	Mumbai	2	20	Slopped	Linear Stem Wall	Average
	Delhi	2	20	Slopped	Linear Stem Wall	Average
China	Harbin	2	20	Slopped	Piers	Big
	Beijing	2	20	Flat	Piers	Big
	Kunming	1	20	Flat	Piers	Big
Palestine	Al Quds	2	12	Flat	Piers	Average
	Gaza	3	12	Flat	Full Stem Wall	Average
Iran	Shiraz	2	12	Flat	Full Stem Wall	Average
	Tehran	3	12	Flat	Piers	Average
	Tabriz	3	12	Flat	Piers	Average
Japan	Tokyo	2	20	Flat	Piers	Big
	Asahikawa	1	20	Slopped	Full Stem Wall	Big

Table A.8 Selected parameters for the input dataset (cont'd)

Kazakhstan	Kostanay	2	20	Slopped	Linear Stem Wall	Big
	Aktobe	1	20	Slopped	Linear Stem Wall	Big
	Almaty	2	20	Flat	Linear Stem Wall	Big
Kenya	Nairobi	3	12	Slopped	Full Stem Wall	Average
	Marsabit	2	12	Slopped	Full Stem Wall	Average
Cameroon	Garoua	2	20	Slopped	Full Stem Wall	Average
	Yaoundé	3	12	Slopped	Full Stem Wall	Average
Libya	Zawilah	2	20	Flat	Full Stem Wall	Small
	Sirte	3	12	Flat	Full Stem Wall	Average
Bosnia	Sarajevo	2	20	Slopped	Piers	Big
	Bileća	1	20	Slopped	Piers	Big
	Derventa	1	20	Slopped	Piers	Big
Belarus	Pinsk	1	20	Slopped	Linear Stem Wall	Big
	Minsk	2	20	Slopped	Piers	Big
	Polotsk	1	20	Slopped	Linear Stem Wall	Big
Finland	Inari	1	20	Slopped	Linear Stem Wall	Big
	Kajaani	1	20	Slopped	Linear Stem Wall	Big
	Helsinki	1	20	Slopped	Linear Stem Wall	Big
Brazil	Manaus	2	20	Slopped	Piers	Average
	Rondonia	1	20	Slopped	Full Stem Wall	Average

Table A.8 Selected parameters for the input dataset (cont'd)

	Rio De Janiero	2	20	Slopped	Piers	Average
Mexico	Monterrey	2	12	Slopped	Linear Stem Wall	Average
	Hermosillo	1	20	Flat	Full Stem Wall	Small
	Mexico	2	12	Slopped	Piers	Average
Canada	Nunavut	1	20	Slopped	Linear Stem Wall	Big
	Edmonton	2	20	Slopped	Linear Stem Wall	Big
	Quebec	1	20	Slopped	Linear Stem Wall	Big
America	Arizona	1	20	Flat	Piers	Small
	Montana	1	12	Slopped	Piers	Average
	Wisconsin	1	20	Slopped	Linear Stem Wall	Big
	Kentucky	1	20	slopped	Linear stem wall	big
	Pennsylvania	1	20	slopped	Linear stem wall	big

Table A.9 Normalized numerical parameters Selected for the input dataset (cont'd)

Country	**City**	**No. of rooms**	**Thickness of the exterior wall**	**The roof shape**	**Type of foundations**	**The size of window**
Turkey	Istanbul	33	100	100	0	100
	Erzurum	33	100	100	0	100
	Mardin	66	0	0	0	50
Iraq	Al Mosel	66	100	0	50	0
	Bagdad	66	100	0	100	0

Table A.9 Normalized numerical parameters Selected for the input dataset (cont'd)

	Al Nassriya	66	100	0	100	0
Indonesia	Jakarta	33	100	100	50	50
India	Mumbai	33	100	100	50	50
	Delhi	33	100	100	50	50
China	Harbin	33	100	100	0	100
	Beijing	33	100	0	0	100
	Kunming	0	100	0	0	100
Palestine	Al Quds	33	0	0	0	50
	Gaza	66	0	0	100	50
Iran	Shiraz	33	0	0	100	50
	Tehran	66	0	0	0	50
	Tabriz	66	0	0	0	50
Japan	Tokyo	33	100	0	0	100
	Asahikawa	0	100	100	100	100
Kazakhstan	Kostanay	33	100	100	50	100
	Aktobe	0	100	100	50	100
	Almaty	33	100	0	50	100
Kenya	Nairobi	66	0	100	100	50
	Marsabit	33	0	100	100	50
Cameroon	Garoua	33	100	100	100	50
	Yaoundé	66	0	100	100	50
Libya	Zawilah	33	100	0	100	0
	Sirte	66	0	0	100	50
Bosnia	Sarajevo	33	100	100	0	100
	Bileća	0	100	100	0	100

Table A.9 Normalized numerical parameters Selected for the input dataset (cont'd)

	Derventa	0	100	100	0	100
Belarus	Pinsk	0	100	100	50	100
	Minsk	33	100	100	0	100
	Polotsk	0	100	100	50	100
Finland	Inari	0	100	100	50	100
	Kajaani	0	100	100	50	100
	Helsinki	0	100	100	50	100
Brazil	Manaus	33	100	100	0	50
	Rondonia	0	100	100	100	50
	Rio De Janiero	33	100	100	0	50
Mexico	Monterrey	33	0	100	50	50
	Hermosillo	0	100	0	100	0
	Mexico	33	0	100	0	50
Canada	Nunavut	0	100	100	50	100
	Edmonton	33	100	100	50	100
	Quebec	0	100	100	50	100
America	Arizona	0	100	0	0	0
	Montana	0	0	100	0	50
	Wisconsin	0	100	100	50	100
	Kentucky	0	100	100	50	100
	Pennsylvania	0	100	100	50	100

Table A.10 Normalized numerical parameters generated by the neural network (cont'd)

Country	City	No. of rooms	Thickness of the exterior wall	The roof shape	Type of foundations	The size of window
Turkey	Istanbul	33	100	100	0	50
	Erzurum	33	100	100	50	100
	Mardin	66	0	0	0	50
Iraq	Al Mosel	99	0	100	50	0
	Bagdad	66	100	0	50	0
	Al Nassriya	99	100	0	100	0
Indonesia	Jakarta	33	100	100	50	50
India	Mumbai	33	0	0	50	0
	Delhi	33	100	100	50	50
China	Harbin	66	100	100	0	100
	Beijing	33	100	0	50	0
	Kunming	0	100	0	0	100
Palestine	Al Quds	33	0	0	0	50
	Gaza	66	0	0	100	0
Iran	Shiraz	0	0	0	50	50
	Tehran	99	0	0	0	50
	Tabriz	66	0	0	50	50
Japan	Tokyo	33	100	0	0	100
	Asahikawa	0	0	100	100	50
Kazakhstan	Kostanay	33	100	100	50	50
	Aktobe	0	100	100	50	0
	Almaty	33	100	0	50	100

Table A.10 Normalized numerical parameters generated by the neural network (cont'd)

Kenya	Nairobi	66	0	100	100	50
	Marsabit	33	0	0	100	50
Cameroon	Garoua	66	100	100	50	0
	Yaoundé	33	0	100	100	50
Libya	Zawilah	66	100	0	100	0
	Sirte	66	0	0	100	50
Bosnia	Sarajevo	33	100	100	0	50
	Bileća	0	0	100	50	100
	Derventa	33	100	0	0	50
Belarus	Pinsk	0	100	100	100	100
	Minsk	33	100	100	0	50
	Polotsk	0	0	0	50	100
Finland	Inari	0	0	100	100	50
	Kajaani	0	100	100	50	100
	Helsinki	0	100	0	50	100
Brazil	Manaus	33	100	100	0	50
	Rondonia	0	100	100	100	50
	Rio De Janiero	33	100	100	50	0
Mexico	Monterrey	33	0	0	100	50
	Hermosillo	0	100	100	100	0
	Mexico	33	0	100	0	50
Canada	Nunavut	0	100	0	50	50
	Edmonton	33	100	100	50	100
	Quebec	0	0	100	50	100

Table A.10 Normalized numerical parameters generated by the neural network (cont'd)

America	Arizona	0	0	0	0	0
	Montana	33	0	100	0	0
	Wisconsin	0	100	100	50	50
	Kentucky	33	0	100	0	50
	Pennsylvania	0	100	100	0	100

CURRICULUM VITAE

PERSONAL INFORMATION

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EDUCATION

Degree	Department	University	Date of Graduation
Master	Architecture	Yildiz Technical University	2017
Undergraduate	Architecture	Islamic University of Gaza	2011
High School	Science	Ahmed Shawqi high school	2006

WORK EXPERIENCE

Year	Corporation/Institute	Enrollment
2012-2012	Islamic University of Gaza	Research Assistant

PUBLICATIONS

Papers

1. Çolakoğlu B., Atawula E., Alkhodari L.,2014, "Facilitating Computational Thinking Through Pattern Generation", 8 Mimarlıkta Sayısal Tasarım Ulusal Sempozyumu, Izmir Yuksek Technology Institute, 26-27 June 2014.