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Post War Reconstruction Priorities of Buildings in Gaza Strip Using Decision Support Systems

تحديد أولويات اعادة الاعمار ما بعد الحرب على قطاع غزة باستخدام أنظمة دعم القرار

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Declaration

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نتيجة الحكم على أطروحة ماجستير

بناءً على موافقة شئون البحث العلمي والدراسات العليا بالجامعة الإسلامية بغزة على تشكيل لجنة الحكم على أطروحة الباحث/ **محمد ابراهيم يوسف لبد** لنيل درجة الماجستير في **كلية *الهندسة*** قسم الهندسة المدنية – تصميم وتأهيل المنشآت وموضوعها:

تحديد أولويات إعادة الإعمار ما بعد الحرب على قطاع غزة باستخدام أنظمة دعم القرار

Post War Reconstruction Priorities of Buildings in Gaza Strip Using Decision Support System

وبعد المناقشة التي تمت اليوم الثلاثاء 04 جمادي الأولى 1438هـ، الموافق 2017/01/31م الساعة الحادية عشر صباحاً، اجتمعت لجنة الحكم على الأطروحة والمكونة من:

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وبعد المداولة أوصت اللجنة بمنح الباحث درجة الماجستير في **كلية *الهندسة*** / قسم الهندسة المدنية- تصميم وتأهيل المنشآت.

واللجنة إذ تمنحه هذه الدرجة فإنها توصيه بتقوى الله ولزوم طاعته وأن يسخر علمه في خدمة دينه ووطنه.

والله ولي التوفيق ،،،

نائب الرئيس لشئون البحث العلمي والدراسات العليا

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Abstract

Governments and decision makers are obsessed with well-planned reconstruction after natural disasters and after human caused disasters. Post war reconstruction of damaged buildings must be well managed. The management can be achieved by creating a suitable program fitting with the situation in a stricken country.

This issue appears in many societies after disasters, because of the large numbers of affected people and their needs to be satisfied. Another issue appeared when there is a lack of construction machines and equipment and human resources which makes it hard to start working on all destructed houses at the same time. Moreover, siege of Gaza aggravates the problem of reconstruction process, due to the very little amount of allowed materials to be distributed in Gaza Strip and the lack of financial support from donors. The main aim of this study is to establish an effective model for post war reconstruction process by identifying the priorities of housing reconstruction based on a predefined specific criteria and using fuzzy logic model. Reconstruction management is achieved in this study by developing a validated model which would help to distribute reconstruction materials and determining the priority of services and affected people according to specific criteria. The developed model consists of two stages. First, four main criteria were evaluated by a fuzzy logic model. The weights obtained from the first stage are applied in the second stage as inputs to identify the priority degree, subjected to maximum achievable difference between priorities. The developed model has been verified and applied on collected data of totally damaged buildings after 2014 conflict on Gaza. North Governorate's data was used as a specific case study where results were linked with Geographic Information System. Totally damaged buildings in North Governorate have been graphically shown through linked GIS and categorized into five groups according to emergency level of reconstruction of damaged buildings. All achieved results prove that the proposed model is effective and can be applied to ensure fair distribution of construction materials and financial support for affected people.

الملخص

تبقى الحكومات وصناع القرار منشغلون بخطط محكمة لإعادة الاعمار بعد حدوث كوارث طبيعية أو كوارث من صنع الانسان، وعملية اعادة الاعمار بعد الحروب تحديدا يجب أن تكون مدارة بشكل جيد. هذا النوع من الادارة الجيدة قد تحقق عن طريق برنامج مصمم بطريقة ملائمة لظروف معايير البيئة في الدراسة.

تظهر مشكلة ادارة الأزمات في بعض المجتمعات بشكل جلي بسبب العدد الكبير من الأفراد المتضررين واحتياجاتهم الواجب تأمينها. وقد تتفاقم هذه المشكلة في حال نقص الموارد ومعدات وآليات البناء مما يجعل العمل على كافة المباني المتضررة في وقت واحد أمرا في غاية الصعوبة، إضافة إلى ذلك فإن الحصار على غزة "على سبيل المثال" يفاقم من مشكلة عملية إعادة الاعمار، وذلك يعود لشح المقومات ونقص الدعم المالي.

إن الهدف الرئيسي لهذه الدراسة يمكن تلخيصه في تحقيق أنموذج فعال لعملية اعادة الاعمار بعد الحرب من خلال تحديد أولوية كل مبنى يحتاج لإعادة اعمار بالاعتماد على عدة معايير معرفة وذلك باستخدام أنموذج المنطق الضبابي(Fuzzy Logic).

إن عملية إدارة إعادة الاعمار في هذه الدراسة تتحقق من خلال تصميم أنموذج من شأنه أن يقوم بتوزيع الموارد والامكانات " على نقصها" ويحدد درجة أولوية كل منزل في اعادة الاعمار من خلال معايير محددة.

النموذج المصمم في هذه الدراسة يتكون من مرحلتين، المرحلية الأولى، تم تقييم أربع معايير أساسية باستخدام أداة المنطق الضبابي. درجة الأهمية المحصلة من المرحلية الأولى تستخدم كمدخلات للمرحلة الثانية لتحديد درجة أولوية كل منزل قائم على تحقيق أكبر فرق ممكن بين درجات الأولوية.

تم تطبيق النموذج المصمم وتم اثبات مدى فعاليته من خلال تطبيقه على البيانات المجموعة للمباني المهدومة كليا بعد حرب عام 2014 على قطاع غزة، وتم استخدام بيانات منطقة شمال قطاع غزة على وده الخصوص كحالة دراسية يمكن ربط نتائجها ببرامج نظم المعلومات الجغرافية، وتم تصنيفها لخمس درجات وفق درجة الأولوية ومدى أهمية اعادة اعمار كل درجة وتم اظهارها بشكل بصري.

جميع النتائج التي تم الحصول عليها تثبت بشكل عملي أن النموذج المصمم والمقترح في الدراسة هو أنموذج فعال وقابل للتطبيق لضمان توزيع عادل لمواد البناء والدعم المتوفر لأصحاب المنازل المهدومة.

Dedication

To the fountain of patience and optimism and hope.

To each of the following in the presence of God and his Messenger.

To the big heart my dear parents.

To those who have demonstrate to me what is the most beautiful of life, my wife, my kids, brother and sisters.

To the people who paved our way of science and knowledge.

All our teachers distinguished.

To the taste of the most beautiful moments with my friends.

I dedicate this work.

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بسم الله الرحمن الرحيم

" قُلْ إِنَّ صَلَاتِي وَنُسُكِي وَمَحْيَايَ وَمَمَاتِي لِلَّهِ رَبِّ الْعَالَمِينَ "

[الأنعام : 162]

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BS	Building Status
BT	Building Type
DBMS	Data Base Management System
DSS	Decision Support System
FIS	Fuzzy Interface System
FLC	Fuzzy Logic Controller
GIS	Geographic Information System
INGO’s	International Non-Governmental Organizations
NGO’s	Non-Governmental Organizations
MF’s	Membership Functions
PD	Priority Degree
QS	Quarter Status
RS	Residents Status

Chapter 1

Introduction

Chapter 1

Introduction

1.1 Background:

Housing is essential to the well-being and development of most societies. It is a complex asset, with links to livelihoods, health, education, security and social and family stability. Housing acts as a social center for family and friends, a source of pride and cultural identity, and a resource of both political and economic importance. Housing is also an extremely vulnerable asset, and the destruction of homes or their loss through displacement or dispossession is one of the most visible effects of conflict and natural disaster. Housing reconstruction should be a more prominent element in post-conflict and post-disaster programming than is currently the case (Barhkat, 2003).

Post war reconstruction of buildings is often construed as a developmental responsibility rather than properly a humanitarian concern, and consequently tends to be low on the humanitarian agenda. Arguably, there is a clear humanitarian imperative to provide victims of conflict and disaster with basic shelter, in the same sense as there is a humanitarian imperative to ensure access to water, sanitation, food and healthcare. Unlike other relief items such as food aid or medicine, housing is a significant, long-term and non-consumable asset. Housing reconstruction is a complex process, and success typically requires a good deal of time and preparation. It argues that housing reconstruction interventions should take into account local resources, needs, perceptions, expectations, potentials and constraints (Barahkat, 1993).

1.2 Problem Statement:

In Gaza strip after 3 wars during 7 years there are a lot of houses still not reconstructed. This delay in reconstruction process refers to using simple criteria and absence of clear strategy to reconstruction process in the organizations that mange the reconstruction process.

Post war reconstruction of damaged buildings must be well managed. The management can be achieved by creating a suitable program fitting with the situation in stricken area such as Gaza Strip which is limited of resources.

This system will be by defining steps to distribute reconstruction and determining the priority of services and affected people reconstruction according to specific criteria.

All these steps are to minimize the time and to ensure fair distribution of construction materials and financial support for affected people.

This problem appears in many societies after disasters, because of the big numbers of affected people and their needs to be satisfied. Another issue appeared when there is a lack of construction machines and equipment and human resources which makes it hard to start working on all destructed houses at the same time.

Add to this, siege of Gaza aggravate the problem of reconstruction process, due to very little amount of allowed materials to distributed in Gaza Strip and the lack of financial support from donors.

1.3 Aim and Objectives

The main aim of this study is to establish an effective model for identifying the priorities of the post-war reconstruction based on a predefined specific criteria, so the objectives to be achieved are:

1. Study the current criteria that is used to evaluate the priorities to distribute the available financial and human aids to affected people from disasters.
2. Investigating the suitability of the current criteria for the situation of Gaza.
3. Develop a model with suitable criteria for reconstruction process in Gaza strip.
4. Establish a suitable fuzzy logic model to evaluate the alternatives.
5. Apply real cases to the validated management system on the reconstruction process in Gaza.

1.4 Research Methodology

To undertake the current study, specific steps must be followed to achieve the desired aims and the objectives.

1.4.1 Reviewing Previous studies

Various publications, for example books, technical papers and reports, were critically reviewed for this study to identify if there is any suitable methods and criterion to determine the priorities of houses to be reconstructed in Gaza Strip.

1.4.2 Gathering Information

Several institutions and organizations existed in the Gaza Strip, for example The Association of Engineers, Ministry of Public Works and Housing, Association of Labors, Nongovernmental organizations, United Nations Associations, were approached, followed by conducting interviews with specialized staff involving in the reconstruction process. The primary concern of these interviews sought addressing the strategies adopted to manage the process of reconstruction in Gaza Strip.

1.4.3 Data Analysis

The data collected of 2014 conflict on Gaza will be analyzed using tools for decision support system like fuzzy logic.

1.4.4 Verification of the Developed Model

The reasonable selected criteria for Gaza Strip will be verified by applying them through built model for the reconstruction process in Gaza Strip after 2014 conflict.

1.5 Research Organization

Chapter one : explains a background about the topic of the study, problem statement, research aim and objectives and methodology.

Chapter two : explains the researches that discussed management process after disasters in many countries. This chapter separated into global studies, regional studies and case of Gaza Strip reconstruction management after 2008 conflict.

Chapter three : discusses decision support system and tools used to develop systems to help decision makers to reach the best decision.

Chapter four : shows the built model to determine the importance weight of affected buildings after 2014 conflict based on specified criterion gathered from previous studies and information from Palestinian Central Bureau of Statistics.

Chapter five : explains and discusses the results after running the model on data collected from ministry of public works and housing for affected buildings after 2014 conflict.

Chapter 6 : includes conclusion and recommendations in addition to future thoughts for future research.

Chapter 2

Literature Review

Chapter 2

Literature Review

2.1 Introduction:

The ongoing natural and human made disasters have been making researchers focus on developing reconstruction management in order to ensure basic living conditions for affected people. It is worthwhile to search in resourcing, integrated development, sustainable construction and embodied resilience, but this require either existing tools to be adapted or new tools developed to allow efficient management and evaluation of reconstruction process (Yi & Yang, 2014).

2.2 Previous studies around the world:

- Sultan Barahkat (2003) studied the disaster in Philippines, he noticed that the beneficiaries of reconstruction program had to satisfy a set of stringent criteria in order to be eligible. These criteria are, having a secure land title, residence in an existing dwelling on the land, poorness, and being excepted from assistance by another agency (Barhkat, 2003).
- Due to Mahdi and Mahdi, Iran has a Housing Foundation (semi-governmental) start the reconstruction of affected houses after an earth quake. But the government had prepared temporary shelters or tents for survived people. In the reconstruction or rehabilitation , Housing Foundation started building in rural area because of simplicity of building. After that it started preparing to reconstruct in urban area with a special team has engineers and architecture and specialists (Mahdi & Madi, 2013).
- Boen and Jigyasu (2003) discussed the case of relocating two villages in Flores, Indonesia after 1992 earthquake, they found that relocated people from their original villages beside the beach didn't adapt with new places, and they returned to their original villages (Boen & Jigyasu, 2003).
- Roosli and Collinsb (2016) discussed the case of natural disaster stroked Kelantan in Malaysia, when the flood destructed so many homes and led to high lose in humans life. They studied the main reason of destroying buildings and the best design to avoid similar disaster losses, they suggested a proper design for the area and recommended that organizations such as NGOs, universities and private firms with uniform based

bodies can be involved in earlier stage of reconstruction to achieve the goal of reconstruction (Roosli & Collinsb, 2016).

- Jigyasu (2001) studied reconstruction program following Marathwada earth quake of 1993 in India, he found that the developers and donors suggested to rebuild the affected buildings in new area with more organized plan to build organized city, where it was located so far from the original village. But this plan failed because it was not suitable for villagers and didn't match their habitants and traditions and incompatible with their life. Beside this, they lost their agriculture lands and become landless (Jigyasu, 2001).
- Vladimir Ladinski (1995) as cited in Boen and Jigyasu (2003) had done in his study analyses the impact of internationally led 1963 earthquake reconstruction of Skopje. His study also reveals that the immediate housing, which was provided by building on agricultural land away from the city center, has caused many problems. Also the acceptance of 'modern' ideas for the city center redevelopment led to transformation of the city and departure from traditional organic approach to planning. The decision to protect buildings with technology solely based on earthquake engineering principles led to damage of integrity, identity and the originality of the built heritage (Boen & Jigyasu, 2003).
- Robert Geipel (1991) had done an interesting study on long-term consequences (1976-1988) of reconstruction of Friuli, Italy after 1976 earthquake. In his detailed analysis of three settlements, Geipel points out that 'modern' layout and architecture has more or less satisfied the basic needs of inhabitants. However, he cited problems like "less communication", "more anonymity" and "worse neighborhood relationships" due to lack of cultural considerations in reconstruction (Geipel, 1991).
- After war in Kosovo, housing reconstruction program collected the data of affected people from the war and School of Technology in Italy studied the cases and determined the priority degree for beneficiaries using predefined criterion these criterion were residents stability, family size, social situation of the family, poorness degree of the family and the family at risk from their present living conditions. The criterion were developed by Municipal Housing Committees composed of representatives from local and national government, and external agencies (Corrado Minervini, School of Technology, Architecture and Towns in Developing Countries, 2002).

2.3 Regional previous studies:

- Barahkat (1993) has done another interesting study on long-term impact of the contractor built reconstruction in Yemen following the 1982 Dhamar earthquake. Here, Government gave more emphasis to the tender (contractor built approach) by relocating villages, rather than the self-help or repair approaches. Barahkat discovered that in some cases, new settlements within an acceptable distance were actually competing with the old ones since they were neither close enough to merge with the original village, nor far enough away to establish a new center. Moreover, the relocation of villages closer to main roads and the provision of services and infrastructure have had a detectable impact on the economic and social structure of settlements (Barahkat, 1993).
- El-Masri and Kellett (2001) prepared a study about reconstruction in Lebanon after the civil war (1975 to 1991) and discussed the top-down approach to reconstruction. They categorized the displaced people into three categories: Peoples live in refugee and started rebuilding their homes in the origin village, Peoples live in refugee and didn't start rebuilding their homes in the origin village and People live in original village and started rebuilding their homes. The researcher concluded from their study that physical results does not ensure that people will stay in their villages and establishing local committees encourages reconciliatory dialogues between opposing groups which should be expanded to encourage a common vision towards village reconstruction (EL_Masri & Kellet, 2001).
- Due to consequence and variety of disasters in Egypt, Abu_Alnour discussed this issue in full length article. He suggested a plan to efficient disaster management in Egypt. He suggested guidelines to follow in each disaster, studying risk and loss management, control of events, resource management and impact reduction. These steps lead to efficient disaster management system in Egypt. To prove the availability of his system, he applied the system on the provision of integral post disaster settlements in Egypt (Abu_Alnoour, 2014).

2.4 Previous studies in Gaza Strip:

- After 2008 conflict on Gaza Strip, 3408 units were destroyed and 20000 persons lost their homes and became homeless. And with the siege on Gaza through this period and limitation of building materials, authorities suggested a plan to rebuild the affected buildings, and they stated criterion to choose the first affected buildings to rebuild. The starting was with ground floor units and with specific criterion. These criterion were, the land must be legal, the unit busy at the time of damage, there is no other home for the affected person and the rebuilding must be in the same land of damage if there is no any constraints. This plan was to rebuild 1000 units after 3 years of really hard closure and siege on Gaza Strip (Oudeh & Al_Ostaz, 2015).

2.5 Conclusion remarks:

Some researches around the world developed new tools to allow efficient management and evaluation of reconstruction process , but this depends on the capacity and the economy of affected country. On the other hand, other researchers had to use existing tools to ensure basic living conditions for affected people. In this study many constraints must be taken into account and existing tools must be adapted to allow fair reconstruction management.

Chapter 3

Decision Support System

Chapter 3

Decision Support System

3.1 Introduction

Decision Support Systems (DSS) were defined by Scott (1971) as "interactive computer-based systems, which help decision makers utilize data and models to solve unstructured problems." Keen & Scott (1978) defined a DSS as a computer-based support system for management DMs who deal with semi-structured problems. A DSS couples the intellectual resources of individuals with the capabilities of a computer to improve the quality of decisions.

A popular conceptual framework for DSS evolved from work at the IBM Research Laboratory in San Jose, California, during the late 1970s. This framework was first articulated by Sprague (1980) and developed later by Sprague & Carlson (1982). Watson & Sprague (1989) depicted the component parts of a DSS as dialogue, data, and model. In this conceptualization, the dialogue between the user and the system provides some data that support the system, and models provide the necessary analysis capability.

3.2 Decision Support System Components

3.2.1 Dialogue

Dialogues allow commands, requests, and data to be entered into the DSS and results and information to be generated. A well-designed dialogue should provide a user-friendly interface that allows users to avail themselves of the full potential of the system. Bennett (1977) defined dialogue components to include the knowledge base, the action language, and the presentation language (Bennett, 1977). The knowledge base includes what the user knows about the decision and about how to use the DSS. The action language serves to direct the system's actions. The actions that the user can take to control the DSS can be described in a variety of ways, depending on the system's design. For example, some DSS use an input-output form approach. The user is provided an input form and enters the required data. After all the data are input, the DSS performs the analysis and presents the results. The presentation language provides alternative presentations of the system's responses. The output is often presented on the screen, internalized by the DM's, and discarded.

3.2.2 Data

Data play an important role in a DSS. Data can be either stored in the DSS and accessed by the user or inputted manually to the models for processing. The capability of a DSS is constrained by the availability and the accuracy of the data. Data can be categorized as external data (data outside organizations) and internal data (data inside organizations). Typically, data can be obtained in two ways. One way is to have the database management system (DBMS) extract the transaction data, summarize them, and make the results available to the DSS. The other option is to extract the data but have the summarization done externally using a computerized process or manual processing (Watson & Sprague, 1989).

In addition, other internal data may be needed such as subjective estimates from managers. These data are seldom available from normal data processing activities but are sometimes crucial in decision making.

3.2.3 Models

Models provide the analysis capabilities for a DSS and can be classified as optimization or descriptive (Watson & Sprague, 1989). An optimization model seeks to identify points of maximization or minimization. It is usually utilized in a profit or revenue maximization or cost minimization scenario. On the other hand, descriptive models serve to describe the behavior of a system, but do not suggest optimizing conditions. Models can also be classified as strategic, tactical, and operational Watson & Sprague, covering a wide variety of issues from company objectives planning (strategic), to worker requirements planning (tactical), to credit scoring and production scheduling (operational). In addition to strategic, tactical, and operational models, the model base includes model-building blocks and subroutines (Watson & Sprague, 1989). These tools can be adopted separately for ad hoc decision support and might range from a designed subroutine for solving a specific problem to a packaged set of programs for exploring a generic class of problems (Watson & Sprague, 1989).

3.3 Fuzzy set theory

Fuzzy control, introduced in 1970’s, occupies an obvious attention among intelligent controllers. Fuzzy set theory, which has been derived to overcome the roughness of classical set theory, is the kernel of fuzzy logic based on approximating rather than precision. Knowledge based systems developers developed fuzzy logic to define system values as true or false, fuzzy logic depends on information provided by membership functions (MFs) and uses fuzzy sets and rules for controlling actions. There are many available computer applications and software for designing and building such fuzzy logic model. (Abhisek, 2007)

Figure 3.1, taken from Abhisek (2007), shows how fuzzy set theory differs from classical set theory. As shown on the left side of the figure, there is roughness in classical set in making decision that is any value less than 30 is considered as short and any value equals or exceeds 30 is considered as tall, but what would 29.99 high be considered ?. In classical set theory the output is defined by one input only, so 29,99 is considered as short and this is the main difference between classical and fuzzy set theories.

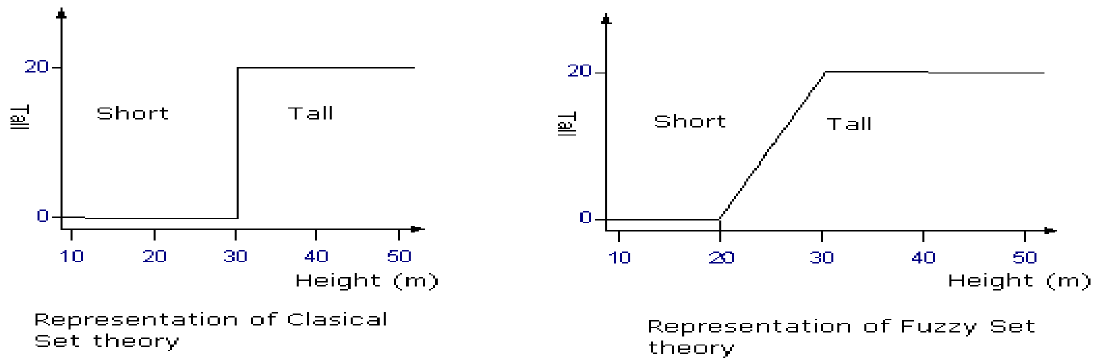

Figure (3. 1): Set theory representation (Abhisek, 2007)

On the right side of Figure 3.1 , the output of fuzzy set is not defined by single input .It is defined by a set of MFs and rules as part of both inputs. Fuzzy set theory gives more realistic answer such that 29.99 height is 90% tall and 10% short or something different according to how user defines MFs. In fuzzy logic there is number of linguistic terms can be used in defining MFs.

Table 3.1 shows some of these terms .These terms, however, are just representation and fuzzy set theory is the responsible for manipulation.

Table (3. 1): Typical Linguistic Terms in Fuzzy Logic (Abhisek, 2007)

Linguistic term	Meaning
PL	Positive large
PM	Positive medium
PS	Positive small
ZE	Zero
NS	Negative small
NM	Negative medium
NL	Negative large

Again, fuzzy set is represented by MFs divided into regions (linguistic terms). If we apply these information to detect the price of a house keeping into account that it is dependent on the newness and the location of the house, inputs and outputs need to be defined by MFs as shown in Figure 3.2. Now, location and newness are the inputs while the price is the output. Next ,rules must be defined for the system such that :

If house is old and location is far, price is cheap.
If house is old and location is relatively far, price is cheap.
If house is old and location is close, price is average.
If house is new and location is far, price is average.
If house is new and location is relatively far, price is expensive.
If house is new and location is close, price is expensive.

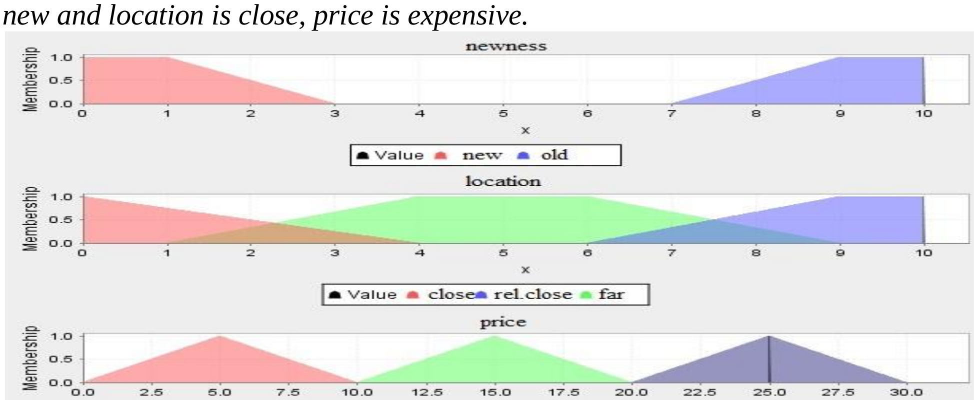

Figure (3. 2): Fuzzy Set Membership Function Representation

Basic Fuzzy Logic:

Fuzzy set is defined as : set F in a universe U and takes values between zero and one (Chuen , 1990) (Abhisek, 2007). U can be discrete or continuous and F can be characterized by μF.

If U is continuous universe, F can be formulated as (Abhisek, 2007):

$$F = \sum_{i=1}^{n} (\mu F(x_i) \, / \, x_i) \qquad (3.1)$$

And for discrete U :

$$F = \int_U \mu F \ (x)/x \qquad (3.2)$$

Fuzzy set is defined according to the representation of MFs as: (Chuen , 1990)

Numerical definition

Each input in the fuzzy set is a range of numerical values and the output is evaluated only for those values.

Functional definition

Unlike numerical definition, MFs are represented functionally. Function can be sinusoidal, trapezoidal, triangular and sigmoid ..etc.

Figure 3.3 is a representation of basic Fuzzy Logic Controller (FLC).

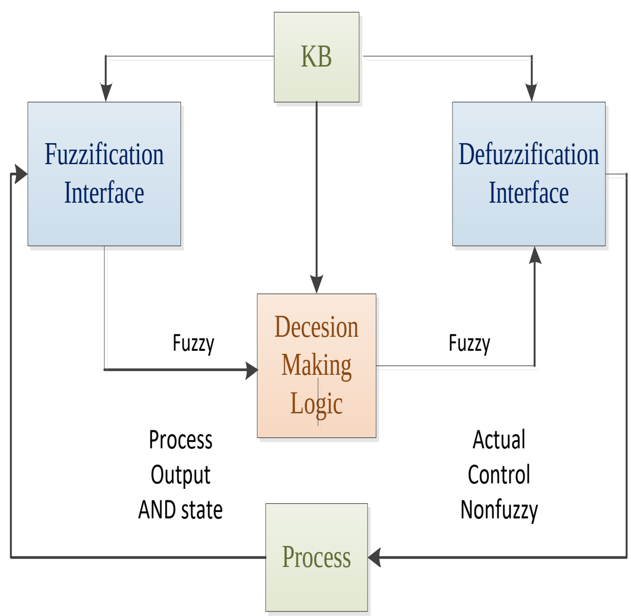

Figure (3. 3): Basic Fuzzy Logic Controller (FLC) (Chuen , 1990)

The block diagram in Figure 3.3 contains the basic components of FLC , the most important components can be summarized as :

Fuzzification:

- Measures input variables (Chuen , 1990)
- Related to fuzzy set definitions, Fuzzification converts numerical values in MFs (Abhisek, 2007)

Knowledge Base, it is data based and rule based where , data base defines fuzzy sets and rule base defines the control rule (Chuen , 1990).

Decision Making Logic, in this step, fuzzy logic rules examines knowledge representations from previous step (Abhisek, 2007)

Defuzzification, converts logic values taken from fuzzy set to scaled values. Away from accounting all methods, CENTROID and MAXIMUM are the most common for Defuzzification (Abhisek, 2007)

Chapter 4

Developed Model for Reconstruction Process

Chapter 4

Developed Model for Reconstruction Process

4.1 Introduction

Housing is essential to the well-being and development of most societies. It is a complex asset, with links to livelihoods, health, education, security and social and family stability. Housing is also an extremely vulnerable asset especially after natural or human made disasters where large number of houses make it necessary to urgently develop multi objective plans. Destruction of homes or their loss through displacement or dispossession is one of the most visible effects of conflict and natural disaster. Reconstruction should be a more prominent element in post-conflict and post-disaster programming than the currently case. Reconstruction projects are often unsustainable: at best, houses are remodeled by their occupants; at worst, they are simply rejected and abandoned.

Housing reconstruction is often construed as a developmental responsibility rather than properly a humanitarian concern, and consequently tends to be low on the humanitarian agenda. Arguably, there is a clear humanitarian imperative to provide victims of conflict and disaster with basic shelter, in the same sense as there is a humanitarian imperative to ensure an access to water, sanitation, food and healthcare. Unlike other relief items such as food aid or medicine, housing is a significant, long-term and non-consumable asset.

Housing reconstruction is a complex process, and success typically requires a good deal of time and preparation. It argues that housing reconstruction interventions should take into account local resources, needs, perceptions, expectations, potentials and constraints.

4.2 Constraints on reconstruction process

After 2014 conflict, Gaza strip needed construction materials for 11168 completely damaged units, 5318 severely damaged units and 126682 partially damaged units as mentioned in Table 4.1 (Oudeh & Al_Ostaz, 2015).

There are a lot of constraints on reconstruction of affected buildings in Gaza Strip because of the huge number of affected people and their needs to be satisfied. Another issue appeared when there is a lack of construction machines and equipment's and human resources, it was not possible to start working on all destructed houses at the same time.

In addition, the import limitation of so called 'dual used materials' especially construction materials like cement, aggregate and steel reinforcement. Moreover, continued closure of Rafah border is exacerbating the problem side by side with the lack of financial support from donors.

Table (4. 1): number of totally damaged houses and units in Gaza Strip after 2014 conflict **(Oudeh & Al_Ostaz, 2015)**

Governorate	**Number of buildings**	**Number of units**
North	1443	2861
Gaza	1768	4075
Middle	781	1273
Khan-Younis	1298	1936
Rafah	653	1023
Total	5943	11168

4.2.1 Lack of buildings materials

The amount of building materials estimated before summer 2007 was more than 70000 tons per month for concrete and dual use reinforcement steel , and reduced after that to 20%, but from 2008 to 2010 the amount of materials that imported officially was approximately zero. Statistics estimated that Gaza needs 1000 tons of cement, 1000 tons of reinforcement steel, 16000 tons of aggregates and 13000 tons of base coarse daily to reconstruct all affected units after 2014 conflict and cumulative residential houses through last 7 years. INGO's estimated that 1.5 million tons of concrete needed to reconstruct affected houses. But after a year from

2014 conflict the amount of cement allowed to enter Gaza Strip was 338000 tons, which means that with this range (22% of actual quantity), reconstruction process needs 4 years to complete (Ead, 2015).

Add to this Karm Abu-Salem cross point is not suitable and not prepared with sufficient technical equipment and facilities limits the amount of trucks that can enter Gaza Strip, where its capacity is 700 tons per day, but 5000 tons are needed daily to reconstruct affected houses after 2014 conflict (Ead, 2015).

4.2.2 Building and rubble removal machines

Limited number of building machines is a very affecting constraint in reconstruction after the disaster. Depending on the statistics from ministry of transportation there are 3 building cranes in Gaza Strip in 2015, 7 air settlements, 6 small bulldozers, 4 bulldozers, 17 track bulldozers, 17 track digger and 3 engineering machines. These numbers decreased through the last 10 years in Gaza Strip because of the siege. Table 4.2 shows numbers of the building machines through last 5 years (Nesman, 2015).

Table (4. 2): number of heavy vehicles in Gaza strip (2012 – 2015) **(Nesman, 2015)**

Machine Type	2012	2013	2014	2015
Building crane	4	4	3	3
Air settlement	9	9	7	7
Small Bulldozer	9	8	6	6
Bulldozer	6	6	4	4
Track Bulldozer	20	20	19	17
Track Digger	21	21	17	17
Engineering Machines	3	3	3	3

4.2.3 Pledged money from the donors:

An important constraint is money transfer from donors due to serious restrictions on money transfer to affected persons through INGO's and MPWH. Depending on the reports, the donors from Cairo conference pledged to pay 5.4 billion dollars to Gaza Strip after 2014 conflict, 2.7 billion dollars will be to reconstruct the affected houses after 2014 conflict, but actually until the end of 2015, 30% were transferred.

Table A.1 in APPENDIX A explains what the donors have pledged to Gaza in Cairo conference depending on the international bank report in millions. (Ead, 2015)

4.3 Implementation of assessment criteria evaluation using Fuzzy Logic theory:

Four main criteria are considered to determine the priority of affected buildings; building status, resident status, quarter status and building type. A comprehensive description of each criteria can be found in the next sections. The importance weight of each criterion plays an important role in priority detection of the affected building. Due to this fact, it is important to set these weights through the reconstruction organizations, stakeholders, governmental ministries involved and local committees.

In Abu mahadi and others, 2014 study, they determined multi criteria through a questionnaire and expert choice program in their study to determine weights for buildings using analytical hierarchy process as shown in Table (4.3). They used 15 criteria without classification. The questionnaire was distributed on professional offices, professional engineers, and involved organizations in reconstruction process (Abu mahadi, Al_Sayed, Bassiouni, & Al_Aila, 2014). Table (4.3) shows the weights of used criteria.

Table (4.4) shows the importance weights factor used in this study which is approximately equal to their importance weights, but with arranging these criteria and classifying them in logical way. In this study the weights will be assumed as shown in Table (4.4). These weights can be changed or modified if needed, furthermore quarter status criteria was not considered in the previous study, so in this study it considered with sub criteria related to the location of affected building.

Table (4. 3): Weights used in **(Abu mahadi, Al_Sayed, Bassiouni, & Al_Aila, 2014)** study:

Criteria	Expert Choice program	Questionnaire
Land type	2.7%	5.54%
Building Type	4.6%	5.71%
Number of floors	5.1%	6.79%
Number of Units	6.4%	5.71%
Number occupied of units	12.6%	9.14%
Number of empty units	4.5%	2.86%
Type the roof	5.6%	4.21%
Use of the building	13.4%	10.71%
Unit Area	6.0%	6.96%
Households in the unit	8.2%	9.64%
People in the unit	10.0%	8.18%
Registered with UNRWA	3.3%	3.11%
Residents in the house at the time of the damage	6.4%	6.86%
Current place of residence	6.9%	10.43%
Finishing of the interior	4.3%	4.14%
Total	100.0%	100.00%

Table (4. 4): Weights used in this study compared with A.Mahadi,2014 study

Main criteria	Sub criteria	Current study	(Abu mahadi, Al_Sayed, Bassiouni, & Al_Aila, 2014) **study**	
			Questionnaire weights	**Expert Choice program weights**
Building status	land type	30%	5.54	2.7
	number of floors		6.79	5.1
	number of units		5.71	6.4
	number of occupied units		9.14	12.6
	total		27.18	26.8
Residents status	unit area	30%	6.96	6
	residents in the unit		8.18	10
	current place of stay		10.43	6.9
	house hold in the unit		9.64	8.2
	total		35.21	31.1
Quarter status	Quarter Location	20%	not used	not used
	Number of Destroyed Buildings			
Building type	building type	20%	5.71	4.6
	use of the building		10.71	13.4
	total		16.42	18

The implemented fuzzy logic model is shown in the figures in next sections. In this model four main criteria were selected to study the importance weight of each affected building. These four criteria are building status, residents status, quarter status and building type with many sub criteria that have been analyzed to be suitable for each main criterion. Weights are assumed depending on previous studies and statistics from Palestinian central bureau of statistics related to the social situation in Palestine and Gaza specifically. The main four criteria were chosen with their sub criteria as shown in next sections. Building status will weigh 30% of the importance weight, residents' status will weigh 30%, quarter status weight is 20% while quarter status weight is 20%. Each criterion contains different sub criteria gathered from collected data that will be evaluated using fuzzy logic models.

4.3.1 Building status:

This criterion will weigh at maximum value $\mathbf{W_{BS}}$ 30% of the total weight of the importance weight, and this criteria is divided into three sub criteria, $\mathbf{W^{F}_{BS}}$ number of floors, $\mathbf{W^{U}_{BS}}$ ratio of occupied units and it is a ratio from occupied units to total units of destroyed building and $\mathbf{W^{L}_{BS}}$ building legality. Building status will be evaluated using fuzzy logic model through these sub criteria as shown in Figure 4.1.

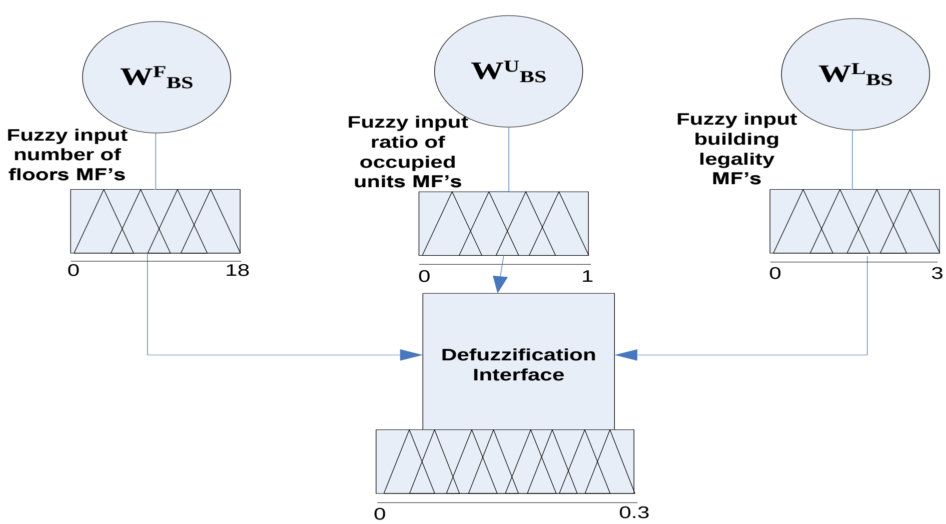

Figure (4. 1): Implemented fuzzy model for Building Status criterion

- **Number of floors W^F_{BS}**

Number of floors sub criteria is divided into classes depending on the system of structure and simplicity of building, that buildings with floors more than 6 consume more time and must be built with shear walls . Thus, maximum priority is for buildings with floors from 4 – 6 floors.

Number of floor classes:

1- Number of floors 0 to 5 will be at low class.
2- Number of floors from 3 -10 will be the high class
3- Number of floors from 8 - 15 will be the lowest important.

Number of floors W^F_{BS} is the first input for 'building status' and represented by three trapezoidal MF's as shown in figure 4.2 . Figure 4.2 has been created from designed FIS. Table 4.5 summarizes the linguistics values description and ranges.

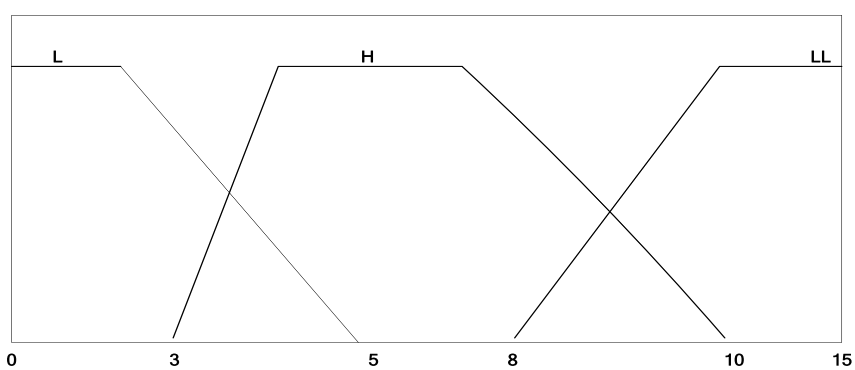

Figure (4. 2): Specifying the First Input Variable as W^F_{BS}

Table (4. 5): Ranges for input number of floors Variable

W^F_{BS} description	Linguistic term	Range
Short buildings	L	0 to 5
Average height buildings	H	3 to 10
High rise buildings	LL	Larger than 8

- **Ratio of occupied units W^{U}_{BS}**

Ratio of occupied units is the ratio of occupied units to total units in the building. Ratio of occupied units W^{U}_{BS} is the second input for 'building status' and represented by three triangular MF's as shown in figure 4.3 . Figure 4.3 has been created from designed FIS. Table 4.6 summarizes the linguistics values description and ranges.

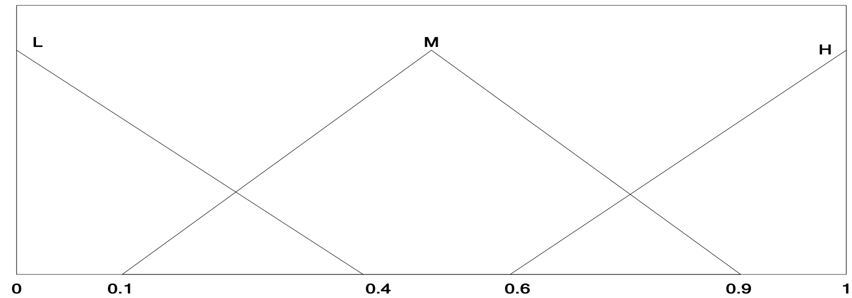

Figure (4. 3): Specifying the second Input Variable as W^{U}_{BS}

Table (4. 6): Ranges for input ratio of occupied units variable

W^{U}_{BS} description	Linguistic term	Range
Low settlement	L	0 to 0.4
Medium settlement	M	0.1 to 0.9
High settlement	H	0.6 to 1

- **Building legality W^{L}_{BS}**

Building legality varies upon the legality of the land. For governmental lands the value is the lowest importance degree for this sub criteria but ,in the fact, legality of the land does not cancel people's right to rebuild .

Building legality W^{L}_{BS} is the third input for ' building status' and represented by three detective MF's as shown in figure 4.4 . Figure 4.4 has been created from designed FIS. Table 4.7 summarizes the linguistics values description and ranges.

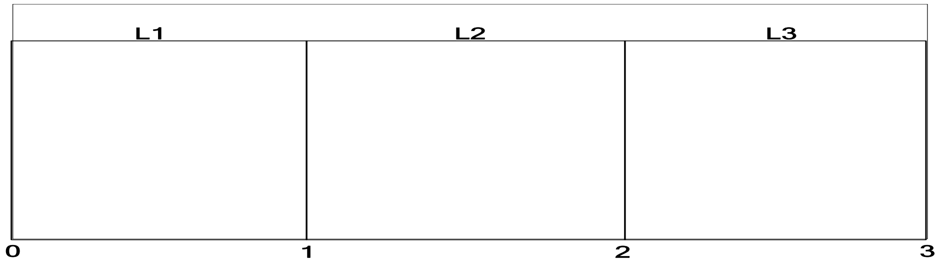

Figure (4. 4): Specifying the Third Input Variable as W^{L}_{BS}

Table (4. 7): Ranges for input legality of the building variable

W^{L}_{BS} description	Linguistic term	Range
Owned	L1	1
Waqif	L2	2
Governmental	L3	3

- **Building status importance weight output W_{BS}**

This criterion will weigh at maximum value $\mathbf{W_{BS}}$ 30% of the total weight of the importance weight. The output building status which measures the building status of each affected building is represented by five triangular MFs shown in Figure 4.5. Figure 4.5 has been created from designed FIS. Table 4.8 summarizes the linguistic values description and ranges.

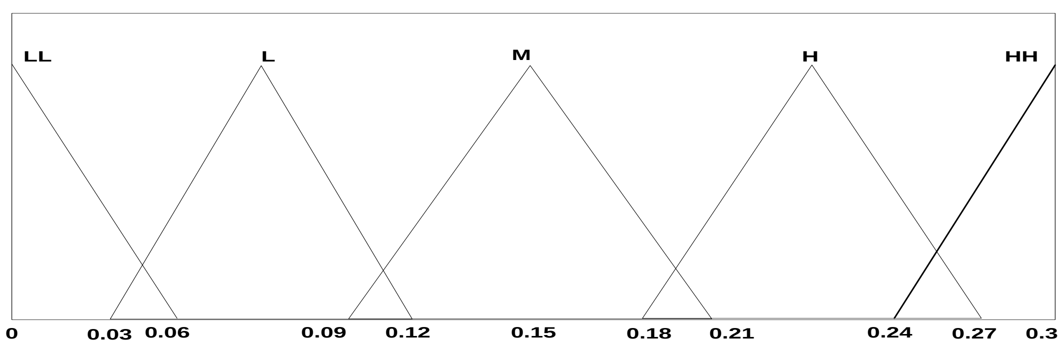

Figure (4. 5): Specifying the output Variable as W_{BS}

Table (4. 8): Ranges for output building status variable

W_{BS} Description	Linguistic term	Range
Very low	LL	0 to 0.08
Low	L	0.03 to 0.12
Medium	M	0.09 to 0.21
High	H	0.18 to 0.27
Very high	HH	0.24 to 0.3

4.3.2 Residents status

Rebuilding for highest number of affected people is very important issue, so number of persons live in a destructed building will be very important criteria. Depending on Palestinian Central Bureau of Statistics, 6 persons is the average family size in Palestine. Table 4. 9 explains housing density (person per room) through 2011 – 2013 with average 3 rooms for each family and figure 4. 6 explains the distribution of households in Palestine by housing density (Person per Room), 2013 (Palestinian Central Bureau of Statistics, 2015)

Table (4. 9): Percentage Distribution of Households in Palestine by Housing Density (Person per Room), 2011-2013 **(Palestinian Central Bureau of Statistics, 2015)**

Housing Density (Person per Room)	2011	2012	2013
Less than 1	13.5	17.0	14.5
1.00- 1.99	48.6	51.1	46.9
2.00- 2.99	27.4	24.3	27.6
3.00+	10.5	7.6	11.0
Total	100	100	100
Average Housing Density	1.6	1.5	1.6

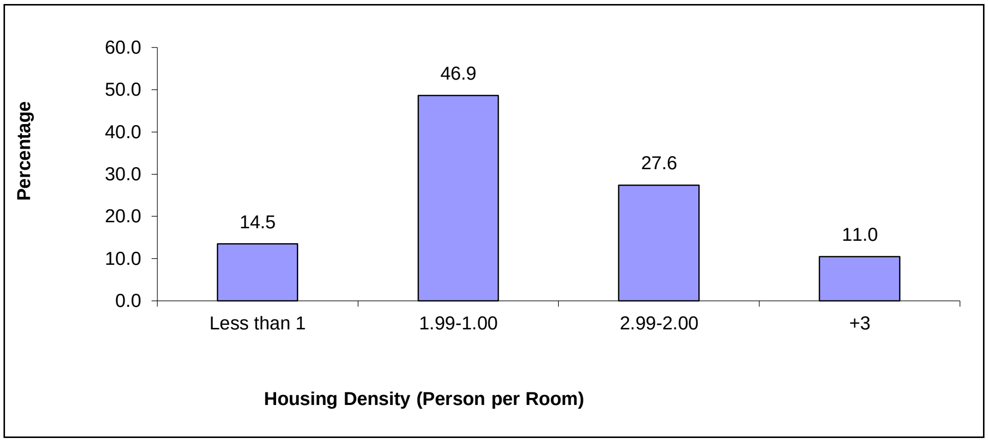

Figure (4. 6): Percentage Distribution of Households in Palestine by Housing Density (Person per Room), 2013 **(Palestinian Central Bureau of Statistics, 2015)**

So resident status criterion will weigh at maximum value $\mathbf{W_{RS}}$ 30% of the building importance weight and will be evaluated using fuzzy logic model through three sub criteria to study the social situation and stability of affected people as shown in Figure 4.7.

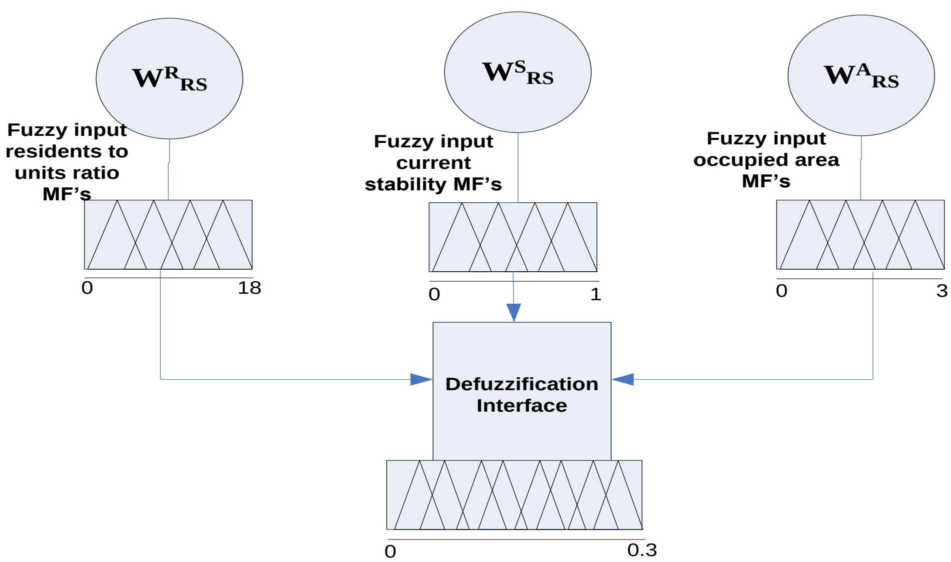

Figure (4. 7): Implemented fuzzy model for Residents Status criterion

- **Residents number to units number $\mathbf{W^R_{RS}}$**

Residents number to units number ratio will be calculated then sub criteria $\mathbf{W^R_{RS}}$ will be divided into three classes. Residents number to units number W^R_{RS} is the first input for ' residents status' and represented by three triangular MF's shown in figure 4.8 . Figure 4.8 has been created from designed FIS. Table 4. summarizes the linguistics values description and ranges.

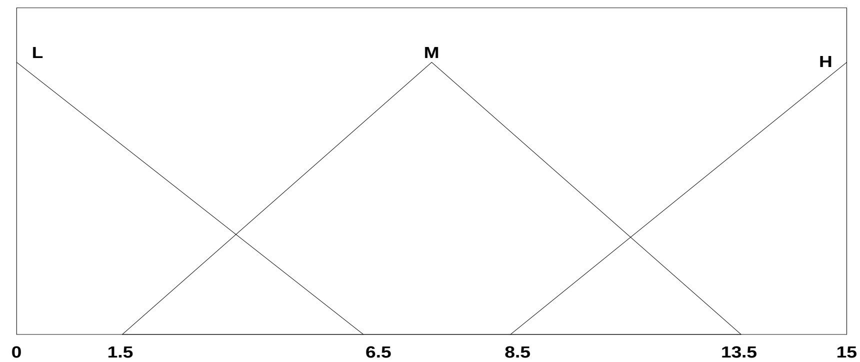

Figure (4. 8): Specifying the first input Variable as W^R_{RS}

Table (4. 10): Ranges for input residents number to units number variable

W^R_{RS} description	Linguistic term	Range
Low residents	L	0 to 6.5
Medium residents	M	1.5 to 13.5
High residents	H	more than 8.5

- **Current stability of residents W^S_{RS}**

Current stability of residents affects the value of the weight ,so stability will be considered as sub criteria of resident status criteria .

This factor depends on one main situation which is the current place of living. Because there are persons live in tents, lodging with other families, hired units and there are persons own alternative houses. The ratio of unstable units to the total units will be calculated depending on the current living condition of affected persons.

Current stability of residents W^S_{RS} is the second input for ' resident status' and represented by three triangular MF's shown in figure 4.9 . Figure 4.9 has been created from designed FIS. Table 4.11 summarizes the linguistics values description and ranges.

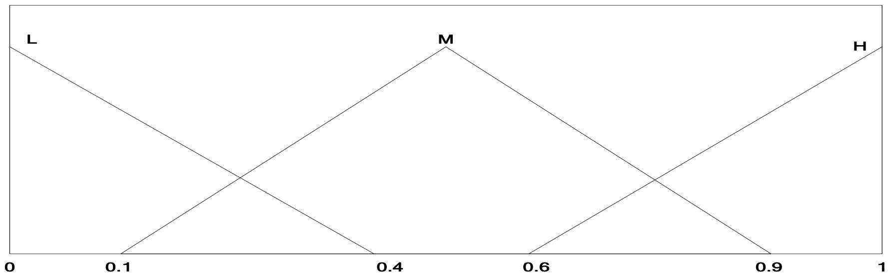

Figure (4. 9): Specifying the second input Variable as W^S_{RS}

Table (4. 11): Ranges for input current stability of residents variable

W^S_{RS} description	Linguistic term	Range
Low stability percentage	L	0 to 0.4
Medium stability percentage	M	0.1 to 0.9
High stability percentage	H	0.6 to 1

- **Occupied area per person W^A_{RS}**

Average area of resident houses in Palestine is 120 m^2 and average number of family size is 6 persons, so every person approximately occupies 20 m^2 . (Palestinian Central Bureau of Statistics, 2015). So occupied area per person will be considered as the third sub criterion $\mathbf{W^A_{RS}}$ of the residents status criterion, so using the ratio of total area of all units in the building to the total number of residents in the same building determines the area for each person. Classifying the areas in phases will determine the importance weight for each area.

Occupied area per person W^A_{RS} is the third input and represented by two triangular MF's and one trapezoidal MF shown in figure 4.10. Figure 4.10 has been created from designed FIS. Table 4.12 summarizes the linguistics values description and ranges.

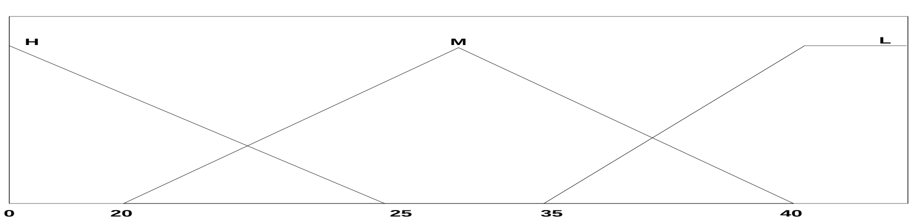

Figure (4. 10): Specifying the third input Variable as W^A_{RS}

Table (4. 12): Ranges for input occupied area per person of residents variable

W^A_{RS} **description**	**Linguistic term**	**Range**
Low area per person	H	0 to 25
Medium area per person	M	20 to 40
High area per person	L	larger than 40

- **Residents status importance weight output W_{RS}**

This criterion will weigh at maximum value $\mathbf{W_{RS}}$ 30% of the total weight of the importance weight. The output residents status which measures the residents value of each affected building is represented by five triangular MFs as shown in Figure 4.11 Figure 4.11 has been created from designed FIS. Table 4.13 summarizes the linguistic values description and ranges.

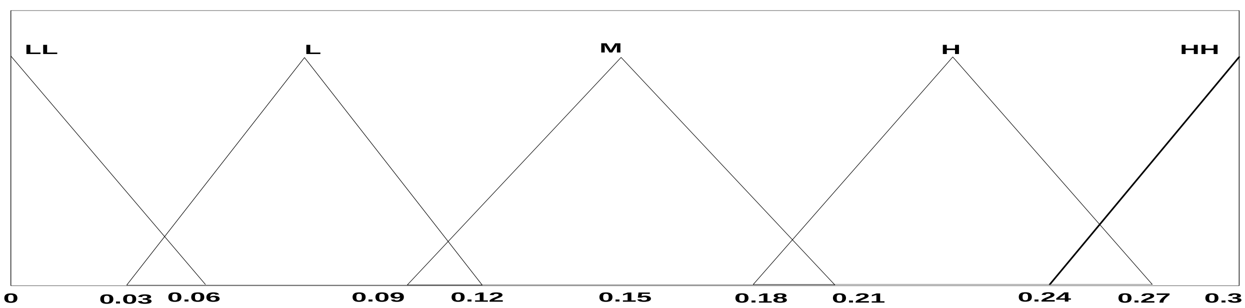

Figure (4. 11): Specifying the output Variable as W_{BS}

Table (4. 13): Ranges for output residents status variable

$\mathbf{W_{RS}}$ Description	Linguistic term	Range
Very low	LL	0 to 0.08
Low	L	0.03 to 0.12
Medium	M	0.09 to 0.21
High	H	0.18 to 0.27
Very high	HH	0.24 to 0.3

4.3.3 Quarter status:

The location of damaged houses affects the priority degree, that number of destructed houses at one location will be easier to rebuild than single houses at separated locations.

Furthermore, the location of the house beyond borders or far will change the priority, so this criterion will detailed into two sub criteria, totally damaged buildings in the quarter and quarter location and will be evaluated through them using fuzzy logic model as shown in Figure 4.12.

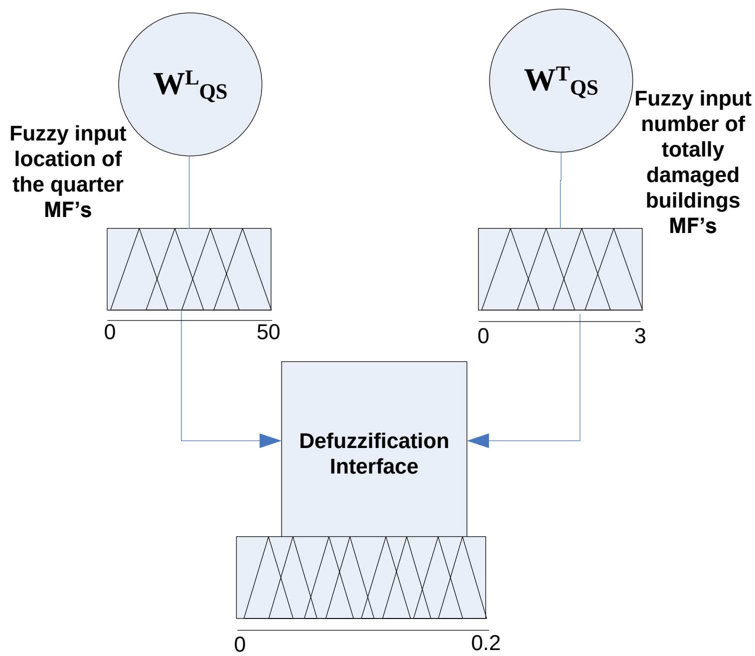

Figure (4. 12): Implemented fuzzy model for Quarter Location criterion

- **Total number of damaged houses in the quarter W^{T}_{QS}**

Totally damaged buildings in the quarter $\mathbf{W^{T}_{QS}}$ will be classified into three classes. Totally damaged houses W^{T}_{QS} is the first input and represented by two triangular and one trapezoidal MF's as shown in figure 4.13 . Figure 4.13 has been created from designed FIS. Table 4.14 summarizes the linguistics values description and ranges.

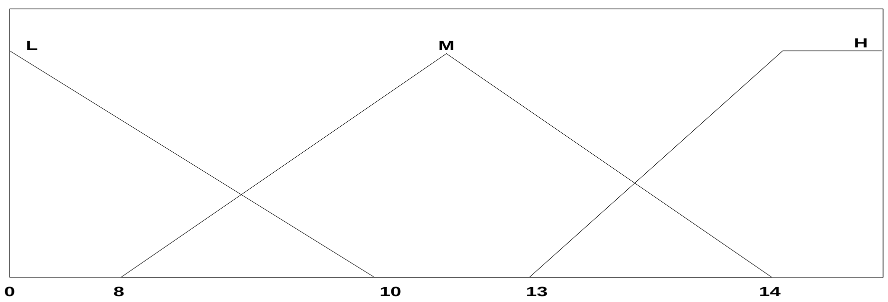

Figure (4. 13): Specifying the first input Variable as W^T_{QS}

Table (4. 14): Ranges for input total damaged houses in the quarter variable

W^T_{QS} description	Linguistic term	Range
Low number of destroyed houses	L	0 to 10
Medium number of destroyed houses	M	8 to 14
High number of destroyed houses	H	More than 13

- **Location of the quarter W^L_{QS}**

Quartet location sub criteria W^L_{QS} value will vary depending on the distance from the borders, and high priority to border quarters.

So the classes will be:

1- If the quarter at borders the affected houses will have high priority.
2- If the quarter is a city, affected houses will have the second importance.
3- If the quarter is a village , affected houses will have the third importance

Quarter location W^L_{QS} is the second input and represented by detective MF's as shown in figure 4.14 . Figure 4.14 has been created from designed FIS. Table 4.15 summarizes the linguistics values description and ranges.

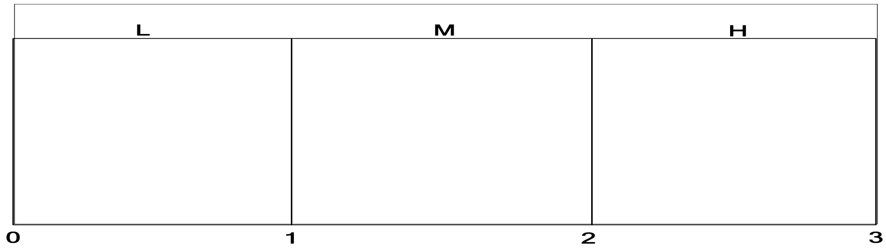

Figure (4. 14): Specifying the second input Variable as W^{L}_{QS}

Table (4. 15): Ranges for input location of the quarter variable

W^{L}_{QS} description	Linguistic term	Range
Village quarter	L	1
City quarter	M	2
Border quarter	H	3

- **Quarter status importance weight output W_{QS}**

This criterion will weigh at maximum value $\mathbf{W_{QS}}$ 20% of the total weight of the importance weight. The output quarter status which measures the quarter value of each affected building is represented by three triangular MFs shown in Figure 4.15 . Figure 4.15 has been created from designed FIS. Table 4.16 summarizes the linguistic values description and ranges.

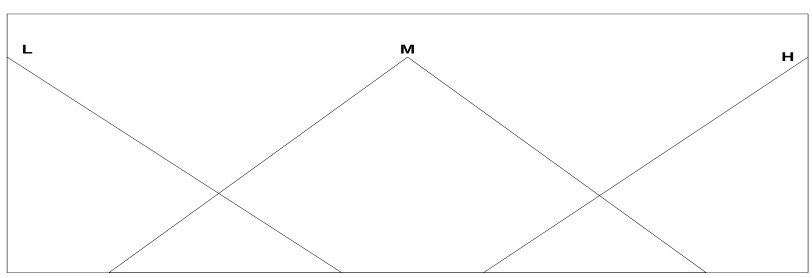

Figure (4. 15): Specifying the output Variable as W_{QS}

Table (4. 16): Ranges for output quarter status variable

W_{QS} description	Linguistic term	Range
Low	L	0 to 0.4
Medium	M	0.1 to 0.9
High	H	0.6 to 1

4.3.4 Building type:

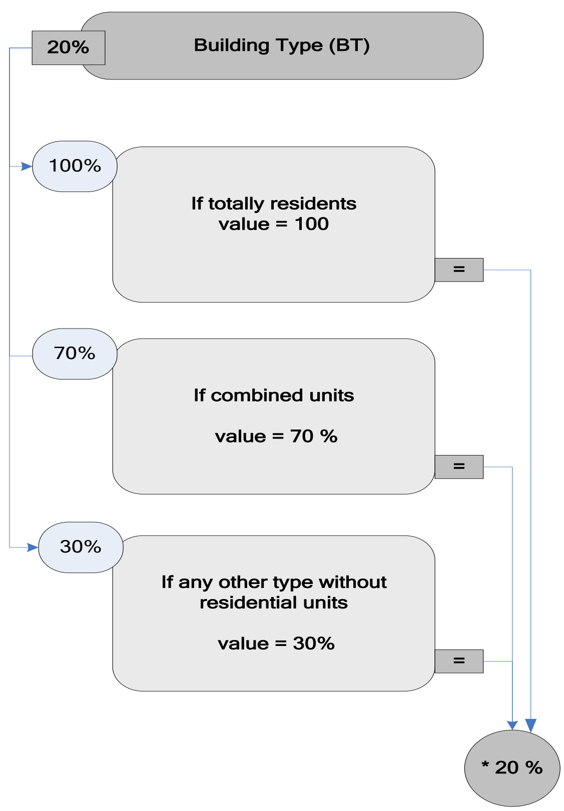

Figure (4. 16): Building type criteria flow chart

Building type is determined within three classes and depends on the type of using the destroyed buildings, residential, combined purposes and other usage. The commercial building can't neglected and must be considered because rebuilding of this type of buildings will improve the economic side and bush up the affected people to start their works and help in the recovering, but it's not more important than residential buildings.

So the criteria weigh at maximum value $\mathbf{W_{BT}}$ 20% of the total building weight and classified into three classes:

1- If the building totally residential the weight equal to $\mathbf{W^{T}_{BT}}$ 100% of the sub criteria weight.
2- If the building combined usage the weight will equal to $\mathbf{W^{C}_{BT}}$ 70% of the sub criteria weight.
3- If the building usage for other purposes without residential usage the weight equal to $\mathbf{W^{O}_{BT}}$ 30% of the sub criteria weight.

So total importance weight of building type will be calculated as:

$$\mathbf{W_{BT} = (W^{T}_{BT} \text{ or } W^{C}_{BT} \text{ or } W^{O}_{BT}) * 20\%} \qquad \textbf{(4.1)}$$

All above information about the criteria will be considered in analyzing data by calculating the weight of each criteria based on the values of sub criteria.

After that each evaluated criteria will be considered as the inputs of fuzzy logic model.

4.4 Implementation of priority detection using Fuzzy Logic theory

4.4.1 Objective

Applying fuzzy logic in this study is to find the priority degree of each affected building after crises, by maximizing the priority degree itself between any two affected buildings. Distinguishing the degree between houses with similar priorities can be achieved using fuzzy logic controller by enlarging the number of digits.

Objective:

$$\left[\max_{i=1\to n} \left|\mathbf{P}_{i} - \mathbf{P}_{i-1}\right|\right] \qquad \textbf{(4.2)}$$

n: number of affected houses

Pi: priority degree of any affected house

Pi-1: priority degree of any other affected house.

Subject to affected families current stability and their urgent need for building reconstruction.

4.4.2 Implementation of priority degree using fuzzy logic

There are many software used to design and build fuzzy controller. In this chapter MATLAB, Fuzzy Logic Toolbox is used.

MATLAB is the most famous software for technical computing. It has the property of working within one environment by consolidating programming, visualization and computation in the same environment. It can express and solve problems in frequent mathematical notation. In this thesis m files in MATLAB has been used to code the computation of weights of criteria and sub criteria. Fuzzy Inference System FIS has been used to build fuzzy model for priority detection through multi steps process starting with identifying 4 inputs and related membership functions MFs, then identifying one output and related MFs. " If , then " rules have been built through rule building process . Built fuzzy model through FIS is imported within coded m file in order to have results by only one run.

First step is to define inputs and outputs to Fuzzy Inference System (FIS). Building status (BS), residents status (RS), quarter status (QS) and building type (BT) are considered as inputs while priority degree (PD) is considered as output as shown in figure 4.17.

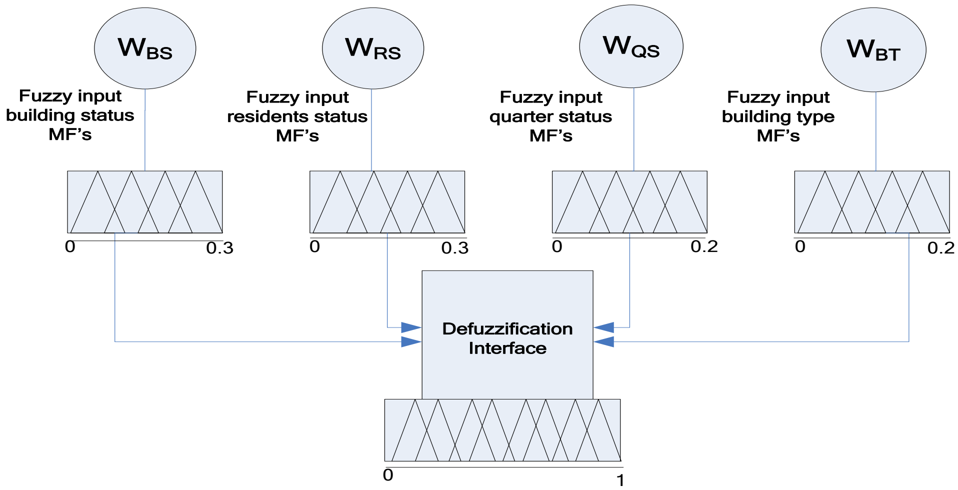

Figure (4. 17): Implemented fuzzy model

- **BS (Building Status)**

BS is the first input and represented by three triangular MF's shown in figure 4.18. Figure 4.18 has been created from designed FIS. Table 4.17 summarizes the linguistics values description and ranges.

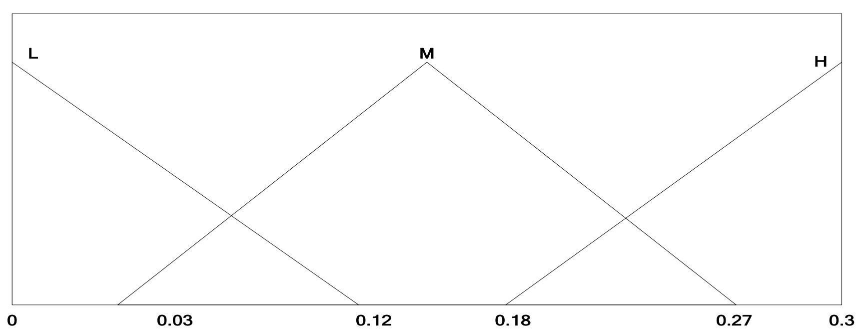

Figure (4. 18): Specifying the First Input Variable as BS

Table (4. 17): Ranges for Input BS Variable

BS Description	Linguistic term	Range
Low	L	0 to 0.12
Medium	M	0.03 to 0.27
High	H	0.18 to 0.3

- **RS (Residents Status)**

RS is the second input and represented by three triangular MF's shown in figure 4.19. Figure 4.19 has been created from designed FIS. Table 4.18 summarizes the linguistics values description and ranges.

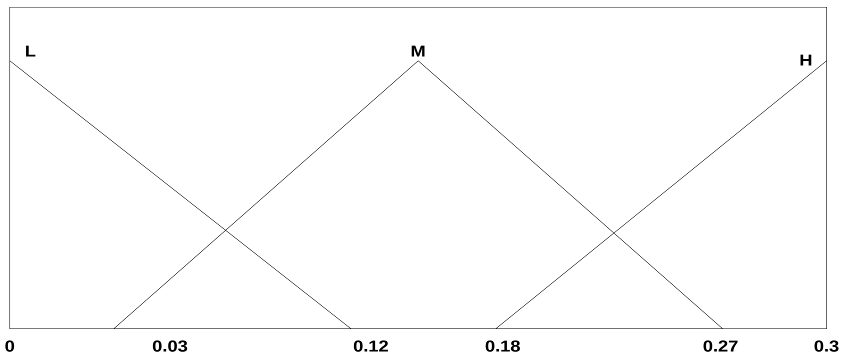

Figure (4. 19): Specifying the First Input Variable as RS

Table (4. 18): Ranges for Input RS variable

BS Description	Linguistic term	Range
Low	L	0 to 0.12
Medium	M	0.03 to 0.27
High	H	0.18 to 0.3

- **QS (Quarter Status)**

QS is the third input and represented by three triangular MF's shown in figure 4.20. Figure 4.20 has been created from designed FIS. Table 4.19 summarizes the linguistics values description and ranges.

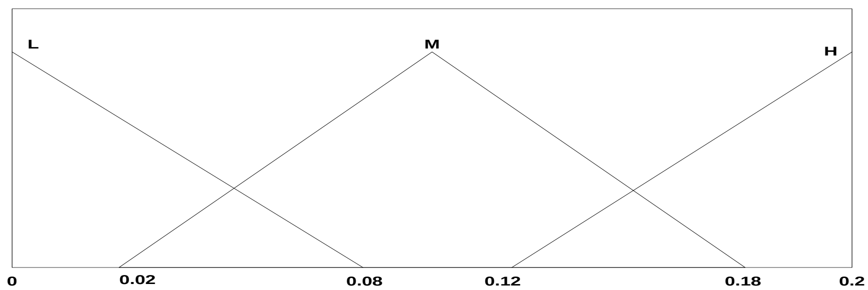

Figure (4. 20): Specifying the First Input Variable as QS

Table (4. 19): Ranges for Input QS variable

BS Description	Linguistic term	Range
Low	L	0 to 0.08
Medium	M	0.02 to 0.18
High	H	0.12 to 0.2

- **BT (Building Type)**

BT is the fourth input and represented by three triangular MF's shown in figure 4.21. Figure 4.21 has been created from designed FIS. Table 4.20 summarizes the linguistics values description and ranges.

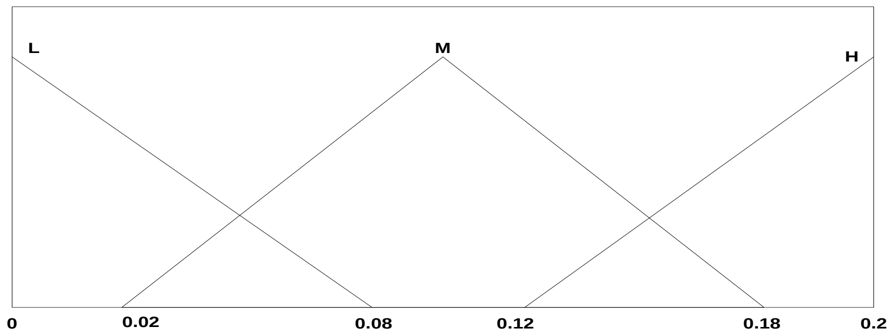

Figure (4. 21): Specifying the First Input Variable as BT

Table (4. 20): Ranges for Input BT variable

BS Description	Linguistic term	Range
Low	L	0 to 0.08
Medium	M	0.02 to 0.18
High	H	0.12 to 0.2

- **PD (Priority Degree)**

The output priority degree which measures the priority of each affected building is represented by six triangular and one trapezoidal MFs shown in Figure 4.22. Figure 4.22 has been created from designed FIS. Table 4.21 summarizes the linguistic values description and ranges.

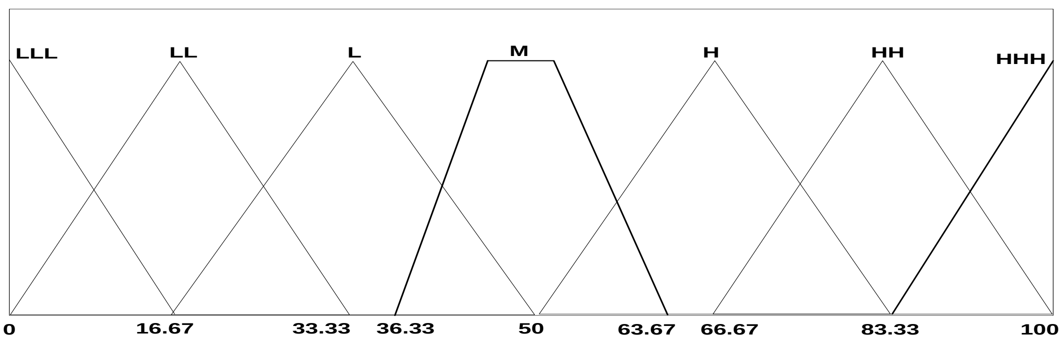

Figure (4. 22): Specifying the Output Variable priority degree

Table (4. 21): Ranges for Output priority degree Variable

Suitability-Degree Description	Linguistic term	Range
Very very low	LLL	0 to 16.67
Very low	LL	0 to 33.33
Low	L	16.67 to 50
Medium	M	36.33 to 63.67
High	H	50 to 83.33
Very high	HH	66.67 to 100
Very very high	HHH	83.33 to 100

Affected buildings with highest priority degree are selected to be reconstructed first. Priority degree value is evaluated by CENTROID Defuzzification depending upon the inputs and the rules defined in fuzzy inference system . IF-Then operation is the rule controller, 81 rules are written in FIS tool box.(Table B.1 in the APPENDIX B shows the rules).

Chapter 5

Results and Analysis

Chapter 5

Results and analysis

5.1 Case study

The feasibility of the proposed model has been tested on system of input matrix 5943*10. All available data of 5943 buildings had been destroyed and totally damaged in 2014 conflict on Gaza Strip. Input data can be divided into five areas according to local governorate (see table 5.1).The rebuilt approach can be applied individually on the divided area if each governorate has its own reconstruction plan and own fund code. However, in the case of centralized society the model can be applied on the whole 5943 affected houses.

Table (5. 1): Number of totally damaged houses and units (Oudeh & Al_Ostaz, 2015)

Governorate	Number of units	Number of buildings
North	2861	1443
Gaza	4075	1768
Middle	1273	781
Khan-Younis	1936	1298
Rafah	1023	653
Total	11168	5943

5.1.1 Proposed approach verification

Analytical hierarchy process (AHP) decision making approach had been applied previously on the area (Gaza Strip) for houses reconstruction. The previous approach had been applied in 2014 on data of totally damaged buildings in 2008 war on Gaza Strip. This study determined the criteria based on a questioneer made by Abu Mahady and others (2014) study and based on criteria determined by the study itself using expert choice program.

The feasibility and effectiveness of the proposed approach had been firstly tested by applying the approach on sample of 2008 data which were used in the previous study. Table 5.2 shows data of affected buildings to be reconstructed after 2008 on Gaza Strip. A comparison of priority detection using AHP in previous study and using fuzzy in this study, is in the last two columns of table 5.2.

Table (5. 2): Comparison of priorities based on the affected buildings 2008 war. (MPWH, 2008)

#	Building Area	Number of floors	Number of units	Used units	Unstable units	Building usage	Size Of the family	Number Of affected Houses In Quarter	Priority Using AHP Abu mahadi and others, 2014 study	Priority Using Fuzzy
1	160	4	4	4	0	residential	7	9	80.2654	61.2662
2	180	3	4	4	0	residential	7	2	80.2525	59.7884
3	120	1	1	1	1	residential	9	78	79.5213	88.3034
4	210	1	1	1	0	residential	5	2	79.2148	55.0555
5	288	2	2	2	1	residential	8	3	78.0679	58.053
6	130	1	1	1	1	residential	8	1	76.7787	74.6751
7	180	1	1	1	1	residential	10	58	76.7859	88.3034
8	150	3	3	3	2	residential	2	3	75.1955	60.6309
9	85	1	1	1	1	residential	7	2	79.1647	71.6569
10	115	1	1	1	1	residential	7	32	78.7032	88.3034
11	195	3	3	3	3	residential	8	78	78.4325	66.9656

Cont. Table (5. 3): Comparison of priorities based on the affected buildings 2008 war. (MPWH, 2008)

#	Building Area	Number of floors	Number of units	Used units	Unstable units	Building usage	Size Of the family	Number Of affected Houses In Quarter	Priority Using AHP Abu mahadi and others, 2014 study	Priority Using Fuzzy
12	180	3	4	4	3	residential	7	2	78.1966	59.5245
13	288	2	2	2	1	residential	8	3	78.0679	58.053
14	274	2	3	3	3	residential	3	8	77.8789	56.4936
15	180	2	3	3	2	residential	8	11	77.6867	50
16	155	1	1	1	1	residential	8	11	77.5975	83.3252
17	180	1	1	1	1	residential	10	8	77.2027	81.9594
18	180	1	1	1	1	residential	8	58	76.5472	88.3034
19	130	1	1	1	1	residential	13	23	75.361	94.3263
20	135	2	1	1	1	residential	6	78	75.646	67.8552

Taking into account that the criteria classification and importance weight of current study had been determined based on Abu mahadi (2014) study with some reasonable improvements, a difference between results was recorded in table 5.2 and graphed as shown in figure 5.1.

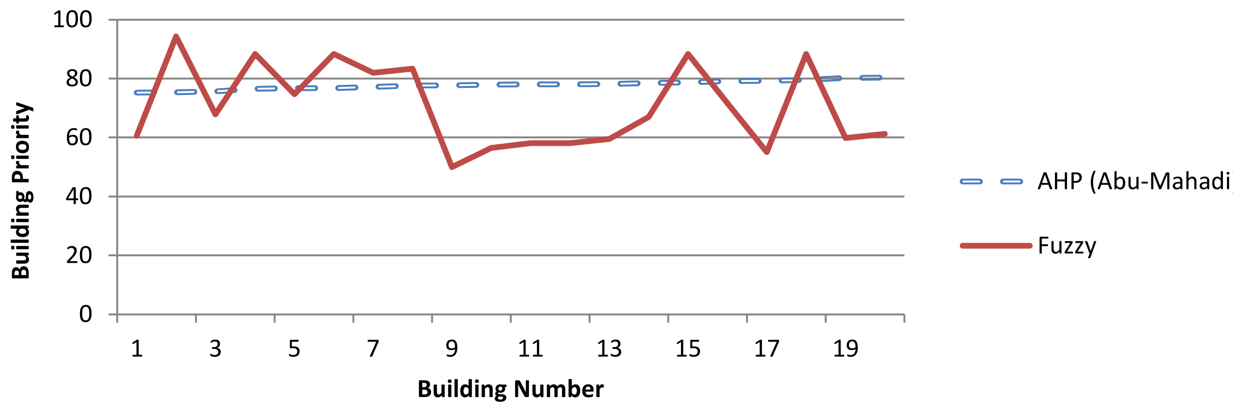

Figure (5. 1): priority degree comparison between AHP and Fuzzy(Abu-Mahadi)

Since the priority detection of thousands houses depends on the maximum available distinction, the smooth curve of AHP approach would not lead to clear decision making. The sharper the curve is the most effective the results are. Not only curve difference, but also some opposite records between A. Abu mahadi, 2014 study and current study are recorded.

In AHP approach, the first affected building in table 5.2 has larger priority degree than the nineteenth affected building, but the current study gives larger priority degree to nineteenth affected building as shown in table 5.3

Table (5. 4): Comparison between 1st and 19th affected houses priority degree

#	Building Area	Number of floors	Number of units	Used units	Unstable units	Building usage	Size Of the family	Number Of affected houses	Priority Using AHP	Priority Using Fuzzy
1	160	4	4	4	0	1	7	9	80.2654	61.2662
2	130	1	1	1	1	1	13	23	75.361	94.3263

Table (5. 5): Shows analysis to criterion and weights of both affected building

Criteria	Building status	Residents status	Quarter status	Building type
Sub criteria weights	0.228	0.012	0.182	0.2
	0.204	0.3	0.2	0.2

Although the ratio of unstable units in first building is 0 and the ratio of total area to the total number of residents is more than 90m2, A. Abu mahadi study gave this affected building larger priority degree than the affected building of 100% unstable units and ratio of occupied area per person 10m2 / person.

The built AHP system in A. Abu mahadi study does not translate the reasonable criterion and weights into reasonable results.

Referring to table 5.2, second affected building with third affected building, 10th with 11th, and 18th with 19th have the same situation where current study achieved more effective and reasonable results than A. Abu mahadi study.

5.1.2 Verification using selected data of 2014 conflict

After analyzing 2014 data sample from three affected buildings gathered and posted in table 5.5 to discus and analyze.

Table (5. 6): sample from analyzed data from 2014 war (Oudeh & Al_Ostaz, 2015)

#	Location	Building Area	Number of floors	Number of units	Used units	Unstable units	Building usage	Family Size	affected houses	Priority degree
1	City	30	1	1	0	0	Combined	0	8	29.4254
2	Border	180	3	3	3	3	Residential	21	27	94.0673
3	Border	200	2	2	2	2	Residential	12	27	94.2017

From table 5.5 the first affected building is classified as residents and commercial building, but the unit is empty, and there is not any family with unstable current status is recorded.

These information and all available data leads to expect low priority degree which matches fuzzy result 29.4254.

The second building is residential with 100% units with unstable current situation are recorded. These information and the fact that the occupied area per person is less than 20m2 leads to expect high priority degree which matches fuzzy result 94.0673. The results of first and second buildings show how effective the proposed fuzzy and approach are.

Table 5.6 shows analyzing to criteria and sub criteria weights for the second and third buildings and its clear how it is difficult to determine which building has larger priority degree.

The results 94.0673 for second building and 94.2017 for third building show how sensitive the built fuzzy is.

Table (5. 7): analysis of 2nd and 3rd buildings criteria

Criteria	Building status	Residents status	Quarter status	Building type
Sub criteria weights	0.158	0.132	0.122	0.2
	0.4	0.4	0.3	
	0.2	0.245		
Sub criteria weights	0.155	0.134	0.7	0.2
	0.4	0.4	0.3	
	0.2	0.242		

5.2 Results

Priorities have been evaluated for each affected building in the divided five areas. More than 5000 buildings have been passed through process of weight evaluating then defuzzification in order to have priority degree with maximized obtained difference between buildings. Results have been divided according to areas and municipalities and charts for each area have been graphed as shown below.

- **North Governorate**

Four municipalities are selected in the north governorate .All necessary data for buildings to be reconstructed have been used in MATLAB by the built model for weight evaluating of criteria and sub criteria. The outputs of first step have been used as 4 inputs of built fuzzy model which has single output 'priority degree'.23% of damaged buildings have largest priority degree of 90 and more , while the largest number of buildings share the priority 70-80. A chart of priority distribution percentages for the north governorate is shown in Figure 5.2

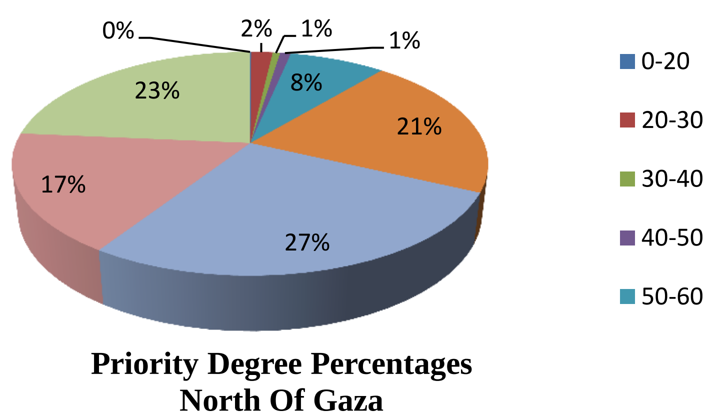

Figure (5. 2): Priority Degree Percentages –North Governorate

Priority degrees are coded with scaled color and the distribution of building's priorities is shown in Figure 5.3 to Figure 5.6 for sample of affected buildings in the 4 municipalities of north governorate. Table 5.7 describes the emergency level of reconstruction through coded colors.

Table (5. 8): Reconstruction emergency levels

Priority Degree	Values
Not urgent	Less than 50
Less urgent	50 - 70
Medium urgent	71 - 80
Urgent	81 - 90
Highly urgent	More than 90

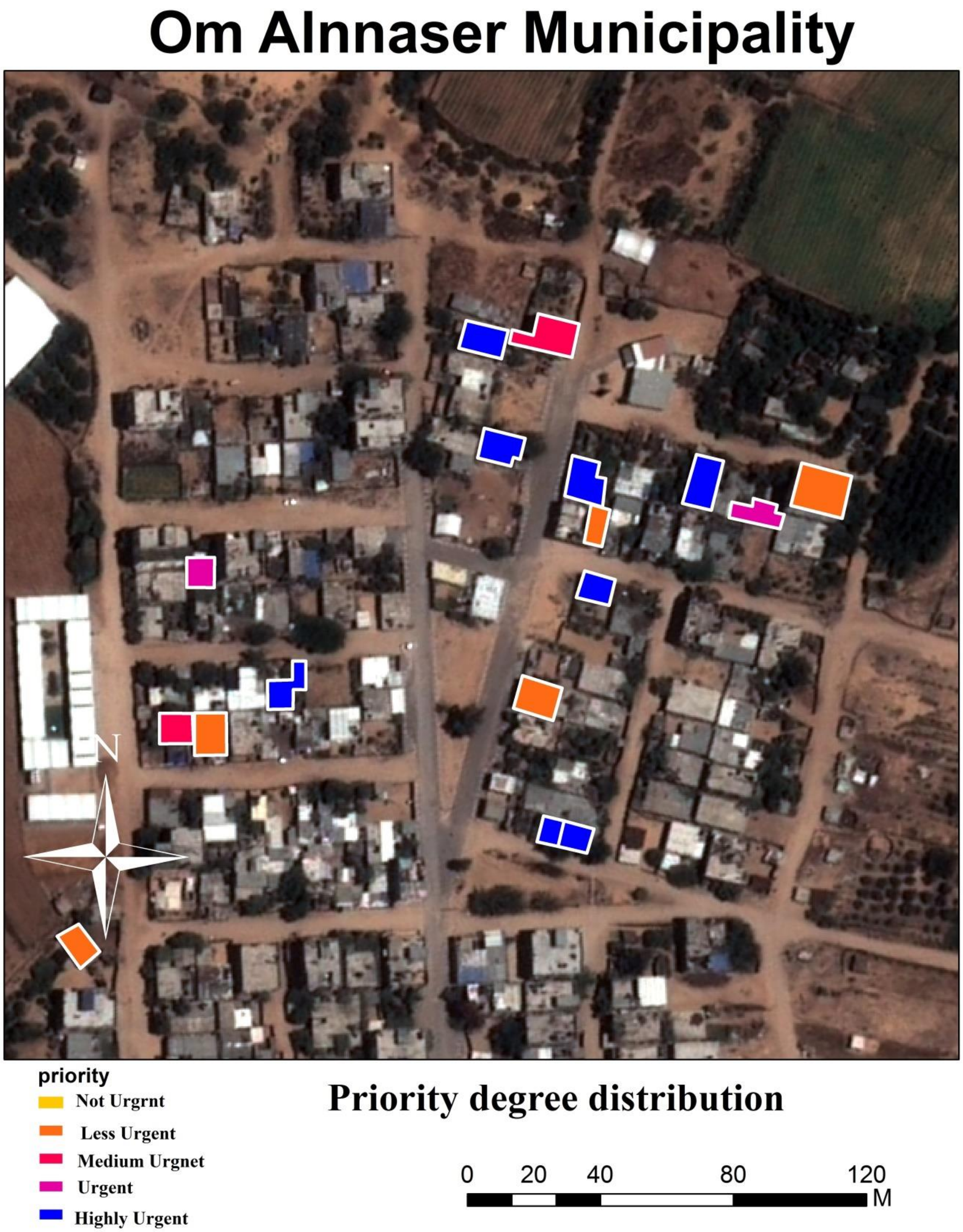

Figure (5. 3) : Color Coded Priority Distribution – Om Al Nasser Municipality

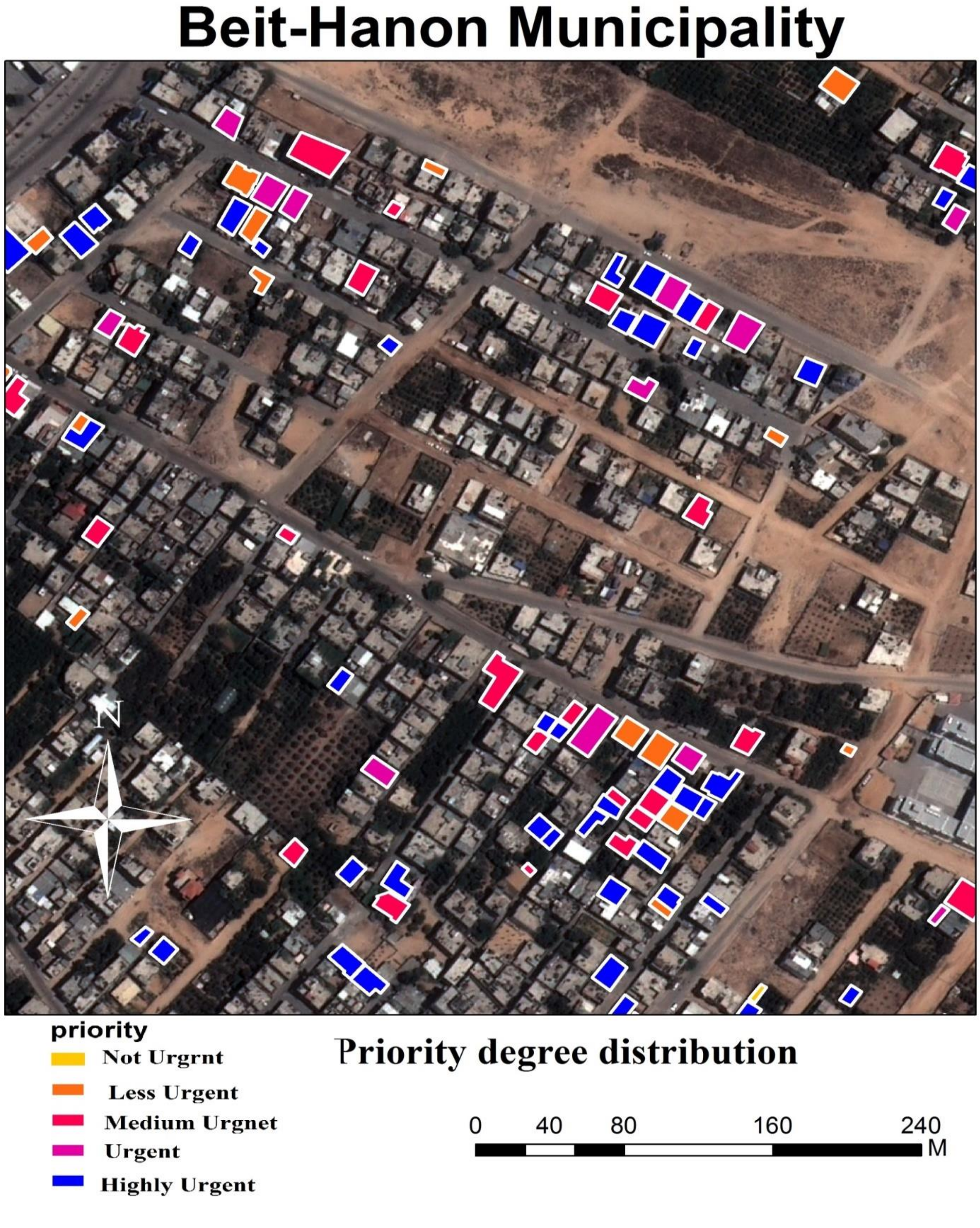

Figure (5. 4): Color Coded Priority Distribution – Beit – Hanoon Municipality

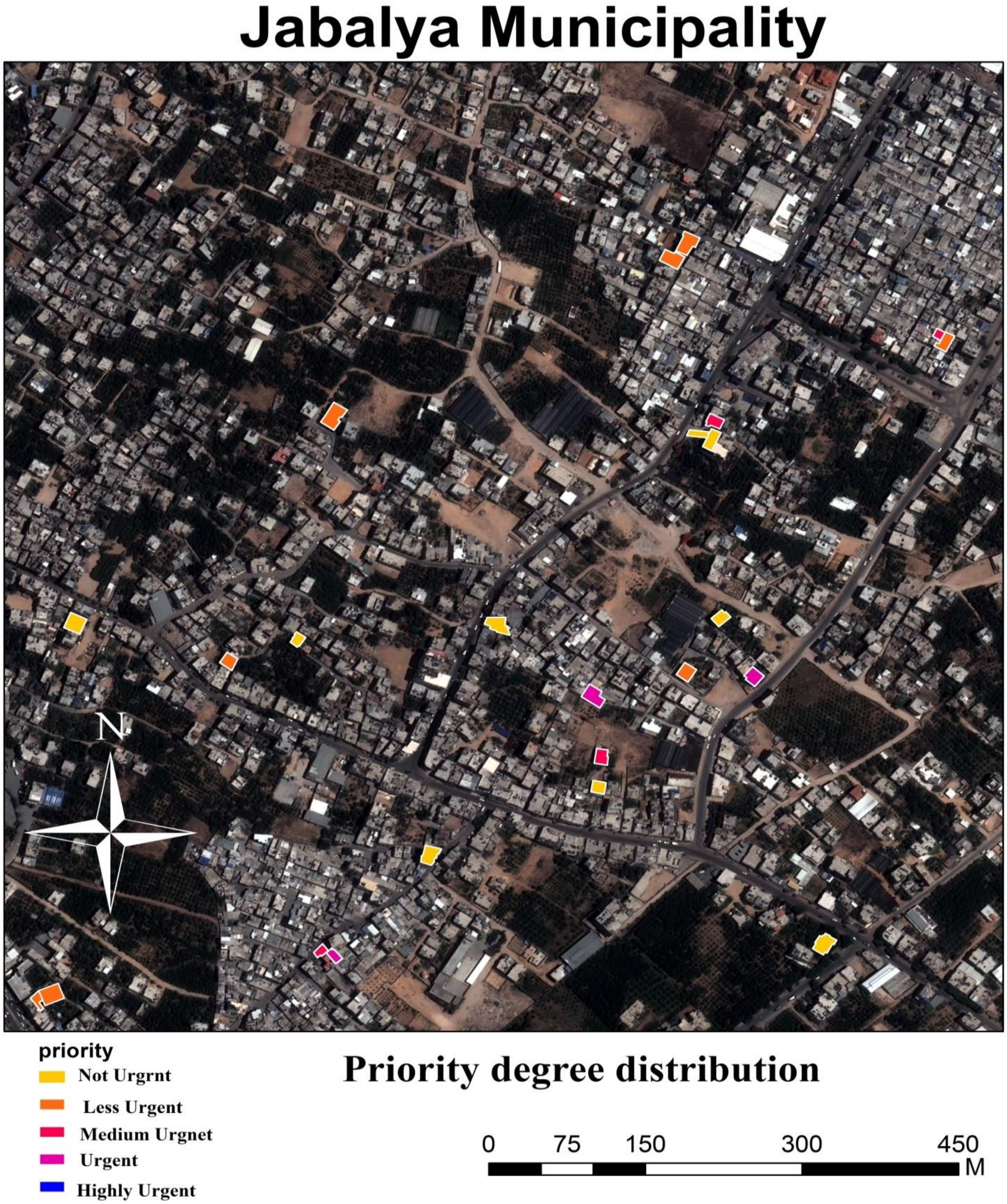

Figure (5. 5): Color Coded Priority Distribution – Jabalya Municipality

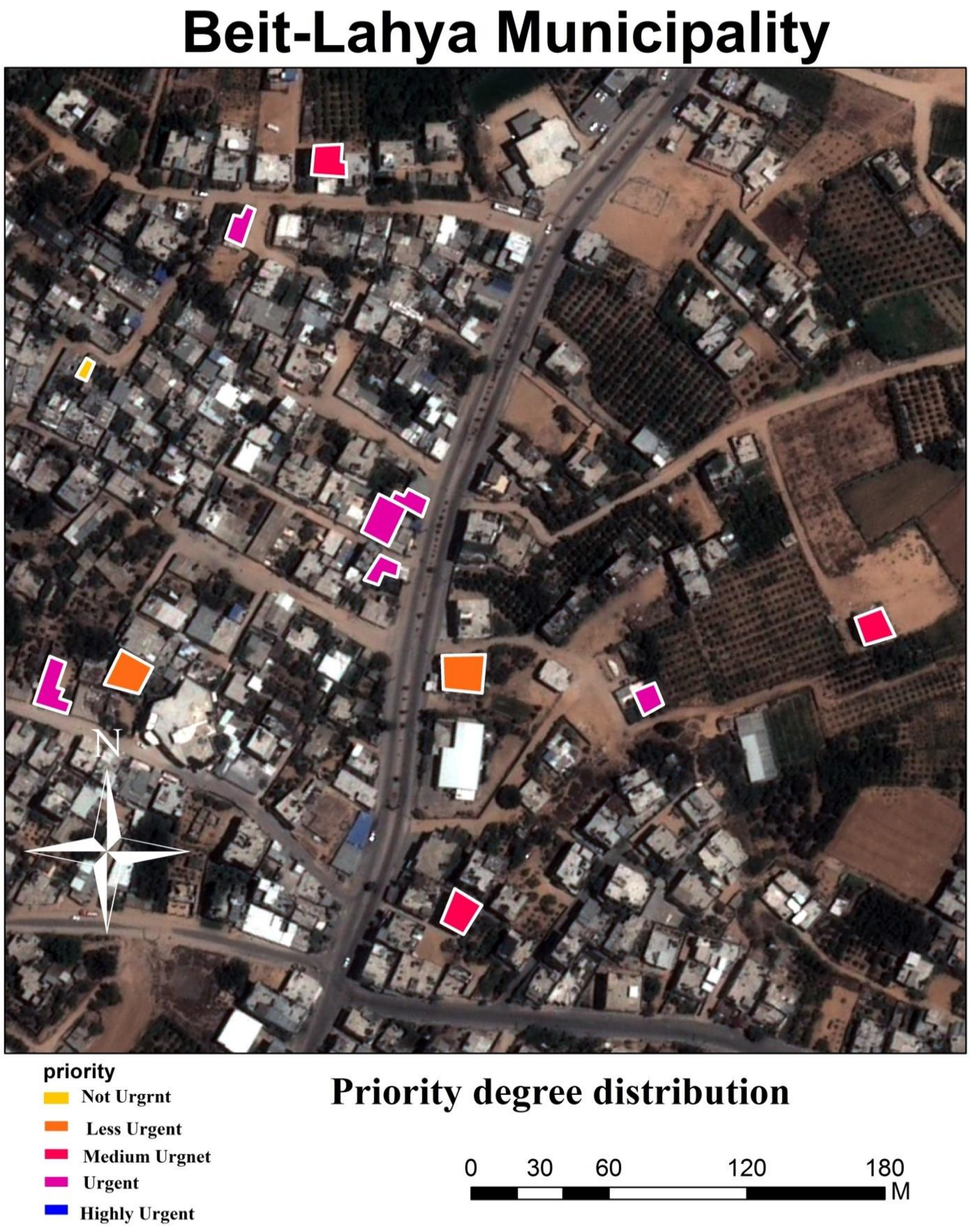

Figure (5. 6): Color Coded Priority Distribution – Beit_Lahia Municipality

- **GAZA Governorate**

4% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 60-70. No building of priority less than 20% is recorded. A chart of priority distribution percentages for the Gaza governorate is shown in Figure 5.4

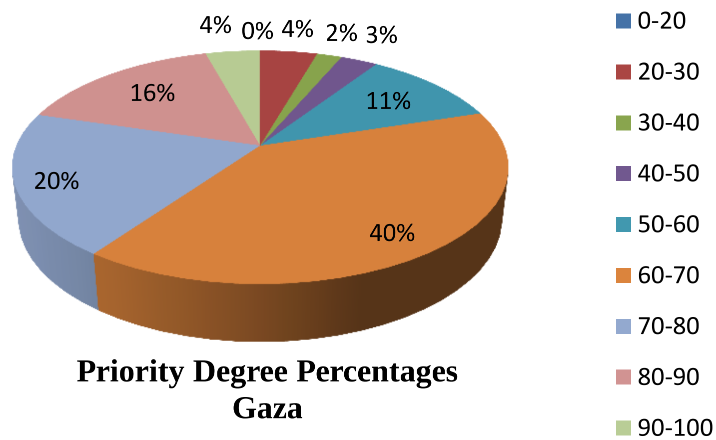

Figure (5. 7): Priority Degree Percentages –GAZA Governorate

- **Middle of Gaza Governorate**

10% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 60-70. No building of priority less than 20% is recorded. A chart of priority distribution percentages for the Gaza governorate is shown in Figure 5.5.

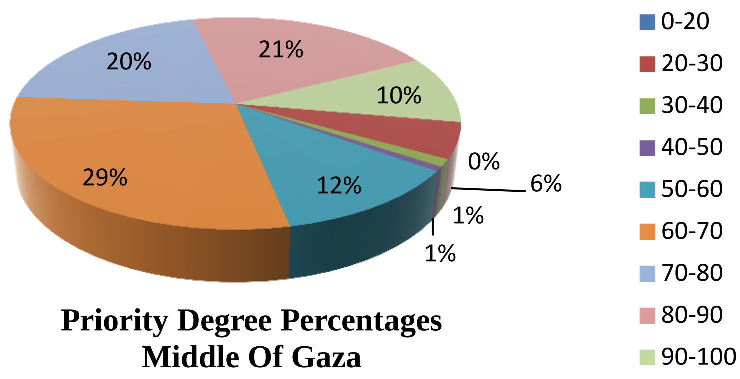

Figure (5. 8): Priority Degree Percentages –Middle of Gaza Governorate

- **Khan Yonus Governorate**

11% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 60-70. No building of priority less than 20% is recorded. A chart of priority distribution percentages for the Gaza governorate is shown in Figure 5.6

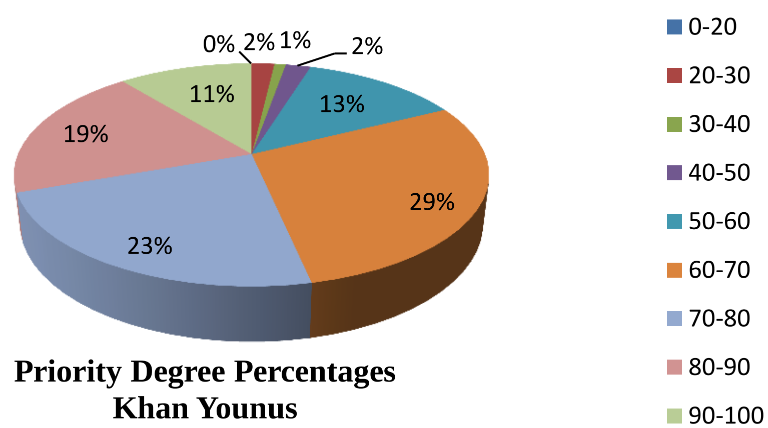

Figure (5. 9): Priority Degree Percentages –Khan Yonus Governorate

- **Rafah Governorate**

9% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 70-80. No building of priority less than 20% is recorded. A chart of priority distribution percentages for the Gaza governorate is shown in Figure 5.7.

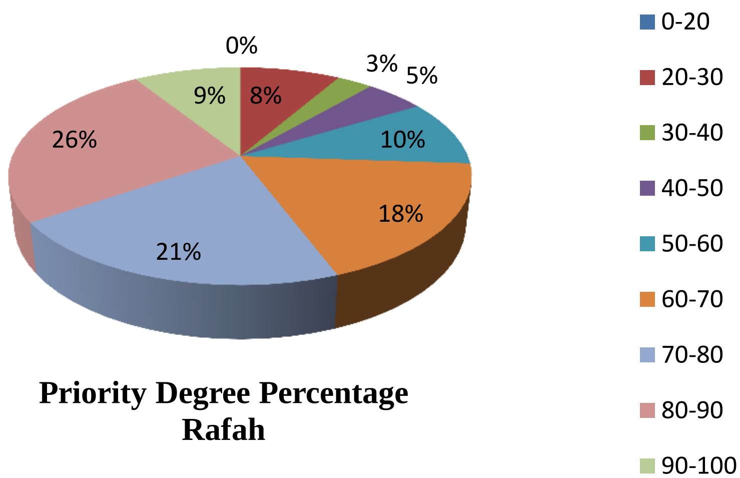

Figure (5. 10): Priority Degree Percentages –Rafah Governorate

5.3 Summary of results

Less than 4% of damaged building in whole Gaza Strip has priority between 20 and 30. Buildings of 30-40 and 40-50 priorities form 4% of total number of buildings. 11% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 70-80. Being damaged, ensures priority around 20% whatever other criteria is, so no building of priority less than 20% is recorded. A chart of priority ranges and results for all damaged buildings is shown in Figure 5.8.

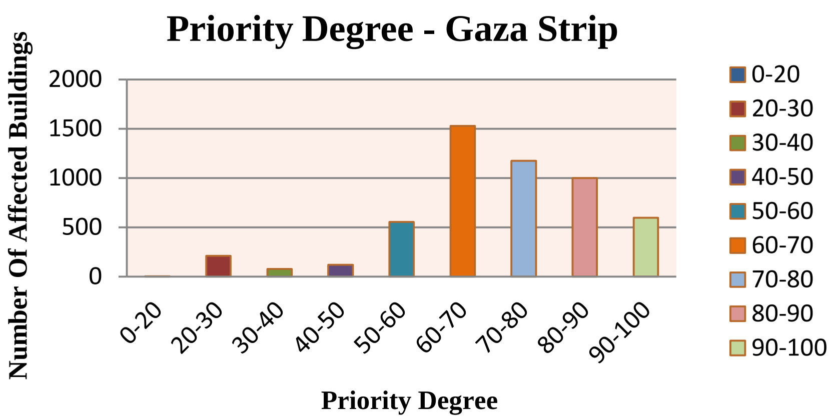

Figure (5. 11): Priority Degree Ranges and Results –Gaza Strip

The proposed model for priority detection maximized the distinguished between affected buildings to be reconstructed until 4 digits after comma.

Number of digits can be enlarged by increasing MFs but this will lead to huge numbers of rules in built FIS which is not necessary and cause time consumption as long as 4 digits are sufficient to determine the priority degree. Reaching results with 4 distinguishing digits shows how effective the proposed approach is.

All data is analyzed and sample are attached in APPENDIX C and the data shows the priority degree through the model used in this study.

Chapter 6

Conclusion and Recommendations

Chapter 6

Conclusion and Recommendations

6.1 Introduction:

This study aims to provide a favorable approach to ensure stability and security of houses reconstruction after disasters and can be divided into two axes:

1) As reconstruction process is restricted by many constraints and cannot be achieved on all affected buildings at the same time , in this study a reasonable weighing approach for each affected building is provided. Weights were given taking into account all constraints and all relative families situations before and after disaster.
2) Governments and decision makers are obsessed with fair consequence of reconstruction. For this purpose they need plans and procedures in order to have the optimal consequence of thousands of totally damaged buildings. This study provides an effective model based on fuzzy logic model, unlike classical set models, maximizes the difference between priorities of buildings.

6.2 Conclusions on the model:

This study tries to provide a model to provide such a fair priority distribution. Many researchers studied reconstruction plans. Most of these researches relocate affected people in different places in order to obtain modern style of the country. Modern style of country cannot be taken into account neglecting the life style of affected people and relocating their houses transfers them from active into inactive status.

This study firstly provides reasonable weights of each building and then fuzzy model was built to evaluate priority degree of each building individually, subject to maximum achievable difference between priorities.

All achieved results prove that the proposed approach is favorable, effective and can be applied on area with complex conditions like Gaza Strip.

6.3 Results Conclusions:

1) IN North Gaza governorate 23% of damaged buildings have largest priority degree of 90 and more , while the largest number of buildings share the priority 70-80%.
2) In Gaza governorate 4% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 60-70%.
3) In Middle of Gaza governorate 10% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 60-70%.
4) In Khan _Younus governorate 11% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 60-70%.
5) In Rafah governorate 9% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 70-80%.
6) Less than 4% of damaged building in whole Gaza Strip has priority between 20 and 30. Buildings of 30-40 and 40-50 priorities form 4% of total number of buildings. 11% of damaged buildings have largest priority degree of 90 and more, while the largest number of buildings shares the priority 70-80.
7) Being damaged, ensures priority around 20% whatever other criteria is, so no building of priority less than 20% is recorded.

6.4 Recommendations:

Results proved that the proposed approach is favorable and applicable in area with difficult conditions like Gaza Strip, however, proposed approach provided best achievable results within limits related to available data and available fund. Thus, there are recommendations in which better results can be achieved and can be divided into three axes:

- **Improvement of data collection**

Since units in last floors cannot be reconstructed before units in first floors even if their priority degrees are larger , it is strongly recommended that for data to be collected for buildings not for units. Gathering data of units to form building data was a kind of time consumption in this study. Moreover, dealing with affected buildings within specific governorates is recommended rather than dealing with it as single area of large number of units. This leads to higher efficiency in controlling the process of reconstruction. Add to this , it is worthwhile to collect data about the contribution of each building in national income.

- **Centralizing fund**

Most of provided funds were restricted and directed into specific units area. Its strongly recommended to propose a methodology to donors in which all fund from all donors can be controlled and directed from main insurance box according to plans driven by specialists who are more capable to evaluate the situation.

- **Built model**

MF's of fuzzy inputs and output can be increased in order to get results with digits larger than four, but this will lead to huge number of rules in built fuzzy model. Thus, a necessity measuring system is recommended to make right decision of enlarging number of rules according to number of buildings to be reconstructed. Moreover, a modification in built model in which it can evaluate the cost of reconstructing buildings share the same range of priority degrees is recommended. This can help in presenting fund proposals.

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Appendices

Appendix A

Table (A. 1): Donor Total Pledges announced at Cairo Conference Of which Support to Gaza in millions dollar (Ead, 2015)

Country	pledged amount	Country	Pledged amount
Romania	0.05	France	50.66
Russia	10	Germany	63.32
Saudia Arabia	500	Greece	1.27
Serbia	0.05	Hungary	0.16
Singapore	0.1	India	4
Slovakia	0.05	Indonesia	1
Slovenia	0.19	Ireland	3.17
South Africa	1	Italy	62.9
South Korea	12	Japan	200
Spain	45.59	Kuwait	200
Sudan	20	Luxembourg	37.72
Sweden	410	Malaysia	1.45
Switzerland	130	Mexico	1.1
The Netherlands	227.97	Norway	362.44
Turkey	200	Poland	0.1
UAE	200	Portugal	0.03
UK	32.16	Qatar	1000
USA	414	World Bank	62
Algeria	61.4	Chile	0.25
Argentina	2.14	China	1.6
Australia	83.5	Croatia	1.24
Austria	8.8	Czech Republic	3.75
Bahrain	6.5	Denmark	186.17
Belgium	7.92	Estonia	1.27
Brazil	5	European Investment Bank5	70
Bulgaria	0.06	European Union6	348.28
Canada	14.66	Finland	29.57

Appendix B

Table (B. 1): Fuzzy Decision Matrix

	then				
	BS	RS	QS	BT	PD
	L	L	L	L	LLL
	L	L	L	M	LLL
	L	L	L	H	LL
	L	L	M	L	LLL
	L	L	M	M	LL
	L	L	M	H	LL
	L	L	H	L	LL
	L	L	H	M	LL
	L	L	H	H	L
	L	M	L	L	LLL
	L	M	L	M	LL
if	L	M	L	H	LL
	L	M	M	L	LL
	L	M	M	M	M
	L	M	M	H	M
	L	M	H	L	L
	L	M	H	M	L
	L	M	H	H	M
	L	H	L	L	LL
	L	H	L	M	L
	L	H	L	H	M
	L	H	M	L	M
	L	H	M	M	M
	L	H	M	H	H
	L	H	H	L	M

	then				
	L	H	H	M	H
	L	H	H	H	HH
	M	L	L	L	LLL
	M	L	L	M	L
	M	L	L	H	M
	M	L	M	L	L
	M	L	M	M	M
	M	L	M	H	M
	M	L	H	L	M
	M	L	H	M	M
	M	L	H	H	H
	M	M	L	L	L
	M	M	L	M	M
	M	M	L	H	M
	M	M	M	L	M
	M	M	M	M	M
	M	M	M	H	M
	M	M	H	L	M
	M	M	H	M	M
	M	M	H	H	H
	M	H	L	L	M
	M	H	L	M	M
	M	H	L	H	H
	M	H	M	L	H
	M	H	M	M	H
	M	H	M	H	HH
	M	H	H	L	H
	M	H	H	M	HH
	M	H	H	H	HHH

	then				
	H	L	L	L	L
	H	L	L	M	M
	H	L	L	H	H
	H	L	M	L	M
	H	L	M	M	H
	H	L	M	H	HH
	H	L	H	L	H
	H	L	H	M	HH
	H	L	H	H	HH
	H	M	L	L	M
	H	M	L	M	H
	H	M	L	H	HH
	H	M	M	L	M
	H	M	M	M	H
	H	M	M	H	HH
	H	M	H	L	H
	H	M	H	M	HH
	H	M	H	H	HHH
	H	H	L	L	H
	H	H	L	M	HH
	H	H	L	H	HH
	H	H	M	L	HH
	H	H	M	M	HH
	H	H	M	H	HHH
	H	H	H	L	HH
	H	H	H	M	HHH
	H	H	H	H	HHH

Appendix C

Table (C. 1): Sample of the results analyzed for Beit_Hanoon Municiapility:

Building ID	Municipality	Land	Building Area	No. of floors	No. of units	No. of used units	No. of unstable units	Building usage	Family size	No. of nearby affected buildings	Priority degree
N-20-10-1001	3	3	208	5	8	8	8	3	47	93	72.1742
N-20-10-1002	3	3	450	5	7	7	7	1	52	93	75.2402
N-20-10-1003	3	3	104	5	4	4	4	1	23	93	78.7932
N-20-10-1004	3	3	72	1	1	1	1	1	2	93	72.1823
N-20-10-1005	3	3	68	1	1	1	1	1	6	93	94.537
N-20-10-1006	3	3	72	1	1	1	1	1	2	93	72.1823
N-20-10-1007	3	3	70	1	1	1	1	1	2	93	72.5928
N-20-10-1008	3	3	190	1	1	1	1	1	10	93	94.537
N-20-10-1010	3	3	165	1	1	1	1	1	11	93	94.537
N-20-10-1011	3	3	70	1	1	1	1	1	2	93	72.5928
N-20-10-1012	3	3	50	1	1	1	1	1	2	93	79.4518
N-20-10-1013	3	3	56	1	1	1	1	1	7	93	94.537
N-20-10-1014	3	3	75	1	1	1	1	1	4	93	89.6463
N-20-10-1015	3	3	90	1	1	1	1	1	6	93	94.537
N-20-10-1016	3	3	70	0	1	1	1	1	6	93	94.3589
N-20-10-1017	3	3	60	0	1	1	1	1	1	93	81.2016
N-20-10-1018	3	3	110	1	1	1	1	1	5	93	82.0161
N-20-10-1019	3	3	100	1	1	1	0	1	3	93	66.6794
N-20-10-1020	3	3	100	1	1	1	1	1	2	93	68.0088
N-20-10-1021	3	1	70	1	1	1	1	1	6	93	94.3263
N-20-10-1022	3	3	450	5	24	24	24	1	130	93	85.8062

Building ID	Municipality	Land	Building Area	No. of floors	No. of units	No. of used units	No. of unstable units	Building usage	Family size	No. of nearby affected buildings	Priority degree
N-20-10-1024	3	3	450	5	22	22	22	1	116	93	81.0354
N-20-10-1025	3	3	416	5	20	19	19	1	100	93	77.2403
N-20-10-1026	3	3	230	1	1	1	1	1	13	93	94.537
N-20-10-1027	3	3	85	0	1	1	1	1	7	93	94.3589
N-20-10-1029	3	3	60	1	1	0	0	1	0	93	33.3254
N-20-10-1030	3	3	120	1	1	1	1	1	5	93	79.4518
N-20-10-1031	3	3	39	1	1	1	1	1	1	93	74.3931
N-20-10-1032	3	3	100	1	1	1	1	1	6	93	94.537
N-20-10-1033	3	3	110	1	1	1	1	1	2	93	66.9247
N-20-10-1035	3	3	130	1	1	1	1	1	2	93	66.6748
N-20-10-1036	3	3	60	1	1	1	1	1	8	93	94.537
N-20-10-1037	3	3	40	1	1	1	1	1	3	93	86.1569
N-20-10-1038	3	3	40	1	1	1	1	1	2	93	83.4621
N-20-10-1039	3	3	60	1	1	1	1	1	5	93	94.4384
N-20-10-1040	3	3	130	1	1	1	1	1	7	93	94.4855
N-20-10-1041	3	3	60	1	1	1	1	1	9	93	94.537
N-20-10-1042	3	3	170	1	1	1	1	1	9	93	94.537
N-20-10-1043	3	3	90	1	1	1	1	1	8	93	94.537
N-20-10-1044	3	3	40	2	1	1	1	1	6	93	94.537
N-20-10-1046	3	3	140	1	1	1	1	1	5	93	76.2582
N-20-10-1047	3	3	124	1	1	1	1	1	6	93	85.9619
N-20-10-1048	3	3	40	1	1	1	1	1	2	93	83.4621
N-20-10-1049	3	3	26	1	1	1	1	1	5	93	94.4384
N-20-10-1050	3	3	100	1	1	1	1	1	6	93	94.537

Table (C. 2): Sample of the results analyzed for Beit_Lahia Municipality:

Building ID	Municipality	Land	Building Area	No. of floors	No. of units	No. of used units	No. of unstable units	Building usage	Family size	No. of nearby affected buildings	Priority degree
N-40-0-1006	2	1	156	3	2	2	2	1	15	2	67.4648
N-40-0-1011	2	3	200	2	2	2	1	1	9	2	50
N-40-10-1001	2	1	150	3	3	2	2	1	16	58	62.7599
N-40-10-1002	2	1	162	2	1	1	1	1	7	58	68.4939
N-40-10-1003	2	1	108	1	1	1	1	1	2	58	64.3094
N-40-10-1004	2	1	220	2	2	2	2	1	16	58	76.218
N-40-10-1005	2	3	137	1	1	1	1	1	3	58	65.3139
N-40-10-1006	2	3	130	2	3	3	3	1	14	58	77.1162
N-40-10-1007	2	3	90	1	1	1	1	1	6	58	88.3034
N-40-10-10133	2	3	45	1	1	1	1	1	1	58	68.4229
N-40-10-1021	2	1	80	1	1	1	1	1	5	58	88.3034
N-40-10-1025	2	3	100	1	1	1	1	1	3	58	69.0381
N-40-10-1026	2	3	100	1	1	1	1	1	7	58	88.3034
N-40-10-1027	2	3	85	1	1	1	1	1	7	58	88.3034
N-40-10-1028	2	3	120	1	1	1	1	1	8	58	88.3034
N-40-10-1029	2	3	75	1	1	1	1	1	5	58	88.3034
N-40-10-1030	2	3	90	1	1	1	0	1	8	58	62.7599
N-40-10-1031	2	3	90	1	1	1	1	1	2	58	65.6414
N-40-10-1032	2	3	90	1	1	1	1	1	6	58	88.3034
N-40-10-1034	2	3	65	1	1	1	1	1	2	58	69.8147
N-40-10-1035	2	3	140	1	1	1	1	1	6	58	74.9801
N-40-10-1036	2	3	75	1	1	1	1	1	2	58	68.108
N-40-10-1038	2	3	100	1	1	1	1	1	7	58	88.3034

Table (C. 3): Sample of the results analyzed for Om_Alnasser Municipality

Building ID	Municipality	Land	Building Area	No. of floors	No. of units	No. of used units	No. of unstable units	Building usage	Family size	No. of nearby affected buildings	Priority degree
N-10-10-1005	1	3	70	1	1	1	1	1	3	15	72.799
N-10-10-1006	1	3	50	1	1	1	1	1	3	15	78.059
N-10-10-1007	1	3	100	1	1	1	1	1	8	15	83.9951
N-10-10-1009	1	3	80	1	1	1	1	1	4	15	77.481
N-10-10-1010	1	3	100	1	1	1	1	1	8	15	83.9951
N-10-10-1013	1	3	100	1	1	1	0	1	6	15	56.1534
N-10-10-1014	1	3	80	1	1	1	1	1	2	15	61.7935
N-10-10-1015	1	3	80	1	1	1	1	1	7	15	83.9951
N-10-10-1016	1	3	80	1	1	1	1	1	6	15	83.9951
N-10-10-1017	1	3	100	1	1	1	1	1	2	15	58.0394
N-10-10-1018	1	3	140	1	1	1	1	1	7	15	81.118
N-10-10-1019	1	3	70	1	1	1	1	1	5	15	83.9951
N-10-10-1020	1	3	70	1	1	1	1	1	6	15	83.9951
N-10-10-1022	1	3	90	1	1	1	1	1	2	15	59.7873
N-10-10-1024	1	3	70	1	1	1	1	1	1	15	56.1534
N-10-6-1001	1	1	140	3	4	3	3	1	7	18	66.6724
N-10-6-1002	1	1	100	1	1	1	1	1	5	18	86.1569
N-10-6-1003	1	1	150	2	2	2	2	1	8	18	70.4402
N-10-6-1004	1	1	115	1	1	1	1	1	9	18	94.3263