A PROPOSED FRAMEWORK FOR RESILIENCE TO BIOLOGICAL DISASTERS:THE CASE OF MERS-COV THREAT IN A TRANSIENT MASS GATHERING EVENT

Saud Ali Alshehri

A thesis submitted in partial fulfilment of the requirement of the degree of Doctor of Philosophy

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Cardiff University

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- ALSHEHRI, S. A., REZGUI, Y. & LI, H. 2015b. Disaster community resilience assessment method: a consensus-based Delphi and AHP approach. Natural Hazards, 1-22.
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ABSTRACT

The increase in disasters in recent decades has impacted on humanity through large loss of life and negative long-term economic and environmental consequences. Disasters cannot always be prevented but their impacts can be mitigated through adapted disaster management strategies, including improving community resilience. The aim of this thesis is to develop a framework of community resilience to disaster in Saudi Arabia (CRDSA). Saudi Arabia has experienced a number of disasters between 2005 and 2014; two were of a biological nature H1N1 and MERS-CoV while the rest were caused by flooding.

The study uses a mixed-method approach and paradigm of pragmatism, and is structured into three stages. First, based on the literature review, a survey questionnaire is used to examine the public perception of risk of disaster. The second stage is divided into two steps: 1) the Delphi consultation is employed to refine a set of initial criteria, organised into dimensions, derived from a review of the literature, and to explore additional criteria to inform the development of CRDSA. The Delphi technique combines a quantitative calculation to justify each dimension and associated criteria with qualitative views of experts to reach consensus around the proposed CRDSA. Data collection involved three-round questionnaire before achieving experts' consensus; 2) AHP is used to achieve the objectives of: a) local priority weights from pair-wise comparative methods of judgment and b) determining the importance of the dimensions of the framework. The third stage focuses on the validation of the CRDSA through a real mass gathering event. The approach involves a field study investigation, including interviews and observations during the 2013 Hajj to 1) determine community resilience level at the Hajj, 2) inform prevention strategies against the risk of a MERS-CoV epidemic; and 3) validate the CRDSA in a real situation.

The study finds that the proposed CRDSA framework can be used as an assessment tool to build community resilience to disasters in permanent and transient communities.

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Abbeviations

AHP	Analytic hierarchy process.
ARI	Acute respiratory infections.
BT	Bioterrorism.
BWC	Biological Weapons and Toxin Convention.
CDSI	Central Department of Statistics and Information.
CRDSA	Community Resilience to Disaster in Saudi Arabia.
E	Economic Dimension.
EM-DAT	Emergency Events Database.
G	Governance Dimension.
H1N1	Swine flu.
H5N1	Bird flu.
HIV/AIDS	Human immunodeficiency virus infection and acquired immune deficiency syndrome.
HW	Health and well-being Dimension.
IC	Information and communication Dimension.
MERS-CoV	Middle East respiratory syndrome coronavirus.
MOH	Ministry of Health.
PAR	Pressure and Release.
PE	Physical and environmental Dimension.
S	Social Dimension.
SARS	Severe Acute Respiratory Syndrome.
UNDP	United Nations Development Programme.
UNUSDR	United Nations International Strategy for Disaster Reduction.
WHO	World Health Organization.

Chpter:1 Introduction

Introduction

The purpose of this study is to develop a framework of disaster management in context of Saudi. In relation to that, this chapter begins with highlighting the background of the study, the importance of studying this topic and provides an overview of the major concepts. Thereafter, this study provides an outline of the problems and clarifies why it is important to have a study within the context of Saudi Arabia. It also presents the contributions of this research. Following these, this chapter concludes with description of the research process and an outline of the next chapters of this thesis in order to provide a clear structure of this thesis.

1.1 Background of the study

Several studies have indicated that continued increase in disasters at the global level in recent decades has had a direct impact on human societies from large loss of life and the negative social effects of long-term economic and environmental consequences (Neumayer and Barthel, 2011, Schipper and Pelling, 2006). The threat of biological disasters such as epidemics, pandemics and insect infestations remains a prospective risk in several parts of the world (Gunasekera, 2010). According to Guha-Sapir et al., (2014) biological disasters proportion to the major disaster almost 13%, which have been accrued since 2000, in the world, as seen in Figure (1-1).

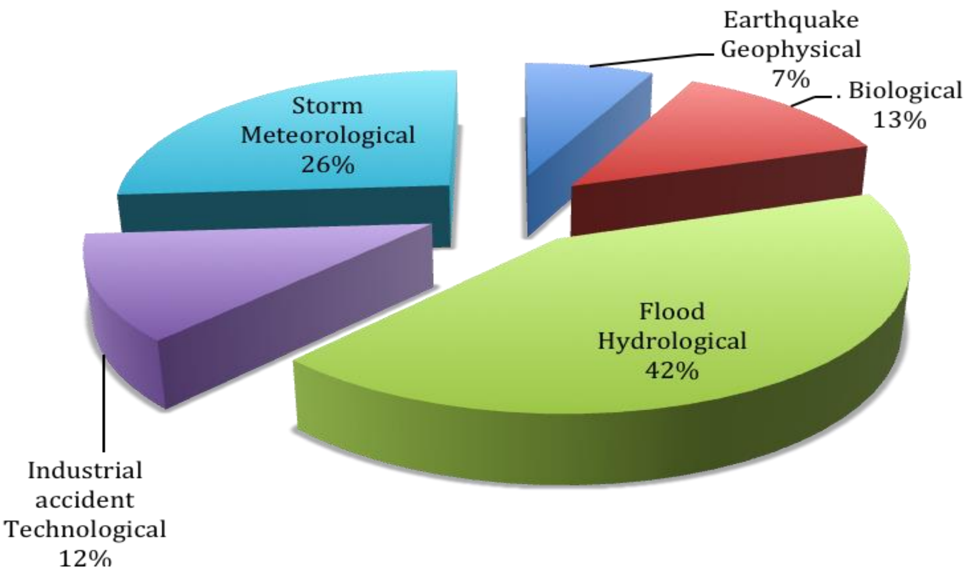


Figure 1-1: Biological disasters Proportions of the major disasters in the world since 2000-2015

Biological disaster may be classed as a sub-group of natural disasters (Guha-Sapir et al., 2010, Shaluf, 2007b, Olivia et al., 2009) (e.g. Severe Acute Respiratory Syndrome (SARS) (Leach et al., 2010), avian flu (Minami, 2007) and influenza virus A (H1N1), frequently referred to as "swine flu"(Kamate et al., 2009), and as man-made (technological) disasters due to either intentional hazards (Shaluf, 2007a, Olivia et al., 2009) (e.g. biological warfare capability (Ligon, 2006b) , bioterrorist attack (Glik et al., 2004) or insufficient biosafety and biosecurity measures in clinical and research laboratories (Rusnak et al., 2004). In contrast, mortility and morbidity are gradually raised resulting from communicable diseases following disasters (Waring and Brown, 2005) due to such factors as inadequate medical care, sanitary water, and waste management (Bellos et al., 2010). Biological disasters may occur as a consequence of the impact of either natural or man-made hazards (Jones et al., 2008); for example, in the last decade various infectious disease epidemics have followed disasters including earthquakes, floods, tsunamis and conflicts (Kouadio et al., 2012), and it is increasingly important to manage such disasters. Several studies covering hazardous events, either natural or man-made disasters, indicate risk perception as a factor that may affect willingness and motivation to implement precautionary behaviours, or to reduce the risk (Ho et al., 2008, de Zwart et al., 2009). Risk perception can also determine the response of individuals or communities to disasters (Howe, 2011). For instance, a community with low risk perception is likely to cope poorly with disasters, while a community with high risk perception tends to behave in a positive, anticipatory way to build more disaster-resilient communities (Gaillard and Texier, 2010). Understanding public perception of biological threats could support public health agencies in determining the knowledge required for educational programmes to raise community awareness (Balkhy et al., 2010), which in turn may provide an incentive for the development of strategies (Parkins and MacKendrick, 2007). Furthermore, public perception of a potential pandemic can be beneficial in identifying how to change public behaviour during the early periods of any future biological threat (Kamate et al., 2009) and can be important in determining compliance with official advice (Rubin et al., 2009). By taking public perception into consideration decision makers may assist the exchange of information with the community thereby increasing confidence in, and acceptance of, information and helping to reduce the risks of disasters (Renn, 2004).

The negative impact of disease outbreak following a disaster makes it important to manage the consequences of such disasters. Perry and Lindell (2003, p.59) note that "*Emergency management that is not based on accurate knowledge of both the threat and principles of human response is destined to fail*" (Perry and Lindell, 2003).

As a result of these challenges, national and local governments are considering implementing disaster management strategies to attenuate their impacts. The researcher believes that the best way to reduce the impact of biological risks is to establish well disaster management of disaster in general. Hence, the building of community resilience to disasters is an essential element of disaster management (Joerin et al., 2012, Ainuddin, 2012). However, measuring community resilience to disasters is difficult due to the lack of standard criteria to assess the capability of the community to manage disasters (Cimellaro et al., 2010, Norris et al., 2008).

In light of these issues, this thesis proposes a community resilience framework to disaster in Saudi Arabia is based on criteria considered at the community level. The propsed framework is aimed at all type pf disasters, but was specfically validated on the biological case study.

1.2 Problem Definition

Saudi Arabia is a region of the world which is not widely known for natural or man-made disasters, despite the presence of volcanic and seismic areas (Al-Saud, 2010) and the political instability in the region. While the intensity and impact of disasters is not comparable to other developed and developing countries (Guha-Sapir et al., 2011), the rate of their occurrence has increased in recent years (as seen in Figure 1-2) (Al-Saud, 2010, Guha-Sapir et al., 2011).

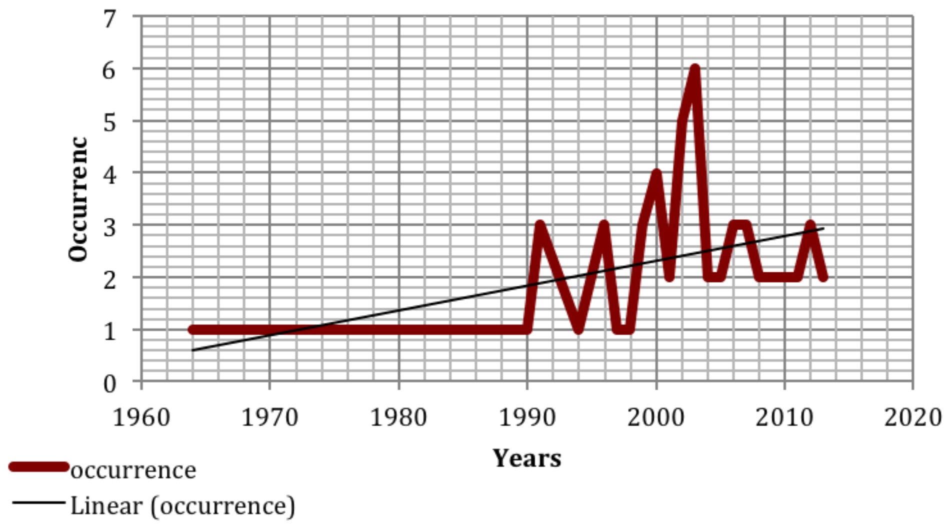


Figure 1-2: The rate of disasters occurrence in Saudi Arabia

One third of the damaging natural disasters that occurred between 2000 and 2011 are attributed to epidemics (biological disasters) such as swine flu (H1N1) and the Rift Valley Fever in Jizan (AlMazroa et al., 2010, Guha-Sapir et al., 2011).

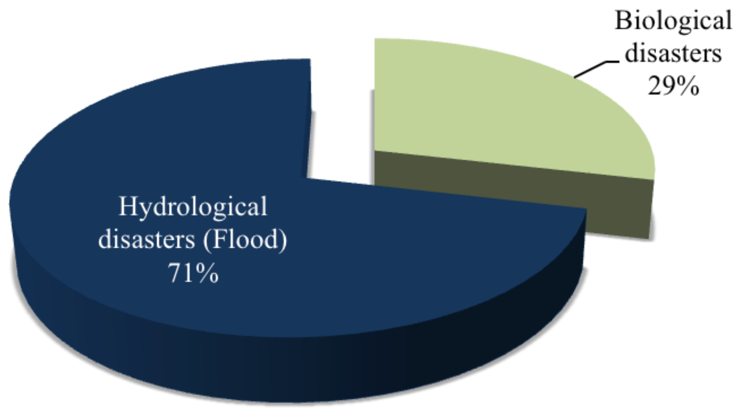


Figure 1-3: Biological disasters proportion to the major disaster in Saudi Arabia (AlMazroa et al., 2010, Guha-Sapir et al., 2011).

Other types of hazards include Ramadan and Hajj which are two special seasons on the Islamic calendar. Annually, Saudi Arabia attracts over three million visitors to the Holy Mosques in Makkah and Medina (Memish, 2010), presenting unique challenges to local authorities (Memish et al., 2009) such as infectious disease outbreaks (e.g. meningococcal disease and respiratory tract infections), which have been reported frequently during and following the Hajj (Memish, 2010). Additionally, Saudi Arabia has suffered from several terrorist attacks in the last decade such as the Riyadh and Khobar bombings (Hegghammer, 2008). The following section will focus on the general aim of this study and the research objectives.

1.3 Research Aim and objectives

This study aims to establish the applicable community resilience framework needed to building the community resilience to disasters in the Saudi Arabian context. To address this aim, this study focuses on the following objectives:

- To investigate the Saudi public's perception of the risk of disasters in general and biological disasters in specifically.
- To identify the factors which enhance community readiness in Saudi Arabia in order to reduce the negative impacts of disasters.
- To investigate the experts' opinions to the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context.
- To validate the proposed framework in real case of mass gathering of people such as the pilgrimage (Hajj) to gain a picture of the resilience of community.

1.4 Research Questions

As result of the above discussion, the attempt of building a resilient community is becoming essential. Therefore, there are main questions that need to be answered which are:

- RQ1- What are the Saudi's public attitudes towards the risk of disaster in general and biological disaster in particular?

- RQ2- What specific cultural and demographics factors (such as faith, age, and gender) affect the Saudi public’s perception of disaster in general and biological disaster in specific?
- RQ3- What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?
- RQ4- What are the most adapted resilience assessment weighting system that best conveys community resilience measurement in the context of Saudi Arabia?
- RQ5- To what extent do the dimensions and criteria of the proposed community resilience to disasters in Saudi Arabia (CRDSA) determine the measureable outcomes of community resilience?
- RQ6-What is the level of community resilience of the Hajj community under the epidemic threat of MERS-CoV?

Table 1-1 illustrates summary of the research aim, objectives, research questions, methods and chapters.

Table 1-1: Summary of the Research Aim, Objectives, Research Questions, Methods and Chapters

Aim	Objective	Research Questions	Method	Chapter
To establish the applicable community resilience framework needed to building the community resilience to disaster in the Saudi Arabian context.	To investigate the Saudi public's perception of the risk of disaster in general and biological disaster in specific.	RQ1- What are the Saudi's public attitudes towards the risk of disaster in general and biological disaster in particular?	*Survey (Questionnaire)*	Four
		RQ2- What specific cultural and demographics factors (such as faith, age, and gender) affect their perception of disaster in general and biological disaster in specific?		
	To identify the factors which enhance community readiness in Saudi Arabia in order to reduce the negative impacts of disasters. To investigate the experts' opinions to the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context.	RQ3- What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?	*Consensus (Delphi)*	Five
		RQ4- What is the most adapted resilience assessment weighting system that best conveys community resilience measurement in the context of Saudi Arabia?	*AHP*	Six
		RQ5- To what extent do dimensions and criteria of the proposed community resilience to disasters (CRDSA) determine measureable outcomes of community resilience?		
	To validate the proposed framework in real case of mass gathering of people such as the pilgrimage (Hajj) to gain a picture of the resilience of community.	RQ6-What is the level of community resilience of the Hajj community under the epidemic threat of MERS-CoV?	*Interview - Observation - Software -*	Seven

1.5 The Contributions of this Study

This Ph.D. thesis has been completed with funding from the Saudi Arabia government. This thesis contributes to:

- New classification of biological disasters.
- Provide the fundamental study of the Saudi public's perception of the risk of disaster in general and biological disaster in specific. As far as the researcher is aware this is the first study of its kind conducted in Saudi Arabia.
- Provides the first milestone towards the process of building community resilience to disaster in Saudi Arabia (CRDSA).
- Develops a tool to assess the community resilience of mass gathering of people.
- A software (prototype) to measure the community resilience was produced.

1.6 Description of the Research Process

In this section, the focus will be on an overview of the search process that has been used in this study. As described in the Chapter 3, the researcher started by selecting a suitable research gap as result of review of literature related to disaster management. Therefore, the data collection will then be considered. In this study the mixed-method and paradigm of pragmatism have been used. Consequently, the research design has been divided to three phases. Firstly, as result of the literature review, the researcher decided to use the survey questionnaire to examine the public perception of risk of disaster. This step will be used as the platform of the rest of the study. The second phase has been divided to two steps firstly; the researcher employed the Delphi consultation to refine criteria and to explore the other criteria which can be used to build community resilience to disasters in context of Saudi Arabia. The Delphi technique has combined quantitative calculation to justify the dimension and their criteria and the qualitative attitudes of experts to further criteria. The researcher considered this method to collect the data using three-round questionnaire to achieve the consensus of the experts' panel. Secondly, the AHP has been used in this study to reach the objectives of using AHP which are: a) local priority weights from pair –wise comparative method of judgment and b) determine the important of dimensions of the framework. The third stage of this research was the validation of this framework in real mass gathering event. The researcher used interview methods for decision makers and pilgrims. The researcher also used observation to utilise data for some criteria of the framework.

The survey questionnaire will be hosted online using “SurveyMonkey” in both Arabic and English for the first phase and in English in the second phase. Descriptive statistics and all data analyses were conducted using SPSS versions 18.0 and 20.0, in phases one and two respectively of the study. Since 2011, Survey Monkey has added an advanced spreadsheet export, which is a better option as long as the data is in numerical format, (SurveyMonkey.com 2013).

1.7 Thesis Structure

This thesis has been divided into 8 chapters as illustrated in Figure (1-3). The following subsections will illustrate in brief the content of each chapter:

1.7.1 Chapter one: Introduction

This chapter outlines and describes the main aims of the thesis. Moreover, it summaries the problems and clarifies why it is important to have a study within the context of Saudi Arabia. It also delivers details of contents covered in each chapter of this thesis.

1.7.2 Chapter two: A literature review.

After the initial introduction, chapter two presents a review of the literature which focuses further on (a) the concept of resilience in disaster management, and (b) the need for adapted frameworks to assess and build community resilience. It also provides an overview of the concept of disaster in general and biological disasters in specific.

1.7.3 Chapter three: Thesis Methodology.

This chapter provides an overview of the methodology adopted by the researcher to recognise objectives of the thesis. It refers to the procedure to be used by the researcher for conducting this study. This chapter discusses the philosophical assumptions and also the design strategies supporting this research study. Furthermore, this chapter presents the research approach used when collecting the data for this study and the methods used to analyse the data that were collected. It also discusses three phases of the employed methodology, which are public perception survey, the Delphi method and the Analytic Hierarchy Process (AHP) and the validation phase including interview of decision makers and observation.

1.7.4 Chapter four: Public perception of the risks of disaster in Saudi Arabia.

This chapter uses the data gathered through questionnaire survey aims to understand and analyse public perception of the risk of disasters in Saudi Arabia. It outlines a presentation and discussion of the survey results. The chapter then provides concluding remarks. This chapter also answers the research questions 1,2 and 3.

1.7.5 Chapter Five: Establishment of a community resilience framework (Delphi Consultation Study).

In this chapter, lists of community resilience criteria are presented resulting from a literature review and the public perception survey. The chapter also provides results and discussion of conducting the Delphi consultation in refining the reviewed dimensions and criteria of the proposed framework. Hence it identifies the criteria of community resilience in context of Saudi Arabia. One of the Research Questions, which is "What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?" is addressed in this chapter.

1.7.6 Chapter six: Analytic hierarchy process (AHP) for priorities the proposed community resilience framework

This chapter provides background of AHP and It specifics the methods that have been used. It also presents the findings and analysis of AHP in order to determine the important of dimensions and criteria of the framework which has been delivered from Delphi technique (Chapter 5).

1.7.7 Chapter seven: the validation of the proposed framework

In this chapter the case study of the validation of the proposed framework is presented. This chapter provides the analysis pf the data that have been collected through the Hajj season. It also presents the discussion of the interview and observation results in order to validate the proposed framework. Morovere, it illustrates a software that has been developed in order to validate CRDSA.

1.7.8 Chapter eight: Conclusion

This chapter offers a summary of the thesis. It provides the main conclusion of the research findings, answers the research questions, discusses the limitations of the research, and provides suggestions for future research. This chapter also presents recommendations disaster management and building of community resilience to disaster in the context of Saudi Arabia.

1.8 Appendix

This part provides copies of the survey instruments that have been used within this thesis.

1.9 Summary

In this chapter an overview of the research topic is introduced. This chapter explains the important of this study to Saudi Arabia. The aim and objectives with research questions of this research are presented. This chapter provides the contributions of this study, and then a brief outline of description of the research process is explained. After that, the structure of this thesis is illustrated, which explain, in brief, the content of the eight chapters of the thesis. The next chapter present a literature review covering many aspects in order of the topic of this study.

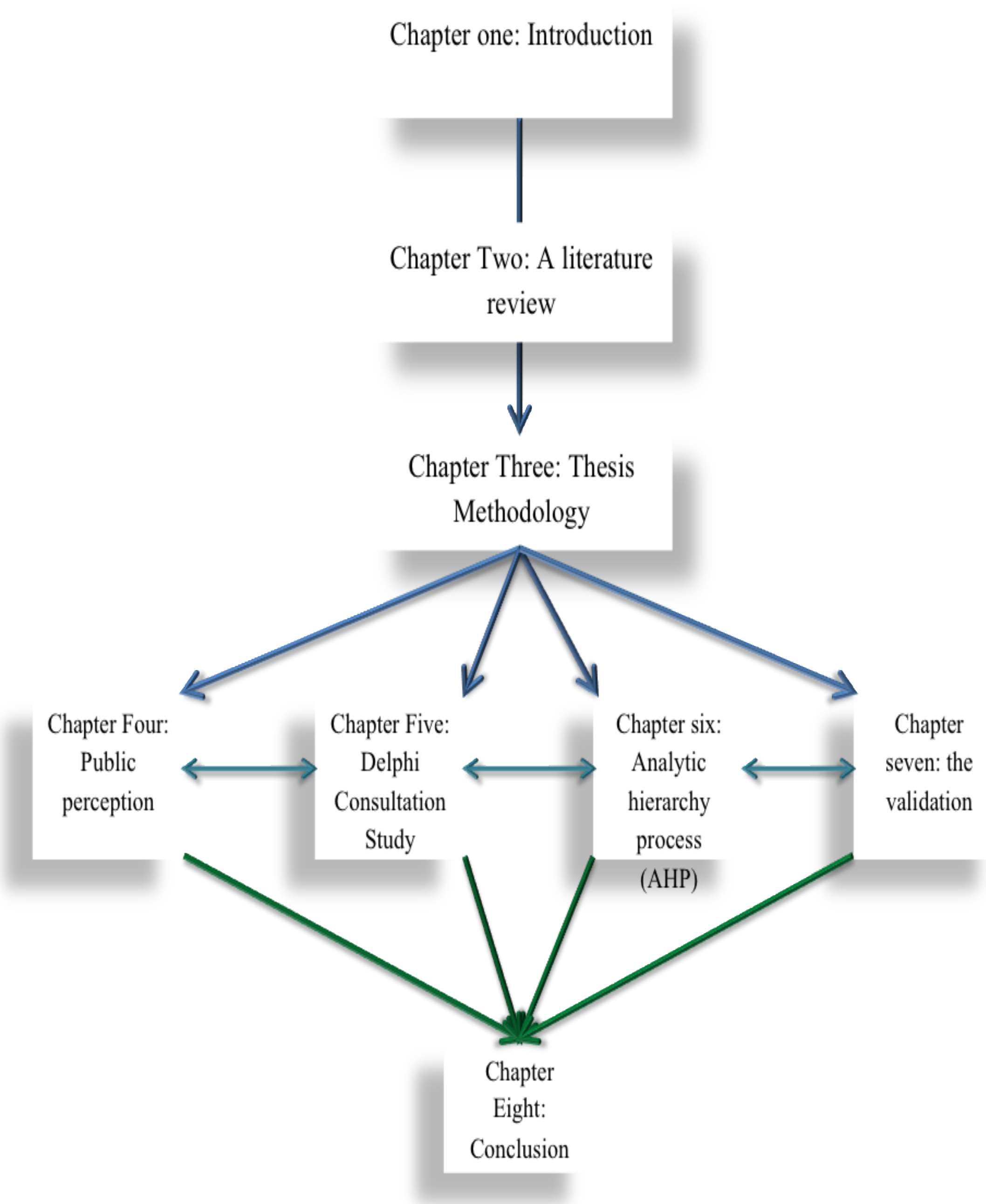


Figure 1-4: Thesis structure

Chpter:2 Literature review

Some of this chapter have been published in the following scientific journal:

- Alshehri S, Rezgui Y and Li H, (2016). Public perceptions and attitudes to biological risks: Saudi Arabia and regional perspectives. Disasters**,** DOI: 10.1111/disa.12179.

Introduction

The purpose of this chapter is to review the literature related to the research topic of building a community resilience framework to disasters in Saudi Arabia. The chapter provides an overview of disasters and their impact to communities around the world, gives an illustration of the disaster management continuum, and explores what the preparedness phase entails in detail. Moreover, this chapter also reviews the proposed frameworks conducted on the role of community resilience.

This chapter is divided into the following sections (see Figure 2-1); the first section presents an overview of disasters with an emphasis on biological disaster, which is the focus of this study, in the second section. The third section explores disaster management including the resilience construct with respect to its definition and relationship with vulnerability. The fourth section focuses on a variety of conceptual models, providing the building of the community resilience framework to disaster. The last section summarises the chapter.

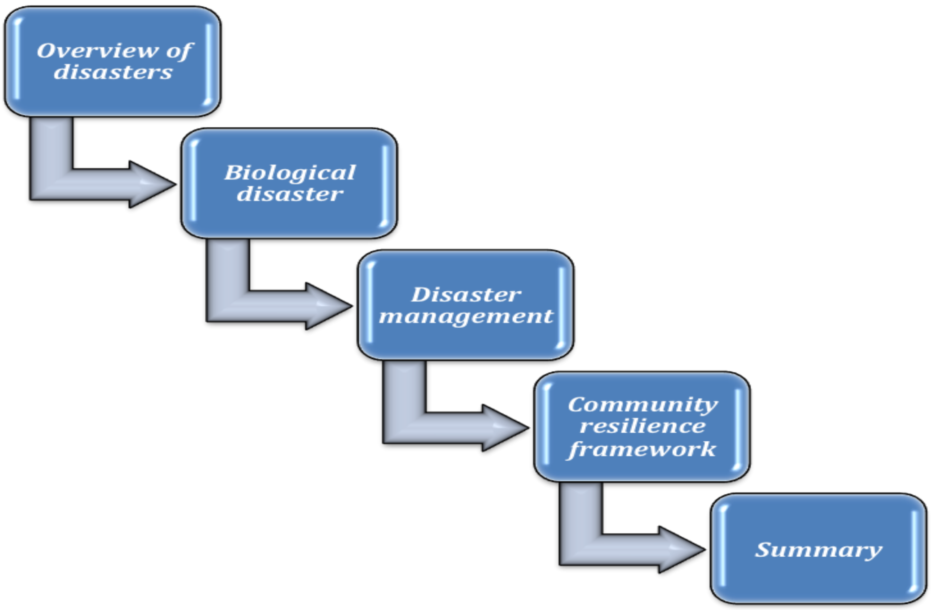


Figure 2-1: Structure of the second chapter.

2.1 Overview of disasters

Disasters are on the increase worldwide (Becken and Ren, 2012, Gaillard and Texier, 2010, Kouadio et al., 2012). Over the past 20 years, many parts of the world have been affected by either natural or man-made disasters which have a significant impact on the lives of the people and can also result in considerable economic loss (Jafari et al., 2011b, Becken and Ren, 2012).

2.1.1 Definition of Disaster

The origin of the term ‘disaster’ is derived from the Italian ‘disastro’, which means ‘ill-starred’ (Olivia et al., 2009). In the word ‘disastro’, the first part of this word ‘dis’ means away or without and the second part ‘astro’ means star or planet (Olivia et al., 2009).

According to Modern Language Association (MLA) 2015, the disaster refers to an occurrence producing huge destruction and distress (Dictionary.com, 2015). Gaillard and Texier (2010) note that disasters mostly result from the conjunction of the occurrence of a harmful natural hazard and a vulnerable human society. The definition of the term ‘disaster’ has been discussed over the past decades (Shaluf, 2007a). Thus, an incident cannot be constituted a disaster if there are no deaths, serious injuries or losses involved (Rutherford and De Boer, 1983). However, the concept of ‘disaster’ can be applied to a variety of events (Evans, 2010, Glass and Noji, 1992), which prevents the general acceptance of a specific definition of disaster (Shaluf, 2007a, Turner and Pedgeon, 1997, Jan, 1990, Kelman, 2005, Larson, 2008). Thus, researchers, international and local organizations and research centres have provided different definitions of disaster (Shaluf, 2007a).

Disasters have commonly been linked to religion as result of the widespread perception that disasters represent an 'Act of God' (Gaillard and Texier, 2010). Furthermore, the fatalistic notion of disasters can be attributed to the way in which disasters have been described throughout the history (Ghafory-Ashtiany, 2009). For example, the Maya people had a god of thunderstorms called Hurakan (hurricane), a god of earthquakes called Pillan and a god of thunder (Ghafory-Ashtiany, 2009a). Moreover, Greek, Roman and Egyptian civilizations all had gods that killed people who disobeyed them (Ghafory-Ashtiany, 2009). Likewise, there are several disaster stories mentioned in the three major monotheist religions, Islam, Judaism and Christianity (Gaillard and Texier, 2010). Furthermore, natural disaster has been explained as the anger of the gods (Ghafory-Ashtiany, 2009)**.** For instance, Campbell-Nelson (2008) described that the earthquake that struck Alor, Indonesia, in 2004 was seen by Church leaders as God's judgment on the sins of the people of Alor (Rokib, 2012, Campbell-Nelson, 2008).

Moreover, the Noah's Ark story is noted in the holy Qur'an as punishment from God "And Nûh's (Noah's) people, when they denied the Messengers, We drowned them, and We made them as a sign for mankind. And We have prepared a painful torment for the polytheists and wrong-doers" (Qur'an) 25:37).

However, in contrast and more pragmatically, Oliver-Smith (1999) claims that the definition of disaster has been discussed by sociologists and geographers since the sixteenth century (Oliver-Smith, 1999). In this context, Fritz takes a functionalist viewpoint, defining disaster as follows:

> An event, concentrated in time and space, in which a society, or a relatively self-sufficient subdivision of society, undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfilment of all or some of the essential functions of the society is prevented (1961, p. 655).

This view focuses on the risk of the event itself, but NeSmith (2006) notes that the concept of disaster has been developed according to the causes of disaster (NeSmith, 2006). Thus, it is often believed that a disaster can be defined based on variables such as geographic position, and the economic and political climate of disaster-prone countries (Quarantelli, 1998).

Provitolo et al. (2011) describe the four main properties that characterise disasters as: "(a) events that are identified in space and time (date, frequency and duration) (b) that have impacts, (c) on social units, (d) which in return come up with responses or adjustments to those impacts" (Provitolo et al., 2011)(Fritz, 1961). Quarantelli (2005) adopts a different approach and categorises the concept of a disaster into three types, which are emergencies, disasters, and catastrophes. There are qualitative differences between each of these types in terms of the size of the event, the magnitude of impact and damage, the level of vigilance required by both the government and the community, and decision-making at each stage of the event (Quarantelli, 2005). Furthermore, According to Rosenfeld et al., 2005, the term disaster can be separated from everyday emergencies should the event exhibit the following key characteristics: a) can cause damage or loss of property, life; b) has negative impact on a population; c) is out of everyday experience; d) has strong effects to cause most people stress, and e) limited time (cited in (Guterman, 2005, p.2).

Disaster has been further defined based on the meeting of such criteria relative to its setting. For example, in 1980, the definition of disaster from a medical point of view (as produced by an international working party) was as follows: "A disaster is a destructive event which, relative to resources available, causes many casualties, usually occurring within a short period of time" (cited in (Rutherford and De Boer, 1983, p.10). This definition was prepared with consideration given to two criteria, casualties and extra mobilization of medical resources (Jan, 1990). Also from a medical point of view, The Centre for Research on the Epidemiology of Disasters (CRED) defines a disaster as "a situation or event which overwhelms local capacity, necessitating a request to a national or international level for external assistance; an unforeseen and often sudden event that causes great damage, destruction and human suffering" (Guha-Sapir et al., 2010).

Data on disasters and their impacts on human life are documented in the EM-DAT database, which has worldwide coverage (Cavallo Eduardo et al., 2011, Peduzzi P. et al., 2009). For a disaster to be entered into the EM-DAT database, e.g. a biological event such as an epidemic or insect infestation, at least one of the following criteria must be fulfilled:

- At least ten people reported as killed;
- At least 100 people reported as affected;
- A state of emergency declared;
- A call for international assistance (Noy, 2009).

These criteria have been used by the World Health Organization (WHO), which focuses on the health outcomes of disasters, adopting the term ‘Health Action in Crises’ (WHO). WHO defines a disaster as “a sudden ecological phenomenon of sufficient magnitude to require external assistance” (cited in (Guerdan, 2009, p.32).

According to CRED (2009), the data resulting from disaster is broad and complex, and due to the absence of a standard definition of disaster, the reporting of impact cannot be consistent with that of other disasters (UNISDR, 2009). Moreover, such absence prevents the comprehensive planning for disaster rescue (Yang, 2010).

Overall, the definition of a disaster varies greatly depending on the relationship between the quantity and quality of its impact on human life, human society, economy and environment. For example, what one country considers a disaster may not constitute a disaster in another country (Eshghi and Larson, 2008).

2.1.2 Classification of Disasters

Disaster types have been classified by many scholars and organisations in a variety of ways (Larson, 2008). For example, Rutherford and de Boer (1983) classified disasters from a medical point of view, and in accordance with six categories (see Table 2-1).

Table 2-1: Classification of disasters from a medical point of view.

Categories	Classification
The effect on the surrounding community	➢ A simple disaster ➢ A compound disaster
The case	➢ Natural, Man-made disaster
The duration of development in the cause of disaster	➢ Short <1hour ➢ Fairly long 1- 24 hours ➢ Long >24 hours
The extent of disaster area (where causalities have occurred)	➢ According to the area: ❖ <1 Km, ❖ 1-10 Km ❖ >10 Km
The number of casualties	➢ Minor 25-100 casualties ➢ Moderate100-1000 casualties ➢ Major >1000 casualties.
Pathology	➢ Suffering from mechanical injuries, Radiation injuries, ➢ Emotional shock and Other illness

Source: (Rutherford and De Boer, 1983).

The classification of disaster focuses on three categories, natural, man-made (Shaluf, 2007a, Shaluf, 2007b, Guha-Sapir et al., 2005), and hybrid disasters, which are combination of the previous two types as result of human error and natural powers such as floods ravaging a community built on a known floodplain and landslides as result of the extensive clearing of jungles (Shaluf, 2007a, Shaluf, 2007b, Eshghi and Larson, 2008). Natural disasters are catastrophic events which occur without human influence, such as floods, landslides, and earthquakes (Shaluf, 2007b), and are often termed an “Act of God” (Geoff O’Brien, 2010). This type of disaster is classified into 5 sub-groups: Meteorological, Hydrological, Biological, Geophysical and Climatological (see Table 2-2) (Shaluf, 2007b, Guha-Sapir et al., 2010) which in turn cover 12 disaster types and more than 30 sub-types (Shaluf, 2007b).

Man-made disasters are events that occur as a result of human actions (Shaluf, 2007a), which have increased exponentially since the mid-1990s (Coleman, 2006). These disasters can be sudden and have short-term physical effects, such as those of the toxic chemicals, which are released after fire and explosion or have long term effects (Shaluf, 2008), such as those of Chernobyl, the Challenger disaster and Bhopal (Shaluf, 2008, Pidgeon and O'Leary, 2000).

This study focuses on biological disasters, which are discussed in detail in the following sub-section. Table 2-2 shows the classification of natural and man-made biological disasters.

Table 2-2: The classification of biological disasters adopted from (Rusnak et al., 2004, Shaluf, 2007b, Shaluf, 2007a, Guha-Sapir et al., 2010, Evan and Hays, 2006).

<table>
<tr><th>Disaster type</th><th colspan="2">Sub-disaster</th><th>Name of disaster</th></tr>
<tr><td rowspan="17">Natural</td><td colspan="2" rowspan="3">Natural phenomena beneath the Earth's surface</td><td>Earthquakes</td></tr>
<tr><td>Tsunamis</td></tr>
<tr><td>Volcanic eruptions</td></tr>
<tr><td colspan="2" rowspan="2">Topographical phenomena</td><td>Landslides</td></tr>
<tr><td>Avalanches</td></tr>
<tr><td colspan="2" rowspan="7">Meteorological/hydrological phenomena</td><td>Windstorms (cyclones, typhoons, hurricanes)</td></tr>
<tr><td>Tornadoes</td></tr>
<tr><td>Hailstorms and snowstorms</td></tr>
<tr><td>Sea surges</td></tr>
<tr><td>Floods</td></tr>
<tr><td>Droughts</td></tr>
<tr><td>Heat waves/cold waves</td></tr>
<tr><td colspan="2" rowspan="2">Biological phenomena</td><td>Infestations (locust swarms, mealy bug)</td></tr>
<tr><td>Epidemics (cholera, dengue, ebola, malaria, measles, meningitis, yellow fever, HIV/AIDS, tuberculosis)</td></tr>
<tr><td rowspan="3">Man-made</td><td rowspan="15">Socio-technical</td><td rowspan="6">Technological disasters</td><td>Fire</td></tr>
<tr><td>Explosions (munitions explosions, chemical explosions, nuclear explosions, mine explosions)</td></tr>
<tr><td>Leakage</td></tr>
<tr><td></td><td>Toxic release</td></tr>
<tr><td></td><td>Pollutions (pollution, acid rain, chemical pollution, atmospheric pollution)</td></tr>
<tr><td></td><td>Structural collapse of physical assets</td></tr>
<tr><td></td><td rowspan="3">Transportation disasters</td><td>Air disasters</td></tr>
<tr><td></td><td>Land disasters</td></tr>
<tr><td></td><td>Sea disasters</td></tr>
<tr><td></td><td rowspan="3">Stadia or other public places failures</td><td>Fire</td></tr>
<tr><td></td><td>Structural collapse</td></tr>
<tr><td></td><td>Crowd stampede</td></tr>
<tr><td></td><td rowspan="3">Production failure</td><td>Computer system breakdown</td></tr>
<tr><td></td><td>Distribution of defective products</td></tr>
<tr><td></td><td>Civil war</td></tr>
<tr><td></td><td rowspan="9">Warfare</td><td rowspan="6">National</td><td>Civil strikes</td></tr>
<tr><td></td><td>Civil disorder</td></tr>
<tr><td></td><td>Bomb threats/terrorist attack</td></tr>
<tr><td></td><td>War between two armies from different countries</td></tr>
<tr><td></td><td>Sieges</td></tr>
<tr><td></td><td>Blockades</td></tr>
<tr><td></td><td rowspan="3">Non-conventional war</td><td>Nuclear</td></tr>
<tr><td></td><td>Chemical</td></tr>
<tr><td></td><td>Biological</td></tr>
<tr><td rowspan="2">Hybrid</td><td colspan="2" rowspan="2">Natural and man-made events</td><td>Floods ravage community built on known floodplain</td></tr>
<tr><td>Location of residential premises, factories, etc., at the foot of an active volcano, or in an avalanche area Landslides</td></tr>
</table>

2.2 Biological Disaster

According to National Disaster Management Guidelines—Management of Biological Disasters, (2008), biological disasters are *"scenarios involving disease, disability or death on a large scale among humans, animals and plants due to toxins or disease caused by live organisms or their products. Such disasters may be natural in the form of epidemics or pandemics of existing, emerging or re- emerging diseases and pestilences or man-made by the intentional use of disease causing agents in Biological Warfare (BW) operations or incidents of Bioterrorism (BT)*" (Disasters, 2008).

The history of biological disasters, as a result of the spread of disease, goes back to the past that has been associated to God (Kopelman, 2002). For instance, Christian churches believe that God punishes people by sending disease as a result of their sins (Kopelman, 2002, Cunningham, 2008). Moreover, as Muslims, each of these types of disasters including biological disasters such as pandemic has come in the Quran as punishment "So We sent upon them the flood and locusts and lice and frogs and blood as distinct signs, but they were arrogant and were a criminal people" 7:133(Qur'an).

فَأَرْسَلْنَا عَلَيْهِمُ ٱلطُّوفَانَ وَٱلْجَرَادَ وَٱلْقُمَّلَ وَٱلضَّفَادِعَ وَٱلدَّمَ ءَايَٰتٍ
مُّفَصَّلَٰتٍ فَٱسْتَكْبَرُوا۟ وَكَانُوا۟ قَوْمًا مُّجْرِمِينَ ١٣٣

According to Morens et al., (2009), the terms epidemic and pandemic were used in the 17th and 18th centuries in social and medical contexts. The term of epidemic, *demos* in Greek, is "any disease that kills many people, kills them quickly, kills them in an unpleasant way, and which usually is arbitrary in its manner of action, not being choosy as to whether the victims are old or young, fit or unfit" (Cunningham, 2008, p. 29).

On the other hand, pandemic is a term origin from the Greek (Cunningham, 2008) which is defined by WHO as the worldwide spread of a new disease (WHO, 2010).

Following the findings of the literature review, the researcher, of the current study, classifies natural and man-made biological disasters into two types: primary and secondary disasters (see Figure 2-2) (Alshehri et al., 2016). ***Primary*** disaster, refers to the main disaster, that may be caused for instance by a large scale spread of certain kind of living organisms such as a virus or bacteria that may lead to epidemics (Shaluf, 2007b). These biological *primary* disasters can be classed as:

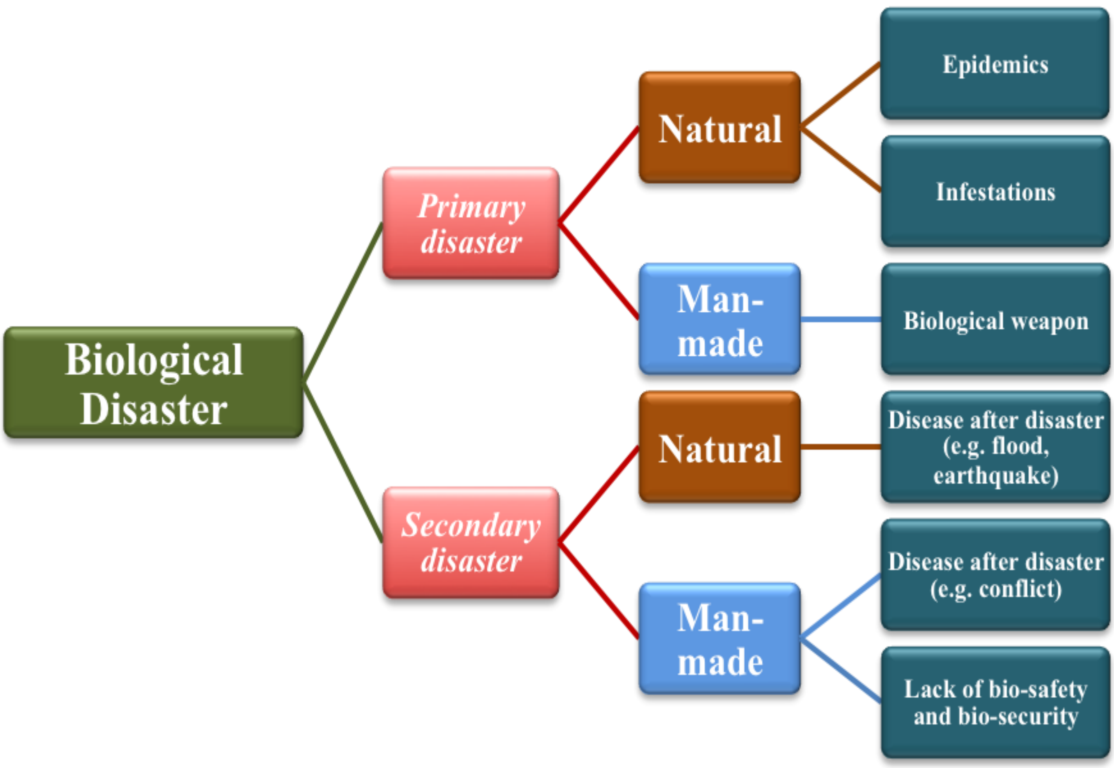


Figure 2-2: The classification of biological disasters (Alshehri et al., 2016).

1) Natural disasters

Many studies clasified biological disasters as natural disasters (Guha-Sapir et al., 2010, Shaluf, 2007b, Olivia et al., 2009). Several pandemics of the past of which were recorded including: (a) 1348-49: plague which known as the Black Death, (b)

1490s: the sexually-transmitted disease known in the past as “the French disease.” (Syphilis), (c) 1490s: typhus, the deadly disease of those crowded together, (d) 1831-32: cholera, (e) 1890s: plague, from China to Europe, and the greatest pandemic was in 1918: called “Spanish flu” which killed 20 million people in seventeen weeks.

In the last decades, various biological disasters as natural are affected the world which includes conditions such as Human immunodeficiency virus infection and acquired immune deficiency syndrome (AIDS) (Cunningham, 2008), Severe Acute Respiratory Syndrome (SARS) (Leach et al., 2010), avian flu (Minami, 2007), and influenza virus H1N1, frequently referred to as “swine flu” (Kamate et al., 2009). Moreover, recently, parts of the world have faced major challenges such as Middle East respiratory syndrome coronavirus (MERS-CoV) (Chan et al., 2013) and Ebola.

2) **Man-made (including technological) disasters:**

This is the second type of classification of primary disasters. It is due to either intentional hazards (Shaluf, 2007b, Olivia et al., 2009), such as biological warfare capability (Ligon, 2006b) and bioterrorist attack (Glik et al., 2004) or lack of bio-safety and bio-security (Gmunder and Binz, 2003, Perkins and Nordmann, 2012). It is worth noting that an international treaty commonly called the ‘Biological Weapons and Toxin Convention’ (BWC) was signed in 1972 by 173 countries that prohibited the development, production, stockpiling of biological weapons and raised awareness of biosecurity and biosafety thereby controlling the use of biological agents (McLeish and Nightingale, 2007, UNOG, 2014). However, 10 States that had signed the Convention but had not yet ratified such as Egypt, Syria and Somalia and 16 countries have neither signed nor ratified the Convention including Eritrea, South Sudan and Israel (UNOG, 2014).

On the other hand, the second type of biological disasters is ***secondary*** disaster that may occur as a consequence of the impact of either natural or man-made hazards (Jones et al., 2008). Various infectious disease epidemics have followed disasters during the past (including earthquakes, floods, tsunamis and conflicts) (Kouadio et al., 2012, Alexander, 1982). Mortality and morbidity have gradually increased as a result of communicable diseases following natural and man-made disasters (Waring and Brown, 2005).

This can be attributed to factors such as inadequate medical care, lack of sanitary water, and poor waste management (Bellos et al., 2010). Kouadio et al., (2010) point out that all post-conflict measles outbreaks occurred due to the lack of an immunisation programme of the displaced population prior to their arrival in the refugee camps. The most significant communicable diseases can be classified into the following categories: waterborne diseases, acute respiratory infections, vector-borne diseases and infections from wounds and injuries (Jones et al., 2008, Jafari et al., 2011, Few, 2007). Conversely, secondary disaster may occur as a consequence of man-made biological disaster as a result of insufficient biosafety and biosecurity measures in clinical and research laboratories (Rusnak et al., 2004, Perkins and Nordmann, 2012). For example it has been proven that the lack of awareness of the concept of biosafety in clinical laboratory is one of the most important factors contributing to raising the level of risk among laboratory workers (Alshehri, 2011). In other words, the laboratory workers with high awareness of biosafety will prevent themselves, laboratory, and environmental exposure to potentially infectious agents; thus the bio threat will be reduced to spread to the community (Control and Prevention, 2011) .As result of insufficient biosecurity measures in research laboratories many workers were killed from exposure to anthrax spores which were accidentally released from a secret military facility at a Soviet research centre in 1979, around the city of Svardlovsk (Guillemin, 2006).

In general, mortality and morbidity from communicable diseases rise after disasters (Waring and Brown, 2005). In the last decade, various infectious disease epidemics have followed a number of disasters, including natural and man-made disasters (Kouadio et al., 2012). The most significant communicable diseases resulting from disaster can be classified into the following categories: waterborne diseases, acute respiratory infections, vector-borne diseases and infections from wounds and injuries (Jones et al., 2008, Jafari et al., 2011, Few, 2007). These categories are discussed in the following sub-section.

2.3 Diseases after disasters

The potential impacts on human health subsequent to a disaster event have been recorded (Connolly, 2004, Jafari et al., 2011). Table 2-3 shows the probability of risk of epidemics can increase after disasters (Vogelbacher, 2011). Communicable diseases represent a public health problem in developing countries, especially in those affected by disasters (Noji, 2005), and epidemics may occur several days, weeks or months following the event of disaster (Kouadio et al., 2010). It is noteworthy that over 66% of the deaths of refugees and those displaced by disaster are caused by communicable diseases (Noji, 2005). In addition, (Kouadio et al., 2010) point out that all post-conflict measles outbreaks occurred due to the lack of an immunisation programme of the displaced population prior to their arrival in the refugee camps. Moreover, the potential impact of communicable diseases can be very high amidst the disorder that follows natural disaster (WHO, 2006).

Table 2-3: Shows the health impacts after disasters (adapted from Vogelbacher, 2011)

Health effects	Earthquake	Floods	Land-slides	Epidemics	Conflicts
Deaths/ Sever injuris	Many	Few	Many	Many	Many
Requiring extensive treatment	Many	Few	Few	Few	Many
Increased risk of epidemics	Yes	Yes	Yes	N/A	Yes

Mortality and morbidity has gradually increased as a result of communicable diseases following natural and man-made disasters (Waring & Brown, 2005). This can be attributed to factors such as inadequate medical care, lack of sanitary water, and poor waste management (Bellos et al., 2010). Kouadio et al, (2010) point out that all post-conflict measles outbreaks occurred due to the lack of an immunisation programme of the displaced population prior to their arrival in the refugee camps.

There are several factors that contribute to the increased transmission of diseases after a disaster (see Figure 2-3), especially endemic and epidemic diseases common to the area affected (Connolly, 2004, Watson et al., 2007). These include:

- mass population movements, overcrowding and displacement
- insufficient sanitation and waste management, compromised sources of water, potential food shortages resulting in malnutrition, a low level of immunity and environmental degradation (John T. Watson et al., 2007).

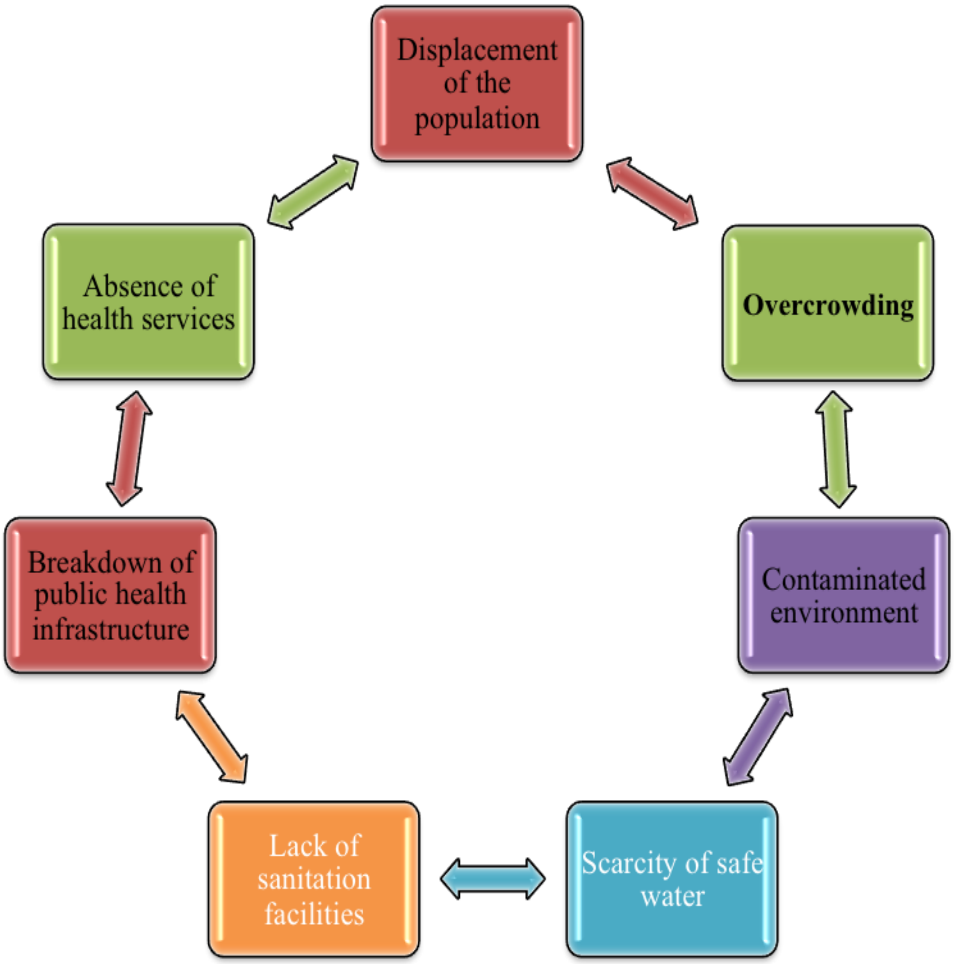


Figure 2-3: Some factors that contribute to increased transmission of diseases after disaster.

Table 2-4 illustrates instances where various infectious disease epidemics have followed disasters since 1984 -2014 (including earthquakes, floods, tsunamis and conflicts).

Table 2-4: Infectious disease epidemics following natural or man-made disasters (Alshehri et al., 2016).

Country	Year	Disaster	Infectious disease	Ref.
Syria	2012,2013	Man-made (Conflict civil war)	Leishmania, Polio	(Tabbaa and Seimenis, 2013, Lancet, 2014)
United States of America (Missouri)	2011	Natural (Tornado)	Mucormycosis	(Gayden, 2011)
Japan	2011	Natural (Earthquake and Tsunami)	Influenza	(Arima et al., 2011)
Haiti	2010	Natural (Earthquake)	Cholera	(Fisher and Kramer, 2012)
Pakistan	2005	Natural (Earthquake)	Diarrhoea, Hepatitis E, Acute Respiratory Infection (ARI), Measles, Meningitis, Tetanus	(Watson et al., 2007, Ligon, 2006a)
United States of America (New Orleans).	2005	Natural (Hurricane Katrina)	Tuberculosis (TB)	(Lemonick, 2011, Ligon, 2006a)
Bangladesh	2004	Natural (Flood)	Cholera	(Weil et al., 2009)
Sudan (Darfur)	2004	Man-made (Conflict)	Measles	(Schipper and Pelling, 2006)
Iran	2003	Natural (Earthquake)	Acute Respiratory Infection (ARI)	(Akbari et al., 2004)
El Salvador	2001	Natural (Earthquake)	Diarrheal infections	(Ligon, 2006a)
Taiwan & China	2001	Natural (Typhoon)	Leptospirosis	(Lemonick, 2011)
United States of America	2001	Man-made (bioterrorist attack)	Anthrax	(Mikszta et al., 2006)
United States of America	1998, 1999	Man-made (bioterrorist attack)	Anthrax	(Keim and Kaufmann, 1999)
Japan (Tokyo)	1990-1995	Man-made (bioterrorist attack)	Botulinum	(Arnon et al., 2001)
United States of America (Virginia)	1992	Man-made (bioterrorist attack)	Anthrax	(Keim and Kaufmann, 1999)
United States of America (Dallas)	1984	Man-made (bioterrorist attack)	Salmonella	(Sobel et al., 2002)

Although, it is a widely held belief that dead bodies also contribute to disease transmission (Lemonick, 2011), human remains do not contribute to the risk of epidemics in cases where death was a direct consequence of the disaster itself (Lemonick, 2011, Ligon, 2006a, Conly and Johnston, 2005). Dead bodies pose health risks in relatively few situations, but require specific precautions (Lemonick, 2011). Some pathogens, such as blood-borne viruses (e.g., Ebola virus, Lassa virus, Marburg virus and Crimean-Congo haemorrhagic fever virus) and enteric pathogens (e.g., V. cholerae) may remain alive for some time in dead bodies (Morgan, 2004). Those who handle the bodies can therefore be at risk of disease due to exposure to contaminated blood and bodily fluids (Lemonick, 2011, Ligon, 2006a).

2.3.1 Food and Water-borne diseases:

Many serious water and food-borne diseases can be spread following disasters such as tsunamis or hurricanes due to contaminated water sources (Ligon, 2006a), shared water containers and cooking pots, lack of hygiene and contaminated food (Lemonick, 2011). Diarrhoeal diseases have been reported after flooding and consequential movement of people, and include Vibrio cholera (O1 Ogawa and O1 Inaba) and enterotoxigenic Escherichia coli (Jafari et al., 2011). A recent manifestation of this phenomena occurred following the Haiti earthquake in 2010; the resultant cholera epidemic caused more than 3,600 deaths, with a further 170,000 being affected (Lemonick, 2011). Many pathogens, including non-toxigenic V. cholerae (the cause of Cholera), have also been confirmed present within the population displaced by Hurricanes Allison (2001) and Katrina (2005) in the United States of America, due to contaminated flood water and overcrowding (Kouadio et al., 2012, Linscott, 2007).

In addition, further water and food–borne disease epidemics, such as Leptospirosis in India and Thailand, occur due to bathing in and the drinking of contaminated water (Kouadio et al., 2012). Hepatitis A and E which can also be transmitted via the faecal oral route due to lack of access to sanitation, and was reported after the 2004 tsunami in Aceh and after the 2005 earthquake in Pakistan (Watson et al., 2007).

2.3.2 Vector borne Diseases

Many vector borne diseases, including malaria, dengue, Japanese encephalitis, and yellow fever, are transmitted by mosquitoes (Lemonick, 2011) following natural disasters such as cyclones, hurricanes and floods. Furthermore, Rowland and Noste (2001) state that major health crises, such as malaria, can also occur during war and its aftermath. Moreover, in Indonesia, where malaria and dengue are endemic, epidemics among refugees were recorded after the 2004 tsunami and resulted from over-crowded living situations, inadequate access to healthcare, and lack of vector controls such as mosquito nets and insecticides (VanRooyen and Leaning, 2005).

Overall, Watson et al. (2007) note that there are numerous factors, which can be attributed to epidemics after disasters such as changes in human behaviour (increased exposure to mosquitoes while sleeping outside, a breakdown in disease control, and living in an endemic area) (Watson et al., 2007).

2.3.3 Acute Respiratory Infections

Acute respiratory infections (ARI), which can be categorised into upper (AURI) and lower (ALRI) acute respiratory infections, are a major cause of morbidity and mortality within displaced populations (Bellos et al., 2010), particularly in children of less than five years of age (Watson et al., 2007). Several cases of ARI were recorded after Hurricane Katrina; the percentage of victims suffering with ARI increased from 12% to 20% during 4 weeks after this disaster (Lemonick, 2011). The majority of deaths between survivors of the tsunami in Aceh in 2004 were caused by ARI (Watson et al., 2007, Lemonick, 2011). The risk of death from ARI increases because of the lack of access to health services and antimicrobial agents for treatment (Watson et al., 2007). Reported incidences of ARI are also said to increase in accordance with many other factors, including over-crowding, inadequate shelter conditions, a decreased coverage of immunization, and lack of or delay in diagnosis and treatment due to insecurity and breakdown in health services (Kouadio et al., 2012, Lemonick, 2011, Linscott, 2007).

In addition, aspiration pneumonia can be seen after flooding and tsunamis, due to inhalation of soil-contaminated salt water (Lemonick, 2011, Linscott, 2007), while incidences of diseases such as meningitis, measles, pneumonia and tuberculosis (TB) have been associated with many natural disasters (Watson et al., 2007, Jafari et al., 2011b, Kouadio et al., 2012). Conversely, some diseases, such as the 2001 outbreak of anthrax in the USA, are related only to bioterrorism and man-made disasters (Rusnak et al., 2004, Rokach et al., 2010).

2.3.4 Wounds, Injuries and Infections:

The inherent chaos and structural collapses following disasters such as earthquakes, floods, tornadoes and hurricanes, can result in various crush injuries, fractures, and wounds; all of which can encourage contamination and infection (Waring and Brown, 2005, Jones et al., 2008). For example, tetanus, which is “a toxin released by the anaerobic tetanus bacillus Clostridium tetani” (Watson et al., 2007) is a major problem in unvaccinated victims of injury (Ligon, 2006a). Moreover, more than 100 cases of tetanus, including some deaths, occurred after the tsunami in Indonesia (Organization, 2005).

2.4 Disaster management

Biological disasters, either natural or man-made, cannot be prevented but their impacts can be mitigated through adapted disaster management strategies (Disasters, 2008). As result of the issues discussed above, the question 'how can the after effects of disasters be managed?' is raised. Hence, this section explains the levels of disaster management according to resilience.

Ahrens and Rudolph (2006) describe disaster management as a combination of emergency response measures taken to reduce the impact of disaster risk in the first instance, not only subsequent relief work (Ahrens and Rudolph, 2006). Disaster management has been recognised by different societies as a cycle of activities that result from the harmful impacts of disasters on said societies (Vasilescu et al., 2008). There are three main stages of this cycle which are 'before', 'during', and 'after' the occurrence of a disaster (Shaluf, 2007b, Janssen et al., 2010). The main objectives of disaster management are to reduce impacts of risks of disasters, to provide assistance to disaster victims, and return to the situation prior to the disaster as rapidly as possible (Vasilescu et al., 2008, Shaluf, 2007b).

Broadly speaking, disaster reduction involves four dimensions: human, social, economic, and political and environmental (Ahrens and Rudolph, 2006). It is also has a number of phases. Thus, Moe (2006) explains that disaster management includes the five basic phases: prediction; warning; emergency relief; rehabilitation; and reconstruction (Lin Moe and Pathranarakul, 2006). However, Khan et al (2008) argue there are at least six main elements in disaster management: prevention; mitigation; preparedness; response and relief; rehabilitation; and reconstruction. Although, in general, the majority of studies show that disaster management cycle consists of four phases which are mitigation, preparedness, response and recovery; beginning and ending with mitigation (see Figure 2-4) (Kusumasari et al., 2010, Shaluf, 2008, Vasilescu et al., 2008).

Figure 2-4: Disaster management cycle

The first phase is mitigation, which refers to pre-activities that will prevent or reduce the impacts of disaster (Shaluf, 2008). According to Davis et al., (2012) the preparedness phase is a crucial element of any disaster management as it reduces the negative impacts of the risks associated with disaster. Preparedness includes activities such as planning, public awareness and education, designing and implementing a warning system, training, risk communication, resource identification, and preparation of the community to respond when a disaster occurs (Said, 2011). Furthermore, community involvement can play important role in pre-disaster preparedness and disaster response; hence it should be integrated into legislation and planning instruments as part of a grand strategy, and supported by local governance, in order to increase the resilience of a community (Van Aalst et al., 2008).

The third phase is response which relates to activities that follow a disaster and can be of an immediate, short-term, or protracted duration (Lin Moe and Pathranarakul, 2006).

These activities are designed to provide emergency assistance to victims through the preservation of life, property, the environment, and the social, economic, and political structure of the community (Altay and Green, 2006). The recovery phase, which is the final one of the disaster management cycle, continues in the long term until all systems return to normal or improved levels after a disaster. It can be accomplished through the following ways: damage assessment; debris removal; and disaster assistance centres (Shaluf, 2008). Altay and Green (2006) summarise the typical activities involved in each of these four stages (Table 2-5).

Table 2-5: The typical activities involved in each of disaster management cycle stages. Adopted from (Altay and Green, 2006)

Mitigation	Preparedness	Response	Recovery
•Zoning and land use controls to prevent occupation of high hazard areas. •Barrier construction to deflect disaster forces. •Active preventive measures to control developing situations •Building codes to improve disaster resistance of structures •Controls on rebuilding after events. •Risk analysis to measure the potential for extreme hazards.	•Recruiting personnel for the emergency services and for community volunteer groups •Emergency planning •Development of mutual aid agreements and memorandums of understanding •Training for both response personnel and concerned citizens •Threat based public education • Reburial of displaced human remains • Budgeting for and acquiring vehicles and equipment •Maintaining emergency supplies •Construction of an emergency operations centre •Development of communications systems •Conducting disaster exercises to train personnel and test capabilities.	•Activating the emergency operations plan. •Activating the emergency operations centre. •Evacuation of threatened populations •Opening of shelters and provision of mass care •Emergency rescue and medical care • Urban search and rescue •Emergency infrastructure protection and recovery of lifeline services • Fatality management	•Disaster debris cleanup •Financial assistance to individuals and governments •Rebuilding of roads and bridges and key facilities •Sustained mass care for displaced human and animal populations •Full restoration of lifeline services •Mental health and pastoral care.

Source: (Adapted from Altay and Green, 2006, p.481).

In essence, disaster management refers to either the reduction of vulnerability or the building of resilience (Thomalla et al., 2006). The term ‘resilience’ is the antithesis of ‘vulnerability’, but both are related terms (Twigg, 2007). Thus, the policies, practices, and theories of disaster management have been determined and applied with the aim of achieving disaster-resilient communities (Chang and Shinozuka, 2004).

2.4.1 Vulnerability

Disasters can be caused and/or exacerbated as a result of the interaction between natural hazards such as hurricanes, tsunamis and earthquakes and social, economic, health, cultural and environmental factors; this is affected by the ability of individuals and communities to prepare for, cope with, and recover from disasters (Cutter et al., 2009, Keim, 2008, Kumpulainen, 2006). In addition, disasters can result from the interactions of society with technological hazards such as chemical spills, or within society itself, such as civil conflict; all of which affect the health of the population (Cutter et al., 2009).

Generally, disaster risk depends on three elements (Weichselgartner, 2001): a) Hazard which refers to the physical process of a hazard event, b) Exposure which is all the people and infrastructure exposed to the hazard event, and c) Vulnerability which is a critical part of hazards and risk research (UNISDR, 2009). This refers to the susceptibility of people, communities or regions to natural or man–made hazards (Kumpulainen, 2006).

According to Weichselgartner (2001), since the 1990s vulnerability has been studied in several fields, including risk, hazard, and disaster mitigation, as well as in the areas of global change and environment, and development studies. The meaning of the concept 'vulnerability' varies depending on the context in which it is used, in a number of disciplines (Füssel, 2007, Vatsa, 2004). A number of studies point out that the origin of vulnerability word is the Latin verb 'vulnerare' which means to wound" (Schroeder and Gefenas, 2009, Jaarsma and Welin, 2012). Specifically, Schroeder and Gefenas state: "To be vulnerable means to be exposed to the possibility of being attacked or harmed, either physically or emotionally" (2009). p.114).

Numerous variables are relevant to the production of a level of vulnerability, and can be applicable to specific groups of vulnerability: (1) physical vulnerability, which relates to the exposure to vulnerable elements within a region; (2) economic vulnerability, which describes the economic resources of individuals, populations groups, and communities; (3) social vulnerability, which involves non-economic factors that determine the well-being of individuals, population groups, and communities, such as the level of education, security, access to basic human rights, and good governance; and (4) environmental vulnerability, which relates to the state of the environment within a region (Birkmann, 2006, Mallick et al., 2011, McEntire, 2001, Alcántara-Ayala, 2002).

In addition to the above named vulnerability groups, Keim (2008) points out that health vulnerability as important of vulnerability groups (Keim, 2008). This relates to public health factors, such as education, health care, public health prevention efforts, and infrastructure; these play major roles in the level of vulnerability displayed (Keim, 2008). Other researchers recognise that there are further factors that may influence vulnerability; for example, Seneviratne et al. (2010) place emphasis on technological variables, such as early detection systems, warning systems and the building of dams (Seneviratne et al., 2011). McEntire (2001) highlights cultural attitudes, such as feelings of apathy towards disasters, failure of traditional coping measures, lack of safety precautions and regulations, and dependency and an absence of personal responsibility (McEntire, 2001).

Importantly, St Cyr (2005) states that vulnerability can be determined by a combination of various factors such as social, political, and economic rather than the degree of just one, and that hazards may impact people differently depending on their personal levels of vulnerability (St Cyr, 2005). Table 2-6 shows the vulnerability factors that have been determined by researchers.

Table 2-6: Shows most of factors of vulnerability

Factor of Vulnerability	Ref.
Crowded living	(Connolly, 2004) (Kouadio et al., 2012)
Population movement	(Connolly, 2004) (Jafari et al., 2011)
Population displacement	(Connolly, 2004) (Bellos et al., 2010) (Jafari et al., 2011)
Poverty	(Alcántara-Ayala, 2002) (Jafari et al., 2011) (Mallick et al., 2011)
Gender	(Cutter et al., 2003) (Lemonick, 2011)
Race and ethnicity	(Cutter et al., 2003)
Age	(Cutter et al., 2003) (Lemonick, 2011)
Lack of protective infrastructure/Lack of shelter.	(Jafari et al., 2011)
Lack of sanitary water	(Waring and Brown, 2005) (Watson et al., 2007) (Lemonick, 2011) (Kouadio et al., 2012)
Poor waste management	(Lemonick, 2011)
Malnutrition due to food shortage	(Waring and Brown, 2005) (Lemonick, 2011)
Personal hygiene	(Lemonick, 2011) (Jafari et al., 2011)
Lack of adequate immunization and medical service	(Lemonick, 2011) (Watson et al., 2007) (Jafari et al., 2011)
Physical ability	(Phillips and Morrow, 2007)
Limited access to political power and representation	(Alcántara-Ayala, 2002) (Birkmann, 2006)
Certain beliefs and customs	(Cutter et al., 2003)
Lack of public awareness (no disaster education)	(Alcántara-Ayala, 2002) (Cutter et al., 2003) (Kumpulainen, 2006) (Mallick et al., 2011) (Jonkman and Kelman, 2005)
Risk perception	(Kumpulainen, 2006) (Miceli et al., 2008)
Early warning system	(Gayer et al., 2007) (Benjamin et al., 2011)
Lack of planning and forecasting	(Benjamin et al., 2011)
Lack of preparedness	(Kusumasari et al., 2010)
Lack of access to information	(Alcántara-Ayala, 2002) (Mallick et al., 2011)
Disintegration of social patterns	(Birkmann, 2006)
Lack of strong national and local institutional structures	(Alcántara-Ayala, 2002) (Birkmann, 2006)
Weak building infrastructure	(Alcántara-Ayala, 2002)
Local insecurity	(Mallick et al., 2011)
Technical infrastructure	(Kumpulainen, 2006)
Lack of transparency	(Benjamin et al., 2011)

There are various analytical concepts and models, which are reflected, in the different facets of vulnerability assessment (Birkmann, 2006). Vulnerability assessments focus on the factors that influence the severity of loss and damage, exposure to threat, and what can be done to reduce vulnerability in a particular area (Birkmann, 2006). Statistical estimates of population exposures and levels of vulnerability can be provided by these assessments either qualitatively or quantitatively (Cutter et al., 2009). Various models have been proposed, including:

- ***The Pressure and Release (PAR) Model***

The Pressure and Release (PAR) Model was proposed by Blaikie et al. (1994), and developed by Wisner et al. (2004) (Mercer et al., 2007). This model views disaster as the connection between processes generating vulnerability and the hazard event (Figure 2-5). Accordingly, vulnerability can be understood within three progressive stages: root causes, dynamic pressures and unsafe conditions (Tapsell et al., 2010, Santha et al., 2015, Tsasis and Nirupama, 2008).

Robert et al., (2009) point out that the PAR model is "an important contribution to conceptualization of vulnerability and, therefore, risk as it treats vulnerability as a process, rather than a state" (Roberts et al., 2009, p.337). The PAR model has been used to analyse various disaster such as the spread of infectious diseases, earthquakes, floods and famines (Santha and Sreedharan, 2010). For example, the PAR has been used to identify the vulnerability to Human immunodeficiency virus infection and acquired immune deficiency syndrome (HIV/AIDS) pandemic, and its relationship to the root causes of transmission (Tsasis and Nirupama, 2008). Tsasis and Nirupama (2008) point out that PAR is usfule by understanding the root causes and determining the stage of HIV/AIDS preparedness in populations that can reduce the spread of the pandemic.

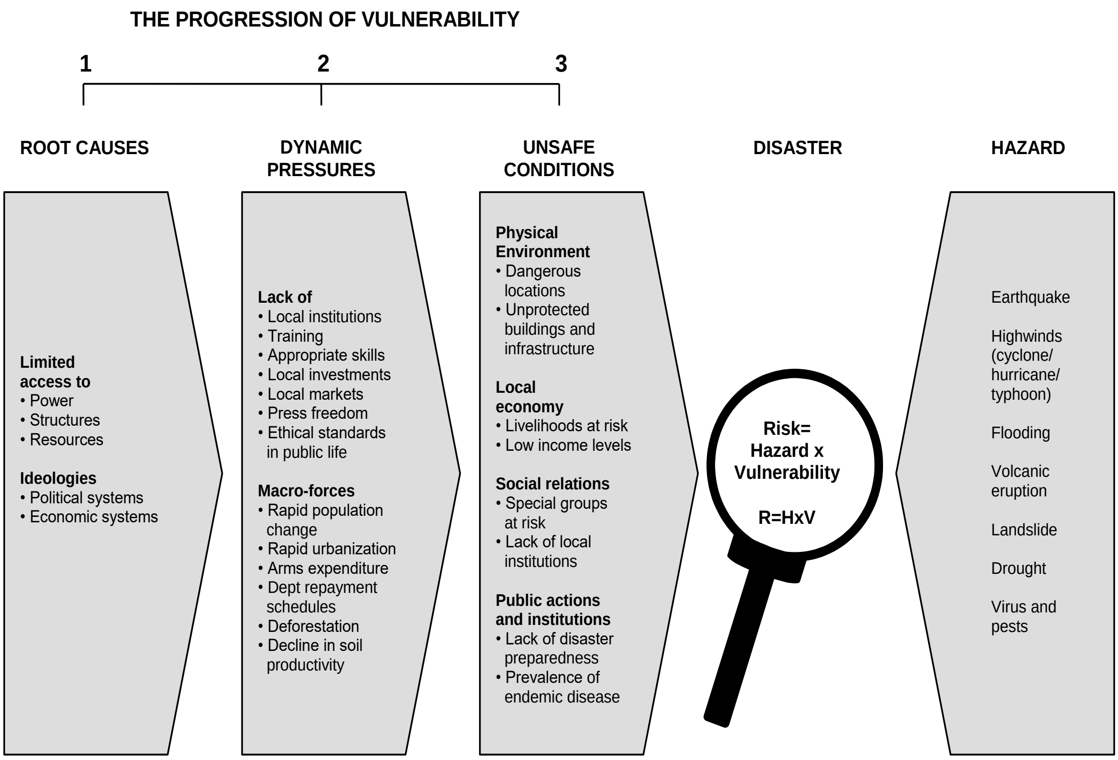


Figure 2-5: The Pressure and Release (PAR) Model (Adopted from Wisner et al. 2004).

- ***The sustainable livelihood framework***

Improved livelihoods are argued to be fundamental for responding to the impacts of natural disasters (Shaw, 2006). The UK Department for International Development (DFID) defines sustainable livelihood as:

> *"A livelihood comprises the capabilities, assets (including both material and social resources) and activities required for a means of living... A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future "* (Brocklesby and Fisher, 2003).

The sustainable livelihood framework can be used as a framework or vade-mecum for vulnerability assessment (Birkmann, 2006) and the concept of sustainable livelihood may be used to design development programming at a community level (Brocklesby and Fisher, 2003). The Sustainable Livelihood Approach, which looks at five types of household assets—natural, social, financial, physical, and human capital—tends to focus on vulnerability in relation to health research (Figure 2-6) (Obrist et al., 2010). Moreover, this has proven to be useful for the assessment of the ability of households to withstand shocks such as epidemics or civil conflict (Hahn et al., 2009). For example, the Sustainable Livelihood Approach, using both quantitative and qualitative methods of data collection, has been applied to explore the effects of HIV/AIDS on the livelihoods of banana-farming households in Maragua district, Central Kenya (Nguthi and Niehof, 2008). Through the application of sustainable livelihood and social relation approaches, the effects of the AIDS epidemic on every part of a livelihood has been determined, as its reach is beyond the volition of individuals (Winford, 2007). The Sustainable Livelihood Approach has also been used to examine the ways in which social actors mobilise, combine and transform capitals on household and community levels to obtain malaria treatment (Obrist et al., 2010).

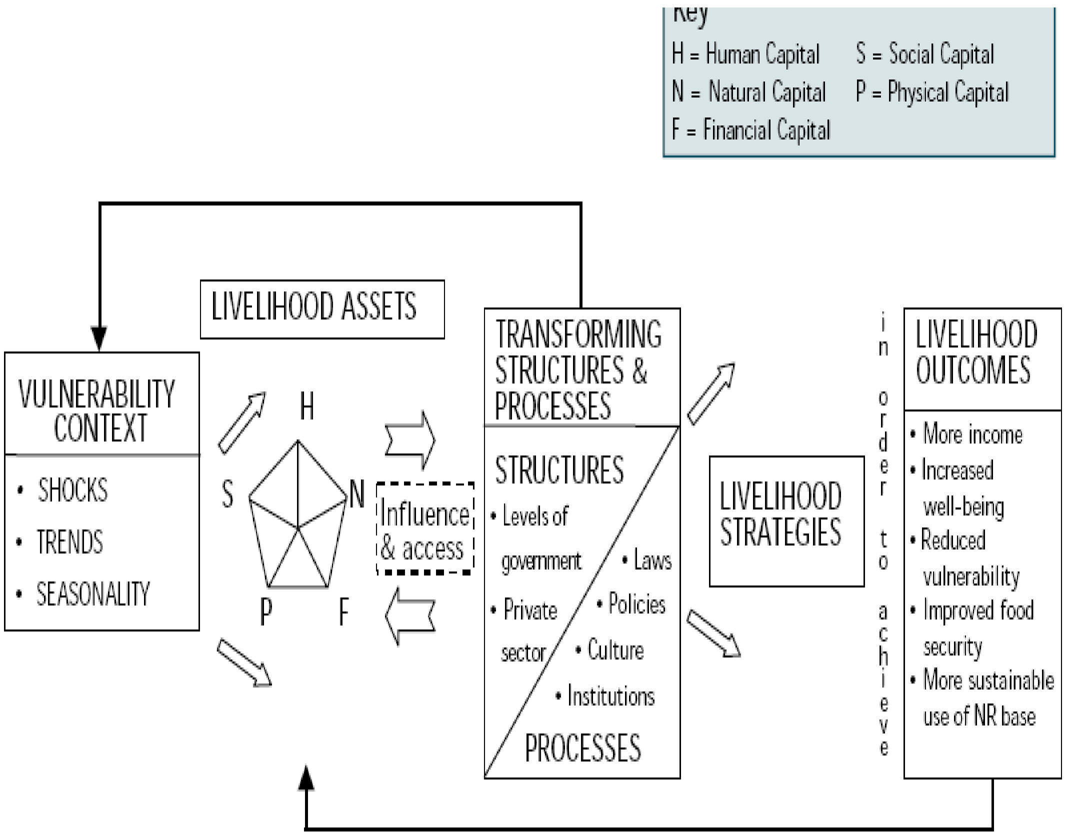


Figure 2-6: The sustainable livelihood framework (Adapted from Obrist et al., 2010)

2.4.2 Resilience

However, the impact of disasters can be exacerbated by a lack of community resilience not only the exposure to poor conditions of the built area and infrastructure (Sungay et al., 2009). At present, greater importance is attributed to the capacity of disaster-affected communities to recover, with or without overseas aid (Bosher and Dainty, 2011). Therefore, a change is required in the disaster risk reduction work culture, with a stronger emphasis being placed upon resilience, rather than vulnerability (Manyena, 2006).

Recently, concepts relevant to resilience, such as ‘sustainable and resilient communities’, ‘resilient livelihoods’, ‘building community resilience’ (Manyena, 2006), ‘disaster resilience’, ‘community resilience’, ‘infrastructure resilience’, ‘ecosystem', and ‘individual’ or ‘psychological resilience’ have become commonplace in related research (Castleden, 2011). Godschalk (2003) points out that many disaster studies recommend the development of resilient communities. Tidball and Krasny (2007) state that returning a community to its former state after a disaster strikes can be complex, expensive, and sometimes even impossible if communities lack resilience; this has been experienced in parts of New Orleans following Hurricane Katrina (Arjen Boin et al., 2010) and Baghdad following the war in Iraq (Tidball and Krasny, 2007). Therefore, the development of strategies and policies to build resilience before disaster strikes is considered fundamental to the management of disasters (Tidball and Krasny, 2007). Recently, resilience has formed a key element of the United Nations International Strategy for Disaster Reduction (UNISDR) (Castleden, 2011). This section elaborates further on (a) the concept of resilience in disaster management, and (b) the need for adapted frameworks to assess and build community resilience.

This concept has been derived from the Latin verb 'resilire' that means to rebound or recoil or return to the original situation (Prosser and Peters, 2010, Zhong et al., 2013). It has been used in several disciplines such as ecology, hazards, psychology, geography, sociology, and public health (Cutter et al., 2010, Norris and Stevens, 2007, Mayunga, 2007, Zhong et al., 2013). However, the definition of resilience was adapted by the ecological community in 1970 to differentiate between a system that works towards a stable state, and the dynamics of the system's behaviour when under pressure, and how the dynamics are driven by this stability (Dalziell and McManus, 2004). The major challenge with the definition of resilience is that is used by researchers in different research fields in different ways. Therefore, it is difficult to find consensus on the definition of resilience (Mayunga, 2007).

Recently, resilience has formed a key element of the United Nations International Strategy for Disaster Reduction (UNISDR) (Castleden, 2011), and in this context is defined with particular reference to natural hazards, 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 through the preservation and restoration of its essential basic structures and functions* "(UNISDR, 2009, p.24)

Table 2-7: Various definitions of resilience concept Adopted from (Manyena, 2006, Mayunga, 2007, John Plodinec, 2009).

Author	Definition
Wildavsky, 1991	Resilience is the capacity to cope with unanticipated dangers after they have become manifest, learning to bounce back.
Holling et al., 1995	It is the buffer capacity or the ability of a system to absorb perturbation, or the magnitude of disturbance that can be absorbed before a system changes its structure by changing the variables.
Mallak, 1998	Resilience is the ability of an individual or organisation to expeditiously design and implement positive adaptive behaviours matched to the immediate situation, while enduring minimal stress.
Comfort, 1999	The capacity to adapt existing resources and skills to new systems and operating conditions.
Pelling, 2003	The ability of an actor to cope with or adapt to hazard stress.
Resilience Alliance, 2005	Ecosystem resilience is the capacity of an ecosystem to tolerate disturbance without collapsing into a qualitatively different state that is controlled by a different set of processes. A resilient ecosystem can withstand shocks and rebuild itself when necessary. Resilience in social systems has the added capacity of humans to anticipate and plan for the future.
Norris, 2008	A process linking a set of adaptive capacities to a positive trajectory of functioning and adaptation after a disturbance.

Source: Adapted from Manyena (2006), Mayunga (2007) and Plodinec (2009)

As the table (2-7) presents, the definitions are varied, reflecting the complex nature of the concept. Therefore, it is difficult to obtain consensus on the definition of the concept of resilience (Mayunga, 2007). However, Catleden (2011) states that "there is a striking degree of commonality in the terms used to describe the different concepts of resilience, even across very different disciplines".

2.5 The concept of resilience in the field of disasters

The concept of disaster resilience has linked to the concept of sustainability (Mayunga, 2007). Manyena (2006) indicates that the main defining characteristics of resilience include: coping with the effects of disasters; recovery from disasters and “bouncing back”; and adaptation to cope better with future risks. Furthermore, Boin and

McConnell (2007) point out that resilience provides a conceptual tool to cope with future change.

The importance of resilience has discussed in several studies. Manyena (2006) states that increased resilience is a significant objective for many reasons. First, it helps gain a complete understanding of risk and vulnerability. Second, it is important to “focus on resilience directly, rather than vulnerability or poverty reduction”. Furthermore, Godschalk (2003) proposes two further reasons why importance should be attributed to resilience. Firstly, it creates the ability to accommodate change during disaster by designing cities that can cope effectively with contingencies, because the vulnerability of technological and social systems cannot be predicted. The second is the loss of people and property in resilient cities is lower than in areas without resilience (Godschalk, 2003). Thus, it is important to focus on resilience with regards to the capacity of a community to deal with disaster, rather than to concentrate on vulnerability to disaster or needs in an emergency situation (Twigg, 2007). In addition, building resilience enables the understanding of risk and vulnerability (Manyena, 2006). Thus, Cimellaro et al., (2010) argue that a community can approach high resilience through preparation, and by the reduction of vulnerability to disaster.

2.5.1 Community resilience

Resilience can operate at various levels, e.g. individual, community and state (Longstaff et al., 2010, Wilson, 2012). The concept of community is important within the context of disaster management (Marsh 2001). It is a contested concept, subject to various interpretations (Jigyasu 2002) as reflected by the various existing definitions (Jigyasu 2002,MacQueen et al. 2001, Marsh 2001). The one used in this study draws upon MacQueen et al., (2001) who argue that a community is “a group of people with diverse characteristics who are linked by social ties, share common perspectives, and engage in joint action in geographical locations or settings". Conversely, Marsh (2001) states that the term 'community' has a geographic and spatial dimension and can be used to describe everybody living in a specific area. However, he argues that: "... Going beyond the mere geographic or spatial description, community involves a sense of belonging and commitment. Time is involved in developing a community. It is a process and not a passive never changing concept. Community equals shared solidarity; its source is a common set of interests, values and attitudes".

The concept of community in the context of Saudi Arabia takes a further dimension in view of the importance of religion, customs and traditions.

Authors such as Rådestad et al, (2013) and Jirwe et al. (2009) highlight the necessity to inform all the experts used in the research about the importance of the study and to define the key terms used such as community. To this end, each expert was contacted by email, face to face or by phone with a view of explaining the purpose of the study, including its underpinning concepts, such as the one of "community". All experts were informed that there would be rounds of questionnaires following the principles of the Delphi method.

A disaster-resilient community is a community that can resist disaster and is able to take mitigating actions consistent with achieving the required level of protection (Cimellaro et al., 2010). Therefore, community resilience to disasters is fundamentally required for hazard mitigation, planning and recovery. Moreover, (Chandra et al., 2010a) emphasis that building community resilience is a basis for national health security. Furthermore, several studies posit a link between individual and community resilience (Bosher and Dainty, 2011, Paton et al., 2006). The importance of community resilience is reflected by the ability of a community to withstand and recover from disasters through undertaking activities that build community resilience (Chandra, 2011).

López-Marrero and Tschakert (2011) point out that support for community resilience in the face of disaster can be enhanced by: focusing on participants' knowledge; stressing the importance of developing a diverse set of flood management options; and promoting effective connections and collaborations between community members and emergency managers; thus, building high resilience. Maguire and Hagan (2007) indicate that a community with high resilience has the capacity to demonstrate three properties: resistance, recovery and creativity. These properties impact on how people respond to disasters (Maguire and Hagan, 2007).

Communities are always the 'first responders' to disasters; consequently several dimensions such as economic, social, and physical are critical to assessing a community's resilience (Joerin, 2012). Furthermore, research proves that communities have differing levels of resilience to disaster, and numerous authors have established indicators for resilience (Tierney, 2006, Cutter et al., 2003).

2.5.2 Community Resilience Frameworks

Several frameworks and models have been developed in order to assess the resilience of community; however, there is no agreed framework or model to measure and monitor community resilience to disasters (Norris et al., 2008, Cimellaro et al., 2010, Jordan and Javernick-Will, 2013, Ainuddin, 2012). For instance, Mayunga (2007) proposes a framework that uses five capital dimensions including social, economic capital, physical capital, which refers to the built environment, human capital, and natural capital which refers to natural resources (Figure 2-7).

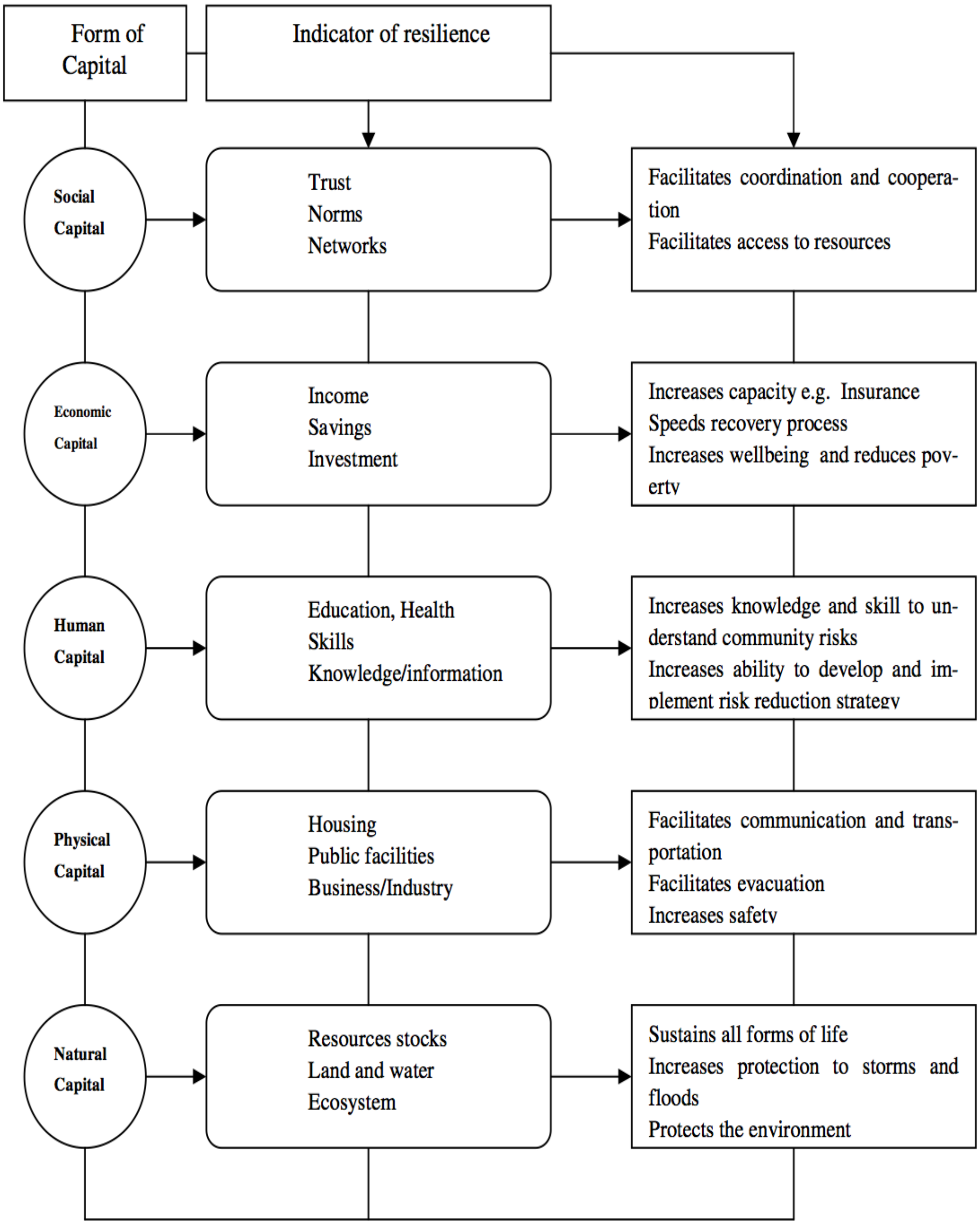


Figure 2-7: Community resilience framework that has been proposed by Mayunga (2007)

In contrast, (Norris et al., 2008) identify four sets of networked resources economic development, social capital, information and communication, and community competence that provide an approach to disaster readiness (Figure 2-8).

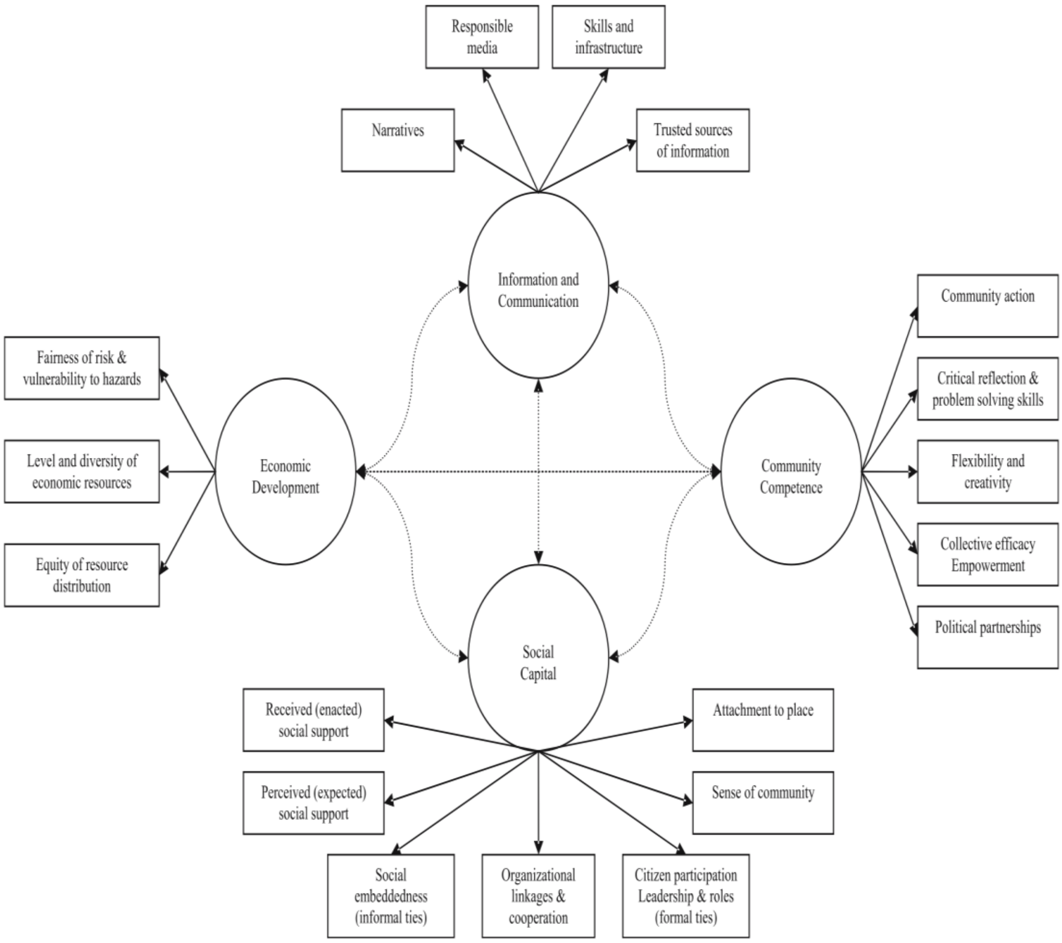


Figure 2-8: Community framework (adopted from Norris et al., 2008).

Meanwhile, Cutter et al. (2008) propose the 'Disaster Resilience of Place' (DROP) model to describe the relationship between vulnerability and resilience, which relies on six dimensions (Figure 2-9). Each of these dimensions has several indicators that can be used to measure disaster resilience at the community level (Cutter et al., 2008):

1) Ecological dimension including: wetlands acreage and loss, erosion rates, impervious surface, biodiversity, coastal defence structures;
2) Social dimension (demographics (e.g. age, gender), social networks and social embeddedness, community values-cohesion faith-based organizations);
3) Economic dimension (employment, value of property, wealth generation, municipal finance/revenues);

4) Infrastructural dimension such as lifelines, critical infrastructure transportation network (stock and age), commercial and manufacturing establishments;
5) Institutional (participation in hazard reduction programs (NFIP, storm ready), hazard mitigation plans, emergency services, zoning and building standards, emergency response plans, interoperable communications, continuity of operations plans); and
6) Community components (local understanding of risk counselling services, absence of psychopathologies (alcohol, drug, spousal abuse), health and wellness (low rates mental illness, stress-related outcomes), quality of life (high satisfaction).

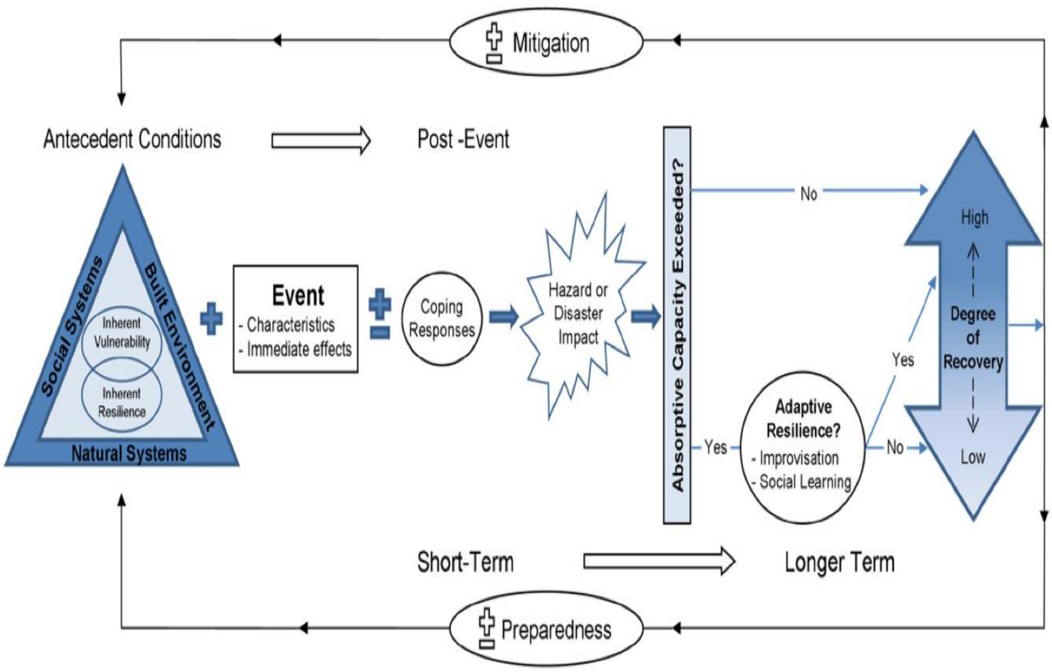


Figure 2-9: Disaster Resilience of Place (DROP) Model (Proposed by Cutter et al. 2008).

In contrast, the Climate Disaster Resilience Index (CDRI) framework considers five resilience-based dimensions in relation to climate-related disasters: natural; physical; social; economic; and institutional (Joerin and Shaw, 2011). In relation to the seismic resilience of communities (Bruneau et al., 2003) highlight four dimensions of community resilience—technical, organizational, social, and economic (TOSE) to quantify a measure of resilience. Whereas Stewart et al. (2009) propose a framework to improve the community resilience during disaster through partnership. They used public and private sector organizations, critical infrastructures and supply chains as main keys of this framework. This study did not cover the potential influences of pre-disaster preparedness and mitigation advantages; it covered only post-disaster response and recovery phases. However, this framework "begins to establish parameters within which issues of national resilience can be addressed" (Stewart et al., 2009, p. 359).

Recently, international efforts have focused on the Hyogo World Conference on Disaster Reduction held in 2005 in Kobe, Japan. The aim of the Conference was to review the progress in disaster risk reduction achieved since the Yokohama Conference of 2009 and to create plans up to 2015 (UNISDR, 2011). The Hyogo Framework for Action argues both the need for, and ways to build resilient communities, by: (a) integrating disaster risk reduction into sustainable development policies; (b) developing and strengthening of local capacity (institutions and mechanisms) for building hazard resilience; and (c) incorporating risk reduction into the design and implementation of emergency preparedness, response and recovery programs in affected communities (Innocenti and Albrito, 2011).

More specifically, Orencio and Fujii (2013) highlight criteria and elements that can be used to increase the resilience of coastal communities using paired comparisons within the Analytic Hierarchy Process (AHP). The criteria are identified under only four dimensions: environmental and natural resource management; sustainable livelihood; social protection; and planning regimes (Orencio and Fujii, 2013).

Overall, the majority of community resilience frameworks, to a degree, agree on a number of dimensions such as economic, social, physical and environmental, institutional and community competence (see Table 2-8). However, the researcher believes that an important pillar of the resilience of community to disaster is not covered by those frameworks as a separately dimension, namely the health dimension).

Table 2-8: Community resilience frameworks.

Framework	Dimensions	Criteria
Resilience Framework PEOPLES	❖ Population and demographics ❖ Environmental/ ecosystem ❖ Organized governmental services ❖ Physical/ infrastructure ❖ Lifestyle and community competence ❖ Economic development ❖ Social-cultural capital	➢ **Composition, Distribution, Socio-Economic status.** ➢ **Air quality, Soil, Biomass, Biodiversity.** ➢ **Legal and security services, Health services.** ➢ **Facilities, Lifelines.** ➢ **Quality of Life.** ➢ **Financial, Production, Employment distribution.** ➢ **Education services, Child and elderly care services.**
Community resilience as a metaphor, theory, set of capacities, and strategy for disaster	❖ Economic Development ❖ Social Capital ❖ Information and Communication ❖ Community Competence	➢ **Resource Volume, Level and Diversity of economic resource.** ➢ **Equity of Resource distribution, Network Structures and Linkages. Social Support whether received (enacted) or perceived (expected). Attachment to place. Sense of community. Citizen participation.** ➢ **Systems and Infrastructure for Informing the Public. Trusted sources of information. Responsible media. Communication and Narrative.** ➢ **Community action. Critical reflection and problem solving skills. Flexibility and creativity. Collective Efficacy (reflects trust in the effectiveness of organized community action) and Empowerment**
Coastal Community Resilience (CCR)	❖ Governance ❖ Society and Economy ❖ Coastal Resource Management ❖ Land Use and Structural Design ❖ Risk Knowledge ❖ Warning and Evacuation	➢ **Leadership, legal framework** ➢ **Communities are engaged in diverse and environmentally sustainable livelihoods resistant to hazards.** ➢ **Active management of coastal resources sustains environmental services and livelihoods and reduces risks from coastal hazards.** ➢ **Effective land use and structural design that complement environmental, economic, and community goals and reduce risks from hazards.** ➢ **Leadership and community members are aware of hazards and risk information is utilized when making decisions.** ➢ **Community is capable of receiving notifications and alerts of coastal hazards, warning at-risk populations, and individuals acting on the alert.**
Climate and Disaster Resilience Index (CDRI)	❖ Physical ❖ Social ❖ Economic ❖ Institutional	➢ **Electricity, Water supply, Sanitation, Solid waste disposal, Internal road network, Housing and land use, Community assets, Warning system and evacuation** ➢ **Health status, Education and awareness, Social capital** ➢ **Income, Employment, Households. assets, Access to financial service, Savings and insurance, Budget and subsidy** ➢ **Internal institutions and development plan, Effectiveness of internal institutions, External institutions and**

	❖ Natural	networks, Institutional collaboration and coordination ➢ **Hazard intensity, Hazard frequency**
Community Disaster (CDRCBA) Resilience: A Capital Based Approach	❖ Social Capital ❖ Economic Capital ❖ Human Capital ❖ Physical Capital ❖ Natural Capital	➢ **Trust, Norms, Networks** ➢ **Income, Savings, Investment** ➢ **Education, Health Skills, Knowledge/information** ➢ **Housing, Public facilities, Business/Industry** ➢ **Resources stocks, Land and water, Ecosystem**
A place-based Community Resilience Model (DROP)	❖ Ecological ❖ Social ❖ Economic ❖ Institutional ❖ Infrastructure ❖ Community competence	➢ **Wetlands acreage and loss, Erosion rates, Impervious surface, Biodiversity, Coastal defense structures** ➢ **Demographics (age, race, class, gender, occupation) Social networks and social embeddedness Community values-cohesion Faith-based organizations** ➢ **Employment Value of property Wealth generation Municipal finance/revenues** ➢ **Participation in hazard reduction programs (NFIP, Storm Ready) Hazard mitigation plans Emergency services Zoning and building standards Emergency response plans Interoperable communications Continuity of operations plans** ➢ **Lifelines and critical infrastructure Transportation network d stock and age Commercial and manufacturing establishments** ➢ **Local understanding of risk Counseling services Absence of psychopathologies (alcohol, drug, spousal abuse) Health and wellness (low rates mental illness, stress-related outcomes) Quality of life (high satisfaction)**
Healthy and resilient communities in hazardous environments		➢ **Capable agencies, leadership and politics, long term commitment, structural changes, societal changes, physical location, Age ,health, income, gender, social networks, attitudinal factors, re accumulation of capital, government policies, short term recovery, long term rehabilitation**
Climate-related Disaster Community Resilience Framework (CDCRF)		➢ **Electricity Water Sanitation and Solid waste** ➢ **Health Education awareness Social capital and preparedness** ➢ **Income and employment situation Household assets and Finance and saving**
Community resilience framework for an earthquake prone area in Baluchistan	❖ Physical ❖ Social ❖ Economic ❖ Institutional	➢ **Shelter. Housing age. Location.** ➢ **Educational level. Age. Health coverage.** ➢ **Housing capital. Diversity of income.** ➢ **Mitigation. Awareness building. Municipal services.**
The Community Assessment measures a community's resilience	❖ Community resources, ❖ Development of community resources. ❖ Engagement of community resources ❖ Active agents. ❖ Collective action. ❖ Strategic action. ❖ Equity. ❖ Impact.	

Health is mentioned as a factor under either social or community components in many of those community resilience frameworks. For example, Burton (2012) and Cutter et al. (2008) recognise health as a factor under the social dimension. Although Orencio and Fujii (2013) did identify 'health and well-being' as one of their framework's dimensions, as a result of the AHP outcomes, they considered that the dimension had a low rank and was consequently not selected in their final framework.

2.5.3 Community resilience and health

As discussed, communities are exposed to public health emergencies, which may occur from natural or human disasters such as environmental events, terrorism and pandemics that have vital influences on health and wellbeing of people (Zhong et al., 2013, Council, 2011). Furthermore, WHO (2012) emphasizes that both a resilient health system and the ability to manage risk play a crucial role in the effective management of disasters. In addition, several studies point out that the effectiveness of the health care system is one of the most important elements for reducing the impact of disasters and increasing community resilience (Zhong et al., 2013, Braun and Clarke, 2006).

However, Zhong et al. (2013) highlight that community resilience is a quite new concept related to health community. Nevertheless, Council (2011) stresses that considering all the risks to public health, which can distress the health, economy, and the effectiveness of community, is part of building community resilience. Therefore, the concept of healthcare resilience developed by Zhong et al. (2013). The dimensions in this framework are derived from other sectors related to health services. It has adapted four domains of disaster resilience community connectedness; risk and vulnerability; planning and procedures; and available resources from the Australian government disaster resilience model. These domains have integrated with four criteria of disaster resilience in the Multidisciplinary Center for Earthquake Engineering

Research (MCEER) framework including robustness, resourcefulness, redundancy and rapidity (see Figure 2-10). In addition, the WHO Expert Consultation outlined core health-relevant indicators of effective disaster management (Mitchell et al., 2013) as illustrated in Table 2-10

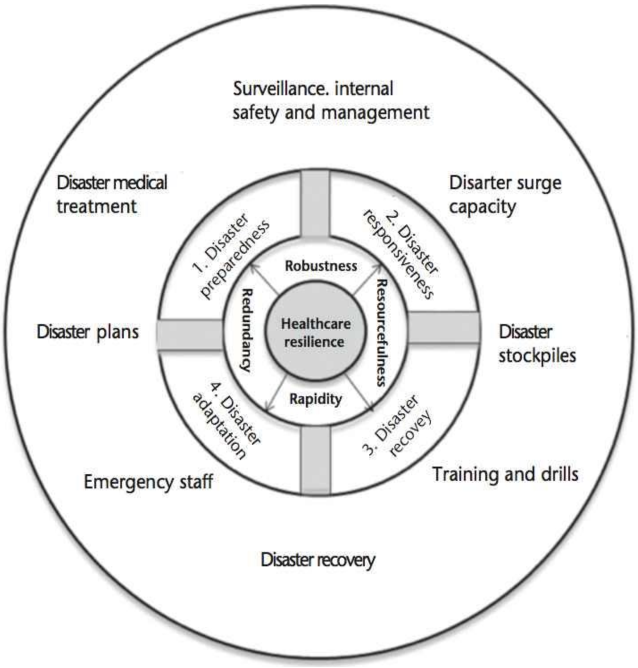


Figure 2-10: Conceptual of healthcare resilience

Source (Zhong et al., 2013)

Moreover, Gospodinov and Burnham (2008) argue that any members of a community including health workers, disaster managers, politicians, economists and the individual will consider the impact of disasters from their point of view (Gospodinov and Burnham, 2008). Therefore, the researcher, in this study, believes that the integration of the most important dimensions including social, economic, physical, and health with their criteria into a disaster management framework should help to reduce the impacts of disasters on public health.

Table 2-9: Fundamental health-relevant indicators of effective disaster management

Description	Possible indicator
Hazard impacts on human health and wellbeing	• Number and rates of disaster-related deaths, injuries, illness, malnutrition, and disability reported annually at national level;
Reporting of disaster data on health impacts at a national level	• Proportion of countries reporting disaster events on an annual basis in terms of deaths, injuries, diseases, missing persons, and disabilities;
Assessment of emergency and disaster-related risks	• Proportion of countries conducting annual multi-sector risk assessments that consider natural, technological, biological, and societal hazards as well as health and human vulnerabilities;
Safer, prepared and resilient health facilities	• Proportion of existing health facilities in hazard-prone areas that have been assessed and improved in terms of safety, security, and preparedness as well as for access to clean energy and water supplies, daily and in emergencies; • Proportion of new health facilities built in compliance with building codes and standards to withstand hazards, and with access to clean energy and water supplies, daily and in emergencies.
National health emergency risk management programmes	• Number of countries with a national programme for all-hazards that includes a multi-disciplinary health emergency risk management coordination body and regular budget with an emphasis on vulnerable populations.
Health services for disasters (health coverage indicator)	• Average population per health unit *(benchmark for this indicator is <10 000 people per unit*

Community resilience	• Members of the population are connected to one another and work together so they are able to:
	  ◦ Function and sustain critical systems, even under stress;
	  ◦ Adapt to changes in the physical, social, or economic environment;
	  ◦ Be self-reliant if external resources are limited or cut off;
	  ◦ Learn from experience to improve over time

Vaccination coverage	
Disease surveillance	• Indicator-based routine surveillance includes an early warning function for the detection of a public health event (i.e. a threat to public health) (IHR p33) • Event based system surveillance is established (IHR p 33) • Number of cases or incidence rates for selected diseases relevant to the local context • Case fatality ratio for most common diseases
International health regulations	• Number of countries meeting and sustaining International Health Regulations (2005)

Source: Adapted from WHO (2012) and Mitchell et al. 2013

2.5.4 Measuring community resilience

Assessing the community resilience to disasters allows a better understanding of the impact of disasters (Cutter et al., 2008, Ewing and Synolakis, 2011) and helps decision-makers to formulate effective strategies in all phases of the disaster (Tianzhuo and Linyan, 2014). Thus, Davis et al. (2005) stress the need for an assessment tool that can help communities identify and increase the criteria to building community resilience. However, there is a lack of instruments for assessing community resilience (Frankenberger et al., 2013). Nevertheless, Buckle (2006) highlights that components of resilience should be measured to assess the resilience of a community on the basis of how best to manage them(Buckle, 2006), while Kirmayer et al. (2009) point out that measuring community resilience is important to indicate the weakness of the community. In that respect, different authors have established various frameworks and indicators of resilience (Tierney, 2006, Cutter et al., 2003).

However, there is no agreed framework or model to measure and monitor community resilience to disasters (Norris et al., 2008, Cimellaro et al., 2010, Jordan and Javernick-Will, 2013, Ainuddin, 2012). Measuring community resilience remains a real challenge (Cutter et al., 2008). For example, Kusel (1996) conducted an assessment of community well-being in the Sierra Nevada to establish the most important aspects affecting community ability and to rank the components of community resilience (Kusel, 1996). Also, Colusso (1999) developed a framework of community resilience comprising four dimensions: people; organizations; resources; and community process (Colussi, 1999).

A number of authors indicate that assessing community resilience has become a difficult process due to several challenges (Mayunga, 2007, Frankenberger et al., 2013, Cutter et al., 2008), including (a) the dynamic and complex interactions of people with their communities and (b) the local environment and their societies. An additional challenge is the lack of method to identify the resilience of a community due to the absence of shocks or stressors during the life of a project (Frankenberger et al., 2013). One of the most important challenges highlighted by Frankenberger et al. (2013) is building a resilience index based on the weighting of each factor to reveal the impact of each on resilience.

However, it is important to measure community resilience over time (Kirmayer et al., 2009). A number of frameworks have been used to assess various forms of resilience (Leykin et al., 2013, Cutter et al., 2008). For instance, the Coastal Community Resilience (CCR) assessment tool is a powerful tool through which to begin the process of increasing resilience (U.S. Indian Ocean Tsunami Warning System Program, 2007). Similarly, Ewing and Synolakis (2011) point out that the Community Resilience Index (CRI) is an assessment tool for examining community resilience to coastal disasters (Ewing and Synolakis, 2011). A toolkit for health and resilience in vulnerable environments (THRIVE) has been also developed, which comprises 20 resilience elements across four areas built environment; social capital; services and institutions; and structural factors as a community assessment tool that can support communities enhancement factors (Davis et al., 2005).

2.6 Summary

Disasters cannot be prevented but their impacts can be mitigated through adapted disaster management plans. Several studies have highlighted that community resilience is a significant aspect in disaster management that helps rebuild an affected community to pre-disaster levels. At present, building a community with greater resilience to disasters is critical for facing the expected increase in disasters in the future (Ziyath et al., 2013). Therefore, a number of frameworks and models have been developed in order to build and assess the resilience of community; however, there is no agreed framework or model to measure and monitor community resilience to disasters (Norris et al., 2008, Cimellaro et al., 2010, Jordan and Javernick-Will, 2013, Ainuddin, 2012). In that respect, measuring community resilience is essential to identify the criteria that can be used to increase the resilience of a community.

This chapter highlights that disasters can cause health problems such as pandemics or biological risks, which can be classified into two types, a) primary and b) secondary disasters. The chapter concludes that integrating the most important resilience dimensions and criteria can mitigate the effects of these disasters.

The next chapter presents the methodological considerations used to establish a community resilience framework (CRDSA). The researcher, in this study, has adopted a mixed method strategy (including quantitative and qualitative research) involving: a literature review, public perception survey, Delphi survey and AHP. It also provides the methodology used to produce a new weighting system for each dimension and criterion. The weighting system provides an assessment tool that can be used for measuring community resilience to cope with disasters in Saudi Arabia.

Chpter:3 Methodology

Introduction

This chapter provides an overview of the methodology adopted to achieve objectives of the thesis. It outlines the procedures used to conduct the research, as well as discussing the philosophical assumptions underlying and the design strategies supporting this study. Furthermore, this chapter presents the approach used for collecting and analysing the data.

3.1 Research Definition and Classification of Research

This section develops an understanding of the research philosophy in order to help build the most suitable research design for answering the research questions. Research is defined as "the systemic and rigorous process of enquiry which aims to describe phenomena and to develop and test explanatory concept and theories, in order to contribute to a scientific body of knowledge" (Bowling, 2009, p.16).

A researcher must choose on a specific type of research before begins to conduct a research. Therefore, authors such as (Saunders, 2009, Bowling, 2009) segregate the types of research according to purpose, process and logic (see Table 1) as they argue it is important to understand the types of research based on purpose that will support justify the use of process and logic. The three type of researches highlighted in Table (3-1) are discussed in the greater detail in the following sections.

Table 3-1: Type of Research and its Classification

Type of Research	Classification
Descriptive and Exploratory	Purpose
Quantitative, Qualitative and Mixed	Process
Detective and Inductive	Logic

Source: Adapted from Saunders (2009) and Bowling (2009).

3.1.1 Descriptive Research

Descriptive research aims to describe phenomena or events or certain things. Descriptive research is common across a variety of disciplines including social study (Berg and Lune, 2004). Burns and Grove (2014) define descriptive research as "as the exploration and description of phenomena in real-life conditions" (Grove et al., 2014, p.201). However, Saunders (2009) notes this type of research may be an extension of exploratory or explanatory research. For the purpose of this study, descriptive research is used to obtain a picture of public perception of the risk of disaster in Saudi Arabia.

3.1.2 Exploratory Research

According to Ryerson (2007), "exploratory research often builds on secondary research such as reviewing available literature and/or data, or qualitative approaches such as informal discussions with consumers, employees, management or competitors, and more formal approaches through in-depth interviews, focus groups, projective methods, case studies or pilot studies" (De Haes and Van Grembergen, 2009).

The main goal of this type of research is to recognise key issues and variables. In this study, the opinions of experts who have experience in disaster management were explored. This research strategy also triangulates between different research methods: literature research, Delphi method research, the Analytic Hierarchy Process (AHP) method, and validation.

3.2 Research Philosophy Paradigms and Research Methods

However, the definition of research is rather broad, and does not take into account differences in the research philosophies. It is important to understand differences in philosophies of researches for a number of reasons. For example, the philosophy of research can guide the researcher in conducting the research (Bowling, 2009). It also helps the researcher to recognize what techniques are suitable for conducting the research (Bryman, 2012). Moreover, philosophy of research is an essential to explain the methods that have been used in the study (Bowling, 2009). Saunders et al., (2007) point out that philosophical background to research is based on a combination of different paradigms.

A paradigm can be defined as a “set of interrelated assumptions about the social world which provides a philosophical and conceptual framework for the organized study of that world” (Filstead, 1979, p. 34). Denzin and Lincoln (2000) argue that the researcher can use the paradigm as guideline in philosophical assumptions about the research (Denzin and Lincoln, 2000). Ng Hà (2011) indicates that researchers classify paradigms in a diversity of ways (Ng Hà, 2011). However, research can be designed based on the basic assumptions of any paradigms include the following dimensions: ontological, epistemological (Ponterotto, 2005, Wahyuni, 2012), and methodology that affect the way in which reality is examined (Wahyuni, 2012).

3.2.1 Ontological Assumptions

Ontology refers to the subject of the nature of reality (Ponterotto, 2005). Bryman (2012) suggests two positions of ontology which are objectivism and constructionism (Bryman, 2012). Objectivism is a position that emphasises that social phenomenon and their meanings have an existence that is independent of social actors (Bryman, 2012). In contrast, constructionism considers that social phenomena are developed in particular social contexts by social actors and reality of social world (Bryman, 2012).

3.2.2 Epistemological Assumptions

Epistemology refers to the ways in which knowledge is gained (Bryman, 2012). According to Bryman (2012) epistemological assumptions are divided into three positions: positivism, interpretivism (phenomenology) and realism, which are discussed in greater below. Roth and Mehta (2002) state that both terms positivism and interpretivism are used to varying degrees across the social sciences and the distinction between them is commonly accepted in the social sciences (Roth and Mehta, 2002). However, Liamputtong (2010), along with other researchers, notes that there are five paradigms of epistemology which can provide different concepts of reality and how to find out reality to those in nature and social (Liamputtong, 2010). This chapter focuses on the following paradigms:

3.2.2.1 *Positivism*

The concept of positivism is related to the idea of objectivism (Bryman 2012). The term 'positivism' was developed by the early nineteenth-century French philosopher Auguste Comte (Bowling, 2009). In this kind of philosophical approach, the study of social reality and beyond, is concerned with how the social world can be analysed along the lines of a natural science (Bryman 2012). In this paradigm, researchers are concerned with collecting data from a large social sample instead of focusing on the details of research (Muijs, 2010). According to Bowling (2009), the positivist approach in the social sciences assumes that human behaviour is the result of a reaction to external stimuli in the environment and therefore can be measured by using the deductive methods (Bowling, 2009). In this context, Bryman (2012) emphasizes that knowledge can be gained by gathering the facts which provide the basis of laws.

3.2.2.2 *Interpretivism*

This concept is the opposite of the positivist paradigm which was the orthodox position for many decades (Bryman, 2012). Interpretivism can be seen as "predicated upon the view that a strategy is required that respects the differences between people and the objects of the natural sciences" (Bryman, 2012:30). This paradigm argues that the subjective position of researcher and research community are important for the interpretation of reality (Saks and Allsop, 2012, Bryman, 2012). (Saks and Allsop, 2012) stress that the interpretivism paradigm is based on qualitative research and uses methods such as interviews, focus groups and observations.

3.2.2.3 *Pragmatism*

Saunders (2009) stresses the debate between positivism and interpretivism often appears to portray that research should be undertaken on the basis of a choice between the two. However, the pragmatism paradigm, which has seen a recent revival, combines both philosophies. Giacobbi Jr et al., 2005, p.19) define pragmatism, which dates back to the work of Peirce (1984) and James (1907), as "a philosophy of knowledge construction that emphasizes practical solutions to applied research questions and the consequences of inquiry" (Giacobbi Jr et al., 2005). It is a paradigm that provides the fundamental philosophical approach for mixed methods research (Saunders et al., 2007).

Saunders et al (2009) plots the three paradigms of social science research, positivism, interpretivism, and pragmatism, against research philosophies in management research (Table 3-2).

Table 3-2: Comparison of three Research Philosophies in management research

	Positivism	Interpretivism	Pragmatism
Ontology: ***the researcher's view of the nature of reality or being***	External, objective and independent of social actors	Socially constructed, subjective, may change, multiple	External, multiple, view chosen to best enable answering of research question
Epistemology: ***The researcher's view regarding what constitutes acceptable knowledge***	Only observable phenomena can provide credible data, facts. Focus on causality and law like generalisations, reducing phenomena to simplest elements	Subjective meanings and social phenomena. Focus upon the details of situation, a reality behind these details, subjective meanings motivating actions	Either or both observable phenomena and subjective meanings can provide acceptable knowledge dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data
Data collection techniques most often used	Highly structured, large samples, measurement, quantitative, but can use qualitative	Small samples, in-depth investigations, qualitative	Mixed or multiple method designs, quantitative and qualitative

Source: (Saunders, 2009)

3.3 Methodological Assumptions

Methodology refers to the strategy or plan for conducting research through the use of particular methods (Saunders et al., 2007, Bryman, 2012) and the knowledge of research methodology can be useful in several fields such as government, community development and social (Kothari, 2004). Each of the paradigms discussed above have certain research approaches which can be used to answer the research questions.

3.4 Research Strategies

In this section attention is turned to the research strategies that may employ in a research. The most popular classification of research methods is into qualitative and quantitative. Thus, Bryman (2012) points out that there are two basic strategies to research,, quantitative and the qualitative, and it is helpful to distinguish between them in order to resolve he methodological issues. Bryman (2012) summaries three fundamental differences in qualitative and quantitative strategies, as seen in Table (3-3).

Table 3-3: Fundamental Differences between Qualitative and Quantitative Research Strategies

Orientations	Qualitative	Quantitative
Principle orientation to the role of theory in relation to research	Inductive; generation of theory	Deductive; testing of theory
Epistemological orientation	Interpretivism	Positivism
Ontological orientation	Subjectivism/constructivism	Objectivism

Source: Bryman (2012: 36)

Each strategy can be used for any research type such as descriptive and exploratory research (Yin, 2003). However, some clearly belong to the deductive approach which is related to quantitative research, while others are suited to the inductive approach which is associated with qualitative research (Bryman 2012). Saunders et al., (2007) summarise the main differences between deduction and induction approaches as seen in Table (3-4). Nevertheless, Roberts (1989) notes that both inductive and deductive can be used in one research. In addition, Saunders et al. (2007) state that combination of both of these approaches is useful not only at the level of research, but at the level of expertise. According to Lindell (2013), disaster studies need both inductive, which starts with data with aim of finding theory, and deductive, which starts with a theory with the aim of expecting about data, approaches for continuity in progress (Lindell, 2013).

Table 3-4: Major Differences between Deductive and Inductive Approaches to Research

Deduction emphasises	Induction emphasises
• scientific principles • moving from theory to data • the need to explain causal relationships between variables • the collection of quantitative data • the application of controls to ensure validity of data • the operationalisation of concepts to ensure clarity of definition • a highly structured approach • researcher independence of what is being researched • the necessity to select samples of sufficient size in order to generalise conclusions	• gaining an understanding of the meanings humans attach to events • a close understanding of the research context • the collection of qualitative data • a more flexible structure to permit changes of research emphasis as the research progresses • a realisation that the researcher is part of the research process • less concern with the need to generalise

Source: Adapted from Saunders et al. (2007,p. 127).

3.4.1 Quantitative Research

Quantitative research is defined by Polit and Beck as "the investigation of phenomena that lend themselves to precise measurement and quantification, often involving a rigorous and controlled design" (Polit and Beck, 2010,p. 565). Thus, Saunders (2009) emphasises that quantitative research is essentially about collecting numerical data in order to explain a particular phenomenon. Similarly, Bryman (2012) states that quantitative research is a research strategy that stresses quantification the data collection techniques and analysis. It requires a deductive approach in relation to hypotheses that are drawn from theory (Bryman, 2012). Quantitative research has a diversity of different designs such as:

- Surveys, including descriptive and analytic surveys,

- Experimental design (quasi-experiments), and
- Classic experiments (studies that have control groups and experimental groups) (Bryman, 2012; Saunders et al., 2007).

3.4.2 Qualitative Research

Qualitative research is defined by Polit and Beck as the "investigation of phenomena, typically in an in-depth and holistic fashion, through the collaboration of rich narrative materials using a flexible research design" (Polit and Beck, 2010, p. 565). In this case, Bryman (2012) emphasises that theory is the outcome of the qualitative research. This type of research is based on text rather than data (Saunders et al., 2007). Moreover, Bryman (2012) notes that qualitative researches tend to be inductive and interprevitism. According to Bryman (2012), there are different types of research methods which are associated with qualitative research such as ethnography (observation), qualitative interviewing, focus groups and case studies.

Table (3-5) illustrates the differences between qualitative and quantitative research approaches. However, Bryman (2012) believes that it is also important to take into account the similarity of these strategies. Hardy (as cited in Bryman, 2012) highlights these similarities as:

- Both strategies attempt to reduce of the amount of data.
- Both are essentially concerned with answering the research questions.
- Both focus on linking the results to the literature review.

Table 3-5: Comparison of Qualitative and Quantitative Strategies

Quantitative	Qualitative
Testing of hypotheses and theories	Development of hypotheses and theories
People's behaviour	Action based
Large number of size sample	Small number of size sample
Numbers	Words
Generalisation	Contextual understanding
Structured	Rich, deep data
Hard, reliable data	Unstructured
Static	Process
Macro	Micro
Artificial settings	Natural settings
Theory testing	Theory emergent
Researcher distant	Researcher close
High reliability	Low reliability
Low validity	High validity

Source: Adopted from Saunders et al. (2007) and Bryman (2012).

3.4.3 Mixed Methods

The mixed method approach attempts to strengthen the research design by compensating for weaknesses in one approach by the strengths of the other (Hoepfl, 1997). Mixed methods research is increasingly being employed in several fields (Bowling, 2009, Bryman, 2012). Johnson and Onwuegbuzie define mixed methods research as "the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study" (Johnson and Onwuegbuzie, 2004). Therefore, this strategy can be classified as "the third major research approach or research paradigm, along with qualitative research and quantitative research" (Johnson et al., 2007, p.112). As Bryman (2012) argues the mixed methods strategy, which can use both deductive and inductive approaches, might provide better understanding of the event than using one method.

The main strength of mixed methods is the opportunity to use different approaches to provide a better understanding of an event than would be possible by just using a single method (Bowling, 2009). Moreover, (Saunders, 2009) points out that there are two main advantages for choosing multiple methods in the same research. First, using different approaches can achieve different objectives in a study improving confidence in the findings. The second advantage is the possibility of using triangulation which refers to the use of more than one method in the same study such as interviews and a questionnaire. Similarly, Teddlie and Tashakkori (2003) argue that the benefits which can be gained from mixed methods research are to: answer research questions that other methodologies cannot;;offer stronger inferences; and provide the opportunity for presenting a greater diversity of divergent views (Tashakkori, 2003).

Bryman (2012) categorises several ways of combining qualitative and quantitative research in a mixed methods such as triangulation, offset, different research questions and instrument development (for more detail see Bryman, 2012, p. 633-634). Bowling (2009) highlights other approaches including case study, consensus methods, action research and rapid appraisal techniques and document research.

Stalling (2006) asserts that disaster research needs to use different research methods including mixed methods. Therefore; this thesis employs a mixed method approach using surveys, Delphi survey and Analytic Hierarchy Process (AHP).

3.5 Data Collection Methods

The data collection method is arrived at after identifying the problem and defining the research design. Therefore, in this section, overview of these methods will be explained. There are two types of data collection to be considered by the researcher, primary and secondary data (Kothari, 2004). Primary data refers to the data that the researcher collects directly for the first time, whereas secondary data are those which have already been published or which have been collected and recorded (Kothari, 2004). In view of this difference, there is a difference in the methods of data collection. For example, there are several methods which can be used for collection of primary data. Kothari (2004) identifies some of them including: interviews, observation, questionnaires and schedules. In contrast, secondary data can be collected through sources such as books, periodicals, journals, or from organisations that have their own data or organisations which are specialized in collecting and recording data and information (Kothari, 2004), such as the Ministry of Planning and the Central Agency for Public Mobilization and Statistics. In this study, both primary data (public perception survey) and secondary sources are used.

3.6 Sampling

Kothari proposes the definition of sampling as “the selection of some part of an aggregate or totality on the basis of which a judgement or inference about the aggregate or totality is made”. (2004, p.152). According to Kothari (2004), there are many reasons for using sampling including the following:

- it can save time and money;
- it may allow more accurate measurement;
- it is the only way when a test involves the destruction of the item under study; and
- it assists to estimate the sampling errors which can support to gain information of the population.

There are many sampling techniques which are the scientific procedures of selecting those sampling units. There are two types of sampling techniques available to the hazards’ researcher (Table 3-6). The first is probability sampling which associated with quantitative research while the second is non-probability sampling that associated with qualitative research (Bird, 2009 Bowling, 2009; Bryman, 2012). As Kemper et al. (2003) point out both these types of sampling can be used with either quantitative or qualitative researches and are also common in mixed methods research (Kemper et al., 2003).

Table 3-6: Types of Sampling Available to the Hazards' Researcher

Sampling technique	Description
Probability	
· **Simple random**	Gives all people within a target population an equal chance of being selected. Methods used to generate this random sample are by lottery, computer etc
· **Cluster**	The first groups of clusters are selected and then individual participants are selected from these groups
· **Longitudinal**	The same participants from an original sample are studied on more than one occasion
· **Spatial**	Sampling people who have temporarily congregated in a specific space
Non-Probability	
· **Accidental**	All people that the researcher accidentally meets during a certain period are considered for the investigation
· **Purposive**	Participants who are thought to be relevant to the research are purposively chosen
•**Quota**	A "quota" of participants to be chosen from a specific population group is predetermined
•**Snowball**	The first participant recommends other people who meet the research criteria

Source: (Bird, 2009).

- **Snowball Technique**

Snowball is a non-probability sampling technique (Bird and Dominey-Howes, 2008b), which allows researchers to penetrate an anonymous community and identify and recruit key informants (Bird, 2009). It is useful in situations where it is difficult or expensive to locate respondents in the study population (Singh et al., 2007). It can be used "when the researcher needs to focus upon or to reflect relationships between people tracing connections through snowball may be a better approach than conventional probability sampling" (Coleman cited in Bryman, 2012, p. 203). For example, according to traditions in Saudi Arabia recruiting female respondents is difficult (Zabin, 2010). Moreover, snowball sampling has been found to be economic, efficient and effective (Singh et al., 2007). Data are collected by recognising participants through direct contacts, who are then asked to recruit others (Sadavoy et al., 2004). This process continues until a target sample size is reached. It is often used with small sized samples when there is a need to choose participants (Bryman, 2012). Therefore, it is employed in the second stage of this research during Delphi method and in the third phase to validate the framework.

3.7 Research Design and Data Collection

This thesis stems adopts a mixed method strategy (including quantitative and qualitative research) and comprise a literature review, web survey, Delphi survey and AHP. The design is divided into three phases (see Fig.3-1), following the literature review which determines the research gap in relation to disaster management. The researcher uses a quantitative strategy to establish the public's opinion of the risk of disasters in Saudi Arabia because there is a lack of information on this subject. In the second phase, the Delphi method, which is a qualitative strategy, and AHP are employed to create a framework of community resilience to disaster in Saudi Arabia. In the final stage, the researcher validates the framework in a case study based on Hajj season by using interview and observation tools.

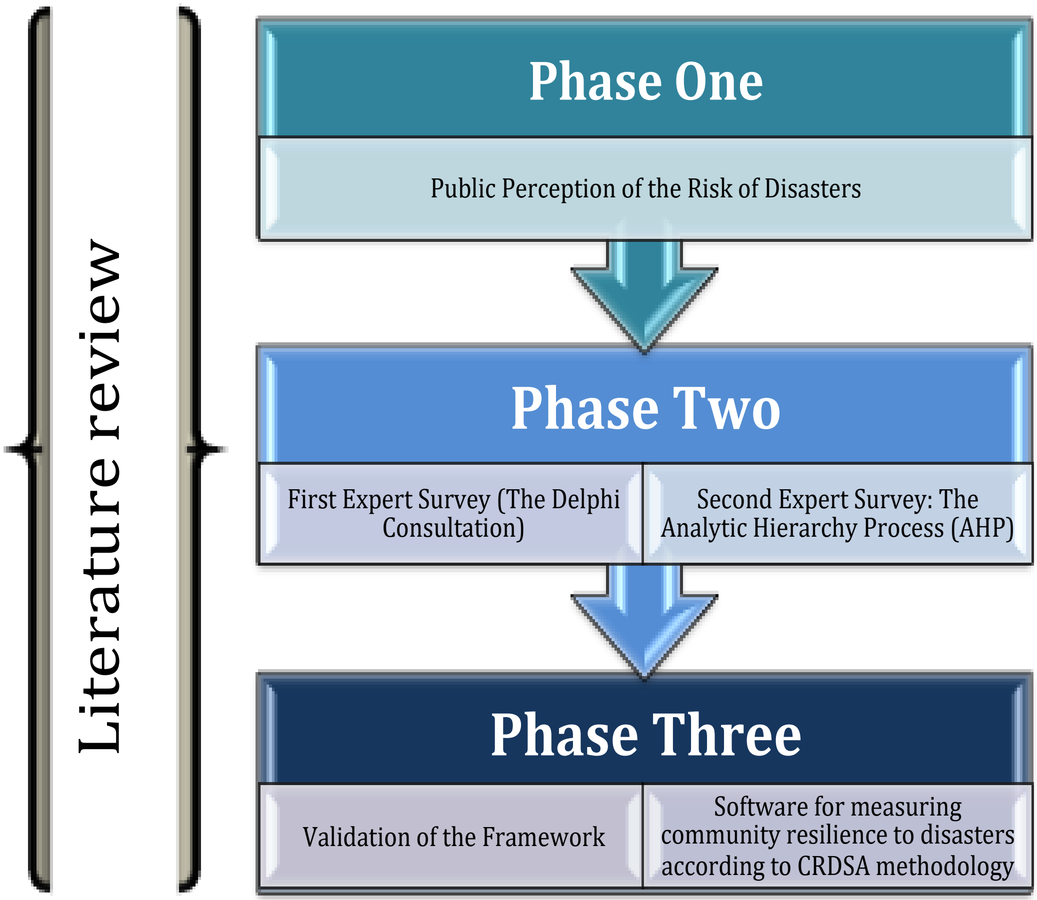


Figure 3-1: Strategy of the Thesis

3.8 Ethical Approval

Saunders et al., 2007 point out that ethics refers "to the appropriateness of your behaviour in relation to the rights of those who become the subject of your work, or are affected by it" (2007, p. 178). Ethical approval is required in relation to the research topic, research design and gaining access, collecting, processing and storing to the research data, in a correct and responsible way (Saunders et al., 2007)..

According to the policy of the Cardiff University, all research involving human participants, human material or human data is subject to formal ethical review and approval before such work can start. Therefore, the ethical approval was obtained from the "Ethical Approval Committee" at Cardiff University (reference No. RC12-015).

3.9 PHASE ONE: Public Perception of the Risk of Disasters.

The rise of research related to disaster risk is based on several aspects, such as changes in cultural attitudes toward disaster which are related to stages of development within the community (Dynes, 1988). Other reasons include differences among people as to the risk of disaster and to the ways in which responsibilities for disasters are institutionalized (Dynes, 1988) . Lindell (2013) emphasises that it is essential to identify all variables that are needed for enhanced disaster risk management.

Analysing public perceptions to disaster risk is fundamental for this research and focuses on four main objectives:

1. Assessing the population's general knowledge of disasters;
2. Assessing the population's general knowledge of biological threats;
3. Examining how factors such as faith and personal responsibility can affect perception of the risk of disasters; and
4. Determining the main information sources regarding the risk of disasters

(Alshehri et al., 2013).

The method used to collect information from a population to measure their attitudes and knowledge of such an event is the survey (Bowling, 2009). Lindell (2013) notes surveys have been conducted in several researches to study subjects related to disasters such as perception and response and emergency and preparedness to disasters. Surveys usually can be undertaken through techniques such as questionnaires (Bowling, 2009, Bryman, 2012).

3.9.1 Questionnaire Survey

Various techniques can be used to examine public perceptions of hazard and risk (Bird, 2009, Bird and Dominey-Howes, 2008). In order to gain information about the public's understanding in relation to a particular hazard type, it is essential to design information gathering techniques such as questionnaire surveys (Bird, 2009; Bird & Dominey-Howes, 2008). The questionnaire survey is one of the most popular instruments to gather numerical data in disaster studies (Lindell, 2013). Figure (3-2) illustrates the steps in this phase.

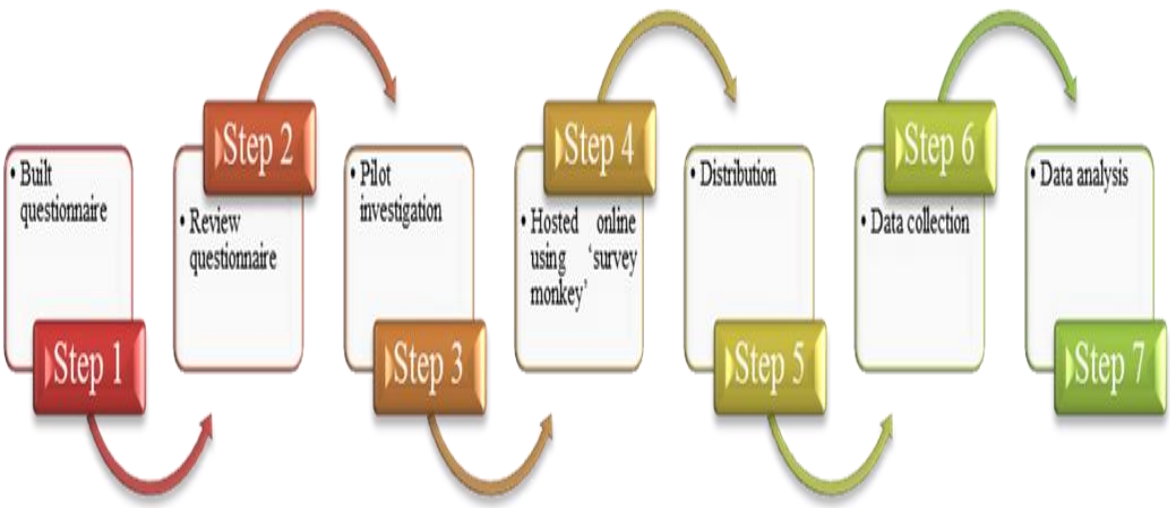


Figure 3-2: The Steps Involved in Phase One: Understanding Public Perception

3.9.2 Questionnaire Design

A well-designed questionnaire is important as the design will affect the type of responses obtained (Bowling, 2009). Leung (2001) clarifies two main objectives of designing a questionnaire: to ensure a high return from the respondents; and to gain accurate answers related to the survey (Leung, 2001) . To achieve these objectives it is important to focus on aspects such as simplicity, a clear presentation, unambiguous wording, and keeping questions and answers together (Bowling, 2009; Bryman, 2012).

The questionnaire survey was structured as follows:

- Classification questions to determine gender, age, level of education, employment status;
- Responsibility questions to determine what individuals would do to cope with disasters;
- Knowledge questions to determine what factual information a person has about the risk of disasters;
- Perception questions to understand the thinking and interpretive processes of people and to explore their emotional responses to their experience about the risk of disasters.

The design of the questionnaire was informed by a number of related surveys: (Bird & Dominey-Howes, 2008; PRRI, 2011; Spence et al., 2010). The questionnaire comprised 35 predominantly multiple-choice questions, many of which were in multiple parts (Alshehri et al., 2013) (as seen in appendix A).

3.9.3 Presentation of Responses

Bowling (2009) stresses the importance of clarity in the questionnaire by using a clear question form. This, in turn, helps to improve the quality of the answers and not distract responders.

There are two types of questions: open-ended and closed questions (Leung, 2001, Bryman, 2012). In an open-ended question, the respondents express the answer in their own words (Bryman, 2012), while in closed questions, respondents have to answer from the available options that have been given (Bryman, 2012). Leung (2001) notes it is possible to use both types questions in a survey. Therefore, to avoid restricting or guiding responses to closed questions with an ordinal selection, the option “other, please specify” was offered where applicable.

One of the most popular tool for measuring the perception is the Likert scale (Saunders, 2009). This technique was developed by a sociologist at the University of Michigan named Dr. Rensis Likert (Christensen, 2009). In this study, Likert scale (five points), which is the most commonly adopted type (Bryman, 2012), were used in order to gain the information from the participants. The scale ranged from “Completely Disagree” to “Completely Agree” with “Neither Agree nor Disagree” in the middle (Fig. 3-3).

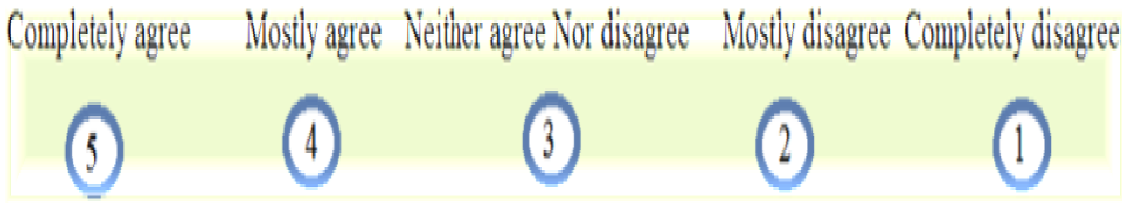


Figure 3-3: Likert 5-point Scales

3.9.3.1 Conducted Survey

One of the questionnaire’s types is self-administered questionnaires that are completed by the respondents. These questionnaires can be delivered by using methods such as the internet (internet-mediated questionnaires) or intranet (intranet-mediated questionnaires), posted to respondents (postal or mail questionnaires), or delivered individually to each participant by hand then collected when completed (Fig.3-4) (Saunders et al., 2007).

Internet- and intranet-mediated questionnaires (electronic questionnaires) are used in this study, because the large size of Saudi Arabia, as noted previously, makes it difficult to cover all regions effectively. The method presents advantages such as cost-effectiveness, time to consider responses, and overall higher response rates (Bird, 2009, Saunders et al., 2007). Similarly, Bryman (2012) summarises the advantages of online surveys as low cost, faster response, attractive formats, fewer unanswered questions and better data accuracy, particularly in the case of Web surveys. However, there are a number of drawbacks such as restricted to online populations, requires motivation and multiple replies.

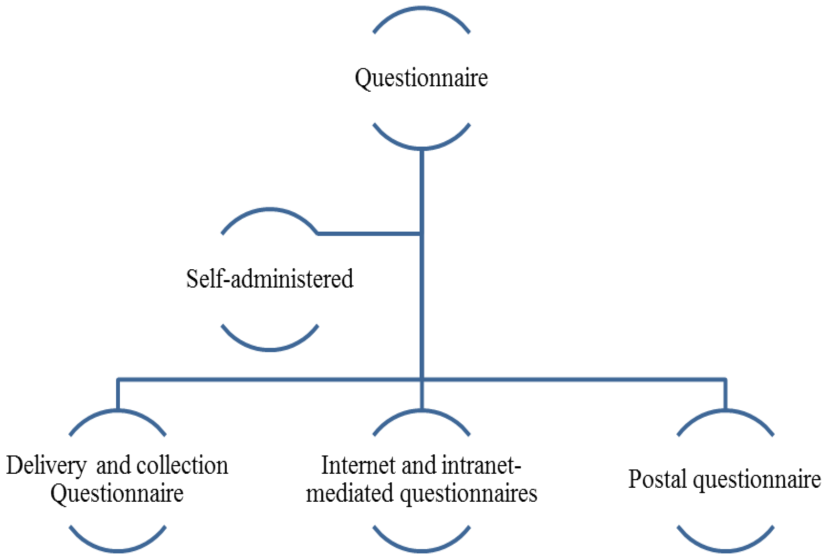


Figure 3-4 : Types of Questionnaire by Method of Delivery

Source: Adapted from Saunders et al. (2007)

In this research, once the ethical approval was obtained, the survey questionnaire was hosted online using "SurveyMonkey" (www.surveymonkey.com) in both Arabic and English. SurveyMonkey.com™ is an online software tool for creating and administering web-based questionnaires, the researcher used the GOLD professional plan that allows unlimited questions and unlimited responses, which at the time of writing charged £299 per year (SurveyMonkey.com 2013). The particular type of SurveyMonkey was chosen as result of its features which reduce certain of the disadvantages discussed above. For example, one of its features is 'Set Collection Restrictions' that restrict responses by IP address (SurveyMonkey.com 2013).

The link was distributed via email and Facebook with an invitation and link posted on the most popular community Facebook pages. The snowball sampling technique was used to gain the target sample size (male and female) across the 13 regions in Saudi Arabia between March and June 2012 (Alshehri et al., 2013). The final version of the questionnaire took approximately 20-30 minutes to complete which was deemed acceptable for the participants.

3.9.3.2 Pilot Study

A pilot study is usually used for testing the questionnaire for any weaknesses (Kothari, 2004) and also to ensure that the questionnaire operates effectively (Bryman, 2012). Moreover, it is essential for providing suggestions that help the researcher to make the necessary adjustments to questionnaire including clarifying questions (Saunders et al., 2007). Kothari (2004) argues that there are three main points on which the researcher should focus during the pilot study: general form, question sequence and question formulation and wording.

The questionnaire was piloted by 20 participants, which is considered as an acceptable number (Saunders et al., 2007), during January and February 2012. Furthermore, the questionnaire was arbitrated by Dr. Khalied Albraithn, Assistant Professor, at King Abdul Aziz City for Science and Technology, Saudi Arabia, who reviewed and clarified the final version of the questionnaire in Arabic. Therefore, adjustments were made to the survey tool to correct and clarify items for the final version in both English and Arabic (Alshehri et al., 2013).

3.9.3.3 Response Rate

Response rate is the proportion of people who respond to the survey (SurveyMonkey.com 2013). The response rate is an essential feature in measuring the value of research findings and high response rates are considered to be more beneficial (Baruch and Holtom, 2008). According to several studies, there are wide variations in the rates of response as result of the change and the expansion of Internet access (Sax et al., 2003). Couper et al. (2001) indicate the low of non-response measurement error can be reduced by using Web surveys (Couper et al., 2001).

As result of using SurveyMonkey in this study, the researcher calculated the response rate by using the following equation (SurveyMonkey.com 2013):

Response Rate = Number of Completed Surveys / Number Who Opened the Survey x 100%.

The number of participants who opened the survey was 1731 and the respondents who completed it numbered 1164. Consequently, response rate of this study is 67.24% which is a significant accomplishment (McColl et al., 1998).

3.9.3.4 Data Analysis

Statistical Package for the Social Studies (SPSS) is probably the most commonly available and most widely used comprehensive statistical computer package available to academic researchers in the social and behavioural sciences (Bryman, 2012; Landau & Everitt, 2004). There are versions of SPSS for Windows (Landau and Everitt, 2004). Descriptive statistics and all data analyses in this phase of the study were conducted using SPSS version 18.0, which is called PASW Statistic 18.

SurveyMonkey has an advanced spreadsheet export facility, which is a suitable option if the data is in a numerical format (SurveyMonkey.com 2013). Moreover, one of the main advantages of using SurveyMonkey Gold plan is that uploading data to SPSS takes seconds. In addition, this option makes it easier to enter and to save data free from errors; hence, it saves time, effort and money. Therefore, the researcher used SurveyMonkey Gold plan to convert all data automatically with coding. However, the researcher reviewed all data before starting the analysis to ensure there were no errors.

3.9.3.5 Data Quality

Questionnaire data need to be checked for reliability before being analysed in order to establish that the participant's selection is constant and the questionnaire structure is consistent (Deng et al., 2011). Hassad (2010) notes that items with an alpha correlation of 0.70 and higher are deemed to be acceptable (Hassad, 2010); however, for other studies the Cronbach's alpha (α) of scale 0.6 and over is classed as an adequate level of reliability (Hair J.F et al., 2006). The overall reliability of the items in this questionnaire according to Cronbach's alpha (α) is acceptable at 0.78.

Following on from the findings in phase one, which are presented in chapter 4, and the literature review the researcher moved to the second phase in order to establish a community resilience framework in context of Saudi Arabia. Hence, the following section focuses on the methods that used in that phase.

3.10 PHASE TWO: Establishment of a Community Resilience Framework.

The main methodology comprises the Delphi Method and AHP which are described in detail below.

3.10.1 First Expert Survey (The Delphi Consultation)

The research methodology in this phase is designed to answer the research question "What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?" This research question is addressed through a survey based on the concept of Delphi. As Bowling (2009) stresses the Delphi survey technique can be used in a mixed methods approach. In this research, Delphi method is used as it "lends itself especially well to exploratory theory building on complex, interdisciplinary issues, often involving a number of new or future trends" (Akkermans et al., 2003).

The Delphi method, a multi-round survey of experts, has been widely used to obtain the consensus opinion of experts (De Villiers et al., 2005, Okoli and Pawlowski, 2004, Verhagen et al., 1998). It is considered as an important data collection method for gathering information from experts in the topic of interest (Hsu and Sandford, 2007) and how to evaluate those views and include the possibility of changing their opinions (Kennedy, 2004). To this end, the study follows the Delphi process of anonymous rounds of survey with feedback after each round. Once the criteria, scale and format of the questionnaire were drawn up, a pilot survey was conducted, involving 10 participants, in order to test the ease of taking the survey. As a result of the pilot, a number of changes were made. Thereafter, the survey was conducted online through SurveyMonkey® (www.surveymonkey.com) in three rounds from 15 April to 15 June 2013.

3.10.1.1 Delphi Method

The Delphi technique is a method used to gather consensus of experts on a certain issue (Yousuf, 2007). The Delphi method has been developed since the 1950s and is widely used in various fields including disaster research (Jordan and Javernick-Will, 2013). It has its origins in the American business community, and has since been widely accepted in many industrial sectors including health care, defence, business, education, information technology, transportation and engineering (Skulmoski et al., 2007).

This concept refers to the legend of the Greek Delphi oracle (Marchais-Roubelat and Roubelat, 2011). "Delphi may be characterised as a method for structuring a group communication process so that the process is effective in allowing a group of individuals, as a whole, to deal with a complex problem". (Linstone and Turoff, 1975). It is a systematic method, which involves a number of experts in a process to derive consensus in a group on a specific topic (Adler and Ziglio, 1996). The valuable features of Delphi study are that (a) it guarantees the anonymity of experts; (b) uses repetition to strengthen the data; (c) provides organised feedback; and (d) allows statistical analysis of the experts' responses (De Vet et al., 2005, Pill, 1971, Bailie, 2011). Loo (2002) classifies five major characteristics of the Delphi method as:

1. The panel of experts should represent a broad spectrum of opinion on the topic or issue being examined.
2. The anonymity of participants.
3. The researcher-prepared questionnaires and feedback reports for the experts' panel during the Delphi process.
4. It is an iterative process, which has many rounds of questionnaires and feedback reports.

5. Prepare a final report containing the results of Delphi method, the forecasts, policy and program options with their strengths and weaknesses, action plans for developing and implementing the policies and programs and recommendations to higher authorities (Loo, 2002).

3.10.1.2 Types of Delphi Method

There are many types of Delphi studies (Hanafin, 2004). According to several studies (Hanafin, 2004, Van Zolingen and Klaassen, 2003, Keeney et al., 2006), the main types are:

3.10.1.2.1 The Classical Delphi

This type of Delphi method is a one in which data is collected from experts in a number of rounds and the results of each round are fed back to the experts until consensus is achieved. The core aim is to reach consensus with anonymity of participants, through an iteration process (Van Zolingen and Klaassen, 2003).

3.10.1.2.2 The Policy Delphi

This type of Delphi is similar to the Classical Delphi. However, Policy Delphi is widely used in social and political issues and is more suitable for application in the social sciences. The aim is to create policy alternatives by using a structured public dialogue (Van Zolingen and Klaassen, 2003). They classify four features of this type of Delphi including: selective anonymity; iteration controlled feedback; polarized group response; and structured conflict.

3.10.1.2.3 The Decision Delphi

This type of Delphi method seeks to achieve a decision-making outcome in a specific field, through the coordination of thoughts about this field, taking into account all the developments and changes that can occur in the future of this field (Rauch, 1979). The Decision Delphi is more general and more comprehensive than the previous types

(Rauch, 1979). According to Van Zolingen and Klaassen (2003), there are five distinctive features of this type which are: quasi-anonymity (the experts are known by name to everybody from the beginning of study); iteration; feedback; statistical group response; and constancy in responses among the experts on a specific issue.

3.10.1.3 Panel Selection

An important component in the Delphi method is the selection of experts as the results rely on their judgement (Woudenberg, 1991). Four ‘expertise’ requirements should be taken into account: a) knowledge and experience of the field of study; b) ability and willingness to participate; c) adequate time to participate; and d) effective communication skills (Adler and Ziglio, 1996). Thus, the criteria include: number of years of experience; number of publications; and other expert qualifications. For this panel, a list of people with expertise in the disaster management domain was drawn up. These experts were asked to identify others, in relevant fields. This resulted in a panel of 71 experts from ten different countries, each with at least five years’ experience in disaster management and a relevant degree.

It is recommended to involve experts with various expertise and geographic locations in the Delphi experts’ panels (Keeney et al., 2006, Rådestad et al., 2013). The main motivation is to capture non-context specific issues that may be overlooked by local participants, and thus ensure a more holistic, objective and positivist grounding of the resulting framework (Jeste et al., 2010). Moreover, one of the criteria with regard to the selection of the experts’ panel is that it should represent variety within the relevant discipline (Keeney et al., 2001, Hill and Fowles, 1975). Therefore, the experts were recruited from a variety of disciplines in disaster management, locally and internationally, with an in-depth understanding of local and wider issues. Moreover, all international experts: (a) understand or share the same local cultural and religious values and many have worked previously in Saudi Arabia; and (b) contribute their wider international experience acquired through extensive work in developed countries and relevant international organizations. Forty nine experts accepted the invitation while only 40 are completed all three rounds (42% hold a PhD with the rest holding either an MSc or Bachelor degree). Authors such as Rådestad et al. (2013) and (Jirwe et al., 2009) highlight the necessity to inform all experts used in the research about the importance of the study, and to define the key terms used, such as “community”. To this end, each expert was contacted by email, face-to-face or by phone with a view of explaining the purpose of the study, including its underpinning concepts, such as the one of “community”. All experts were informed that there would be rounds of questionnaires following the principles of the Delphi method.

3.10.1.4 Size of Experts’ Panel

As Witkin (1995) indicates the usual size of a Delphi panel is below 50, with 15-30 people considered to be an acceptable panel size, according to Clayton’s rule-of-thumb (Clayton, 1997). However, the most commonly recommended panel size is between 20 to 50 (Endacott, 1999, cited in Jirwe et al., 2009). Seventy one experts were invited to participate. However, 49 experts accepted the invitation while 40 completed all three rounds.

3.10.1.5 Conducting the Delphi Survey

Each of the experts was invited by e-mail to participate in the three rounds of the Delphi study. A link to the online questionnaire, which was in English, was included. After two weeks, non-responders were sent a reminder. The survey, administered using SurveyMonkey® (www.surveymonkey.com), continued for three rounds, after which time the experts came to consensus on each of the criteria under all six dimensions. All experts were provided with a guarantee of confidentiality as an important component of the Delphi procedure.

3.10.1.6 Response Rates

Seventy one expert were initially invited; thus, the response rate for the first round was 69% (n = 49). In the second round, all experts that had taken part in the first round were invited. Hence, the response rate for this round was about 88% (n = 43). In the third round 40 experts completed the questionnaire. Therefore, the valid response rate for this round was about 93% (n = 40).

3.10.1.7 Delphi Rounds

A three-round Delphi method was used in this study (as seen in appendix B). After rounds 1 and 2, the experts' opinions were analysed and used for the next round (see Fig. 3-5).

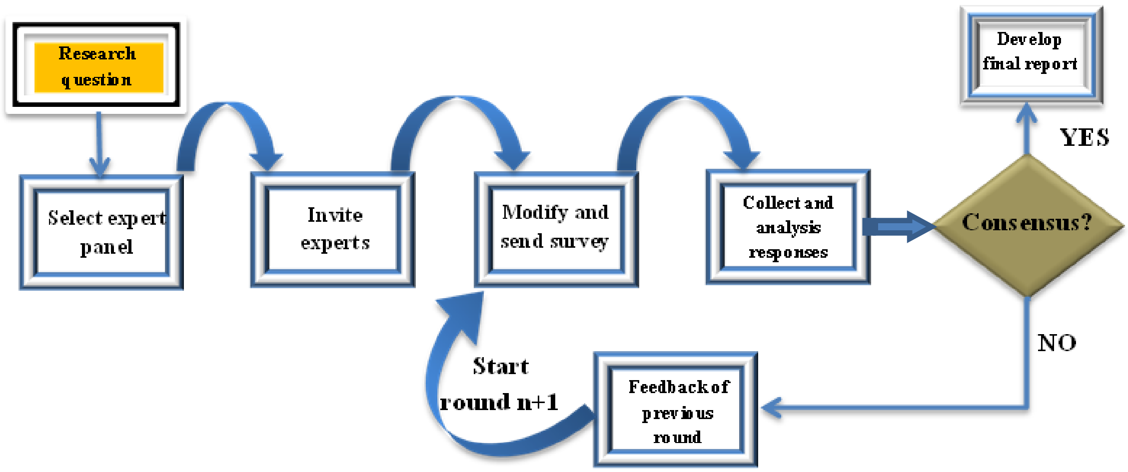


Figure 3-5: Summary of the Planned Delphi method (Alshehri et al., 2015a).

According to Burton (2012), studies agree that the concept of resilience in relation to disasters involves the following categories: social, economic, institutional, infrastructural, community, and natural/ecological. Moreover, most of these dimensions are used in frameworks as the main elements of community resilience (Twigg, 2007, Cutter et al., 2008, Norris et al., 2008, Ainuddin, 2012, Mayunga, 2007, Burton, 2012).

The initial phase of the community resilience framework development is informed by these concepts with a view to delivering a comprehensive set of categories and criteria drawn from the literature. Overall, six dimensions were suggested: social; economic; physical and environmental (covers the infrastructural and natural/ecological aspects); governance; information and communication (Norris et al., 2008); and health and well-being (covers the medical issues before, during and after a disaster) (Kirmayer et al., 2009).

Several criteria under the proposed six dimensions were selected based on the outcome of the national survey, which was conducted by the researcher in Saudi Arabia (Alshehri et al., 2013), combined with the literature review of related studies in the field (Twigg, 2007, Cutter et al., 2008, Norris et al., 2008, Ainuddin, 2012, Mayunga, 2007, Burton, 2012).

3.10.1.7.1 The First Round

In this round, all dimensions and their corresponding criteria were presented to the experts' panel in order to determine their perceptions as to level of importance for each dimension and criterion in relation to community resilience to disaster management in Saudi Arabia. The experts assessed each dimension and criterion on a 5-point Likert scale (1 = not important, 5 = extremely important). In addition, the experts were, as part of the Delphi consultation process, asked to provide further criteria that they considered important for community resilience to disasters in Saudi Arabia, which were in subsequent rounds submitted for approval and ranking by panel members until a consensus was reached.

3.10.1.7.2 The Second Round

According to several studies, experts' panel have the opportunity to revise their judgments and to change their answers in order to achieve the required consensus as the

Delphi process is iterative and incremental (Bailie, 2011, De Vet et al., 2005). Therefore, the second round questionnaire was developed in response to the first round answers and sent to the respondents for further consideration, together with feedback from the first round. All respondents from the first round were invited by e-mail to participate in the second round; the invite included the link to the questionnaire. The experts were given a chance to give their opinion about the importance of the new criteria that have been added. Thus, the experts were again asked to rate the answers on a 5-point Likert scale (1= not important, 5= extremely important) as suggested in various Delphi studies (Mertens et al., 2004, Duffield, 1993). The selection of a 5-point Likert scale is motivated by evidence from the literature which suggests that it "provides more precise information about the intensity with which an individual may hold specific value" (Daud Marsam, 2000). This is considered important given the nature (community resilience) of the consultation. After two weeks, all non-responders received a reminder. Overall, only 43 experts completed this questionnaire.

3.10.1.7.3 The Third Round

In this round, each expert received a questionnaire that contained all criteria, including the criteria on which there was no consensus, and the ratings summarized by the facilitator in the previous round. The experts were given the opportunity to revise his/her judgments of the relative importance of each criterion.

3.10.1.8 Defining Consensus

As mentioned earlier, the purpose for using a Delphi method is to achieve consensus among a group of experts on a topic. In order to measure consensus, a number of methods are used, including interquartile range (IQR), standard deviation, mean and rank (Bailie, 2011). In this study, the IQR, which is considered stronger than the other statistical methods (Murphy et al., 1998), was used for each criterion and all dimensions beginning with the second round. (Rayens and Hahn, 2000) consider than an IQR of 20% of the rating scale is acceptable for consensus; hence, an IQR ≤ 1 can be considered as good consensus on a 5-point Likert scale in this study. Furthermore, the standard deviations for each criterion were calculated in order to indicate the level of consensus within the expert panel. Criteria with a standard deviation close to 0 indicates that the panel had a strong consensus, while those with a standard deviation of 1.5 or greater had a weak consensus (Goldman et al., 2008). Finally, the mean was also used as a method of understanding the panel's judgment on the importance of the criteria (Greatorex and Dexter, 2000). The criteria was considered to be important if ≥ 60% of the respondents were in agreement (Mundt and Connors, 1999).

3.10.2 Second Expert Survey: The Analytic Hierarchy Process (AHP)

Since the goal of this study is to develop a framework for community resilience to disasters, the AHP is established using scientific methods. The AHP approach has been used in several studies that were designed to enhance development in different areas such as disaster and risk management (Carreño et al., 2007).

This section presents the objectives of using AHP which are:

- Establishing local priority weights from pair-wise comparative method of judgment.
- Determining the important of dimensions of the framework.

The achievement of these objectives contributes towards assessing the community resilience to disaster in order to facilitate building a resilient community.

A multi-criteria decision-making (MCDM) approach is crucial to the performance evaluation of disaster management (Jiang and Yu, 2013). Jiang and Yu (2013) confirm that MCDM is an effective technique for increasing the overall agreement for the final decision in the group. However, it is difficult to select a mathematical model based on MCDA (Melón et al., 2008). There are several methods of MCDM of which AHP is one of the best methods.

AHP was first presented by Saaty in 1980 (Saaty, 1990, Saaty, 1994). AHP is an approach that can be used to create measures in both the social and physical fields (Saaty and Vargas, 2001) and is widely used among researchers and decision-makers (Vaidya and Kumar, 2006). as well as organizations and governments (Viswanadhan, 2005).

Melón et al. (2008) note all MCDM methods have advantages and drawbacks. In terms of AHP, it has the advantage of constructing a hierarchy of the criteria, which offers a greater emphasis on specific criteria and sub-criteria when allocating the weights (Ishizaka and Labib, 2009). Furthermore, the AHP has been used as an effective measurement approach to provides consistency of judgement (Alidi, 1996), simplifying preference ratings among decision criteria using pair-wise comparisons (Tahriri et al., 2008). A further advantage of AHP is it is possible to derive priorities among criteria and alternatives (Alidi, 1996, Vaidya and Kumar, 2006). Vaidya and Kumar (2006) add that it presents a methodology by which to calibrate the numeric scale for the measurement of both quantitative and qualitative subjects. One of AHP reasonably is "having enough knowledge and experience and access to the knowledge and experience of others to assess the priority of influence and dominance (importance, preference, or likelihood to the goal as appropriate) among the relations in the structure" (Saaty, 1990, p.77).

Importantly, Zhang and Fu (2012) argue AHP can be used with, or in support of, other methodologies. Thus, Lin et al. (2010) used AHP in conjunction with the Delphi methodto generate a basic course outline that satisfied the industry's needs. Ercoskun and Global (2012) suggested a technique integrating four methods: SWOT-CATWOE analysis, Delphi, AHP, and a Geographic Information System, to evaluate the land-use suitability for cities. In that study, AHP was used to measure the importance or weight of each criterion (Ercoskun and Global, 2012).

In addition, the AHP has been combined with other approaches (Vaidya and Kumar, 2006). For example, the ranking of enterprises according to the achieved level of business efficiency has been achieved by using the PROMETHEE (Preference Ranking Organization Method for Enrichment Evaluations) method, which is one of the MCDM methods, and AHP (Babic and Plazibat, 1998). The PROMETHEE method is used for final ranking whereas AHP is used to determine the importance of criteria (Babic and Plazibat, 1998). A further example is by Zhang and Fu (2012) who integrated AHP with the Data Envelopment Analysis (DEA) to in order establish a logistics system performance. AHP was used to calculate the weights of the indicators of the performance. Moreover, Lalib et al. (1998) suggest a model using AHP and a fuzzy integrated approach in order to help take maintenance decisions. The AHP in that study is used to prioritize dimensions of the framework and to help the decision-maker achieve the correct decisions (Vaidya and Kumar, 2006) .

However, AHP suffers from a number of drawbacks. For example, Märkälä and Jumpponen (2006) argue that the AHP needs experience, knowledge and judgment which is subjective for each decision-maker. Moreover, Aruldoss et al (2013) point out that one of the disadvantage of AHP is several pair-wise comparisons are needed (Aruldoss et al., 2013). Nevertheless, Karapetrovic and Rosenbloom (1999) claim that AHP does not require advanced knowledge of either mathematics or decision analysis in order to perform hierarchy structuring and data collection. Thus, Viswanadhan (2005) confirms that computational issues such as defining and synthesising weights can be achieved either using software such as Expert Choice or manually. Melón et al. (2008) indicate that the support software (Expert Choice) supports the calculations and presentation of the results easily and quickly. It also can be used to reach consensus (Vaidya and Kumar, 2006). Hence, in this study, the presence of multiple experts means that the use of AHP, supported by Expert Choice software (2013), is adopted.

3.10.2.1 The Analytic Hierarchy Process

This section discusses the methodology of AHP the majority of studies indicate that the AHP process comprises the following steps (Lin et al., 2010, Tahriri et al., 2008):

- Constructing the hierarchy.
- Create pair-wise comparisons in order to collect the data and establish priorities among the elements in each level in the hierarchy.
- Synthesise judgments (to obtain the set of overall or weights for achieving the goal).
- Evaluate and check the consistency of judgements.

For this research, 23 experts were invited from those who participated in the Delphi surveys (see Chapter 5 and 6) in order to avoid inconsistency and overlapping information (Lin et al., 2010); only 16 experts agreed to participate, which is an acceptable number (Omar and Jaafar, 2011). Although the sample size was small, several studies point out that panel size is not a limitation as AHP can be conducted with small number of responses (Lee and Walsh, 2011).

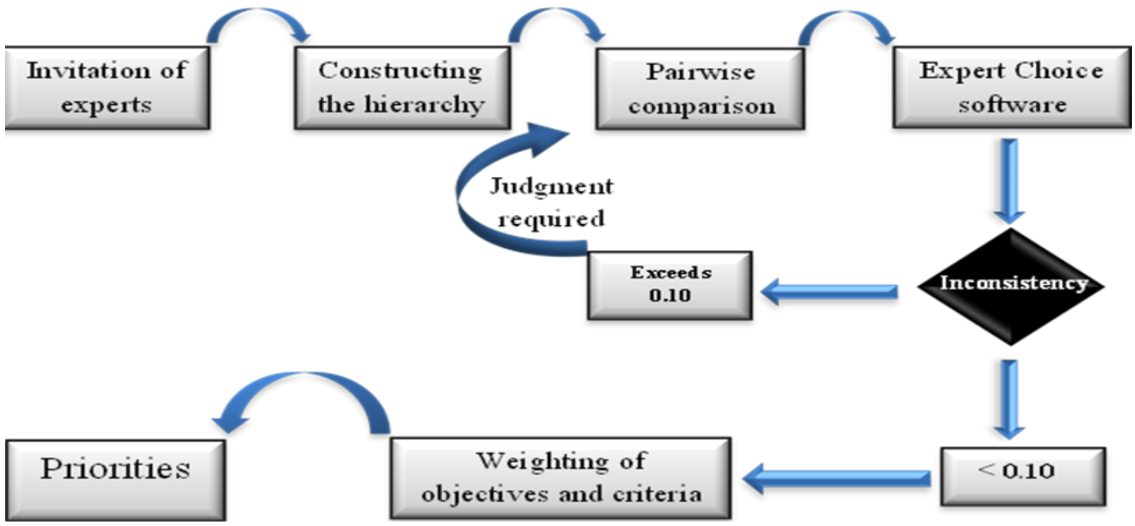


Figure 3-6: The Process of Constructing Assessment of Community Resilience to Disaster. (Alshehri et al., 2015b).

The selected experts' experiences related to disaster management averaged five years, and as stated earlier, they were all involved in the Delphi surveys of this project. The experts in this study were recruited from a variety of disciplines in disaster management, locally and internationally with an in-depth understanding of local and wider issues. Moreover, all international experts (a) understand or share the same local cultural and religious values and have for many of them worked previously in Saudi Arabia and (b) contribute their wider international experience acquired through extensive work in developed countries and relevant international organizations.

The pair-wise comparison matrices at the first level (dimension) of the hierarchy were completed and sent via email as a PDF to the 16 selected experts (as seen in Appendix C). The experts were asked to complete the pair-wise comparison matrices then submit their response online. Two experts were rejected because of their inconsistency ratio (larger than desired); the results of the remaining 14 experts were used to decide the rating. Finally, the consensus of the groups was calculated using Expert Choice software to generate the weights. The following sub-sections explain the AHP process steps in detail for the current study.

3.10.2.2 Constructing the Hierarchy

Constructing the hierarchy means breaking down the decision-making problem into a hierarchy. This can be divided into three parts: goal, criteria and its sub-criteria, and alternatives (Ishizaka and Labib, 2009). This study derives the critical success criteria related to community resilience to disasters from the Delphi method; it has established six dimensions: social, economic, physical and environmental, governance, health and well-being, and information and communication. The components that best described community resilience to disaster were presented on a three-tier hierarchy in an AHP model (see Chapter 6), wherein the top level characterized a goal related to the problem. The second tier comprised of six categories determined based on the resilience dimensions. Finally, in the third dimension there were 62 criteria with between seven and 14 criteria in each dimension. Each of the 62 criteria met the criteria for consensus, a firm consensus was revealed within the expert panel in Delphi method (see Chapter 5 and 6).

3.10.2.3 Pair-wise Comparison

Pair-wise comparison is the core of the AHP (Saaty, 1994). Thus, the first step after constructing the hierarchy in the AHP process is to make pair-wise comparisons between each dimension or criterion based on the scale for comparison (Saaty and Vargas, 2001, Saaty, 2008). Pair-wise comparisons provides the importance between items for reaching the overall a goal (Tahriri et al., 2008).

For determining the importance of the dimensions, the experts made pair-wise comparisons between each dimension. The basis of judgment of the comparison is Saaty's nine-point scales (see Table 3-7) where higher number means the chosen dimension is considered more important to a greater degree than the other dimension with which it is being compared. The pair-wise comparison values for the top level dimensions were determined by the researcher based on Delphi surveys (see Chapter 5). The results of these pair-wise comparisons are discussed in the result section chapter6.

Table 3-7: Saaty's Nine-Point Scales

Intensity of importance	*Definition and Explanation*
1	Equally important
2	Equally to moderately more important
3	Moderately more important
4	Moderate to strongly more important
5	Strongly more important
6	Strongly to very strongly more important
7	Very strongly more important
8	Very to extremely strongly more important
9	Extremely more important

Source: Adapted from (Saaty, 2008, Saaty, 1994)

The comparisons were employed into the pair-wise matrix with each of the six dimension compared with each other, and then 15 matrices were prepared. Consequently, the first level dimensions pair-wise comparisons were completed by using matrices that are used in this study to define the weighted hierarchy for the community resilience to disasters in context of Saudi Arabia (see Table 3-8 as an example).

Table 3-8 An example of Pair-wise Comparison Matrix of the Dimensions with Respect to the Goal (Alshehri et al., 2015b).

9 = Extreme 7 = Very strong 5 = Strong 3 = Moderate 1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Health and wellbeing																		Governance
Health and wellbeing																		Information and Communication
Health and wellbeing																		Physical and Environmental
Health and wellbeing																		Social
Health and wellbeing																		Economical

However, the difficulty of doing comparisons with more than seven objectives without becoming confused has been proven (Bahurmoz, 2006, Saaty and Vargas, 2012), Thus, Bahurmoz (2006) argues that the number of alternatives should be small in order to improve the consistency of the judgments. Hence, pair-wise comparison at the second level was more difficult and time-consuming as there were 62 criteria which would require 303 comparisons.

The next step was to use Expert Choice software (2013) to transform the comparisons of the dimensions into weights. The assignment of the pair-wise comparison value was applied while maintaining the consistency level under 0.1 for each dimension comparison.

3.10.3 Expert Choice Software

The consistency of judgments that the experts revealed during the series of pair-wise comparisons is an important consideration in terms of the quality of the crucial decision (Saaty, 1999). The AHP has the ability to measure the consensuses of expert's judgments by calculating the consistency ratio (CR) (Liedtka, 2005). A CR of < 0.10 is considered acceptable (Saaty, 1994). Saaty (1999) points out that the inconsistency may occur in judgments of experts as this is inherent in the process of judgment, therefore the inconsistency of less than 0.10 is deemed acceptable. If the inconsistency exceeds 0.10, some reviews of judgment may be required (Andijani, 1998, Saaty, 1999).

Software, such as Expert Choice software system, has contributed to the success of the AHP method (Ishizaka and Labib, 2009). Expert Choice software system combines many useful aspects such as automatic calculation of priorities, provides information about the inconsistencies of respondents' judgments and provides different methods to achieve a sensitivity analysis (Ishizaka and Labib, 2009, Yang et al., 2007).

Expert Choice, can be used to calculate CR automatically for the full set of pair-wise comparisons (Liedtka, 2005, Saaty and Vargas, 2001, Yang et al., 2007, Ishizaka and Labib, 2009). Hence, in this study, after all the pair-wise comparisons were assigned between the dimensions at the first level, the weighted hierarchy model was developed to form the complete weighted AHP in Expert Choice format.

3.10.3.1 Weighting of the Criteria: Third Level

As discussed in Section 9.2.3 it was difficult to adopt a weighting system for 62 criteria. Therefore, the researcher used a calculation method to find weights for each criterion. He combined the results of means, which were obtained from the Delphi method (see Chapter 5), with the AHP result as follows::

1. Collect the overall mean for each dimension
2. Divide the mean of each criterion by the overall mean of its dimension
3. Multiply the result of each criterion with the weight of its dimension obtained from the AHP.

The following equations explain this method (Alshehri et al., 2015b).:

- *t* = The total means of dimension's criteria
- p = Proportion' criterion to the rest of the criteria in its dimension.
- *m* = Mean of criterion (Delphi method).
- *wd* = Weighting of dimension (AHP).
- *wc* = Weighting of criterion.

$$t = \text{Mean of criterion}_1 + \text{Mean of criterion}_2 + \cdots + \text{Mean of criterion}(n)$$

$$t = \sum_{i=1}^{n} mi = m_1 + m_2 + \cdots + mn$$

Equation 3-1

$$p = \frac{\text{Mean of criterion}}{\text{The total means of dimension's criteria}}$$

Equation 3-2

$$p = \frac{m}{t}$$

Equation 3-3

$$wc = p * \text{ Weighting of dimension (AHP)}$$

$$wc = p * wd$$

Equation 3-4

3.10.3.2 Proposed Community Resilience Framework (CRDSA)

The proposed framework for assessment and implementation of community resilience to disaster in this research includes examining the status of the six dimensions of this framework which are social, economic, physical and environmental, governance, health and well-being, and information and communication.

The researcher used the equations 3-1, 3-2 and 3-3 to determine the weights for each criterion. The next step was to employ Microsoft Excel 2010 to identify units as a percentage of each criterion which could then be used to facilitate the assessment process pf the community resilience.

The following equations have been used to do explain the final result of the assessment of community resilience to disaster (Alshehri et al., 2015b).

$$tp = \sum_{i=1}^{n} pi = p_1 + p_2 + \cdots + pn$$

Equation 3-5

tp = total of proportion of criteria for each dimension.

$$WD = wd * tp$$

Equation 3-6

WD = the new weight of the dimension.

When the new weight of each dimension (WD) is obtained then the total assessment of community resilience to disasters (CRD) can be calculated by totalling all the new weights in order to the following equation:

$$CRD = \sum_{i=1}^{6} WDi = WD_1 + WD_2 + \cdots + WD_6$$

Equation 3-7

The following step is the validation of the proposed framework. Therefore, the next section focuses on the third phase which is the method that has been used to validate it.

3.11 <u>PHASE THREE:</u> Validation of the Framework .

In order to achieve the aim of this research, a case study approach is used in this phase. Case study research is defined as "an empirical inquiry that investigates a contemporary phenomenon within its real life context, especially when the boundaries between phenomenon and context are not clearly evident" (Yin, 2009, p.18). This method is useful to test a theory (Riege, 2003), and can be completed by using either qualitative or quantitative methods (Darke et al., 1998). However, the most important element of case study research is the use of multiple sources of evidence, which can in the form of data collection techniques such as questionnaires, fieldwork, interviews and observations (Riege, 2003).

In relation to interviews, Bowling (2009) indicates that the interview period can be short or long. Interviews can have one of two basic structures; they can be either structured (closed interview style) or unstructured (open interview style) (Bowling, 2009). The closed interview style raises questions that require precise answers, whereas open-ended interviews mean non-specific questions are answered (Bowling, 2009). However, Bowling (2009) notes a third type, in which both closed and open questions are used. These allow the interviewer to probe deeper to gain a more detailed answer to the original closed question from the respondents.

3.11.1Filed study

The current study is conducted using face-to-face and telephone interviews with decision makers directly involved in the Hajj event and with a number of the pilgrims who were at risk from MERS-CoV in Makkah along with observation (Fig.3-7). The proposed methodology is framed to answer the following research questions:

a) What is the level of community resilience of the Hajj community under the epidemic threat of MERS-CoV?
b) Can the proposed resilience to disaster framework inform improved management of mass gathering events such as the one of Hajj?

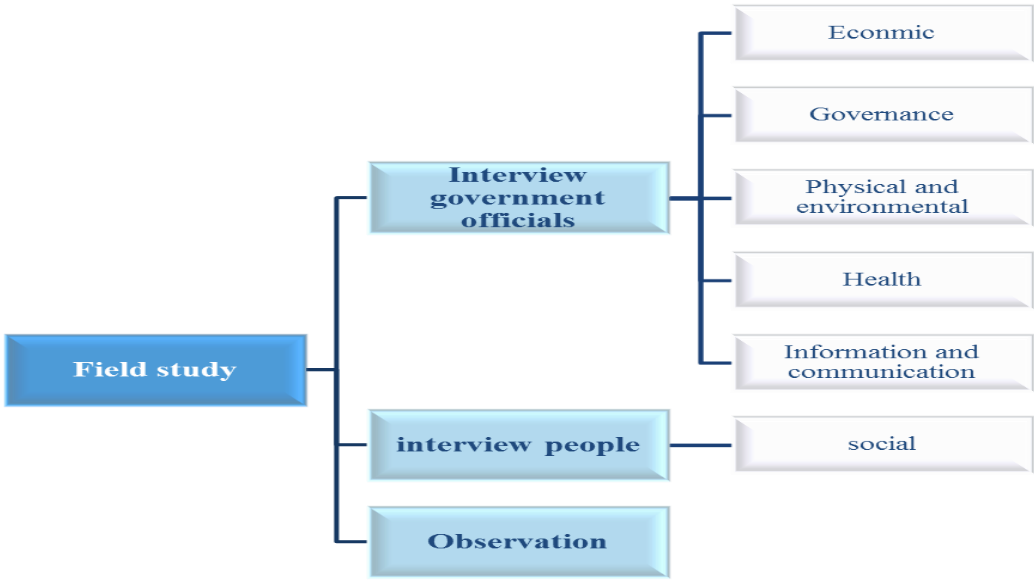


Figure 3-7: Flow Chart of Framework Validation

3.11.1.1 Data Collection

Mixed methods sampling approaches were employed in this study in order to answer a study's questions (Teddlie and Yu, 2007). The data presented in this section was collected during a trip to Saudi Arabia (Riyadh and Makkah) from 21st September to 24th October 2013, which coincided with the *Hajj* period. Between August and September, the researcher started through contacts, interviews and procedures to obtain approval from the Saudi authorities to carry out the application of the framework during the *Hajj* season.

3.11.1.2 Interviews

An interview is defined as "a purposeful conversation in which one person asks prepared questions (interviewer) and another answers them (respondent)" (Frey & Oishi, 1995:1). In other words, an interview is a meeting between the researcher and the respondent in order to obtain oral information. Bowling (2009) indicates that the interview period can be short or long. Interviews can have one of two basic structures; they can be either structured (closed interview style) or unstructured (open interview style) (Bowling, 2009). The closed interview style raises questions that require precise answers, whereas, open-ended interviews mean non-specific questions are answered (Bowling, 2009). However, Bowling (2009) notes a third type, in which both closed and open questions. These allow the interviewer to probe deeper to gain a more detailed answer to the original closed question from the respondents.

3.11.1.2.1 Interviews with government officials

In this study, snowball sampling has been used. Data collected by recognising participants through direct contacts, who are then asked to recruit others (Sadavoy et al., 2004). It is often used with small sized samples when there is a need to choose participants (Bryman, 2012). These participants were selected on the basis of their direct involvement in the Hajj as decision makers and/or experience in disaster management. Many government organizations have responsibility for the Hajj in relation to providing services to the pilgrims, to ensuring the safety of the pilgrimage from any disasters or addressing problems that affect the performance of rituals of the Hajj. The questions addressed the Economic, Governance, Physical and environmental, Health, and Information Technology dimensions of the proposed framework.

Therefore, the researcher interviewed 16 official decision-makers including: Commander of Hajj Civil Defence; Hajj Ministry Director General; the Director General of the Ministry of Health (MOH); Director of Emergency Department and Chairman of the Emergency and Field Medicine Committee during Hajj; 4 members of National Scientific Infectious Diseases and the National Scientific Infection Control; Director of Armed Forces Medical Services in Mina; Director of Emergency Centre of Hajj; Director of Civil Defence Operations Centre; Director of Emergency Room;

Mina's Operation Centre; Director of Arafat's Operation Centre; Director of Disasters Response Department; and Director of Facility Security Force.

3.11.1.2.2 Interviews with pilgrims

The Ministry of Hajj, with the help of the Gulf Cooperation Council (GCC) and the Ministry of Interior, has established six organisations to help control the movement of pilgrims and to provide services for pilgrims (Hajj, 2011). Each organisation has around 100 offices; each is responsible for around 5000 pilgrims (Fig. 3-9) (Hajj, 2011).

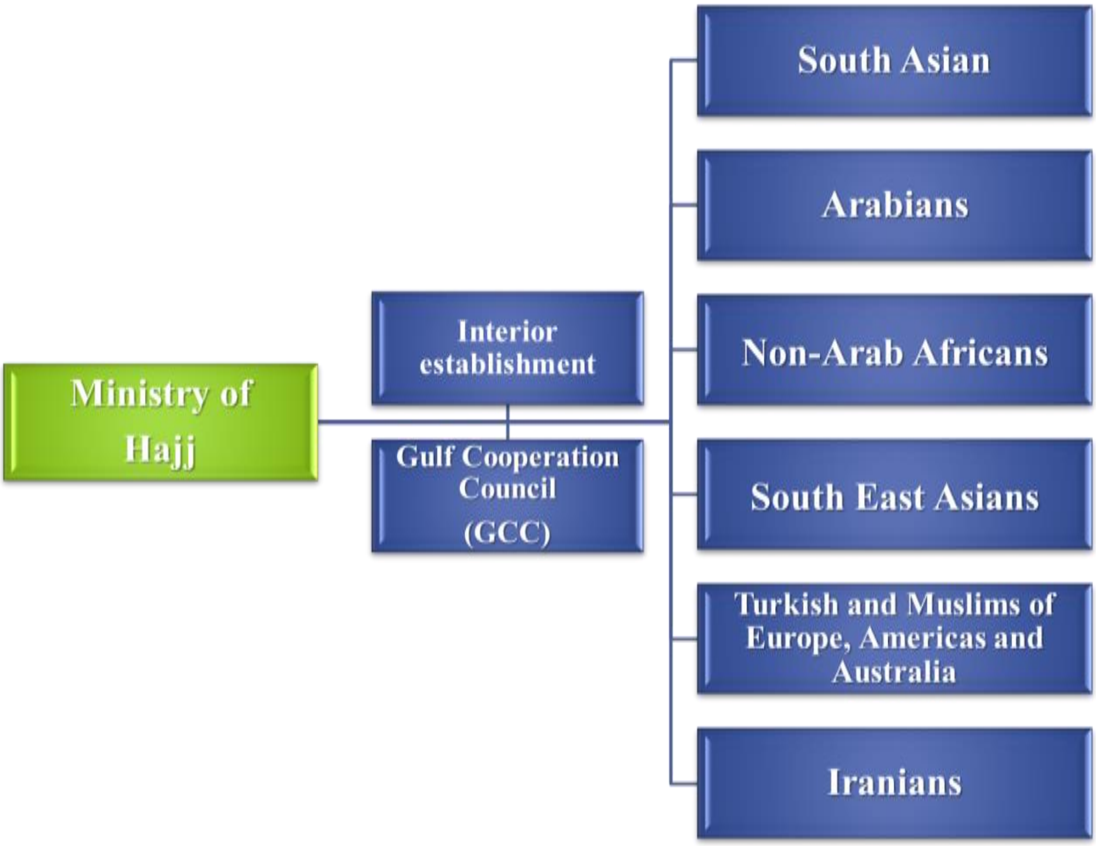


Figure 3-8: Organisations for assisting Pilgrims during the Hajj

Hence, the cluster sampling technique was employed whish is used when the original community is large (Bryman, 2012). This method is more cost-effectively conducted than true random samples in that it allows more interviews to be conducted in same time (Johnston et al., 2007).

The researcher selected these seven organisations using cluster sampling, and he randomly selected 50 responders from each organisation. Unfortunately, only 334 responders participated as result of time limitation and lack of manpower.

Interviews were conducted daily during the Hajj season, from 8 o'clock in morning through to 10 o'clock in the evening. Because of the language barrier, the researcher used paper questionnaire and translators during the interviews in order to collect the social dimension data. Therefore, the researcher had corporation with some translators who their first language is the same as the source the survey language to translate the questionnaire into the relevant languages (see Figs. 3-10 and 3-11)..

The purpose of translation is to prepare a survey in a different language that allows for the proposed meaning of the original questions to be understood (Chávez and Canino 2005). A well-translated survey questionnaire should be readable and understandable for all respondents from their linguistic and cultural perspective (Pan et al. 2007)

Figure 3-9: The researcher used translators

Criteria	Question	Answer		comme nts
		Yes	No	
Risk awareness and training.	Do you know: • What kind of risks in Hajj. • Evacuation and emergency plan. Savez-vous: • Quels types de risques dans le Hajj. • Evacuation et un plan d'urgence. Sie wissen: • Welche Risiken in Hajj, • Evakuierung und Notfallplan क्या आप जानते हैं: हज में जोखिम का • किस तरह, • निकासी और आपात योजना है.. ¿Conoce usted: • ¿Qué tipo de riesgos en el Hajj, • Evacuación y plan de emergencia. Biliyor musunuz: Hac risklerin • Ne tür, • Tahliye ve acil durum planı. Знаете ли вы: • Какие риски в хадж, • Эвакуация и чрезвычайный план.			

Figure 3-10: Example of the Translations of the Questions

3.11.1.3 Observation

Observation, which is useful tool to supplement interviews (Jensen & Jankowski, 1991, p.101), is defined in the social sciences as "a research method in which the investigator systematically watches, listens to records the phenomenon of interest" (Bowling, 2009). Observation has been used in many studies related to disasters (King, 2002). It usually used in conjunction with the survey method such as interviews and questionnaires (King, 2002). There are two types of observation: structured and participant observation (Saunders et al., 2007).

3.11.1.3.1 Structured observation

This type of observation is often associated with organisation and methods research, and structured interviews. It associated with quantitative research (Bowling, 2009) and relies on watching, hearing and feeling rather than talking to collect data (Erlandson et al., 1993, cited in Bowling, 2009). Saunders et al. (2007) highlight the benefits and drawbacks of this structured observation (see Table 3-9).

Table 3-9: Advantages and Disadvantages of Structured Observation

Advantages	Disadvantages
• It can be used by anyone after suitable training in the use of the measuring instrument. Therefore, you could delegate this extremely time-consuming task. In addition, structured observation may be carried out simultaneously in different locations. This would present the opportunity of comparison between locations.	• The observer must be in the research setting when the phenomena under study are taking place.
• It should yield highly reliable results by virtue of its replicability; the easier the observation instrument to use and understand, the more reliable the results will be.	• Research results are limited to overt action or surface indicators from which the observer must make inferences.
• Structured observation is capable of more than simply observing the frequency of events. It is also possible to record the relationship between events. For example, is the visit to the retail chemist's counter to present a prescription preceded by an examination of merchandise unrelated to the prescription transaction?	• Data are slow and expensive to collect.
• The method allows the collection of data at the time they occur in their natural setting. Therefore, there is no need to depend on 'second-hand' accounts of phenomena from respondents who put their own interpretation on events.	
• Structured observation secures information that most participants would ignore because to them it was too mundane or irrelevant.	

Source: Adapted from Saunders et al., (2007, p.306).

3.11.1.3.2 Participant observation

Participant observation, which the researcher can observe, interpret, record and participates in the action being studied (Lichterman, 2002), has been used less than structured observation in management and business research (Saunders et al., 2007). This type of observation is related to qualitative and inductive research (Bowling, 2009). Bryman, (2012) asserts that participant observation can gain further data to support interviews and documents. Saunders et al., (2007) highlight advantages and disadvantage of this method of observation (see Table 3-10). However, Bowling (2009) points out that data observation can be collected using a combination of both types structured observation and participant observation.

Table 3-10: Advantages and Disadvantages of Participant Observation

Advantages	Disadvantages
• It is good at explaining 'what is going on' in particular social situations • It heightens the researcher's awareness of significant social processes • It is particularly useful for researchers working within their own organisations • Some participant observation affords the opportunity for the researcher to the experience 'for real' the emotions of those who are being researched • Virtually all data collected are useful	• It can be very time consuming • It can pose difficult ethical dilemmas for the researcher • There can be high levels of role conflict for the researcher (e.g. 'colleague' versus researcher) • The closeness of the researcher to the situation being observed can lead to significant observer bias • The participant observer role is a very demanding one, to which not all researchers will be suited • Access to organisations may be difficult • Data recording is often very difficult for the researcher

Source: Adapted from Saunders et al. (2007, p. 299)

In this study, the researcher was present in the area of movement of the pilgrims between Holy mosque, Mina, Muzdalifah and Arafat (as mentioned above) for observation. These observations were intended to assess certain criteria related to the proposed framework. The researcher used a car and helicopter from which to undertake the observation.

The researcher developed a software based on the Measurement Resilience tool of CRDSA to test all creteria of this framework as on the following section.

3.11.2 Software for measuring community resilience to disasters according to CRDSA methodology.

Kordon (2002) define prototype as

> *"..any form of specification or implementation of hardware or software (or both) that is built/designed for evaluation purposes"* (Kordon (2002).

It can be used for validating requirements and supporting computer aided design of either software or hardware components of future designs Kordon (2002).

According to Engelberg and Seffah (2002), several studies have mantioned the advantages of prototyping including the following: (a) reach cost savings (b) improving the usability and quality of the final product (c) usability to test the product before coding (Engelberg and Seffah, 2002). Moreover, Sommerville (2007) points out that it supports in validating end-users requirements. It also can identify any difficulties or missing functionality (Sommerville, 2007).

The researcher coordinated with the developer and programmer; hence, based on the Measurement Resilience tool of CRDSA (Fig. 6-5), a software (protoptype) to measure the community resilience was produced. The production of this software passed through the following process (Fig.3-11)

Figure 3-11: The process of CRDSA prototype

All calculations have been done based on the equations in sections 3.10.2 and 3.10.3 in this chapter. This software is divided in three parts including: 1) input data collection, 2) resilience analysis and 3) outcomes. Submission the input data from users is controlled by a username account with email address as password. The input data required by the program are all six dimensions with all their criteria.

In this research, the use of prototyping is for validating the outcomes that have been gained form previous study which is the assessment of the resilience at Hajj community under MERS-CoV threat.

3.12 Summary

This chapter provides an overview of the research design and methodology. It also presents the nature of the current study including paradigms, approaches, tools, designs and methodology. In this study, the mixed-method approach, along with the paradigm of pragmatism are used. Moreover, it was important to give a clear view of the research procedure and methods that are used for conducting the research in a systematic manner.

Consequently, the research design is divided to three phases: public perception of the risks of disaster concentrating on biological disasters in Saudi Arabia. The second phase is divided to two steps. First, the researcher employed the Delphi consultation approach to refine criteria and to explore other criteria that can be used to build community resilience to disasters in context of Saudi Arabia. The Delphi technique combines quantitative calculation to justify the dimension and their criteria and the qualitative attitudes of experts to explore further criteria. The researcher designed this method to collect the data using a three-round questionnaire to achieve the consensus of the experts' panel. Second, AHP is used to reach the objectives of: a) local priority weights from pair-wise comparative method of judgment and b) determining the importance of dimensions of the framework. The third stage is the validation of this framework in real mass gathering event. The researcher used interview methods for decision makers and pilgrims. He also used observation to utilise data for some criteria of the framework. The findings from the national survey as the first phase are discussed in the next chapter.

Chpter:4 Public perception of the risks of disaster in Saudi Arabia

This work has been published in two scientific journals as following:

- Alshehri S, Rezgui Y and Li H, (2013). **Public perception of the risk of disasters in a Developing Economy: the case of Saud**i, Journal of Natural Hazards DOI: 10.1007/s11069-012-0445-5.

- Alshehri S, Rezgui Y and Li H, (2016). **Public perceptions and attitudes to biological risks: Saudi Arabia and regional perspectives**. Disasters**,** DOI: 10.1111/disa.12179.

Introduction

This chapter aims to understand and analyse a quantitative survey of the general public's perception of and attitudes towards risks of disasters in general and to biological disasters in specific. Following this overview the chapter provides a brief description of the important of the public perception in disaster management, followed by a presentation and discussion of the survey results. This chapter then provides concluding remarks followed by directions for future research.

4.1 Overviwe

Understanding the public's perception of risk is important for improving risk communications and designing effective mitigation policies (Ho et al., 2008). Risk has been defined as "the combination of the probability of an event and its negative consequences" (UNISDR, 2009). Risk perception, on the other hand, has defined as "people's beliefs, attitudes, judgments and feelings, as well as the wider social or cultural values and dispositions that people adopt, towards hazards and their benefits" (Pidgeon et al., 1992). Many studies have surveyed a wide range of hazardous events including technical and natural disasters, and several researchers indicate that risk perception can be used either to reduce the risk or to change behaviour (Ho et al., 2008, Martin et al., 2009). For instance, a socio-psychological model of individual responses to hazards comprising risk perception was developed to be a predictor of precautionary behaviour (Grothmann and Reusswig, 2006). Following the issue of tsunami warning alert messages on 2nd April 2007 along the east coast of Australia, the public perception of hazard and risk was investigated to clarify the public understanding and confusion about the warning alerts (Bird and Dominey-Howes, 2008). Moreover, Ho et al (2008) examine how risk perception is influenced by the type of disaster, e.g. flood or landslide, and victim characteristics. On the other hand, comparing risk perception for both the victims and the public gave an explanation why people who have been exposed to disasters such as floods and landslides are less willing to adapt to the effects of mitigation measures disasters (Lin et al., 2008). There have been a number of international surveys involving perceptions of the risk of terrorism. For example Burns (2007) reviewed eight US studies related to the threat of terrorism which point to "the central role perceptions of risk play in people's level of concern and likely behaviour during and following a disaster" (Burns, 2007).

Several studies have been conducted to assess perceptions of preparedness for disasters (Hammad et al., 2011). For example, in Japan, the perception among residents has been studied to determine the acceptance of flood risks (Motoyoshi, 2006). The results of this study indicated that it is possible to activate disaster preparedness plans as voluntary activities within local communities (Motoyoshi, 2006). In Iceland the first studies on the public perception the natural hazard of flooding found that many residents did not acknowledge living in a flood area (Pagneux et al., 2011). These studies have been used to suggest a disaster training programme or to identify shortcomings and lack of disaster response (O'Sullivan et al., 2008, Hammad et al., 2011). The perception of disaster preparedness permanently is important that can assist evaluation of the efficiency of training programs and to assess how perceptions may vary as new events (O'Sullivan et al., 2008).

A study conducted in Nagoya City, Japan, identified four goals in establishing the factors that determine people's preparedness for disasters: a) the relationship between related perception (the level of fear of hazard and hazard anticipation) and preparedness; b) the relationship between hazard experience and preparedness; c) the relationship between the amount of damage from a previous hazard and preparedness;

and d) to examine how owning a home affects a person's preparedness for hazard (Takao et al., 2004). The research has investigated the lack of correspondence between related perception and preparedness to improve people's preparedness for floods (Takao, 2006), and has pointed out that disaster preparedness was positively associated with risk perception (Miceli et al., 2008).

A study has indicated that the important factor affecting attitudes toward preparedness was people's willingness to learn more about such disasters (Takao, 2006). Moreover, Nordentestdt and Ivanisevic (2010) point out that better knowledge in the field of risk perception can consequently increase the quality and effect of decisions through society. Thus, decision makers should take account of public perception and assist the exchange of information with the community which increases the confidence and acceptance of information which will help to raise the reduction of the risks of disasters (Renn, 2004).

4.2 The case study: Saudi Arabia

Befor presenting the results of pesceptions study the next sections will point out an overview of Saudi Arabia and its hazards.

4.2.1 Location

Saudi Arabia is Located in the southwestern corner of Asia. Saudi Arabia covers an area of about 2,240,000 square kilometers, which covers almost four-fifths of the Arabian Peninsula. The country is bordered by the Red Sea to the west, by the Yemen to the south, Oman to the southeast, the Arabian Gulf, the United Arab Emirates and Qatar to the east, and Jordan, Iraq and Kuwait to the north (Central Department of Statistics and Information, 2010, United Nations: Statistics Division, 2008). The country is divided into 13 provinces which are further divided into governorates; each of these has a capital that is headed by a governor (as seen in Figure 4-1).

Figure 4-1: Saudi Arabia's map Source Blanchard - 2014.

4.2.2 Hazards in Saudi Arabia

Saudi Arabia is in a region that is not widely known for natural or man-made disasters, despite the presence of volcanic and seismic activities (Al-Saud, 2010) and overall political instability in the Middle East. While the strength and impact of disasters is not equivalent to other developed and developing countries, such as Indonesia and Pakistan (Guha-Sapir et al., 2011), the rate of their occurrence has increased in recent years (Al-Saud, 2010, Guha-Sapir et al., 2011). One third of the damaging natural disasters that occurred between 2000 and 2011 are attributed to epidemics (biological threat) such as swine flu (H1N1) and the Rift Valley Fever in Jizan (AlMazroa et al., 2010, Guha-Sapir et al., 2011). Furthermore, the scale and significance of disasters in the past decade is unprecedented, such as floods (Jeddah floods 2009 and 2010, Jizan floods 2010) and dust storms (Alshehri et al., 2013). The impacts of these disasters have been severe economically, socially and health-wise due to the lack of experience with disasters.

Moreover, according to EM-DAT, the number of disasters increased sharply in Saudi Arabia between 2005 and 2013 (Guha-Sapir et al., 2014). Two of these disasters were of a biological nature: H1N1 (AlMazroa et al., 2010a) and MERS-Corona (WHO, 2014, MOH, 2014); while the rest were attributed to flooding (Figure 4-2).

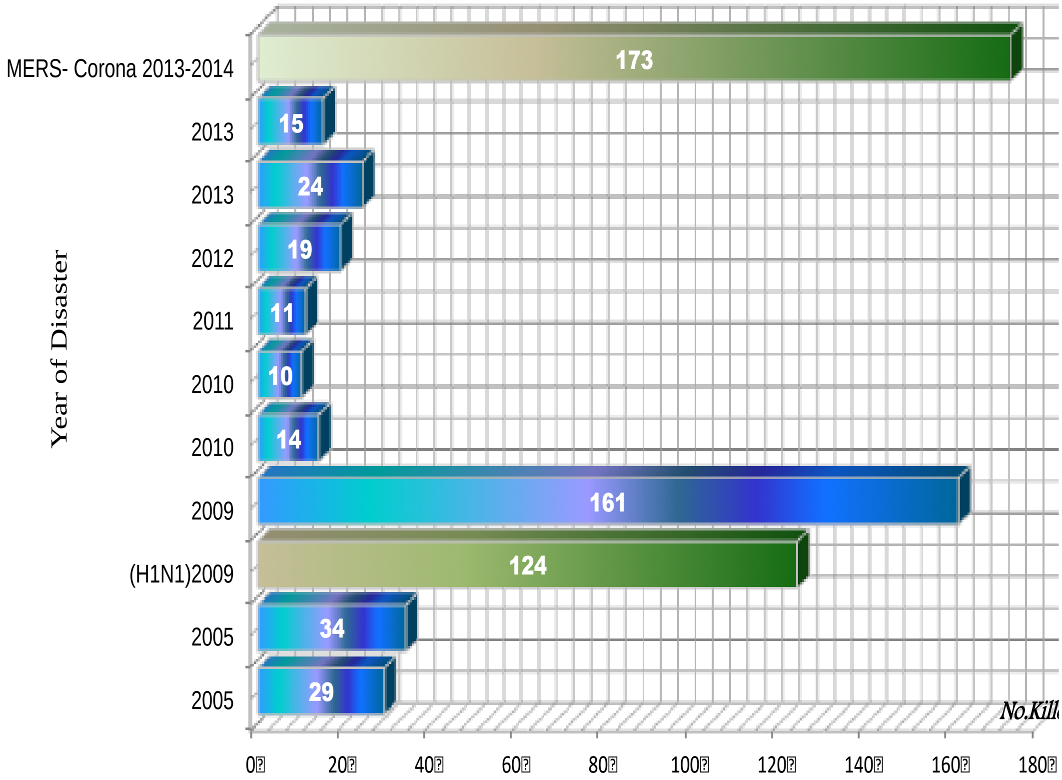


Figure 4-2: Disasters in Saudi Arabia 2005-2013

Other types of hazards are associated with Ramadan and the Hajj which are two special seasons in the Islamic calendar. Annually, Saudi Arabia attracts over three million visitors to the Holy Mosques in Mekkah and Medina (Memish, 2010). These visitors present unique challenges to the local authorities (Memish et al., 2009) such as infectious disease outbreaks (e.g. meningococcal disease and respiratory tract infections), which have been reported frequently during and following the Hajj.

In addition, Saudi Arabia has suffered in the past two decades from a number of terrorist attacks, which are sudden onset man- made disasters (Van Wassenhove, 2006).

These include the Riyadh (36 people were killed, and over 160 wounded) and Khobar (574 people injured and 19 died) bombings (Hegghammer, 2008, Thompson et al., 2004). Moreover, in 2009, al-Houthi rebels from Yemen killed several security officers during gun battles along the border with south of Saudi Arabia.

The rate of disaster occurrence has increased in recent years in Saudi Arabia with a risk of triggering biological threats (Balkhy et al., 2010) as evidenced in recent events. Local authorities' approach in addressing these risks tends to be ill-informed and proceeds in an ad-hoc basis, using established heuristics, with little evidence on public's attitudes and perceptions of the risks of these disasters (Balkhy et al., 2010, Abosuliman et al., 2013b).

Furthermore, Saudi Arabia has in some large fields of volcanoes in the west of Saudi Arabia (Pallister et al., 2010, SGS, 2012b). In 2009, more than 30,000 earthquakes struck one of the lava fields in the province, Harrat Lunayyir, northwest Saudi Arabia. Therefore, Saudi government evacuated about 4000 people from that area (Pallister et al., 2010).

Also, several studies point out that the second cause of death for all age groups is traffic accidents (Al-Honazil I. et al., 2008). This is classed as hazard, which may lead to cause disasters (Peden 2004). However, according to the 'Disaster R&D Investment Strategy' published in 2013, it has been mentioned as Human/Social Disaster (Jeong et al., 2014). In fact, Joffe –Walt (2010) indicates that over the past two decades Saudi Arabia has recorded 4 million traffic accidents which caused 86,000 deaths and 611,000 injuries. According to the Saudi daily Arab News, 6,485 people died and more than 36,000 were injured in over 485,000 traffic accidents during 2008 and 2009 contributing to the highest road accident death in the world (Joffe-Walt, 2010).

4.3 Methodolgy

In order to gain information of public understanding in relation to a particular hazard type, it is essential to design information gathering techniques such as questionnaire surveys (Bird and Dominey-Howes, 2008b, Bird, 2009). Therefore, a questionnaire designed (see chapter 3for more details of the methodology) to address the following objectives.

- To understand of the general public's perception of and attitudes towards risks of disasters in general, this chapter focuses on three main objectives:
- To assess the people's general knowledge of disasters.
- To examine how the surrounding factors such as faith and personal responsibility can affect their perception of the risk of disasters.
- To determine the main information sources regarding the risk of disasters.

The survey focuses also on the biological risks. Thus, this chapter aims to understand the Saudi's perception of, and attitude to, the risk of biological disaster by answering the following underpinning research questions:

- What are the Saudi's public attitudes towards biological risks in the event of a disaster?
- What specific cultural and demographics factors (such as faith, age, and gender) affect their perception of biological risks?
- What are the perceived aspects of resilience and vulnerability factors on Saudi' community?

4.4 Results and analysis

1731questionnaires were accessed in total and 1164 questionnaires were completed.

Fig. 4-3 shows the spatial distribution of the location of the respondents:

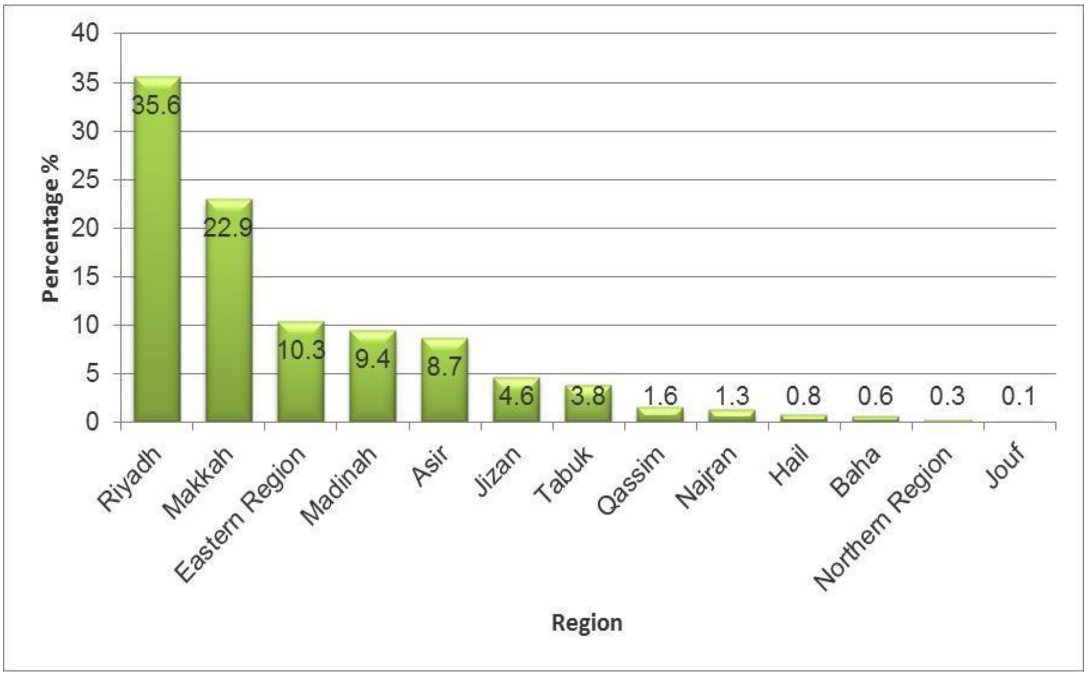


Figure 4-3: Spatial distribution of the respondents' location

Descriptive statistics and all data analyses were conducted using Statistical Package for the Social Studies (SPSS) version 18.0.

4.4.1 Data quality

Questionnaire data need to be checked for reliability before being analysed to investigate whether the participant‘s selection is constant and if the questionnaire structure is consistent (Deng et al. 2011). Hassad (2010) notes that items with an alpha correlation of 0.70 and higher are seen as acceptable; however, for exploratory studies the Cronbach‘s alpha (α) of scale 0.6 and over is classed as an adequate level of reliability (Hair J.F et al. 2006). The overall reliability of the items in this questionnaire according to Cronbach alpha is acceptable (0.78).

4.4.2 General attribution of samples

Table (4-1) illustrates the general attribution of samples and shows that the respondents were distributed in gender, over a range of ages, and were of different levels of education and employment.

Table 4-1: General attribution of samples

Characteristic		Percentage %	Characteristic		Percentage %
Age	Less than 18	1.7	**Level of Education**	Primary school	0.6
	18 -30	38.8		Intermediate school	1.4
	31-50	55.6		High school	14.9
	+ 50	3.9		Diploma	8.8
				Advanced Diploma	3.2
				University Degree	39.8
				Postgraduate Qualification	29.6
				Other	1.7
Gender	Male	74.7	**Employment Status**	Student	15.5
	Female	25.3		Governmental Employee	57
				Private Employee	11.9
				Businessman/ Businesswoman	1.1
				Retired	1.5
				Unemployed	7.6
				Refused	5.6
Marital Status	Married	72.3	**Income - Saudi Riyal**	< 3000 SR	5.1
	Single	27.7		3,000-5,999	6.4
				6,000-9,999	25.3
				10,000-14,999	21.7
				15,000-20,000	14.7
				> 20,000	13.2
				No income	6.6
				Refused	6.9
Number	None	1.0	**Region**	Riyadh.	35.6
	One Child	25.9		Makkah.	22.9
	Two Children	15.8		Eastern Province.	10.3
	Three Children	18.3		Asir.	8.7
	Four or more Children	17.0		Qassim.	1.6
	Refused	21.9		Northern Border.	0.3
				Jizan.	4.6
				Madinah.	9.4
				Baha.	0.6
				Hail.	0.8
				Jouf.	0.1
				Najran.	1.3
				Tabuk.	3.8

About 71% reported being currently employed and roughly 78% indicated that their income is more than 6,000 Saudi Riyal (≈ 1.600$) per month.

4.4.3 Knowledge and perception of disasters

Table (4-2) provides a summary of the responses to the questions (10, 11 and 15) related to the respondents‘ knowledge, including the perceived generators of disasters.

Table 4-2: Summary responses to questions related to knowledge

Question	Response
10. Which of the following do you think can generate a Disaster?	
Earthquake	69.1%
Flood	66.4%
Epidemic	61.7%
Volcanic eruption	41.2%
Tornado	44.2%
Landslide	31.4%
Tsunami	46.8%
Conflicts	79.8%
11. Do you think the region where you live could be affected by Disaster?	Yes 63.6% No 12.4% Don't know 24.1%
15. Do you know when the last Disaster affected Saudi Arabia?	Yes 78.3% No 21.7%

4.4.4 Faith

All respondents were asked four questions regarding their faith (Alshehri et al., 2013). The majority of respondents (97%) tend either to ‘agree‘ or ‘completely agree‘ that God (Allah) is in control of everything that happens in the world which yielded a mean score of 4.8 (scale 1–5) (standard deviation 0.70), indicating the majority ranked the statement “strongly agree”. Although about 93% with a mean score of 4.7 (standard deviation 0.96) believe that earthquakes, floods, epidemic, and other natural disasters are signs from God (Allah). Furthermore, 88% strongly agree (mean score of 4.5, standard deviation 1.05) that biological disasters such as epidemics are God’s way of testing our faith, while slightly more than 70% believe that God (Allah) sometimes punishes nations for the sins of some of its citizens (mean score of 3.9, standard deviation 1.42), indicating a ranking between “agree” and “strongly agree”.

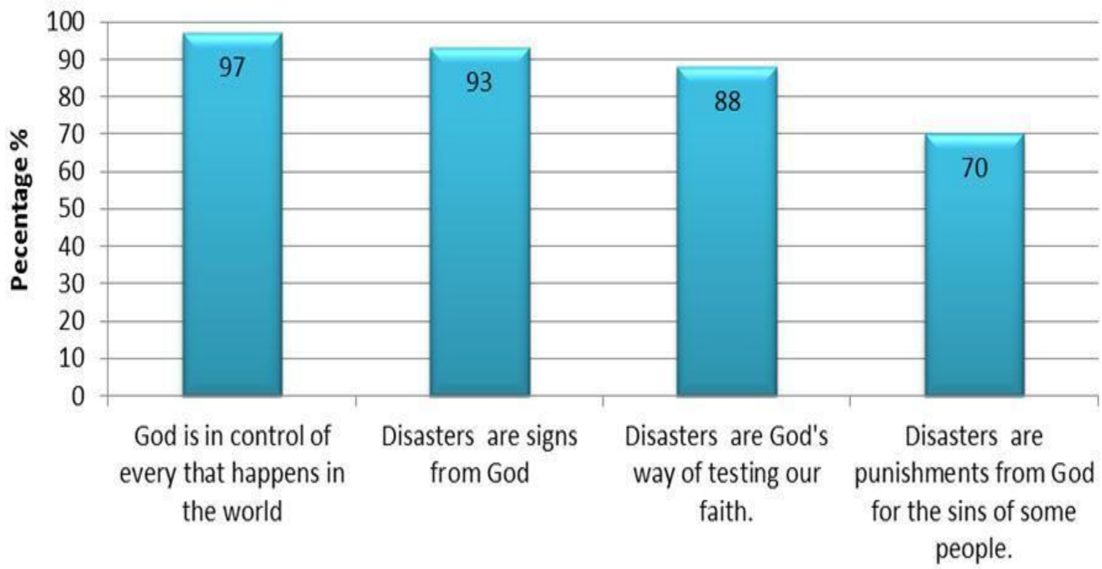


Figure 4-4: Perceptions of the relationship between faith and disasters in Saudi Arabia

In general, correlation and multiple regression analyses were conducted to examine the relationship between public perception and various potential factors such as age, gender, education, experience, and faith as illustrated in Table (4-3) which summarizes the descriptive statistics and analysis results. Table (4-4) demonstrates that each of these factors is positively and significantly correlated with the perception of disaster.

Table 4-3: Descriptive statistic

Descriptive Statistics

	Mean	Std. Deviation	N
Perception	79.0653	11.87644	1164
Age	2.6160	.59037	1164
Gender	1.2534	.43517	1164
Education	5.5876	1.51577	1164
Experience	1.8857	.31826	1164
Faith	17.9364	3.18953	1164

Table 4-4 Correlations Table

Correlations

		AGE	Gender	Education	Experience	Faith	Perception
Perception	N	1164	1164	1164	1164	1164	1164
	Pearson Correlation	.137**	-.164**	.123**	-.074*	.172**	1
	Sig. (2-tailed)	.000	.000	.000	.011	.000	
	N	1164	1164	1164	1164	1164	1164

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

Using the enter method, the multiple regression model with all five elements created r = .072, F (5, 1158) = 18.068, p < .001 (as can be seen in Table 4-5).

Table 4-5: Regression Model Summary Table

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.269[a]	.072	.068	11.46330	.072	18.068	5	1158	.000

The beta value is a measure of how strongly each variable influences the perception. Thus, significant variables are shown in Table (4-6). The overall variance explained by the five factors was 7.2%. Each variables was positively related to the outcome variable, such as age (β = .092, p = .002), gender (β = -.112, p = .000), education (β = .071, p = .019), experience (β = -.070, p =.01 3) and Faith (β = .160, p = .000). Moreover, tolerance values less than 0.1 point out a serious problem, whereas the values lower 0.2 are potential problem (Dhurup and Dlodlo, 2013) . In this study, tolerance values are all close to 1, which suggest the adequacy of the results.

Table 4-6 : The beta value and P values of all variable

Coefficients[a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
	B	Std. Error	Beta			Tolerance	VIF
(Constant)	69.211	3.567		19.406	.000		
Age	1.859	.611	.092	3.044	.002	.869	1.151
Gender	-3.056	.802	-.112	-3.812	.000	.929	1.077
Education	.554	.237	.071	2.339	.019	.877	1.141
Experience	-2.626	1.058	-.070	-2.482	.013	.996	1.004
Faith	.595	.106	.160	5.620	.000	.990	1.010

a. Dependent Variable: Perception

4.4.5 Risk perception and concern

Respondents were asked to indicate the extent to which they agree that people in Saudi Arabia are at risk from disasters and whether or not they are concerned about disasters. Fig. (4-5) shows that (77%) of respondents tend to either agree or completely agree that there are risks to people in Saudi Arabia from disasters. Almost two-thirds (63%) of respondents think that their region could be affected by disaster and 81% tend to agree or completely agree that any type of disaster could strike their community.

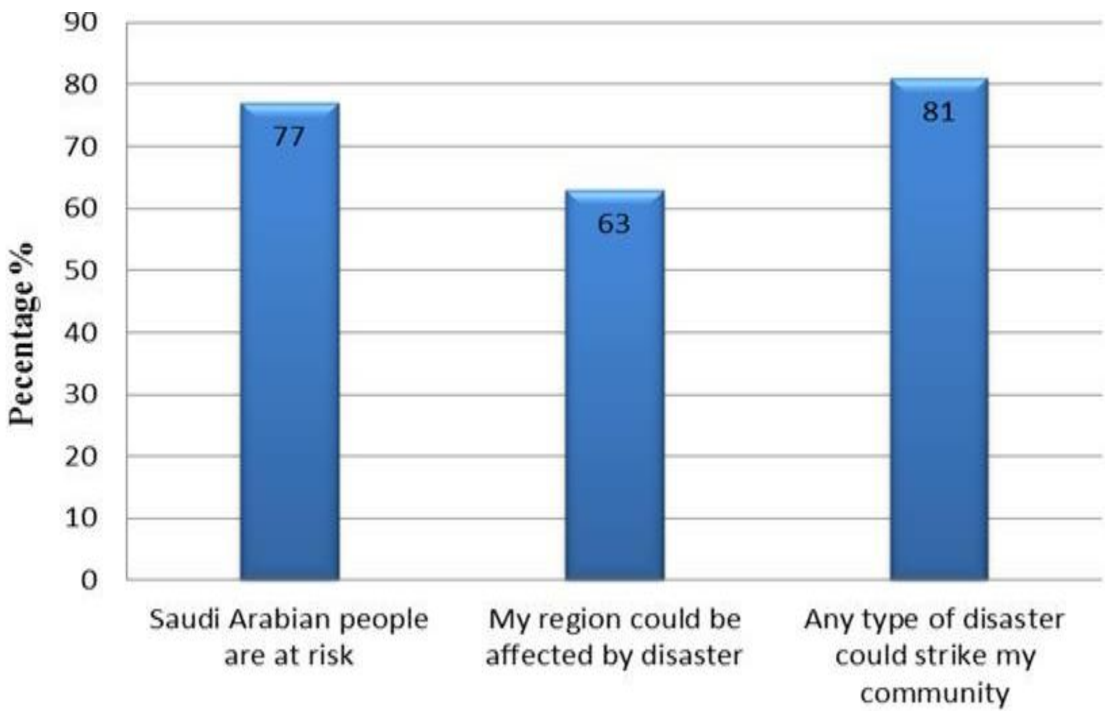


Figure 4-5: Public risk perception about disasters in Saudi Arabia

In general, just over half (54%) of the respondents feel concern about disasters, indicating that they are 'fairly' or 'very' concerned while 8%, 16% and 20% are Not at all concerned,Not very concerned, and Neither agree nor disagree respectively (Fig. 4-6).

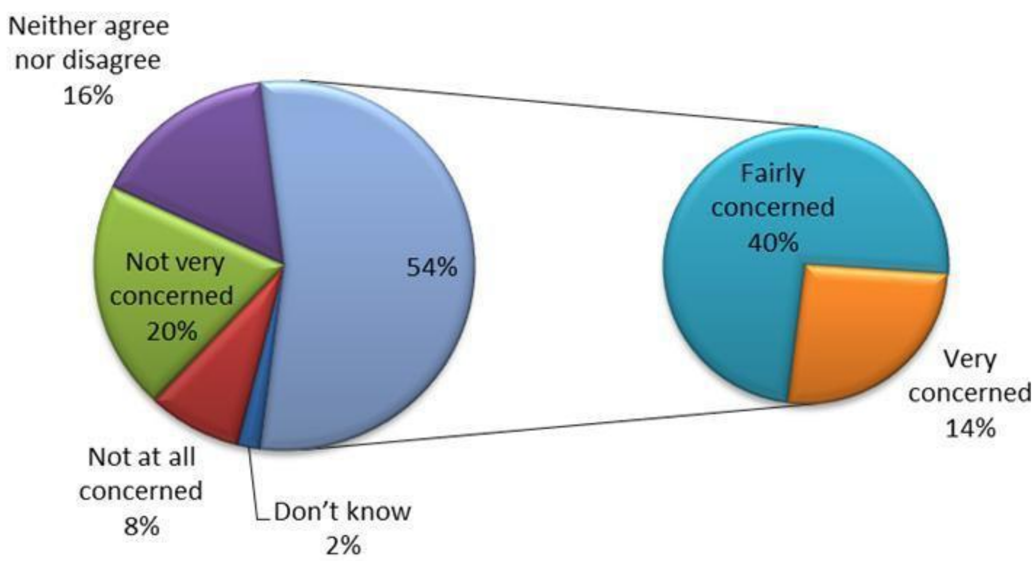


Figure 4-6: Respondents' concern about disaster in Saudi Arabia

The value of Chi-square (56.36) indicates an association between respondents' fear of disasters and their regional location (Table 4-7). This may be related to the frequency of disasters in their regions in recent years (Al-Saud 2010, Pallister et al. 2010).

Table 4-7:The value of Chi-square between regions and the fear of disasters

Variable		Do you think the region where you live could be affected by Disaster			Total
		Yes	No	Don't know	
Region	Riyadh	242	62	110	414
	Makkah	190	20	57	267
	Eastern	85	9	26	120
	Asir	55	12	34	101
	Jizan	42	5	7	54
	Madinah	65	22	22	109
	Najran	10	3	2	15
	Tabuk	33	2	9	44
Total		722	135	267	1124
Chi-square value	*d.f*	Sig.			
56.36	24	0.00			

Table 3In order to assess the experience with the disaster, all participants have been asked "Have you ever experienced a natural disaster". Hence, as illustrated in Figure (4-7), only 11% of respondents have experience with disaster and about 89% have no experience.

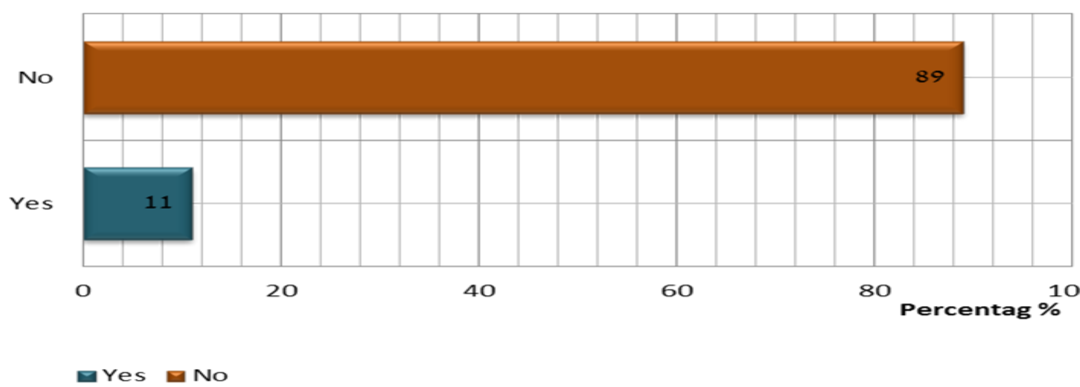
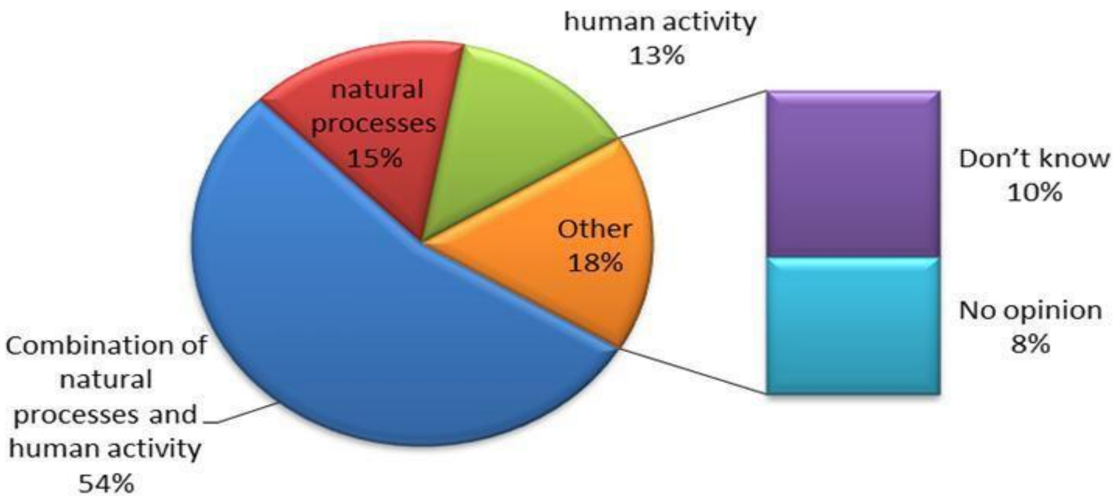


Figure 4-7: Respondents' experience with disasters.

4.4.6 Scepticism and Uncertainty

The survey also assessed public perception of the causes of disasters and reality. Firstly, 54% of the respondents tend to believe that disasters are caused by a combination of human activity and natural processes. On the other hand, the frequencies of those who think that disasters are caused either by natural processes or by human activity alone were 15% and 13% respectively. 18% either do not know or they have no opinion about the causes of disasters (Fig. 4-8).



.Figure 4-8: Perceived causes of disasters

Furthermore, all participants have been asked to rank the potential impacts in terms of importance. As presented in Table (4-8) the respondents think that the greatest impact is death and injury to people (mean 2.22), with concern about the impact of disasters on critical lifelines and infrastructures being second in importance, while the respondents view disasters having impacts on religious tourism (Hajj, Umrah) as less important (mean 5.81).

Table 4-8: Ranking of potential Impacts on Saudi Arabia

Type of affecting	Mean	Std. Deviatio	Rank
Death and injury of people	2.22	2.066	1
Damage and destruction to critical lifelines e.g. water, electricity	3.46	1.589	2
Damage and destruction to homes and Factories	3.51	1.894	3
Damage and destruction to infrastructure such as communication	4.23	1.715	4
Impacts on export of Oil	5.35	2.093	5
Impacts on Environment	5.48	2.247	6
Impacts on agriculture	5.61	1.838	7
Impacts on Religious tourism (Hajj, Umrah)	5.81	2.075	8

Notably, more than 62% of respondents tend to 'disagree' or 'completely disagree' that the seriousness of disasters is exaggerated, with only 10% agreeing. Furthermore, less than 20% tend to agree or completely agree that they are uncertain that disasters are really happening, while nearly 53% disagree with this statement. Just under half of the respondents (48%) agree or completely agree that most scientists believe that humans are causing disasters; only 17% disagree with this statement.

4.4.7 Personal Responsibility

The questionnaire included a series of questions to assess the extent to which the public are personally able to respond to their concern about disasters. Roughly half (51%) of the respondents agree or completely agree that it is their responsibility to help their family and others during disasters and 43% tend to agree or completely agree that they can contribute to reducing disasters. On the other hand, slightly more than 70% of respondents will comply with the evacuation procedures under any circumstances. However, responses to the statements that *they know what to do during disasters* or *they are aware of the emergency procedures* yielded mean scores of 2.53 and 2.41 (scale 1–

5), with standard deviations of 1.36 and 1.45 respectively, indicating an average ranking between "disagree "and "completely disagree". These results indicate that, only 29% and 28% of respondents have knowledge or they are aware of the emergency procedures respectively (Fig.4-9).

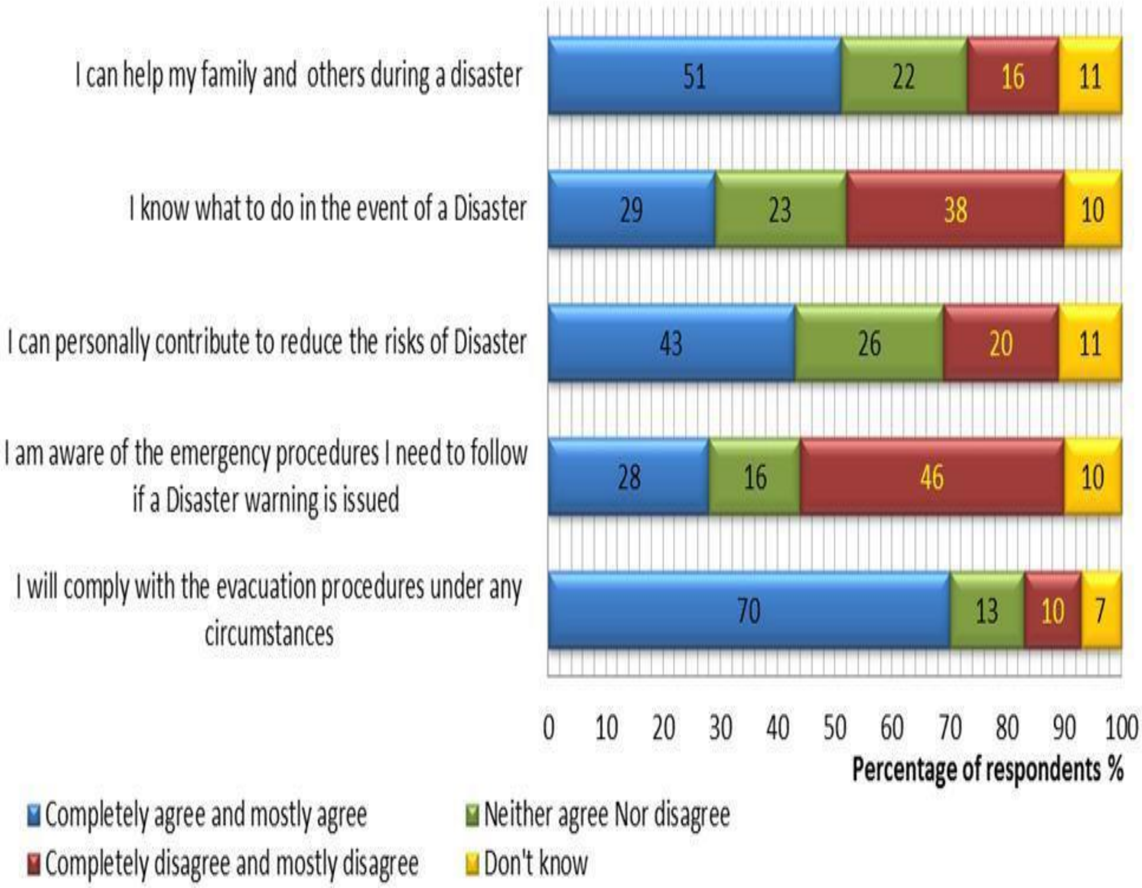


Figure 4-9: Personal responsibility

The majority of respondents (96%) desire to be more active in taking steps to protect their family and home from the effects of a disaster. As illustrated in Table (4-9) and Fig. (4-10), the mode is the value which appears the most often in the data for each factor; therefore, the values which appear most often are ranked from 1-5 according to the impotence of the factor which can reduce the risks of disasters. Thus, Raising risk awareness has been ranked as the most important factor with the minimum mean (2.14) followed by Early warning system, Disaster management, Evacuation plan, and

Prosocial behaviour during disasters with minimum mean 2.55, 2.58, 3.40 and 4.15 respectively.

Table 4-9: Some factors that can reduce the risk of disasters

Variable	Mean	Standard deviation	Mode	Rank
Raising risk awareness	2.14	1.436	1	1
Early warning system	2.55	1.214	2	2
Disaster management	2.58	1.137	3	3
Evacuation plan	3.40	1.070	4	4
Prosocial behaviour during disasters (volunteer, helping others).	4.15	1.271	5	5

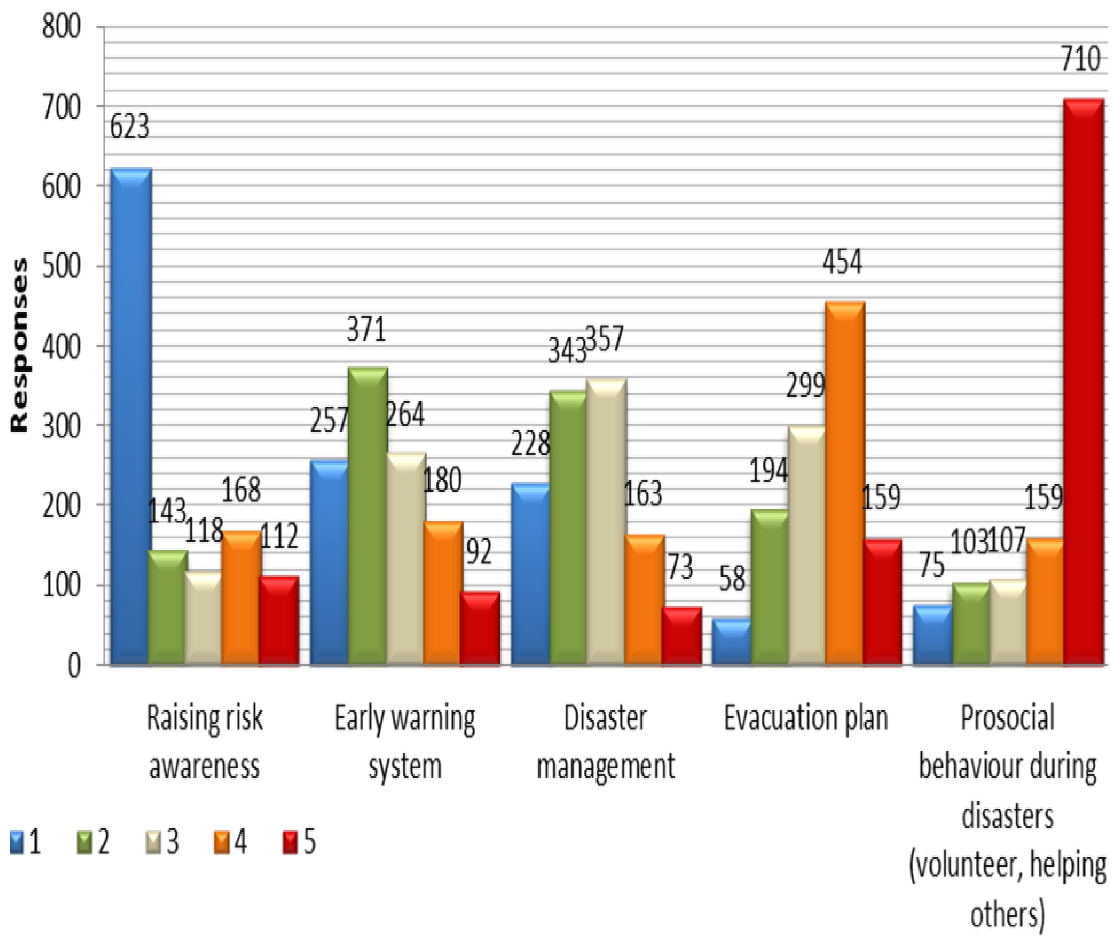


Figure 4-10: The rank of some factors can reduce the risk of disasters

4.4.8 Information Access

The survey included questions to ascertain the methods by which the respondents access information about disasters. More than half (59%) of respondents follow discussions in the media about hazards connected to Saudi Arabia while about 41% do not (Fig. 4-11)

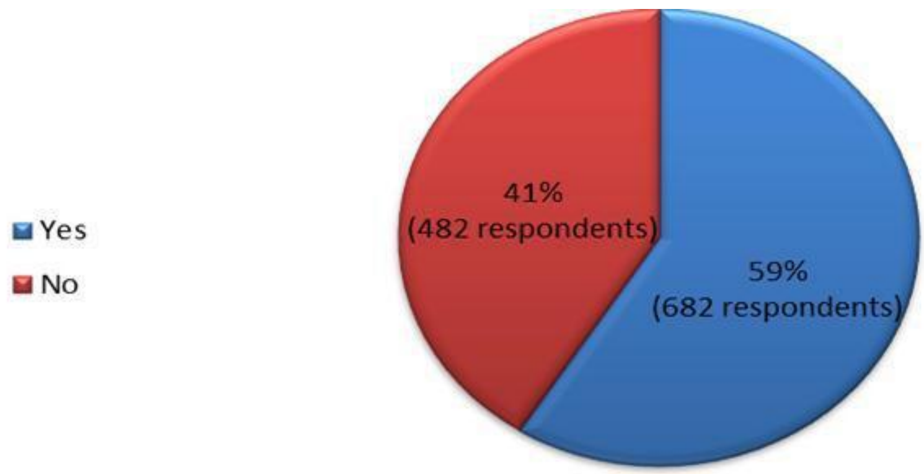


Figure 4-11: Respondents follow discussion in the media about hazards connected to Saudi Arabia.

These participants who follow discussion (682 respondents) were asked to indicate which media methods they use to access information about disasters. As illustrated in Fig.(4-12) the majority (559) receive their information about disasters from the internet as their first option and television (551) as the second media method, followed by newspapers (442) mobile phone (357), and the radio (158). Few respondents use information brochures and books to gain such information.

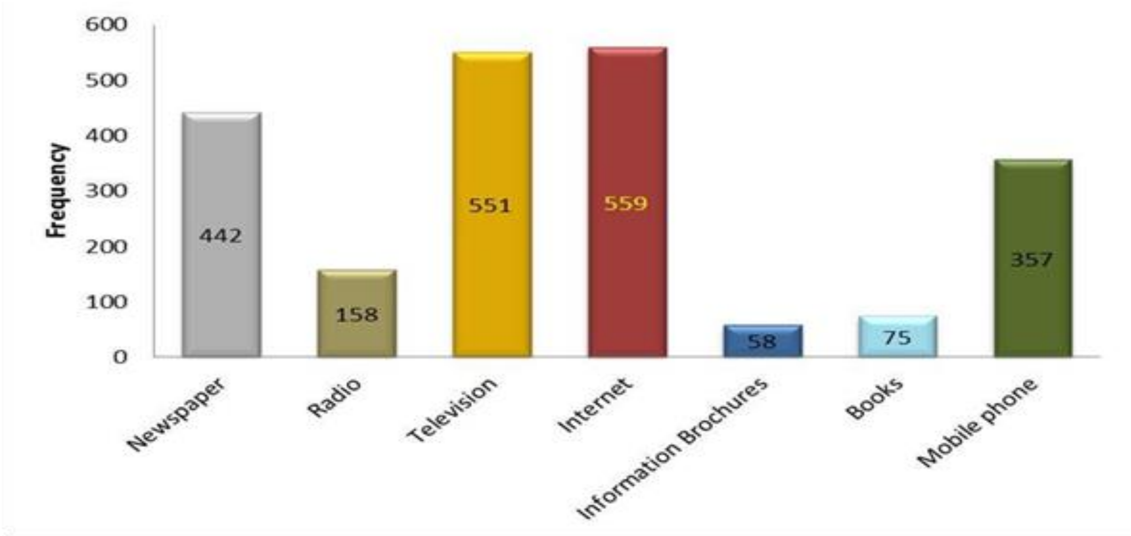


Figure 4-12: Frequencies of use of media to access information about disaster in Saudi Arabia

With regard to the risk of disasters, all the participants have been asked to choose the two best methods to receive disaster safety advice. According to Fig. (4-13) the majority of respondents preferred the television (899) as the first method, followed by mobile phone (698) as the second most important source for receiving disaster safety advice.

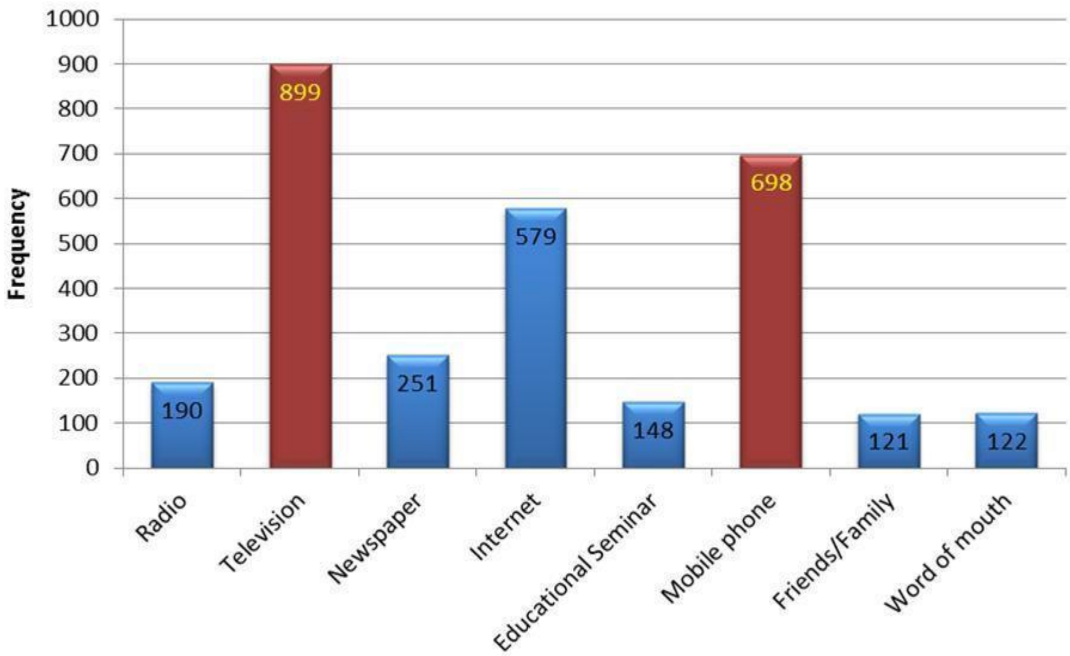


Figure 4-13: Preferred methods to receive disaster safety advice

The majority (55%) use the internet as their first source. However, surprisingly, more than 85%, 60 % and 68% of respondents have not used official websites such as that provided by Civil Defence, the Presidency of Meteorology and Environment, and the Ministry of Health respectively (as seen in Fig.4-14).

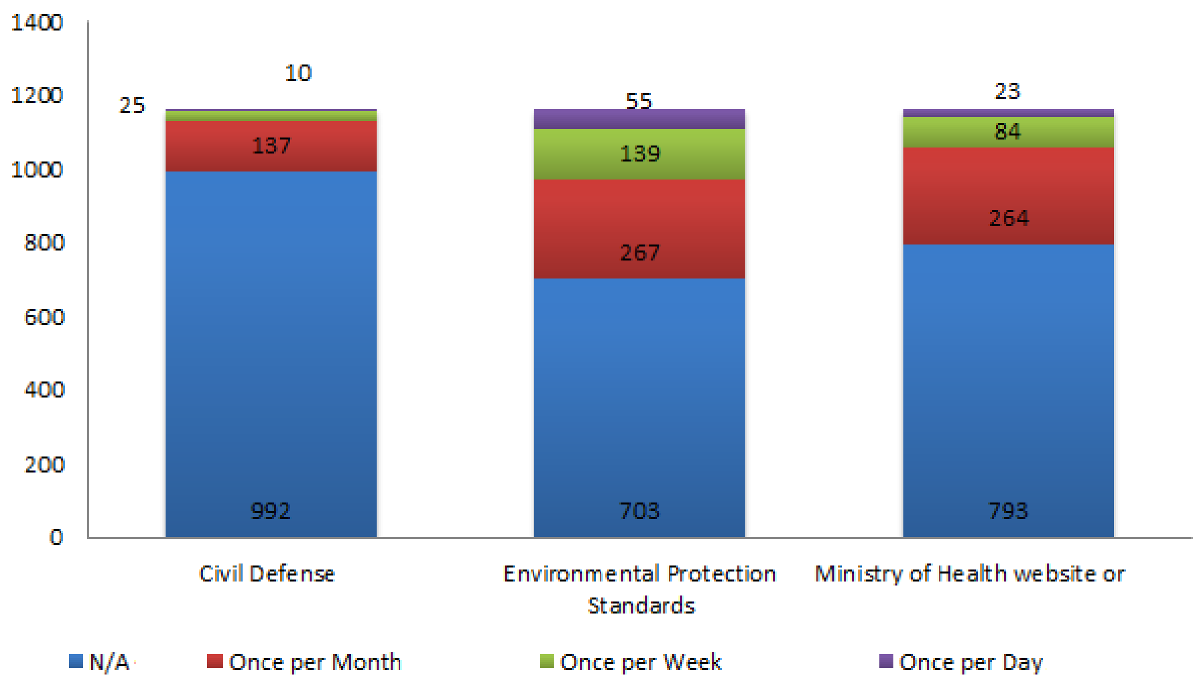


Figure 4-14: using official websites

4.4.9 Biological threat

To answer the questions research in order to understand the Saudi's perception of, and attitude to, the risk of biological disaster, the following findings have been gained:

In general, 62% of the respondents think that an epidemic can generate a disaster but almost half (45%) have heard little or nothing about epidemics after disasters. 78% know when the last disaster affected Saudi Arabia. 64% think that their region could be affected by a disaster, while 12% do not, and 24% "do not know".

Table (4-11) provides a summary of the responses to questions related to the respondents' knowledge of communicable disease and if *Dead bodies transmit diseases after disasters*.

Table 4-10: Responses to questions related to knowledge

Statement	Response					
	Yes		No		Don't know	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
SARS is a communicable disease	625	53.7	77	6.6	462	39.7
Avian Flu (H5N1) is a communicable disease	958	82.3	77	6.6	129	11.1
People can die of an infection from a new flu virus	860	73.9	66	5.7	238	20.4
The impact of a new communicable disease is a threat to the community	1007	86.5	56	4.8	101	8.7
Dead bodies transmit diseases after disasters	956	77.7	54	4.4	220	17.9

Moreover, participants were asked how confident they are about being able to protect themselves from a new disease in case of an outbreak. Responses to the question yielded a mean score of 3.51 (scale 1–5) (standard deviation 1.25), indicating a ranking between "Somewhat confident" and "Quite confident". Out of 1164 respondents, more than half gave this question a ranking of 3, 4, or 5. Thus, the majority of respondents are confident that they can protect themselves from a new disease in case of an outbreak (as seen in Fig. 4-15)

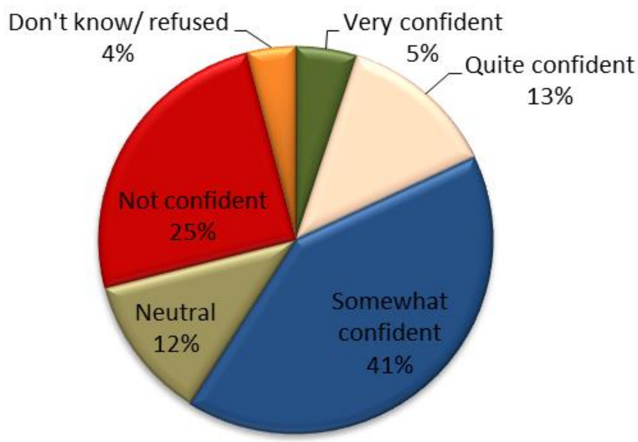


Figure 4-15: Respondents' confident to prevent their selves

Furthermore, the survey participants were asked to rank nine vulnerability factors which may increase diseases after disasters. *Lack of sanitary water* is ranked as the most important factor with a mean of 3.17, followed by *Poor waste management, Crowded living conditions, Lack of adequate immunization and medical services,* and *Malnutrition due to food shortages* with means 4.06, 4.26, 4.33 and 4.59 respectively. *Personal Hygiene* was perceived to be less important than the previous factors with a mean of 5.18 followed by *Lack of protective infrastructure; Population displacement* and *Physical ability (related to respondent's physical health condition. A community with lack of physical ability is less resilient to disasters (Chandra et al., 2010b))* with means of 5.53, 5.60 and 7.38 respectively (see Table 4-12 and Fig. 4-16) .

Table 4-11 : Respondents' ranking of some vulnerability factors that may increase diseases after disasters (Alshehri et al., 2016)

Factor	Mean	Standard deviation
Lack of sanitary water	3.17	2.046
Poor waste management	4.06	2.135
Crowded living conditions	4.26	2.608
Lack of adequate immunization and medical services	4.33	2.508
Malnutrition due to food shortages	4.59	2.112
Personal Hygiene	5.18	2.341
Lack of protective infrastructure (lack of shelter)	5.53	2.506
Population displacement	5.60	2.496
Physical ability	7.38	2.264

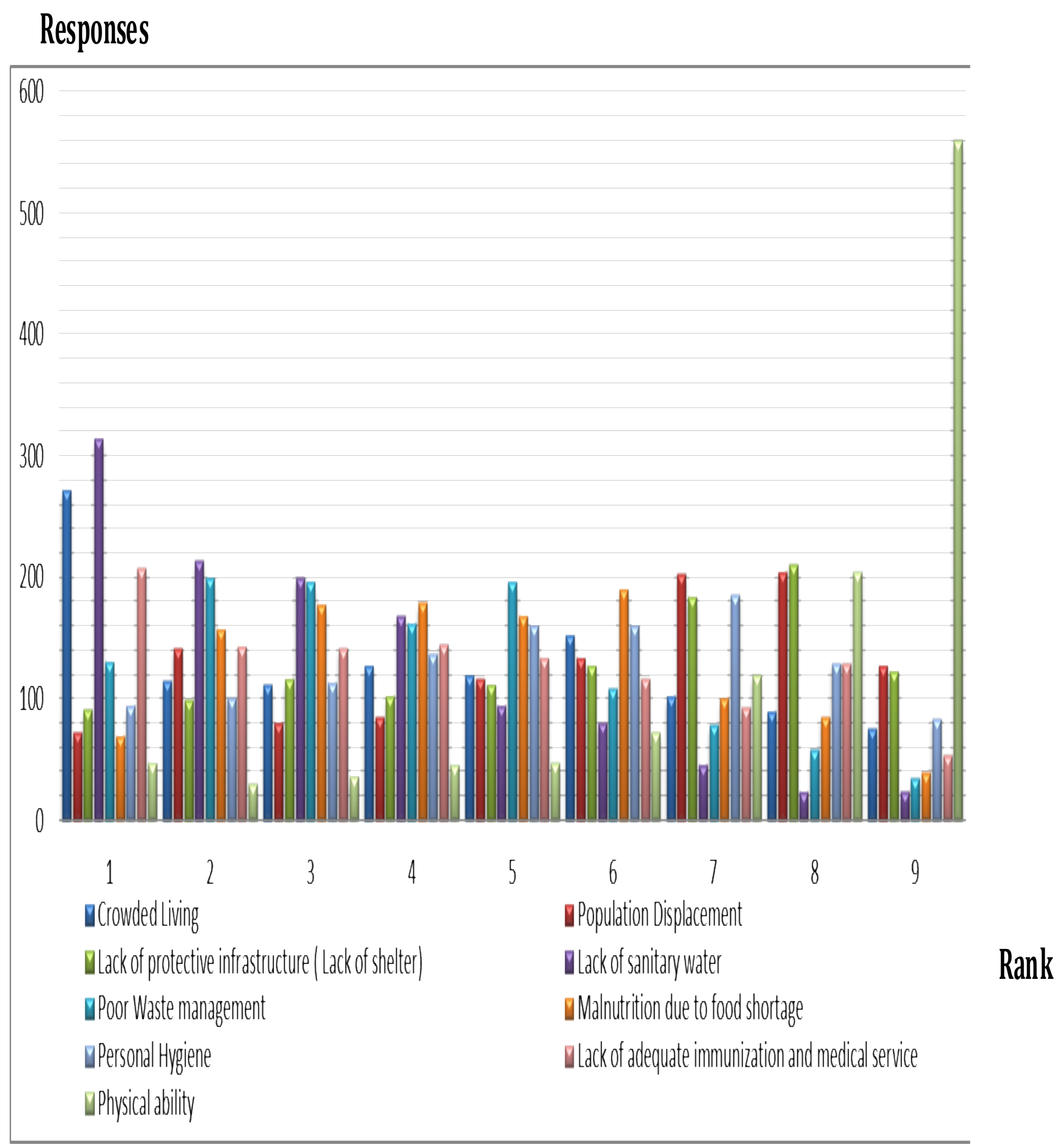


Figure 4-16: The rank of some factors may increase diseases after disasters.

4.5 Discussion

4.5.1 General perception of risks of disasters

The survey results indicate that a high proportion of the respondents have University degrees or postgraduate qualifications; it is worth noting that this is possibly due to the sampling approach adopted, which relied on the respondents having access to the internet and e-mail to receive the link to the questionnaire. As illustrated above (Table 4-2), there are varied rates of agreement on the generators of disasters, which may indicate a general lack of awareness.

The majority of respondents recognise conflict as a generator of disaster. This may be due, in part, to the recent experiences within the region over the past two decades. Saudi Arabia has participated in the war to liberate Kuwait and has been exposed to a number of terrorist attacks in some cities such as Riyadh and Al Khobar. This result could also be linked to the age of the respondents as the majority range in age from 31 to 50 years.

Economic development is an important contributing issue to building community resilience. It may be measured by many factors such as income, property value, and employment (Cutter et al., 2010, Manyena, 2006). For example, wealth can be used directly to raise resilience through increasing the ability and capacity of individuals and communities to overcome the negative impacts of disasters. In terms of the survey, the income of most the participants is beneficial in the sense that there is no poverty.

Overall the study clearly reveals that people in Saudi Arabia have concerns regarding disasters including biological threats such as epidemics. The majority of the survey respondents believe that disasters significantly impact the nation‘s people. This may be attributable to various reasons, for example the increasing frequency of disasters such as floods and dust storms in their regions in recent years, as noted in the literature (Al-Saud, 2010, Pallister et al., 2010). Furthermore, many respondents are either unaware of the emergency procedures or do not know what to do in the event of a disaster, as a result of lack of awareness and training (e.g. some participants noted that training does not exist‖ and others indicated that there is no practical training in schools). It may be argued that these factors can lead to an increase in people‘s fear of the impact of disasters on them personally; the study indicates that most respondents consider that death and injury to people is the most important effect of a future disaster in Saudi Arabia. These data endorse prior evidence from the literature, for example if residents did not fear floods, and they were not concerned about floods (Takao, 2006).

In terms of faith, under Islam faith can often be more important than experience in the public’s perceptions (Paradise, 2005), therefore, the survey examined the respondents’ faith as a factor. The results from these questions indicate that the rate of faith in general is high, which is due to a number of factors. For example Islam is the main religion in Saudi Arabia and the Holy Qur'an its constitution (Madani et al., 2004, CDSI, 2010). Furthermore, religious subjects are taught at all levels up to and including higher education in universities (Prokop, 2003). The survey respondents largely perceive humans to be strongly involved in causing disasters, but human responsibility can be nested within other concepts. For example, the majority of the respondents believe that disasters are a punishment from God. This result broadly aligns with other studies (Alam and Collins, 2010, Bhargava, 2007, Gaillard and Texier, 2010, Paradise, 2005), and is stated explicitly in the Qur’an. For example the Noah’s Ark story is noted in the holy Quran as punishment from God “And Nûh’s (Noah’s) people, when they denied the Messengers, We drowned them, and We made them as a sign for mankind. And We have prepared a painful torment for the polytheists and wrong-doers” 25:37(Qur'an). Moreover, there are many stories, which have been mentioned in the Holy Qur'an, about disasters that can be as punishment from God. One of these stories is Prophet Shu'ayb story who was sent as a prophet to the Midianites to warn them to end their fraudulent ways. When they did not repent, Allah destroyed them. And to Madyan [We sent] their brother Shu'ayb, and he said, "O my people, worship Allah and expect the Last Day and do not commit abuse on the earth, spreading corruption. But they denied him, so the earthquake seized them, and they became within their home [corpses] fallen prone (Qur'an).

وَإِلَىٰ مَدْيَنَ أَخَاهُمْ شُعَيْبًا فَقَالَ يَٰقَوْمِ ٱعْبُدُوا۟ ٱللَّهَ وَٱرْجُوا۟
ٱلْيَوْمَ ٱلْءَاخِرَ وَلَا تَعْثَوْا۟ فِى ٱلْأَرْضِ مُفْسِدِينَ ﴿٣٦﴾
فَكَذَّبُوهُ فَأَخَذَتْهُمُ ٱلرَّجْفَةُ فَأَصْبَحُوا۟ فِى دَارِهِمْ
جَٰثِمِينَ ﴿٣٧﴾

It is of significant note that the survey results differ to those of other studies, which have highlighted that the faithful who believe God is in control of the world should not take action to avoid damage from such disasters (Paradise, 2005). However, Islam does urge that it is most important to prepare the people to escape from disaster; again, from the story of Noah: he built the Ark to escape the flood, "So We revealed to him (saying): Construct the ship under Our Eyes and under Our Revelation (guidance)" 23:27(Qur'an). The results may be interpreted as a clear indication that the survey respondents generally display a willingness to cope with disasters.

The survey reveals some knowledge of disaster risk despite the lack of individual experience with disasters, but this does not reflect respondents' preparedness to deal with disasters, even in the case of those who are highly educated. This result is consistent with the study of Anderson-Berry (2003) who noted that people could reveal general hazard knowledge, but this does not necessarily evidence an understanding adequate enough to transfer into hazard preparedness. The current survey results indicate quite clearly that many respondents believe they are not ready to cope with disasters, but that they are willing to learn more about disasters, thereby positively affecting their attitudes toward preparedness. For instance, they believe that they have a responsibility to help their families during a disaster event. Moreover, they have a desire to contribute to reducing the risk of disasters, and have indicated willingness to comply the evacuation procedures under any circumstances. Overall, the results indicate that raising the awareness of a disaster's risk is the most important factor toward increasing resilience to a disaster, a finding that is consistent with other studies (Ghafory-Ashtiany, 2009) .

The results also indicate that many respondents would be interested in taking part in follow-up discussions relating to disasters in Saudi Arabia. The survey results also indicate that disasters make one third of the respondents think about other topics. One specific topic is climate change, which has strong links with disasters (Birkmann and von Teichman, 2010, Vogel et al., 2007). This result is in accordance with a study conducted in Jeddah, Saudi Arabia, to examine the climate change perceptions of educated people; it showed that participants had high levels of knowledge and concern about climate change when they had mentioned natural disasters such as flooding in Jeddah (Aljohani, 2010).

In terms of information sources, as has been noted elsewhere, it is important to take into account how risk information is acquired by respondents (Al-Zahrani, 2006). The majority of the study participants who follow discussions about disasters in Saudi Arabia prefer to use the internet as their first choice information access medium. Notably, however, a large proportion prefers the television as an official source of information during disasters. Furthermore, the survey shows that the majority of the participants prefer using cell phones as a secondary information source to gain safety advice. This may be due to simplicity of use and the tremendous developments in Information Technology. These findings are consistent with a study conducted after the hurricane Katrina disaster in 2005, which proved that the majority of the participants used the internet and cell phone as information sources (Spence et al., 2007).

The Saudi government provides internet access to official disaster information via Civil Defence, the Presidency of Meteorology and Environment, and the Saudi Geological Survey (SGS), which are the most important government organisations in this respect (Al-Zahrani, 2006, PME, 2012, SGS, 2012b). It is significant to note that the survey results indicate that the vast majority of internet users do not access those sites. This could be due to a lack of awareness of the role of these organisations in disaster situations, a lack of the respondents' knowledge of those sites and their significance, or simply a lack of experience with disasters; as participants indicated "I access to the site if necessary". However, it is also clear that they take seriously warnings that they receive from these organisations via the television.

4.5.2 Biological risks

In terms of the source of disasters, the survey indicates that the respondents are aware of both natural and man-made disasters. The survey reveals a degree of knowledge about natural disasters resulting from biological threats such as SARS and H5N1 flu despite the lack of individual experience with disasters. However, the results demonstrate significant clear differences in the level of awareness of the generators of biological disaster such as epidemics. This may be attributed to a number of reasons, including: (a) the vast majority of respondents have no experience with disasters, and (b) there has been a relatively low occurrence of disasters in the region over the past two decades (Al-Saud, 2010). Nevertheless, this study indicates that the majority of respondents believe that the impact of a communicable disease would threaten the community, and people may die from an infection. This finding is consistent with several studies (Leung et al., 2005, Kamate et al., 2009). As elaborated earlier, recent evidence suggests that communicable diseases, e.g. SARS and H1N1, may result in global pandemics in a relatively short period of time (Kamate et al., 2009, Memish et al., 2009, Gray et al., 2012).

Furthermore, the findings suggest that the geopolitical risk may influence public perception about disasters, and recently, the Arab Spring has resulted in new disaster-related issues in the region. For example, the United Nations announced that Yemen faces famine disaster (TheEconomist, 2012). This regional situation is inciting people to move to Saudi Arabia as refugees, which may increase risk of new outbreaks. Bengtsson et al., (2011) note that population movements during disasters can carry outbreaks rapidly (Bengtsson et al., 2011). Moreover, during the period over which this survey was conducted, there were 15,000 people killed and more than 40,000 people became refugees as result of the conflict situation in Syria. There are also fears that the Syrian regime would use chemical or biological weapons (Blair, 2012) which would impact across neighbouring countries. Reported consequences of climate change, including the increasing occurrence of disasters such as floods and dust storms, which can generate communicable diseases (Purse et al., 2005), can also have an impact on the public perception.

In terms of risk perception, gender differences have been found in a number of studies (Saadatian-Elahi et al., 2010, Howe, 2011). These studies argue that women tend to report higher levels of perceived risk and worry more than men. This study also found that women reported having greater concerns about the impact of disasters than men. This finding is consistent with several studies (Bish and Michie, 2010) whereby women reported being less confident of their ability to protect themselves from a subsequent biological threat than men. However, despite these concerns, the survey reveals that women engaged in the reduction of the risk associated with disaster less frequently than men.

Positively, in terms of averting risk, the study highlights that there are a number of factors which indicate the basis for building resilience in coping with disasters in the future. For example, the survey found that the income for most participants is sufficiently high that there is little poverty, thereby overcoming a major cause of post-disaster problems. Moreover, the majority of the participants expressed the desire to take part in reducing disaster risk. Evidence suggests that if there is a willingness to learn more about disasters and to comply with evacuation procedures under any circumstances, attitudes toward preparedness can be positively impacted (Alshehri et al., 2013).

The demographic characteristics of our sample corroborates statistic figures of population in Saudi Arabia (CDSI, 2010). Most of respondents are within the working age, supporting the positive age factor in building community resilience (Cutter et al., 2010, Manyena, 2006). Educated respondents are relatively high. This is in line with statistical information from the Statistical Centre in Saudi Arabia (CDSI) with 98.6% of the population educated with Saudi Labour Force (15 years and over) (CDSI, 2010). Migrant workers represent about 50 of Labour Force (15 years and over) in Saudi Arabia 97% of them are educated (CDSI, 2010). Also, it has been highlighted that educated people are more resilient to disasters and can help in improving community planning (Jafari et al., 2011b).

One of the important resilience factors in Saudi Arabia is faith (Alshehri,et.al 2014 Disaster Journal), which (a) can be more important than experience in the public's perception (Paradise, 2005), and (b) can play an influential role in the public perception of the risk of disasters (Alshehri et al., 2013). Furthermore, the participation of religious leaders, especially Muslim religious leaders, has increased significantly over the last few years (Suleiman et al., 2012). It has been proven that they have a significant influence on public attitudes and can play a positive role in raising the awareness of the society about healthy behaviour towards epidemics or pandemics such as AIDS (Abu-Moghli et al., 2010). Consequently, faith organisations can play an important role in disaster risk reduction through contributing towards the building of a resilient community that can respond to biological threats over a very short period. However, this issue deserves further attention as religiosity may lead to fatalism and a lack of action, which can be addressed through further education and awareness raising.

In building resilience, it is also important to take into account how risk information is acquired by respondents (Al-Zahrani, 2006, Gray et al., 2012). This survey reveals that the majority of respondents follow discussions about disasters in Saudi Arabia through the Web, and to a lesser extent, television as an official source of information during disasters (Alshehri et al., 2013). However, more than two-thirds of the respondents do not access official information sources such as the Ministry of Health website. This result is consistent with other studies conducted in Saudi Arabia after the swine flu pandemic in 2009 (Balkhy et al., 2010). The current study suggests that the media plays an important role in influencing the public perception of the disaster in two conflicting ways**.** On the positive side, it contributes to increasing knowledge and awareness among people who do not have experience of disasters; it also raises the level of confidence in dealing with any biological threat in the future (although this may be due either to access to information through the media or to their level of education**.** On the other hand, the downside is that the media may contribute to unnecessarily raising the level of concern among people who are not affected by the disaster, and also encourage people to access unreliable information from non-official sources**.**

4.6 Summary

The resilience concept has been considered in several frameworks as mentioned in literature review chapter based on factors that contribute to building community resilience to disasters.

This chapter has explored public's perception of and attitudes towards risks of disasters in general and to biological disasters in specific to identify community resilience factors in relation to explicit indicators at the local level in the context of disasters in Saudi Arabia. The public's perception to disasters was surveyed to asses if factors deemed necessary to building to community resilience were present in Saudi Arabia. These factors included ***Faith***, ***Education level***, ***Economic, Risk Perception, Access to sources and Willingness and Responsibility***. However, other important factors, such as lack of: raising awareness, training, and knowledge regarding information access to official websites, can decrease community resilience are also evident from the survey.

The outcomes of this survey show that the willingness and responsibility of most respondents should present significant opportunities to engage community members with the preparation of responses to disasters and to encourage informed action .

Based on the survey results, the researcher believes that the following recommendations emerge:

Awareness of the hazards and risks of disasters;

- Education: this needs to be greatly increased. Disaster education in schools from the earliest stages will increase the ability of people to cope with disasters and thereby reduce the burden on the government during disasters and pave the way to the possibility of a quick return to normal life after a disaster.

The research findings on education leading to this recommendation are reinforced from other sources in the literature. Shiwaku et al (2007) indicated that awareness about the risks of disasters in early school education can raise risk perception, but community involvement is also a highly important factor; education of the people on the concept of disasters will increase their awareness of this environmental problem. Furthermore, a study found that offering regular education on disasters and follow-up training are important to raise or maintain knowledge, public awareness and skills (Chen et al., 2006).

- Training: Professional organizations such as Civil Defence should be encouraged to utilize the findings from this research to hold training sessions for the public, and conferences, seminars and workshops in coordination with other sectors to educate their employees about the critical issues of disaster preparedness facing the people in Saudi Arabia.
- Volunteering is an effective cornerstone in disaster management. Volunteering is an effective cornerstone in disaster management. It is therefore important that authorities and official institutions raise awareness of the opportunity to volunteer, attract and educate volunteers, and thus take advantage of qualified volunteers in the field. The revitalization of communities in this way will strengthen their ability to prevent disasters.

Information sources:

- Official organisations such as Civil Defence, the Presidency of Meteorology and Environment, and the Saudi Geological Survey (SGS) should develop their web sites and investigate the reasons behind the currently limited public access to those sites.
- These organisations should be encouraged to utilize the results of this study to build a dedicated channel with the public, via networks such as mobile phone, to warn them of any disaster risks.

Chpter:5 Establishment of a community resilience framework (Delphi Consultation Study)

This work has been published in a scientific journal as following:

- ALSHEHRI, S. A., REZGUI, Y. & LI, H. 2015a. **Delphi-based consensus study into a framework of community resilience to disaster**. *Natural Hazards*, 1-25.

Disasters cannot be prevented but the impacts of disasters can be mitigated through suitable disasters management. There are several studies have confirmed that the community resilience is very important for disaster management. Saudi Arabia is part of the world prone to disasters recently. As a result of challenges that have been mentioned in chapter 2, national and local governments are considering implementing disaster management strategies to attenuate their impacts. The building of community resilience to disasters is an essential element of disaster management (Joerin et al., 2012, Ainuddin, 2012). However, measuring community resilience to disasters is difficult due to the lack of standard criteria to assess the capability of the community to manage disasters (Cimellaro et al., 2010, Norris et al., 2008). Therefore, critical to this chapter is:

- *To collate the opinions of experts and to achieve the consensus about the research priorities in what are the applicable community resilience criteria to manage such disasters in Saudi Arabia context.*

A three-round of Delphi study was conducted using a local and an international panel of experts with expertise in the disaster management experience, active researchers and active educators in disaster management. General dimensions and criteria for consideration were derived from the literature analysis undertaken as part of this work. Based on the results, expert panel achieved consensus on a framework of community resilience to disasters in context of Saudi Arabia focused on six resilience dimensions: a) social, b) economic, c) physical and environmental, d) governance, e) health and well-being, and f) information and communication. These dimensions have 62 criteria including 7 to 14 criteria in each dimension. Fifty-seven of these criteria achieved consensus in Round 2. An additional 5 criteria reached consensus in third Round.

The process of the Delphi according to this PhD project has been described in chapter three. In light of these issues, this chapter identfies the proposed community resilience framework to disaster in Saudi Arabia based on criteria considered at the community level. The proposed framework can be used for community awareness, preparedness, coping and recovery from disasters and therefore can manage biological issues such as epidemics that can occur in the aftermath of disasters, either natural or man-made. This chapter is structured into four sections. Following this introduction, a brief overview of Delphi method. The results from the three-round Delphi consultation are then provided, followed by a critical discussion of each dimension of the framework. The final sction provides concluding remarks.

5.1 Overview

This phase of the PhD project was based on the concept of Delphi. This concept refers to the legend of the Greek Delphi oracle. The oracle had a network of informants and was considered to be one of the most truthful – with data derived from many sources. The Delphi method has its origins in the American business community, and has since been widely accepted throughout the world in many industry sectors including health care, defence, business, education, information technology ,transportation and engineering (Skulmoski et al., 2007).

the Delphi method is one of three consensuses methods can be used to establish consensuses opinions of experts (Bowling, 2009, McKee et al., 1991). The second method is the consensus development conference, which sometime called the consensus development panels (Bowling, 2009). According to Jones & Hunter (1995), this type of method needs to have sources beyond the capabilities of many researchers. It also is usually structured by both the National Institutes of Health (NIH) in the United States of

America, and the King's Fund in the UK within defined programmes (Jones and Hunter, 1995, McKee et al., 1991). Therefore, it will not be pointed out in this chapter.

The third method is the nominal group technique NGT which also known as expert panel (Bowling, 2009). The recommended size of expert participants, in this method, is usually 5-12 (Potter et al., 2004, McKee et al., 1991). The NGT can used as a mixed method approach and it takes part in a highly structured meeting for all participants to discuss their individual view (Bowling, 2009). However, on the comparison between Delphi method and NGT, it is clear that Delphi is best suited for the current study as follows:

One of the characteristic of Delphi method is anonymity which has advantages. For example, it will reduce the effect of dominant individuals (Okoli and Pawlowski, 2004). It also avoids socio-psychological pressure on the participants which will increase the response rate (De Vet et al., 2005, Pill, 1971, Bailie, 2011). Moreover, the Delphi method is effective method of gathering information from a large group of experts who are geographically separated (Keeney et al., 2006, Rådestad et al., 2013). Keeney et al (2005) argue that a Delphi survey is appropriate method to establish consensus or obtain a judgment on an issue, because of the possibility of using iteration and feedback (De Villiers et al. 2005).

On the other hand, Okoli & Pawlowski, (2004) point out that the Delphi method is a stronger methodology for a specific requirement of experts. They provide comparison between Delphi study versus the traditional survey approach as a research strategy as seen in Table 5-1(Okoli and Pawlowski, 2004).

Evaluation criteria	Traditional survey	Delphi study
Summary of procedure	The researchers design a questionnaire with questions relevant to the issue of study. There are numerous issues concerning validity of the questions they must consider to develop a good survey. The questionnaire can include questions that solicit quantitative or qualitative data, or both. The researchers decide on the population that the hypotheses apply to, and selects a random sample of this population on whom to administer the survey. The respondents (who are a fraction of the selected random sample due to non-response by some) fill out the survey and return it. The researchers then analyse the usable responses to investigate the research questions.	All the questionnaire design issues of a survey also apply to a Delphi study. After the researchers design the questionnaire, they select an appropriate group of experts who are qualified to answer the questions. The researchers then administer the survey and analyse the responses. Next, they design another survey based on the responses to the first one and read ministers it, asking respondents to revise their original responses and/or answer other questions based on group feedback from the first survey. The researchers reiterate this process until the respondents reach a satisfactory degree of consensus. The respondents are kept anonymous to each other (though not to the researcher) throughout the process.
Sample size for statistical power and significant findings	Because the goal is to generalize results to a larger population, the researchers need to select a sample size that is large enough to detect statistically significant effects in the population. Power analysis is required to determine an appropriate sample size.	The Delphi group size does not depend on statistical power, but rather on group dynamics for arriving at consensus among experts. Thus, the literature recommends 10 to 18 experts on a Delphi panel.
Individual vs. group response	The researchers average out individuals' responses to determine the average response for the sample, which they generalize to the relevant population.	Studies have consistently shown that for questions requiring expert judgment, the average of individual responses is inferior to the averages produced by group decision processes; research has explicitly shown that the Delphi method bears this out.
Reliability and response revision	An important criterion for evaluating surveys is the reliability of the measures. Researchers typically assure this by pretesting and by retesting to assure test-retest reliability.	Pretesting is also an important reliability assurance for the Delphi method. However, test-retest reliability is not relevant, since researchers *expect* respondents to revise their responses.
Construct validity	Construct validity is assured by careful survey design and by pretesting.	In addition to what is required of a survey, the Delphi method can employ further construct validation by asking experts to validate the researcher's interpretation and categorization of the variables. The fact that Delphi is not anonymous (to the researcher) permits this validation step, unlike many surveys.
Anonymity	Respondents are almost always anonymous to each other, and often anonymous to the researcher.	Respondents are always anonymous to each other, but never anonymous to the researcher. This gives the researchers more opportunity to follow up for clarifications and further qualitative data.
Non-response issues	Researchers need to investigate the possibility of non-response bias to ensure that the sample remains representative of the population.	Non-response is typically very low in Delphi surveys, since most researchers have personally obtained assurances of participation.
Richness of data	The richness of data depends on the form and depth of the questions, and on the possibility of follow-up, such as interviews. Follow-up is often limited when the researchers are unable to track respondents.	In addition to the richness issues of traditional surveys, Delphi studies inherently provide richer data because of their multiple iterations and their response revision due to feedback. Moreover, Delphi participants tend to be open to follow-up interviews.

Table 5-1: Comparison between Delphi study versus the traditional survey approach as a research strategy (Okoli and Pawlowski, 2004)

5.2 Methodology

The research methodology was designed to answer the research question "*What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?*" ***This research question is addressed through*** a survey based on the concept of Delphi. Summing up what stated in the third Chapter section 3.10.1 , the Delphi method, a multi-round survey of experts, has been widely used to obtain the consensus opinion of experts (De Villiers et al., 2005, Okoli and Pawlowski, 2004, Verhagen et al., 1998). It is considered as an important data collection method for gathering information from experts in the topic of interest (Hsu and Sandford, 2007). To this end, the study follows the Delphi process of anonymous rounds of survey with feedback after each round. Once the criteria, scale, and format of the questionnaire were drawn up, a pilot survey was conducted, involving 10 participants, to test the ease of taking the survey. As a result of the pilot, a number of changes were made. Thereafter, the survey was conducted online through SurveyMonkey® (www.surveymonkey.com) in three rounds from April 15 to June 15, 2013 (more details in Chapter 3 section 3.10).

5.3 Results and analysis

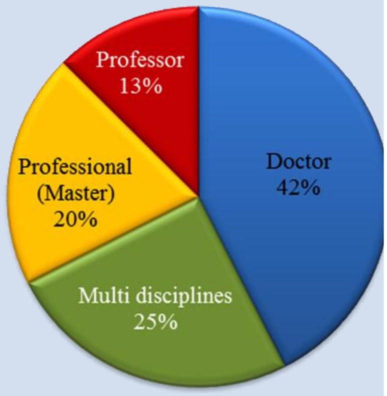
Data were analysed using the Statistical Package for Social Sciences (SPSS) version 20.0. In this research, the survey was designed to determine if consensus were reached in relation to the importance of community resilience criteria to disasters in Saudi Arabia across the six dimensions.

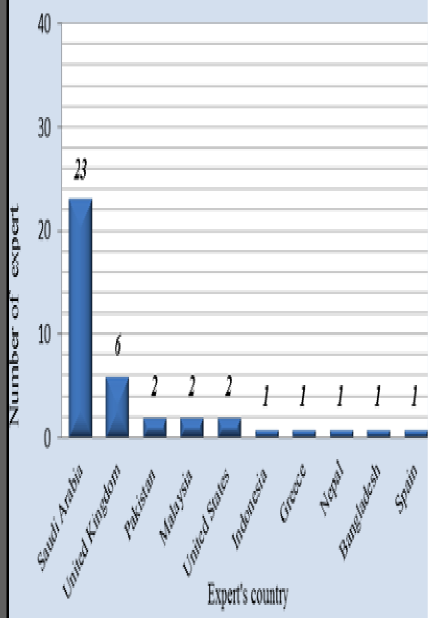
5.3.1 Expert panel

As mentioned in chapter 3, this resulted in a panel of 40 experts from ten different countries; with at least five years' experience in disaster management and a relevant degree (42% hold a PhD with the rest holding either an MSc or Bachelor degree). The experts in research and practice came from a variety of disciplines in disaster management, including international experts, as well as professionals and highly informed local experts from academia, government and medical (see Table 5-2).

Table 5-2: Background of expert's panel (Alshehri et al., 2015a)

Expert	Organisation	Expert's panel distribution
International	· International Red Cross Red Crescent Climate Centre/German Red Cross. · Leeds City Council (UK). · NHS Commissioning Board (London). · Earthquake Reconstruction & Rehabilitation Authority. · Muhammadiyah movement (Indonesia). · Humanitarian Futures Programme (Malaysia/ UK). · Mahila Partnership (USA). · Crowd Modelling Ltd (UK). · Asian Disaster Preparedness Centre. · Caribbean Emergency Responder's Training Academy (USA).	
Official government	· Abdel Aziz City for Science and Technology. · Civil Defence. · MINISTRY OF AGRICULTURE. · Armed Forces Medical Services (MSD). · Royal Saudi Air Force. · Ministry of Health (MOH). · Centre of Excellence for Climate Change Research (CECCR), King Abdul-Aziz University.	
Academia	· King Abdul-Aziz University. · University Putra Malaysia. · University College London. · King Khalid University Umm Al-Qura University. · Naif Arab University for Security Sciences.	
Medical	· Prince Sultan Military Medical City (PSMMC). · NHS South (UK). · King Abdulaziz University Hospital. · King Saud University for Health Sciences.	
Industry	· Saudi Basic Industries Corporation (SABIC).	





5.3.2 The Framework of Community Resilience to Disasters in Saudi Arabia

The final framework, which was derived from the consensus amongst the expert panel, integrates a number of factors that are of particular importance in building community resilience to disasters. Figure (5-1) illustrates the basic framework, and sets out the hierarchy of factors that may influence community resilience. The first level contains the six dimensions and the second level comprises 62 criteria.

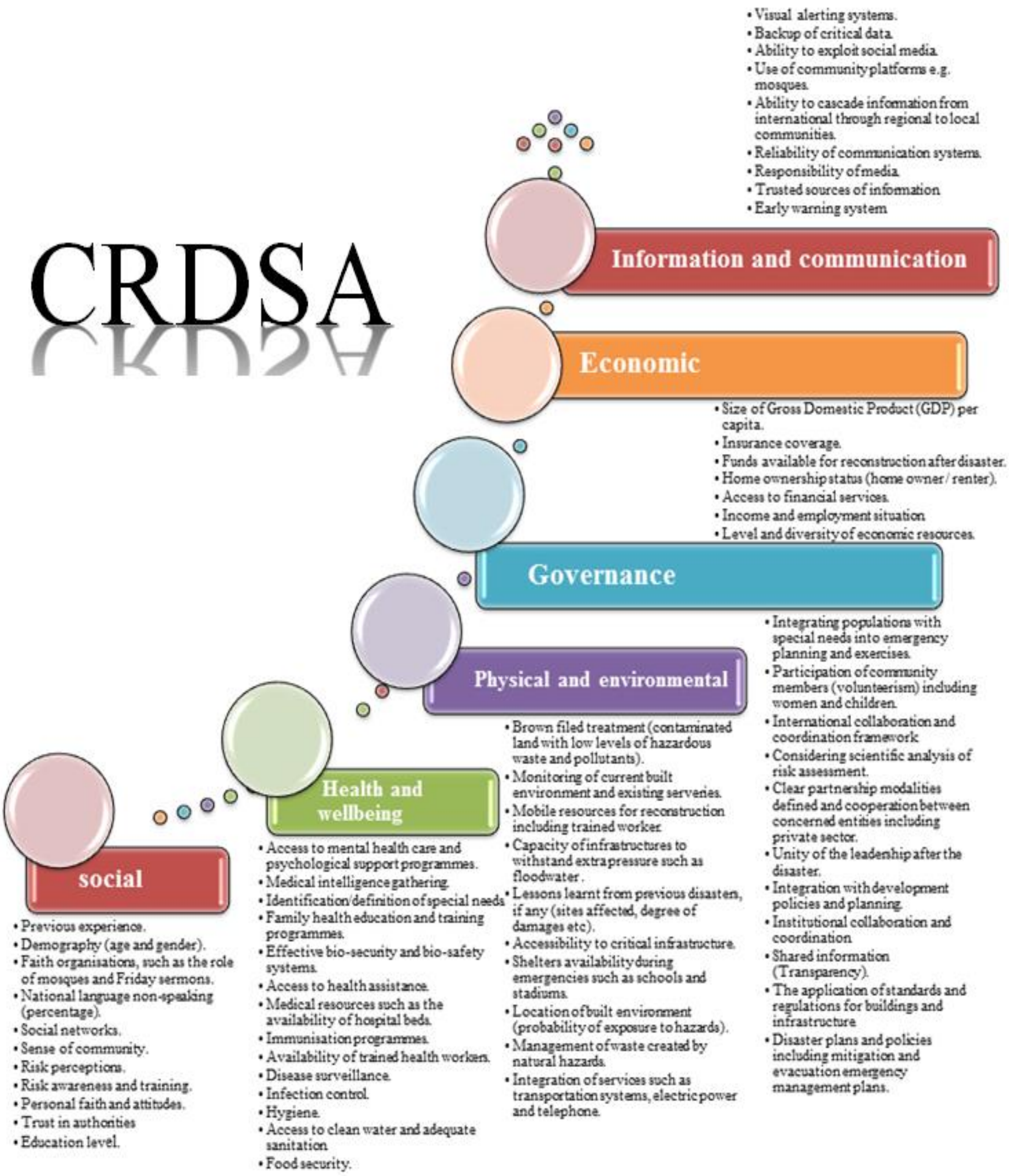


Figure 5-1: The Framework of Community Resilience to Disasters in Saudi Arabia (CRDSA).

In the first round, the criteria under each dimension were sent to 49 experts who were asked to give opinion on the importance of each criterion and also asked to add further relevant criteria. They indicated their rating on a 5-point Likert scale with 1 representing not applicable, 2 representing not important, 3 representing less important, 4 representing important, and 5 representing very important. The resulting mean ratings are presented in Table 5-3.

Table 5-3: Round 1

Dimension	*Criteria*	*Total experts*	*Mean*
Social	• Education Level.	49	4.16
	• Trust in authorities.	49	4.29
	• Personal faith and Attitudes.	49	4.08
	• Risk Awareness and Training	49	4.63
	• Risk perceptions.	49	4.43
	• Sense of community.	49	4.16
	• Social networks.	49	4.10
Economic	• Level and diversity of economic resources.	49	4.14
	• Income and employment situation.	49	4.08
	• Access to financial services.	49	4.08
Physical and environmental	• Integration of services such as transportation systems, electric power and telephone.	49	4.39
	• Management of waste created by natural hazards.	49	4.33
	. Location of built environment (probability of exposure to the hazards).	49	4.49
	• Shelters availability during emergencies such as evacuation time.	49	4.43
	• Critical infrastructure, accessibility.	49	4.53
Governance	• Mitigation and evacuation plan.	49	4.57
	• Disaster plans and policies.	49	4.61
	• Emergency management plans.	49	4.61
	• The application of standards and regulations.	49	4.43
	• Shared information.	49	4.59
	• Institutional collaboration and coordination.	49	4.59
	• Integration with development policies and planning.	49	4.57
	• Integration with emergency response and recovery.	49	4.59
Health and wellbeing	• Trained Health workers.	49	4.55
	• Surveillance.	49	4.49
	• Safe water and adequate sanitation.	49	4.63
	• Personal hygiene.	49	4.33
	• Medical services such as availability of beds.	49	4.45
	• Infection control.	49	4.53
	• Immunisation programme.	49	4.41
	• Food security.	49	4.45

In round two, some criteria were changed according to the comments of the experts. Forty three experts indicated their rating for each criterion based on a 5 point Likert scale with 1 representing not important, 2 representing less important, 3 representing important, 4 representing very important, and 5 representing extremely important (as seen in appednix B Round 2). The answers were analysed first to determine the degree of perceived importance (mean), then by the determination as to whether or not a consensus was reached among the panel of experts (IQR). The mean values ranged from 3.51 to 4.72 indicating that all criteria were regarded as important. Of the 62 criteria listed in the second round questionnaire only five failed to gain gained consensus ($IQR \leq 1$) (see Table 5-4). The five criteria ($IQR= 2$) were: sense of community; personal faith and attitudes; level and diversity of economic resources; integration of services such as transportation systems, electric power and telephone; brown field treatment (contaminated land with low levels of hazardous waste and pollutants); and immunisation programmes.

Table 5-4: Total Criteria Reaching Consensus in Rounds 2 & 3

Dimension	Round 2			Round 3		
	Total criteria	Consensus criteria	%	Total criteria	Consensus criteria	%
Social	11	9	82	11	11	100
Economical	7	6	86	7	7	100
Physical and environmental	10	9	90	10	10	100
Governance	11	11	100	11	11	100
Health and wellbeing	14	13	93	14	14	100
Information and communication	9	9	100	9	9	100
Total	*62*	*57*	*92*	*62*	*62*	*100*

Forty experts completed round 3, in which all 62 criteria under the six dimensions received means between 3.20 to 4.85 (see Figures 5-2 to 5-7), signifying that they were considered important. Furthermore, all received an IQR of between 0 and 1 indicating that consensus was achieved in all criteria. Moreover, all criteria had a standard deviation less than 1 with the exception of 'brown field treatment (contaminated land with low levels of hazardous waste and pollutants)' which had 1.054. The standard deviation indicates that the expert panel achieved a very high level of consensus on 61 of the 62 criteria.

5.3.2.1 Social Dimension

Figure 5-2 illustrates that the standard deviations for the criteria in the social dimension are less than 1, ranging from 0.693 to 0.952. In addition, the IQR of all criteria was ≤ 1, while the mean values for the criteria of social dimension are in the range of 3.2 and 4.4. Therefore, there is a consensus on the importance of the 11 criteria in the social dimension.

Social Dimension	Round3		
Criteria	*Std. Deviation*	*(IQR)**	*Mean*
Risk awareness and training.	0.744	1	4.4
Risk perceptions.	0.733	1	4.22
Sense of community.	0.769	1	4.15
Personal faith and attitudes.	0.790	1	4.12
Trust in authorities	0.693	1	4.07
Previous experience.	0.767	1	4.02
Social networks.	0.744	1	3.9
Faith organisations, such as the role of mosques and Friday sermons.	0.790	1	3.8
Education level.	0.952	1	3.37
Demography (age and gender).	0.882	1	3.3
National language non-speaking.	0.822	0.75	3.2

Figure 5-2: Social Criteria Consensuses Round 3, * (IQR): Interquartile Range

5.3.2.2 Economic Dimension

The standard deviations for the criteria in the economic dimension are less than 1, with a range of 0.590 and 0.902. IQR of each criterion in this dimension is = 1 (see Figure 5-3). The mean values for the criteria of economical dimension are in the range of 3.20 and 4.40. Thus, there is a consensus on the importance of the seven criteria in the economic dimension.

Economical Dimension	Round3		
Criteria	*Std. Deviation*	*(IQR)**	*Mean*
Funds available for reconstruction after disaster.	0.590	1	4.4
Access to financial services.	0.790	1	3.88
Level and diversity of economic resources.	0.843	1	3.83
Insurance coverage.	0.898	1	3.75
Home ownership status (home owner / renter).	0.902	1	3.59
Income and employment situation.	0.873	1	3.59
Size of Gross Domestic Product (GDP) per capita.	0.790	1	3.2

Figure 5-3: Economic Criteria Consensuses Round 3, * (IQR): Interquartile Range.

5.3.2.3 Physical and Environmental

The standard deviations of all criteria are less than 1 with the exception of 'brown field treatment' which was slightly above 1 at 1.054. The IQR of each criterion is 1 (as illustrated in Figure 5-4). The mean values are in the range of 3.38 and 4.58. Hence, there is a consensus on the importance of these criteria, with 'exception of brown field treatment'.

Physical and Environmental	Round 3		
Criteria	*Std. Deviation*	*(IQR)**	*Mean*
Lessons learnt from previous disasters, if any (sites affected, degree of damages etc).	0.594	1	4.58
Capacity of infrastructures to withstand extra pressure such as floodwater.	0.677	1	4.45
Integration of services such as transportation systems, electric power and telephone.	0.671	1	4.4
Shelters availability during emergencies such as schools and stadiums.	0.655	1	4.33
Accessibility to critical infrastructure.	0.563	1	4.3
Management of waste created by natural hazards.	0.790	1	4.2
Mobile resources for reconstruction including trained worker.	0.747	1	4.18
Location of built environment (probability of exposure to hazards).	0.802	1	4.15
Monitoring of current built environment and existing serveries.	0.714	1	4.05
Brown filed treatment (contaminated land with low levels of hazardous waste and pollutants).	1.054	1	3.38

Figure 5-4: Physical and Environmental Criteria Consensuses Round 3, * (IQR): Interquartile Range

5.3.2.4 Governance Dimension

Figure 5-5 illustrates that the standard deviations for the criteria under governance are all less than 1 ranging from 0.543 to 0.891. In addition, the IQR of all criteria was ≤ 1, while the mean values are in the range of 3.38 and 4.58. Therefore, there is a consensus on the importance of the 11 criteria in the governance dimension.

Governance	Round3		
Criteria	*Std. Deviation*	*(IQR)**	*Mean*
Disaster plans and policies including mitigation and evacuation emergency management plans.	0.543	0	4.75
Unity of the leadership after the disaster.	0.638	1	4.55
The application of standards and regulations for buildings and infrastructure.	0.714	1	4.45
Shared information (Transparency).	0.704	1	4.38
Considering scientific analysis of risk assessment.	0.640	1	4.28
Integration with development policies and planning.	0.707	1	4.25
Institutional collaboration and coordination.	0.733	1	4.23
Clear partnership modalities defined and cooperation between concerned entities including private sector.	0.686	1	4.2
Participation of community members (volunteerism) including women and children.	0.729	1	4.08
Integrating populations with special needs into emergency planning and exercises.	0.891	1	4.03
International collaboration and coordination framework.	0.853	1	3.8

Figure 5-5: Governance's Criteria Consensuses Round 3, * (IQR): Interquartile Range

5.1.1.1 Health and Wellbeing Dimension

The standard deviations for the criteria of this dimension are less than 1, ranging from 0.516 to 0.831. Furthermore, the IQR of all criteria is 1, while the mean values are in the range of 4 and 4.7 Thus; there is a consensus on the importance of the 14 criteria in the health and wellbeing dimension (see Figure 5-6).

Health and wellbeing	Round 3		
Criteria	*Std. Deviation*	*(IQR)**	*Mean*
Access to clean water and adequate sanitation.	0. 516	1	4.7
Food security.	0. 579	1	4.65
Availability of trained health workers.	0. 635	1	4.43
Medical resources such as the availability of hospital beds.	0. 671	1	4.4
Infection control.	0. 777	1	4.4
Access to health assistance.	0. 764	1	4.33
Hygiene.	0. 828	1	4.33
Immunisation programmes.	0. 686	1	4.3
Effective bio-security and bio-safety systems.	0. 784	1	4.28
Disease surveillance.	0. 816	1	4.28
Family health education and training programmes.	0. 828	1	4.08
Identification/definition of special needs.	0.749	1	4.05
Access to mental health care and psychological support programmes.	0.831	1	4.03
Medical intelligence gathering.	0.816	1	4

Figure 5-6: Health and Wellbeing's Criteria Consensuses Round 3, * (IQR): Interquartile Range

5.3.2.5 Information and Communication Dimension

Table 9 highlights that the standard deviations for the criteria are less than 1 and in the range between 0.361 and 0.822. In addition, the IQR of all criteria is ≤ 1, while the mean values are in the range of 3.2 and 4.4 Thus; there is a consensus on the importance of these criteria in the information and communication dimension (see Figure 5-7).

Information and communication	Round3		
Criteria	*Std. Deviation*	*(IQR)**	*Mean*
Early warning system.	0. 361	0	4.85
Reliability of communication systems.	0. 715	1	4.53
Trusted sources of information.	0. 678	1	4.48
Backup of critical data.	0. 662	1	4.35
Responsibility of media.	0. 742	1	4.25
Use of community platforms e.g. mosques.	0. 722	1	4.13
Visual alerting systems.	0. 767	1	4.03
Ability to exploit social media.	0. 693	1	3.93
Ability to cascade information from international through regional to local communities.	0. 822	1	3.8

Figure 5-7: Information and communication's criteria consensuses Round 3 , * (IQR): Interquartile Range

5.3.2.6 Overall Ranking of all Frameworks' Dimensions

As result of the above findings, the consensus on the criteria of the six dimensions as a framework of community resilience to disaster in the context of Saudi Arabia has been established. Figure 5-8 displays the status of consensus from the final Delphi round, which clearly represents agreement among the expert panel on all six dimensions. The standard deviations for the criteria are less than 1, ranging from 0.214 to 0.403. Furthermore, the IQR of all dimensions are ≤ 1 and the mean values for the all dimensions are in the range between 3.75 and 4.3.

Dimension	*Std. Deviation*	*IQR**	*Mean*
Health and wellbeing	0.214	0.34	4.3
Governance	0.259	0.37	4.27
Information and communication	0.328	0.53	4.26
Physical and environmental	0.329	0.29	4.2
Social	0.366	0.77	3.87
Economic	0.403	0.30	3.75

Figure 5-8: Dimensions of the Framework Consensus Round 3, * (IQR): Interquartile Range.

5.4 Discussion

Saudi Arabia has faced many disasters in recent years (Al-Saud, 2010, Alshehri et al., 2013). Although these disasters were not large on a global scale, the population's lack of experience with disasters led to a number of deaths and higher economic consequences. In conjunction with the increased vulnerability to disasters, the rapid urbanization and high population growth in Saudi Arabia create a stronger demand for identifying, assessing and monitoring risk of disaster

Although it is difficult to prevent disasters prevention, their impacts can be mitigated through effective disaster management. The burden of disaster management falls on the government and in particular on the Civil Defence authorities and the Ministry of Health (MOH). Nevertheless, it is important to involve the community in order to recover quickly and effectively from future disasters (Joerin et al., 2012).

There are a number of similarities but also differences in the dimensions and associated criteria of community resilience to disaster between the current study and previous ones. Our framework dimensions are in-line with a number of related studies, including (Orencio and Fujii, 2013), (Burton, 2012), and the Disaster Resilience of Place (DROP) model (Cutter et al., 2008) (as illustrated in Table 5-5).

Table 5-5: Comparison between the current study and other frameworks

DROP *(Cutter et al., 2008)*	***Multivariate analysis*** *(Burton et al., 2012)*	***AHP*** *(Orencio & Fujii, 2013)*	***The Current Study***
Ecological	Environmental systems	Environmental and Natural Resources Management	Physical and environmental
Social	Social	Sustainable Livelihoods	Social
Economic	Economic	Social Protection	Economic
Organizational	Institutional	Planning Regime criterion	Governance
Infrastructure	Infrastructure		Information and communication
Community competence	Community subcomponent		Health and wellbeing

However, our framework differs in that two dimensions, namely “Information and Communication” and “Health and Wellbeing” are not mentioned in Orencio and Fujii (2013), (Burton, 2012) or DROP (Cutter et al., 2008) frameworks. Although “Information and Communication” is presented in other resilience frameworks, such as Norris et al. (2008), Health and Wellbeing is a new dimension, along with its associated criteria. It is proposed to cover disasters in general, but with a focus on biological disasters.

Orencio and Fujii (2013) did identify “Health and wellbeing” as one of their framework’s dimension. However, as a result of the AHP outcomes, they considered that the dimension had a low rank and was consequently not selected in their final framework. Moreover, Burton (2012) and Cutter et al. (2008) identify health as a criterion under social dimension. However, it is worth noting that given the consensus of the expert panel in our study, the “Health and Wellbeing” dimension, with standard deviations (0.214) and mean value (4.3), is ranked as the highest dimension in our framework, as illustrated in figure10.

The current study is consistent with other frameworks in many of the criteria that are considered important in influencing the community, including education, religious organizations, training and raising the level of awareness of disaster preparedness. However, a number of criteria that were not used in previous studies are identified, such as “Effective biosafety and biosecurity system”, “Previous experience”, “Use of community platforms”, and “Brown field treatment”.

A further difference when compared with other studies is highlighted in Orencio and Fujii’s (2013) use of the criterion “the community access to basic social services” which they argue is related to the social protection dimension; however, our study elaborates this criterion across two dimensions. Thus, “access to financial services” is included in the Economic dimension, while “access to health assistance” and “access to clean water and adequate sanitation” are included in the Health and Wellbeing dimension. Several key issues appear from this study as elaborated below.

5.4.1 Health and Wellbeing Dimension

Healthcare issues are a critical part of community resilience and play an important role as the backbone of medical response to disasters both natural and man-made (Plough et al., 2013). The importance of this dimension is to ensure access to medical services in the immediate aftermath and to prevent the rise of communicable diseases following a disaster.

Several studies argue that health is part of the social dimension (Shaw and Team, 2009, Norris et al., 2008, Cutter et al., 2010). However, a clear consensus has been achieved in this study that health should be a separate dimension with its own criteria, which can be used in the process of building community resilience to disasters. These criteria covered both mental and physical health issues. Importantly, a number of factors are included that have not been raised in previous community resilience frameworks, such as effective bio-security and bio-safety systems, family health education and training programmes, and medical intelligence gathering. Moreover, the ability to respond effectively to high-consequence disasters requires surge capacity and capability through availability of trained health workers and medical resources such as the availability of hospital beds.

5.4.2 Governance Dimension

One of the most important features for adaptive ability and overall resilience in a community is the way in which the community is controlled and managed after disaster events. Governance refers to laws, regulations, negotiation, conflict resolution, elections, public consultations, and other decision-making processes (Lebel et al., 2006). Participation, transparency and accountability are important principles of governance that are required to reduce the impacts of disasters (Lebel et al., 2006, Ahrens and Rudolph, 2006).

Good governance is considered to be at the core of disaster risk reduction means and outcomes (Bendimerad, 2003). According to the United Nations Development Programme (UNDP): “There is a need for institutional systems and administrative arrangements that link public, private and civil society sectors and build vertical ties between local, district, national and global scale actors” (Pelling et al., 2004).

Citizen participation is generally believed to be an essential component for community resilience. This is covered by the criteria of ‘participation of community members (volunteerism) including women and children’ and ‘integrating populations with special needs into emergency planning and exercises’. Furthermore, partnerships between different institutions are important to the success of preparedness to disasters (Twigg, 2007). Thus, ‘clear partnership modalities defined and cooperation between concerned entities including private sector’, ‘institutional collaboration and coordination’ and ‘international collaboration and coordination’ criteria have achieved consensus in this study. Relatedly, (Goodman et al., 1998) argue that leadership is an important measure of community capacity. This aspect is covered in the study through the criterion of ‘unity of the leadership after the disaster’.

There are essentials factors that measure how governments manage or respond to disasters, such as organizational structure, capacity and assessments of the physical properties, and the availability of disaster plans (Cutter et al., 2008, Tierney and Bruneau, 2007). In this framework, the validated criteria have reached consensus among the panel experts. These criteria can be used to assess the ability of governance to trace and manage the accountability in building community resilience through the following criteria: ***Disaster plans and policies, including mitigation and evacuation emergency management plans; the application of standards and regulations for buildings and infrastructure;*** and ***Integration with development policies and planning.***

Moreover, it is important to take into account the need to reduce barriers to communication with the community through sharing of information (Tompkins and Adger, 2003). Both criteria 'shared information (transparency)' and 'considering scientific analysis of risk assessment' are vital in this context.

5.4.3 Information and Communication Dimension

In disaster conditions, the availability of information and communication services is one of the most important issues (Channa and Ahmed, 2010). The current study emphasises a number of criteria related to this aspect that may contribute to raise the resilience of the community to disasters. First, the availability of 'early warning and visual alerting systems' which can play a critical role in decreasing the negative impact of disasters by evacuating people from the probable area of exposure to hazards. Relatedly, 'trusted sources of information' has been proven essential as several studies reveal that people will ignore early warnings if they do not trust the source of the information (Haynes et al., 2008, Mayhorn and McLaughlin, 2014).

Second, 'reliable communication system' is vital for effective emergency disasters management (Channa and Ahmed, 2010) and achieved consensus under this dimension. Third, the media plays an important role in influencing public perception of disasters. Hence, the criteria 'responsibility of media' and 'ability to exploit social media' are essential to gain the confidence of community members and raise awareness of disaster risk reduction strategies. Finally, the 'use of community platforms' e.g. mosques, in this dimension is an important criterion to assist with contacting people and raising awareness to the risks of disasters.

5.4.4 Physical and Environmental Dimension

Under the physical and environmental dimension, 'Lessons learnt from previous disasters' is considered key to increasing adaptive capacity and to reducing the impacts of future disasters (McDaniels et al., 2008, Litman, 2006). Furthermore, it is important to have a good infrastructure which can withstand disasters and attenuate quickly their effects (Perera et al., 2010). In this study, 'capacity of infrastructures to withstand extra pressure' achieved high consensus among the experts' panel. In addition, the physical and environmental dimension includes other criteria that increase the ability of the community to mitigate disaster. These criteria are: 'integration of services', 'the availability of shelters', 'mobile resources for reconstruction' and 'monitoring of current built environment and existing services'.

Disasters can create waste, including hazardous waste, which can pose threats to human health (Sonak et al., 2008, Pathirage et al., 2010). Therefore, 'management of waste' and 'brown field treatment (contaminated land with low levels of hazardous waste and pollutants)' are emphasised as part of the process of building community resilience.

5.4.5 Social Dimension

The social dimension is an essential part of many of community resilience frameworks (Thompson et al., 2012, Joerin et al., 2012, Cutter et al., 2010, Sherrieb et al., 2010, Ainuddin, 2012). It plays a significant role in increasing the ability of coping with disasters and reducing the impacts of disasters (Joerin et al., 2012, Cutter et al., 2010). This study extracted a number of criteria that can contribute to increase the resilience of the community in this dimension, as elaborated below. 'Risk awareness and training': The increase in the rate of disasters in Saudi Arabia in recent years, along with the lack of public perception to the risk of disasters, has raised the importance of and the need for society to train and prepare for disaster management (Alshehri et al., 2013). As a result, this criterion achieved high consensus amongst the panel.

'Faith organisations, such as the role of mosques and Friday sermons': faith can play a significant part in empowering members of community and developing resilience (Niaz, 2006). This is important in particular in Saudi Arabia which is an Islamic country with a high level of religious faith (Alshehri et al., 2013). Therefore, faith organizations can play an important role in disaster risk reduction in local communities and are often able to respond to disaster within a very short period. Furthermore, mosques can be used to raise the awareness of risks of disasters and build the 'personal faith and attitudes' and 'sense of community' criteria. Additionally, these organizations often gain the trust of local communities (Clarke, 2008). Therefore, religious non-governmental organizations (NGOs) can raise the ability of the community to cope with disasters as evidenced by the number of Christian and Muslim NGOs involved in relief and reconstruction activities in post-disaster recovery in many regions of the world (Gaillard and Texier, 2010). Moreover, it has been proven by mental health workers that religious faith is a major element in assisting victims to recover from the impact of disasters (Niaz, 2006).

'Social Networks': these networks refer to the nature and level of linkages between individuals (Kirmayer et al., 2009), including families, friends, tribal members, work groups, religious affiliations, and other community organizations (Kirmayer et al., 2009). In Saudi Arabia, the strength of Islam, the tribal connections, and the extended family can be used to build a resilient community towards disasters.

In addition, the following criteria in the social dimension should also be considered for building community resilience targets: ‘trust in authorities’, ‘previous experience’, ‘education level’, ‘demography (age and gender)’, and ‘risk perceptions’.

5.4.6 Economic Dimension

The role of economic capital to building community resilience is important in that it raises the capacity of the community to cope with the impact of disasters (Mayunga, 2007). The indicators proposed by this dimension are: ‘funds available for reconstruction after disaster’, ‘access to financial services’, ‘level and diversity of economic resources’, ‘insurance coverage’, ‘home ownership status (home owner/renter)’, ‘income and employment situation’ and ‘size of Gross Domestic Product (GDP) per capita’. Across most other frameworks, there is a strong interest in economic recovery; however, other frameworks use a different set of indicators (Jordan and Javernick-Will, 2013). In this study, ‘Funds available for reconstruction after disaster’ achieved high consensus from the experts. In additional, (Hallegatte et al., 2007) point out that it is a significant criterion to reduce GDP losses.

The ‘level and diversity of income sources’ can be used as an indicator of vulnerability where it is hypothesized that the greater the diversity of income the greater resilience (Neil Adger, 1999). Recently, ‘access to financial services’, which refers to the availability of a supply of reasonable quality financial services at reasonable costs (Beck et al., 2009), has been recognized as an important driver of economic growth (Claessens, 2006, Beck et al., 2009).

Insurance also has a positive and substantial effect on economic growth. Recently, Saudi’s government introduced the insurance to operate on Islamic law (*sharia’h*) basis (Ansari, 2012). Since then, the perception of Saudi’s towards insurance has changed positively (Ansari, 2012); however, there are many who still believe that insurance conflicts with the principles of *sharia'h* or may not be familiar with how insurance works (Ansari, 2012). Hence, the criterion of insurance coverage comes in second in importance in this dimension.

Since the goal of this study is to develop a framework for community resilience to disasters (CRDSA), there is a need to develop a weighting system to establish the relative importance of each identified dimension / criteria of our proposed framework. Therefore, a follow on stage will involve the use of AHP (Analytic Hierarchy Process) to determine these weightings. The AHP approach has been used in several studies, including disaster and risk management (Carreño et al., 2007, Orencio and Fujii, 2013). The objectives of using AHP are to (a) adopt local priority weights from pair–wise comparative method of judgment and to (b) determine the level of importance of each dimension of the framework, with a view to enable effective community resilience assessment and building.

Finally, the proposed framework will be validated in a real-life scenario prior to implementation. The Hajj (pilgrimage) season will be chosen as a case study, in coordination with the various authorities in Saudi Arabia, to validate the framework. It is worth noting that the Hajj is an actual case of mass gathering with up to 3.5 million people visiting the city of Makkah within a 6-days time period. Furthermore, it involves a large number of activities in a confined area. The pilgrims travel from all over the world with different ethnicities and languages.

5.5 Summary

Saudi Arabia has been prone to an increasing rate of disasters in recent years as reported earlier in the thesis. However, its disaster management preparedness lacks effective response and recovery (Abosuliman et al., 2013a). According to (Plough et al., 2013), disaster management preparedness can be significantly enhanced by the presence of community resilience. Moreover, (Ziyath et al., 2013) argue that building a community with greater resilience to disasters is critical in the face of the expected increase of disasters in the future.

The proposed study involves the use of the Delphi method to provide a valuable framework for tapping experts' experience and knowledge in relation to community resilience.

The use of the Delphi technique was significant in reaching consensus around the proposed community resilience framework (CRDSA) (6 dimensions and 62 criteria) for decision-makers in the country (Fig. 5-1).

The researcher believes that this study provides the first milestone towards the process of building community resilience to disaster in Saudi Arabia. Further research is required to expand the proposed criteria system to provide a weighting system for the study's dimensions and criteria using AHP. Therefore, the next chapter will cover this aspect in details.

Chpter:6 Prioritizing and weighting the community resilience framework dimensions and criteria

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Introduction

A Community Resilience to Disaster Framework (CRDSA) is proposed, using the Delphi method, consisting of 62 criteria clustered into 6 dimensions: social; economic; physical and environmental; governance; health and wellbeing; and information and communication (as seen in chapter 5). In current chapter (Chapter 6), a new weighting system for each dimension and criterion is presented. This is derived using the analytic hierarchy process (AHP) and related equations to establish the priorities of community resilience framework. The weighting system provides an assessment tool that can be used for measuring community resilience to cope with disasters in Saudi Arabia. The next section 6.1 delivers overview and section 6.2 provides a brief overview of the underpinning methodology. This is followed by a summary of the initial community resilience framework and expert survey consultation. Section 6.3 describes the proposed weighting system applied to the community resilience framework dimensions and criteria. Section 6.4 elaborates on the findings, analysis, and discussion of the results. Finally, section 6.5 provides concluding remarks and directions for future research.The chapter focuses A weighting system for each dimension and criteria which is proposed using the Analytic Hierarchy Process (AHP). Experts' opinions were collected using pair-wise comparisons and then coded in AHP Expert Choice software to evaluate and give priorities to the possible outcomes of the process. The weighting system provides a quantitative and qualitative assessment tool to measure community resilience to disasters in Saudi Arabia and the surrounding region that shares similar social and cultural characteristics.

6.1 Methodology to Establish a Community Resilience Framework (CRDSA)

To establish a community resilience framework (CRDSA), the researcher have adopted a mixed method strategy (including quantitative and qualitative research) involving: a literature review, Delphi survey and AHP (as described in Chapter3). The design is structured into three phases as illustrated in Fig. (6-1). In the first phase (Chapter 4), the researcher used a quantitative strategy through an opinion survey to establish public perception of the risk of disasters in Saudi Arabia (Alshehri et al., 2013). Several criteria under the proposed six dimensions were selected based on the outcome of this national survey combined with the literature review of related studies in the field (Twigg, 2007, Cutter et al., 2008, Norris et al., 2008, Ainuddin, 2012, Mayunga, 2007, Burton, 2012).

In the second phase (Chapter 5), the Delphi consensus-based consultation is employed. All dimensions and their corresponding criteria were presented to an experts' panel to determine the level of importance and consensus for each dimension and criterion in relation to community resilience to disaster management in Saudi Arabia (Alshehri et al., 2015a). In the final phase, the researcher used AHP and a calculation method to establish the weights for each dimension and criterion. AHP has the ability to mix quantitative and qualitative attributes (Wedley, 1990). Qualitative assessments are converted into quantitative measures by using Saaty Rating 1–9 scale which link the framework together (Shapira and Simcha, 2009). The qualitative dimension is factored in through the initial Delphi consultation (Alshehri et al., 2015a).

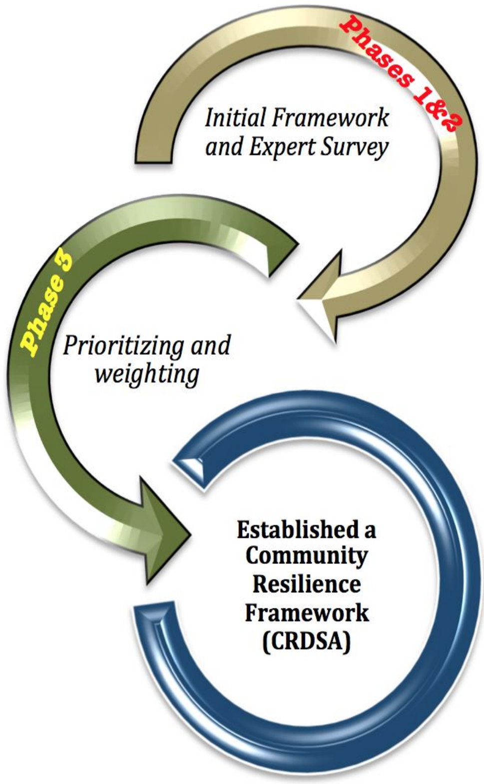


Figure 6-1: Research phases to establish a community resilience framework (CRDSA) (Alshehri et al., 2015b)

After the Delphi expert survey, the CRDSA was finalised. The dimensions and their criteria were then used to strengthen the framework. The next objective, forming the focus of the chapter, is to evaluate the weight of each dimension using AHP methodology. Furthermore, This chapter addresses the following research questions:

RQ. What is the most adapted resilience assessment weighting system that best conveys community resilience measurement in the context of Saudi Arabia?

RQ. To what extent do dimensions and criteria of the proposed community resilience to disasters (CRDSA) determine measureable outcomes of community resilience?

Consequently, between May and June 2013, a questionnaire was prepared and submitted to the experts for effective assessment of the proposed dimensions. Expert

Choice software (2013) is used to codify, evaluate and assess the judgments of the consulted experts.

6.2 Prioritizing and weighting the community resilience framework dimensions and criteria

6.2.1 The AHP process

In the current study, the AHP was developed according to the process shown in Chapter 3 section 3.10.2. For this research, 23 experts were invited from those who participated in the Delphi surveys in order to avoid inconsistency and overlapping information (Lin et al., 2010); only 16 experts agreed to participate, which is an acceptable number (Omar and Jaafar, 2011). Although the sample size was small, several studies point out that panel size is not a limitation as AHP can be conducted with small number of participants (Lee and Walsh, 2011).

6.2.2 Experts selection

The selected experts' experiences related to disaster management averaged five years, and as stated earlier, they were all involved in the Delphi surveys of this project (Alshehri et al., 2015a). The experts in this study were recruited from a variety of disciplines in disaster management, locally and internationally (as illustrated in Table 6-1), with an in-depth understanding of local and wider issues. Moreover, all international experts (a) understand or share the same local cultural and religious values and have for many of them worked previously in Saudi Arabia and (b) contribute their wider international experience acquired through extensive work in developed countries and relevant international organizations.

Table 6-1: Expert's panel

Expert	Organisation
International	• NHS Commissioning Board (UK). • Crowd Modelling Ltd (UK). • Asian Disaster Preparedness Centre (Bangladesh). • Caribbean Emergency Responder's Training Academy (USA). • Experts (Independent Consultant) from other countries (Greece, Nepal).
Government official	• Civil Defence. • Royal Saudi Air Force. • Ministry of Health (MOH). • Centre of Excellence for Climate Change Research (CECCR), King Abdul-Aziz University.
Academia	• Abdel Aziz City for Science and Technology (Saudi Arabia). • King Khalid University (Saudi Arabia). • University Putra Malaysia (Malaysia).
Medical	• Prince Sultan Military Medical City (PSMMC) (Saudi Arabia). • NHS South (UK). • Armed Forces Medical Services (MSD).

6.2.3 Constructing the hierarchy

The pair-wise comparison matrices at the first level (dimensions) of the hierarchy were completed and sent via email in the form of a PDF to the selected experts. Initially, as noted earlier, 16 experts answered the pair-wise questionnaires. The experts were asked to fill in the pair-wise comparison matrices then to submit it online. Two experts were rejected because of their inconsistency ratio; the results of the remaining 14 experts were used to decide the rating. Finally, the consensus of the groups was calculated using Expert Choice (2013) software to generate the weights.

Constructing the hierarchy involves breaking down the decision-making problem into a hierarchy, which can be divided into three parts: goal, criteria and its sub-criteria, and alternatives (Ishizaka and Labib, 2009). In this study, the critical success criteria related to community resilience to disasters, which were derived from the Delphi method (Alshehri et al., 2015a), comprise six dimensions: social, economic, physical and environmental, governance, health and well-being, and information and communication.

The components that best describe community resilience to disaster are presented on a three-tier hierarchy in an AHP model (Figure 6-2), with the top level as a goal related to the problem. The second tier comprises six categories determined based on resilience dimensions (Alshehri et al., 2015a). Finally, these dimensions have 62 criteria (7 to 14 per dimension) represented in the third tier that have been coded (see description of each code in tables 6-2 to 6-7). All these criteria were developed by a firm consensus within the expert panel in the Delphi method (as seen in Chapter 5).

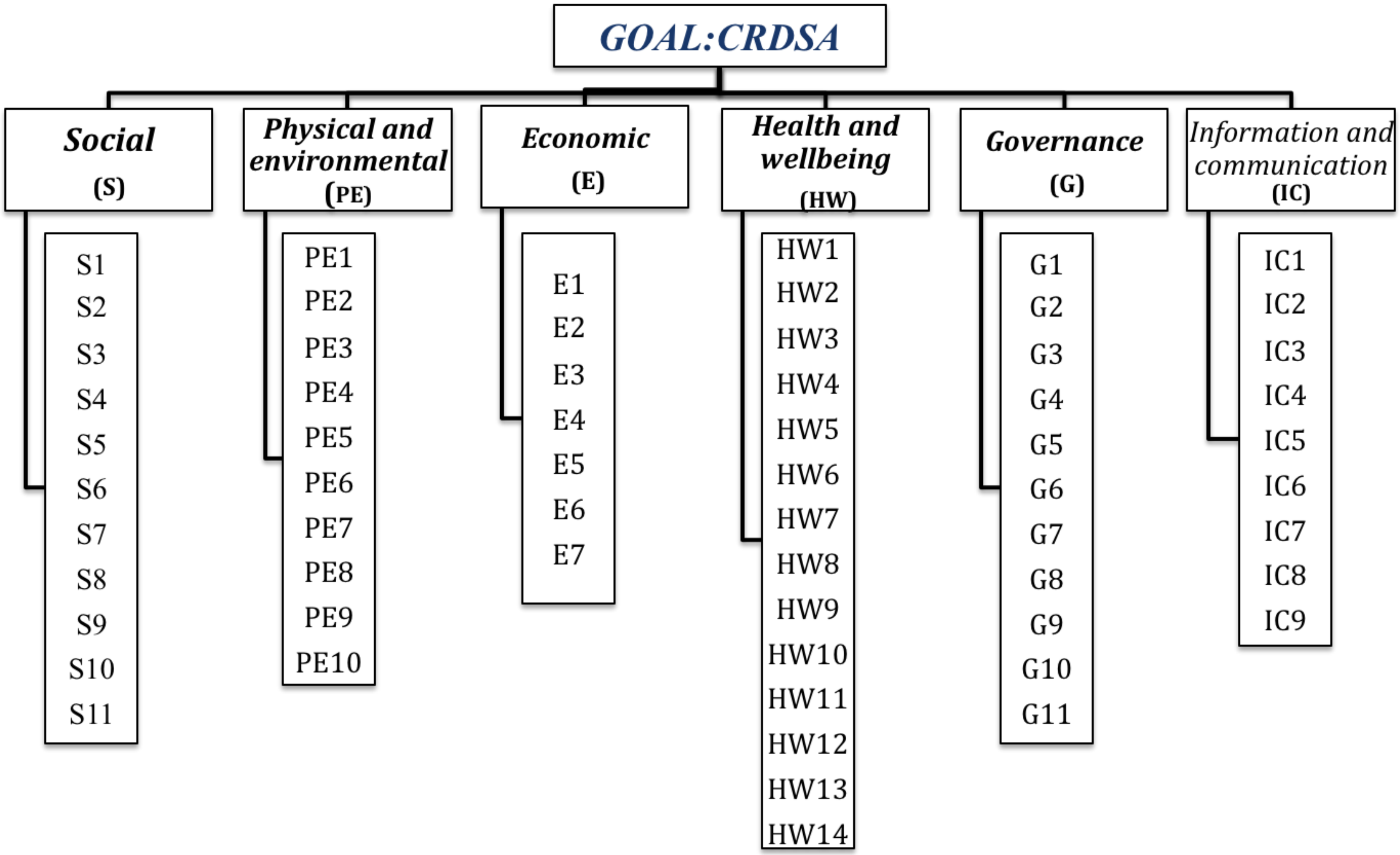


Figure 6-2: Overall hierarchical structure of the AHP (Alshehri et al., 2015b)

6.3 Results and Discussion

According to Chan et al. (2014), consensus around experts' judgement can facilitate the implementation of strategic models such as CRDSA, as corroborated by De Lange et al. (2010). Hence, in this study, the contribution of the participant experts to Delphi and AHP has been the driving force behind the development of the proposed framework for assessing the community resilience to disasters in Saudi Arabia.

6.1.1 Weights allocation

The weights and ranking of the dimensions are derived from using Expert Choice software from the pair-wise comparison matrices (Fig.6-3). The local weights are scaled to 1 across the second level dimension giving 0.099+0.143+0.159+0.174+0.180+0.245 = 1.000.

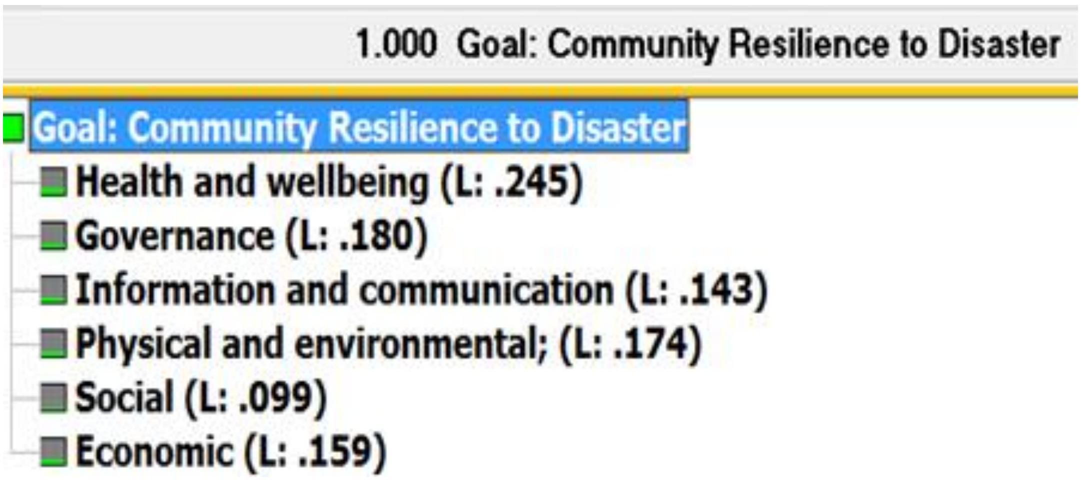


Figure 6-3: Tree view of dimensions' weighting (Alshehri et al., 2015b)

Addressing the consistency of judgments in defining the importance of the criteria forms one of the most important advantages of AHP as there is potential for inconsistency in experts' judgments (Ishizaka and Labib, 2009, Yang et al., 2007). The closer the score is to zero the greater is the consistency (Salmeron and Herrero, 2005).

Figure (6-4) reveals the final weights allocated to each dimension from the pair-wise comparison scores and the index for inconsistency that is 0.00331, which is less than 0.1 and therefore acceptable.

In this Figure, in terms of the dimensions, the results reveal that the health and wellbeing dimension takes the highest overall weight and accounts for 24.5% of the hierarchy total weight. The other dimensions are weighted as follows: governance dimension (18.0%), physical end environmental dimension (17.4%), economic dimension (15.9%), and information and communication dimension (14.3%). The lowest weighted is the social dimension (9.9%).

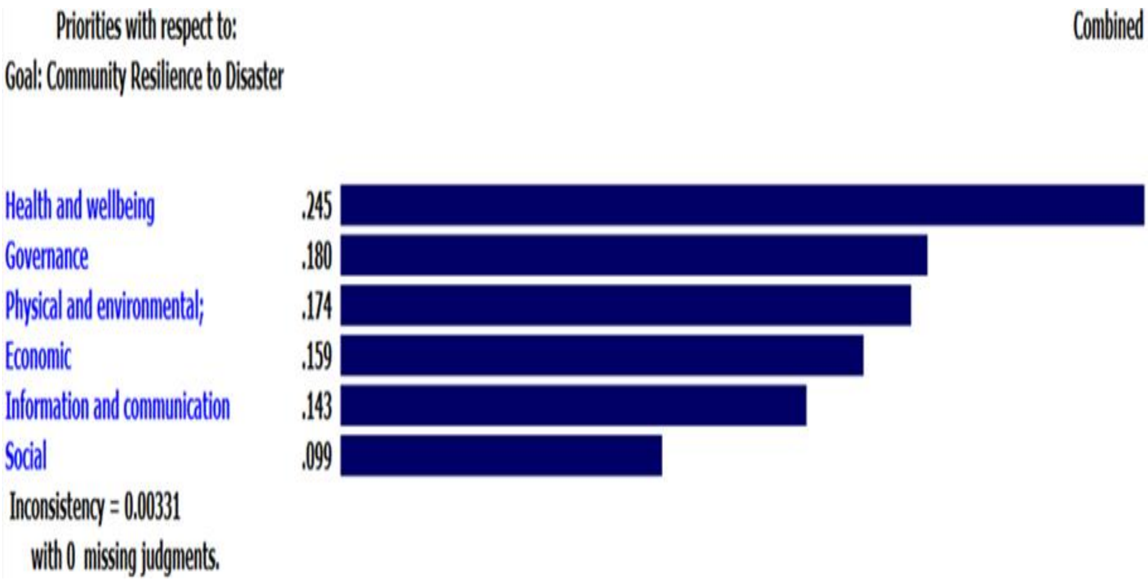


Figure 6-4: Priority of the six dimensions (Alshehri et al., 2015b)

To determine the weight of the criteria under each dimension, the researcher used the equations that were highlighted in chapter 3 (3.10.3.1 and 3.10.3.2). Thus, Tables 6-2 to 6-7 display the credit and the proportion of each criterion against its dimension in the third hierarchy level (ꝑ). Weights allocations of criteria (*wc*) under each dimension appear as elaborated below.

6.3.1 Health and wellbeing (HW)

Throughout the process, this study found that the health and wellbeing dimension has the highest weighting. This result is consistent with previous studies that emphasize the importance of working to strengthen community health and wellbeing in order to cope with disasters (Morrissey and Reser, 2007, Tianzhuo and Linyan, 2014). As shown in Table (6-2), all criteria in this dimension are weighted around the same level of importance to the dimension (between 0.07-0.08). The most important criteria are ‘access to clean water and adequate sanitation’ and ‘food security’ with credits of 0.0191 and 0.0189, respectively.

Table 6-2: The credit and the percentage of each creation in order to Health and wellbeing dimension

Dimension	CODE	Criteria	*p*	*wc*	*wc%*
Health and wellbeing	HW1	Access to clean water and adequate sanitation.	0.08	0.0191	1.91%
	HW2	Food security.	0.08	0.0189	1.89%
	HW3	Availability of trained health workers.	0.07	0.0180	1.80%
	HW4	Medical resources such as the availability of hospital beds.	0.07	0.0179	1.79%
	HW5	Infection control.	0.07	0.0179	1.79%
	HW6	Access to health assistance.	0.07	0.0176	1.76%
	HW7	Hygiene.	0.07	0.0176	1.76%
	HW8	Immunisation programmes.	0.07	0.0175	1.75%
	HW9	Effective bio-security and bio-safety systems.	0.07	0.0174	1.74%
	HW10	Disease surveillance.	0.07	0.0174	1.74%
	HW11	Family health education and training programmes.	0.07	0.0166	1.66%
	HW12	Identification/definition of special needs.	0.07	0.0165	1.65%
	HW13	Access to mental health care and psychological support programmes.	0.07	0.0164	1.64%
	HW14	Medical intelligence gathering.	0.07	0.0163	1.63%
			1	0.245	24.5%

6.3.2 Governance (G)

There are several studies that highlight the importance of governance to reduce the impacts of disasters and return the community to its pre-disaster level (Lebel et al., 2006, Ahrens and Rudolph, 2006). Table 6-3 illustrates all criteria under the governance dimension, which takes the second highest weight of 0.180. The relative importance of each criterion was established between 0.08 and 0.10 (Table 6-3). The most important criterion in this dimension is ‘disaster plans and policies, including mitigation and evacuation emergency management plans’ with a credit of 0.0182. These results are consistent with other studies that confirm the importance of this criterion of good governance (Lebel et al., 2006, Ahrens and Rudolph, 2006).

Table 6-3: The credit and the percentage of each creation in order to Governance dimension.

Dimension	CODE	Criteria	*p*	*wc*	*wc%*
Governance	**G1**	Disaster plans and policies including mitigation and evacuation emergency management plans.	0.1	0.0182	1.82%
	G2	Unity of the leadership after the disaster.	0.1	0.0174	1.74%
	G3	The application of standards and regulations for buildings and infrastructure.	0.09	0.017	1.70%
	G4	Shared information (Transparency).	0.09	0.0168	1.68%
	G5	Considering scientific analysis of risk assessment.	0.09	0.0164	1.64%
	G6	Integration with development policies and planning.	0.09	0.0163	1.63%
	G7	Institutional collaboration and coordination.	0.09	0.0162	1.62%
	G8	Clear partnership modalities defined and cooperation between concerned entities including private sector.	0.09	0.0161	1.61%
	G9	Participation of community members (volunteerism) including women and children.	0.09	0.0156	1.56%
	G10	Integrating populations with special needs into emergency planning and exercises.	0.09	0.0154	1.54%
	G11	International collaboration and coordination framework.	0.08	0.0146	1.46%
			1	0.18	18.0%

6.1.2 Physical and environmental (PE)

All criteria under the physical and environmental dimension are presented in Table (6-4). It also shows the range of proportion of the criteria (0.08-0.11) against the total dimension’s weight (0.174). The most important criterion in this dimension is ‘lessons learnt from previous disasters’ with a credit of 0.019. Other studies consider this criterion as essential to increase the adaptive capacity and to reduce the impacts of future disasters (McDaniels et al., 2008, Litman, 2006). This criterion measures the willingness of the community and the government to increase resilience by avoiding mistakes made in previous disasters. Furthermore, it is important to have a good infrastructure which can withstand disasters and quickly mitigate their effects (Perera et al., 2010).

Table 6-4: The credit and the percentage of each creation in order to physical and environmental dimension.

Dimension	CODE	Criteria	p	wc	wc%
Physical and environmental	PE1	Lessons learnt from previous disasters.	0.11	0.019	1.90%
	PE2	Capacity of infrastructures to withstand extra pressure such as floodwater.	0.11	0.0184	1.84%
	PE3	Integration of services such as transportation systems, electric power and telephone.	0.1	0.0182	1.82%
	PE4	Shelters availability during emergencies such as schools and stadiums.	0.1	0.0179	1.79%
	PE5	Accessibility to critical infrastructure.	0.1	0.0178	1.78%
	PE6	Management of waste created by natural hazards.	0.1	0.0174	1.74%
	PE7	Mobile resources for reconstruction including trained worker.	0.1	0.0173	1.73%
	PE8	Location of built environment (probability of exposure to hazards).	0.1	0.0172	1.72%
	PE9	Monitoring of current built environment and existing serveries.	0.1	0.0168	1.68%
	PE10	Brown field treatment (contaminated land with low levels of hazardous waste and pollutants).	0.08	0.014	1.40%
			1	0.174	17.4%

6.3.3 Economic (E)

Table (6-5) displays all the criteria, which are smaller in number than in other dimensions. The proportion column illustrates the range of proportion of the criteria (ranging from 0.12 to 0.17). The relative importance of each criterion was determined and the most important is 'funds available for reconstruction after disaster' with a score of 0.0267 while 'size of Gross Domestic Product (GDP) per capita' is the lowest at 0.0194. This result underlines the importance of the first criterion for assessment of the resilience to cope with disaster (Hallegatte et al., 2007).

Table 6-5: The credit and the percentage of each creation in order to economic dimension.

Dimension	CODE	Criteria	*p*	*wc*	*wc %*
Economic	**E1**	Funds available for reconstruction after disaster	0.17	0.0267	2.67%
	E2	Access to financial services.	0.15	0.0235	2.35%
	E3	Level and diversity of economic resources.	0.15	0.0232	2.32%
	E4	Insurance coverage.	0.14	0.0227	2.27%
	E5	Home ownership status (home owner / renter).	0.14	0.0217	2.17%
	E6	Income and employment situation.	0.14	0.0217	2.17%
	E7	Size of Gross Domestic Product (GDP) per capita.	0.12	0.0194	1.94%
			1	0.159	15.9%

6.1.3 Information and communication (IC)

Table (6-6) clarifies all criteria under the information and communication dimension which has a weight 0.143. The proportion column represents the range of proportion of the criteria (0.10-0.13) against the total dimension's weight. The relative importance of each criterion was determined with the critical criterion being 'early warning system' with a credit of 0.0181. The importance of this criterion is highlighted in several studies as an essential factor in saving lives and facilitating disaster recovery (Haynes et al., 2008, Mayhorn and McLaughlin, 2014). Moreover, this figure reveals the important of 'the reliability of communication system' criterion as the second most important value in this dimension. It is consistent with (Channa and Ahmed, 2010) which confirms that the reliability of communication systems forms a vital factor for effective disaster management operations.

Table 6-6: The credit and the percentage of each creation in order to information and communication dimension.

Dimension	CODE	Criteria	p	wc	wc %
Information and communication	IC1	Early warning system.	0.13	0.0181	1.81 %
	IC2	Reliability of communication systems.	0.12	0.0169	1.69 %
	IC3	Trusted sources of information.	0.12	0.0167	1.67 %
	IC4	Backup of critical data.	0.11	0.0162	1.62 %
	IC5	Responsibility of media.	0.11	0.0158	1.58 %
	IC6	Use of community platforms e.g. mosques.	0.11	0.0154	1.54 %
	IC7	Visual alerting systems.	0.11	0.015	1.50 %
	IC8	Ability to exploit social media.	0.1	0.0147	1.47 %
	IC9	Ability to cascade information from international through regional to local communities.	0.1	0.0142	1.42 %
			1	0.143	14.3%

6.3.4 Social (S)

The social dimension has been used in several studies to measure the level of community resilience (Sherrieb et al., 2010). In our study, this dimension has the lowest weight from the AHP approach (0.099). Table (6-7) displays the value of each criterion against the total dimension. These range between 0.08 and 0.10. As shown in Table 9, ‘risk awareness and training’ is the critical criterion in this dimension.

These findings are consistent with previous studies which confirm that these factors are important in the measurement of the resilience to deal with disasters. For example, Ainuddin, (2012) proposes a community resilience framework in order to increase community preparedness, awareness and risk perception to disasters in the future. Furthermore, The Coastal Community Resilience Index tool has been developed to increase risk awareness among local communities and to examine their resiliency in terms of some issues such as social system (Thompson et al., 2012).

On the other hand, Ainuddin, (2012) and Cutter et al. (2010) have used awareness and risk perception as parameters to assess the level of community resilience; however, they identify health as a criterion under social dimension. Moreover, in CRDSA, 'health and well-being' has been given the consensus of the expert panel to be considered as a dimension, with its criteria (Alshehri et al., 2015a). Furthermore, the current study has a number of criteria that were not used in previous studies, such as 'effective biosafety and biosecurity system', 'previous experience', 'use of community platforms' and 'brown field treatment' (Alshehri et al., 2015a).

Table 6-7: The credit and the percentage of each creation in order to social dimension.

Dimension	CODE	Criteria	*p*	*wc*	*wc%*
Social	**S1**	Risk awareness and training.	0.1	0.0102	1.02%
	S2	Risk perceptions.	0.1	0.0098	0.98%
	S3	Sense of community.	0.1	0.0097	0.97%
	S4	Personal faith and attitudes.	0.1	0.0096	0.96%
	S5	Trust in authorities	0.1	0.0095	0.95%
	S6	Previous experience.	0.09	0.0094	0.94%
	S7	Social networks.	0.09	0.0091	0.91%
	S8	Faith organisations	0.09	0.0088	0.88%
	S9	Education level.	0.08	0.0078	0.78%
	S10	Demography (age and gender).	0.08	0.0077	0.77%
	S11	National language non-speaking (percentage).	0.08	0.0074	0.74%
			1	0.099	9.9%

6.4 Measuring Resilience

Assessing the community resilience to disasters allows a better understanding of the impact of disasters (Cutter et al., 2008, Ewing and Synolakis, 2011) and helps decision makers to formulate effective strategies in all phases of the disaster (Tianzhuo and Linyan, 2014). However, it is important to measure community resilience over time (Kirmayer et al., 2009). A number of frameworks have been used to assess various forms of resilience (Leykin et al., 2013, Cutter et al., 2008). For instance, the Coastal

Community Resilience (CCR) assessment tool can assist as a powerful tool to begin the process of increasing resilience (U.S. Indian Ocean Tsunami Warning System Program, 2007). Similarly, Ewing and Synolakis (2011) point out that the Community Resilience Index (CRI) is an assessment tool for examining community resilience to coastal disasters. A toolkit for health and resilience in vulnerable environments (THRIVE) has been also developed, which comprises twenty resilience elements across four parts—built environment; social capital; services and institutions; and structural factors—as a community assessment tool that can support communities enhancement factors (Davis et al., 2005).

In this study, CRDSA provides an assessment system, with each criterion weighted to evaluate the level of the community resilience to cope with future disasters. This tool creates resilience scores for each of the six dimensions, as well as an overall score. Hence, it can be used to improve the resilience of community by implementing some of the proposed criteria. Figure (6-5) shows the overview of the final outcome of creating the measurement resilience tool for the CRDSA. To facilitate the computational process and to give results it is assumed that the weight of each dimension is equal to one. The result obtained from the Measurement Resilience tool of CRDSA can be displayed on a spider diagram that illustrates the relative importance of criteria of resilience under all six dimensions.

As result of the above findings, the researcher modified the framework of community resilience to disaster in Saudi Arabia (CRDSA) as seen in Figure (6-6). The adapted CRDSA has all six dimension and their criteria with values.

As to the limitations of this study, including the generalization of the findings, it is worth noting that each community may exhibit unique characteristics, i.e. socio-cultural, geographic, economical, and political (Tam et al., 2013), which can enhance either resilience or vulnerabilities (Smith and Boruff, 2011). The proposed community resilience framework (CRDSA) is the first milestone towards the process of building community resilience to disaster in Saudi Arabia (Alshehri et al., 2015a). This framework is the result of contributions from international experts that complement solicited local experts (Alshehri et al., 2015a).

Therefore, in this study, the results of means criteria of the proposed resilience framework, which were obtained under the Delphi method, have been combined with AHP results that were used as the assessment tool; this may pose some limitations as a result of the importance of each criterion for such community because of the dynamic and complex nature of people interaction with their communities. The researcher believes that this limitation can be solved by the identification of the specific criteria related to their community.

Dimension	AHP weight	New weight (WD)	*Helath and Wellbeing* (HW)		*Governence* (G)		*Physical and Envernomental* (PE)		*Economic* (E)		*Information and Communication* (IC)		*Social* (S)	
Health and wellbeing	25%	0%	HW1	0.0191%	G1	1.82%	PE1	1.90%	E1	2.67%	IC1	1.81%	S1	1.02%
Governance	18%	0%	HW2	0.0189%	G2	1.74%	PE2	1.84%	E2	2.35%	IC2	1.69%	S2	0.98%
Physical and Environmental	17%	0%	HW3	0.018%	G3	1.70%	PE3	1.82%	E3	2.32%	IC3	1.67%	S3	0.97%
Economic	16%	0%	HW4	0.0179%	G4	1.68%	PE4	1.79%	E4	2.27%	IC4	1.62%	S4	0.96%
Information and communication	14%	0%	HW5	0.0179%	G5	1.64%	PE5	1.78%	E5	2.17%	IC5	1.58%	S5	0.95%
Social	10%	0%	HW6	0.0176%	G6	1.63%	PE6	1.74%	E6	2.17%	IC6	1.54%	S6	0.94%
Total	100%	0%	HW7	0.0176%	G7	1.62%	PE7	1.73%	E7	1.94%	IC7	1.50%	S7	0.91%
			HW8	0.0175%	G8	1.61%	PE8	1.72%			IC8	1.47%	S8	0.88%
			HW9	0.0174%	G9	1.56%	PE9	1.68%			IC9	1.42%	S9	0.78%
			HW10	0.0174%	G10	1.54%	PE10	1.40%					S10	0.77%
			HW11	0.0166%	G11	1.46%							S11	0.74%
	wd	Current CRDSA	HW12	0.0165%										
			HW13	0.0164%										
			HW14	0.0163%										
tp				25%		18%		17%		16%		14%		10%
			=		=		=		=		=		=	

Figure 6-5: Measurement Resilience tool of CRDSA Alshehri et al., 2015b

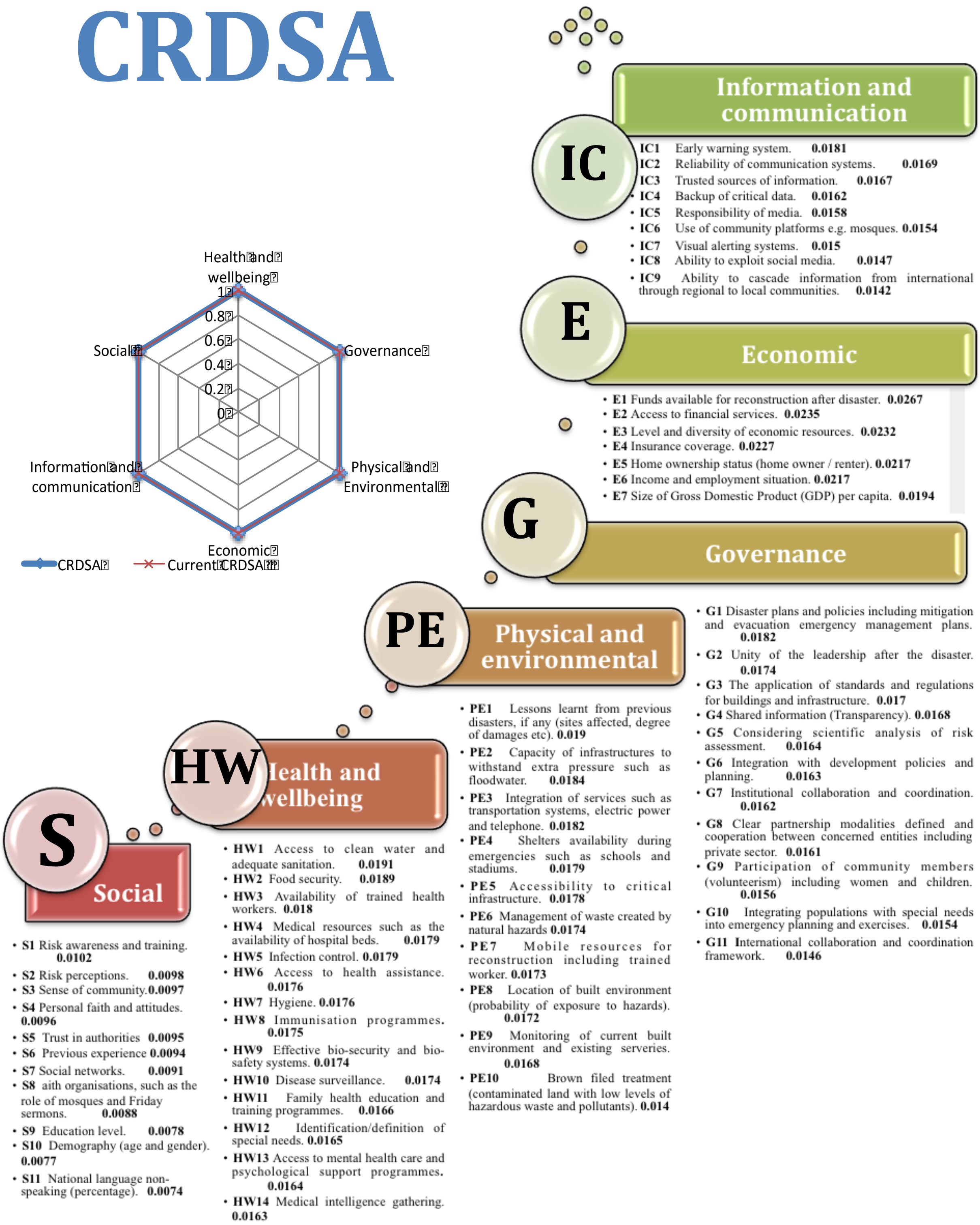


Figure 6-6: The framework of community resilience to disaster in Saudi Arabia (CRDSA) (developed by researcher Alshehri et al., 2015b)

It is important to use benchmarks for community resilience to disaster measurement (Doyle, 1996, US-IOTWS, 2007). The study reviews several studies to determine ranges of resilience scores according to the outcome of the measurement tool of CRDSA. For example, AWM Strategy Team (2010) benchmarked Community Economic Resilience Index in the region of the West Midlands, UK by allocating a score between zero and one to determine their resilience to disasters (AWM Strategy Team, 2010). Moreover, Stephenson et al (2010) suggest a Benchmark Resilience Score between 0 and 100% to measure an organisation's resilience to disasters according to five levels. Scores between 81 and 100% form the top level and convey an excellent resilience; while scores below 49% reflect very poor resilience, forming the lowest level (Stephenson et al., 2010). Furthermore, US-IOTWS, 2007 recognises a scale scores between 0 and 5 which can be used to give an overall indication of resilience community in five levels. These levels are: 5 Excellent (81- 100 %), 4 Very Good (61-80 %), 3 Good (41 - 60 %), 2 Fair (21- 40 %), 1 Poor (1- 20 %) and 0 reveals the absence of resilience (US-IOTWS, 2007).

Therefore, benchmark resilience scores for the CRDSA framework were identified to evaluate the resilience of a community in the context of Saudi Arabia (Table 6-8). This scale indicates the relative resilience scores of a community, using the six dimensions of CRDSA with all 62 criteria, and can be used for evaluating the resilience weaknesses and strengths for each dimension.

Table 6-8: Benchmark Resilience Scores **Alshehri et al., 2015b**.

1	Very High	Resilience	81%≤ R ≤ 100%
0.8	High		61% ≤ R ≤ 80%
0.6	Fair		41% ≤ R ≤ 60%
0.4	Low		21% ≤ R ≤ 40%
0.2	Very Low		1 %≤ R ≤ 20%
0	Absence		R ≤0

Table (6-9) describes the Benchmark Resilience Scores as: the score 0 is considered as "Absence" which means there is no resilience and the community is vulnerable to disasters. A community that scores less than 21 will be considered "Very low", while the community that scores between 21 and 40 will be considered as "Low"; a community evaluated between 41 and 60 will be considered as "Fair"; a community assessed between 61 and 80 will be considered as "High"; and finally a community scored between 81 and 100 will be considered as ''Very High''.

Table 6-9: Description of the Benchmark Resilience Scores of CRDSA Alshehri et al., 2015b.

Score %	Description
81-100 **Very High**	The community has a very high level of resilience to cope with disaster. The majority of criteria have been reached.
61-80 **High**	The community has a high level of resilience to cope with disaster. The community scores well in most criteria. Taking into account that this community needs to focus on criteria which have not met the required score and should work to develop them.
41-60 **Fair**	The community has a moderate level of resilience to cope with disaster. The community meets around half the criteria. The community needs to find criteria which have not met the required score and should work to develop them.
21-40 **Low**	The community has a low level of resilience to cope with disaster. Most of criteria have ***Not*** been reached which makes the community vulnerable to disasters. However, it has a platform of resilience that can be used to increase its resilience.
1-20 **Very low**	The community has a very low level of resilience to cope with disaster. The majority of criteria have ***Not*** been reached which makes the community vulnerable to disasters. It is clear that there is some very simple resilience but not enough to cope with disaster. This level points to the urgent need to build community against disasters.
0 **Absence**	The community has no level of resilience to cope with disaster. It means that the community is vulnerable to disasters. At this level, it is important to find the resilience components of community which can be used to build community resilience to disasters.

6.5 Summary

In summary, community resilience to disasters is necessary to rebuild an affected community to pre-disaster levels. In that respect, measuring community resilience is essential to identify the criteria that can be used to increase the resilience of a community. This study presents the dimensions and criteria of CRDSA collected through the Delphi method. The researcher then used AHP as a systematic methodology of acquiring knowledge from human experts through group decision-making for building the analytical framework.

This project answers the posited research questions by (a) proposing a new weighting system for each dimension and criterion of CRDSA using AHP and related equations, and (b) providing the first assessment tool to measure and grade the level of resilience to disaster of a given community in Saudi Arabia. Dimensions and criteria of the CRDSA can determine measurable outcomes of community resilience based on this tool and the Benchmark Resilience Scores.

Further research is essential to validate the proposed weighting system of CRDSA. The validation and stress-testing of the proposed community resilience framework is essential to ensure that it works. Ho et al. (2009) confirm that strong evidence can be gained when a method is validated during a real study (Ho et al., 2009). The researcher has a good opportunity to validate this framework in a real mass gathering event. Saudi Arabia receives about 3 million people yearly from over the world in Makkah for the Hajj (pilgrimage) event.

The researcher believes that the current framework can be applied for both permanent Local Saudi communities as well as temporary ones such as experienced during the Hajj or Umrah events. This can be explained by the fact that (a) for each Hajj, authorities implement a number of requirements one year in advance such as the coordination of all government sectors, implementation of extensive planning, and the use of vast resources (Memish, 2002, Memish, 2010), and (b) according to CDSI (2014), the population of Saudi Arabia is estimated to be around 30.8 million, of which 10 million (33%) are non-Saudi migrant workers from various geographical and cultural backgrounds.

Hence, the researcher has identified and carried out in the process of delivering this validation component using the Hajj event. The research is commissioned and supported by Saudi authorities who will assist and endeavour to deliver the resulting community resilience framework across the country.

Chpter:7 Implementation and validation of a community Resilience framework (CRDSA) during a mass gathering event under MERS-CoV threat

Introduction

The researcher has a good opportunity to validate this framework in a real mass gathering event. Saudi Arabia receives about 3 million people yearly from over the world in Makkah for the Hajj (pilgrimage) event. *Annually, Saudi Arabia receives millions of pilgrims from around 180 countries to visit Makkah for the pilgrimage (Hajj) event, within a 6-day timeframe. The extreme overcrowding at the Hajj can increase dramatically the risk of disease transmission. In 2013, there was a fear that Middle East respiratory syndrome coronavirus (MERS-CoV), which infects the respiratory tract, could become an epidemic (i.e. a biological disaster) at the Hajj. In this context, this chapter examines the MERS-CoV threat through the implementation of a proposed framework of community resilience to disaster in Saudi Arabia (CRDSA). The Hajj season is chosen as a case study, in coordination with the various authorities in Saudi Arabia, to validate the developed framework. The approach involves a field study investigation, including interviews and observations during the 2013 Hajj to (a) determine community resilience level at the Hajj, (b) inform mass gathering management for protection from MERS-CoV, and (c) validate the CRDSA in a real case mass gathering. This chapter targets to (a) determine community resilience level at the Hajj, (b) identify mass gathering management for protection from the spread of MERS-CoV, and (c) implement the CRDSA in a real mass gathering. The remainder of the chapter is divided into the following sections. Section 7.2 provides an overview of the case study location, identification of the Hajj and its risks. Section 7.3 details the methods used, section 7.4 presents the findings, section 7.5 analyses the results and section 6 summarises this chapter.*

7.1 Overview

The validation and stress-testing of the proposed community resilience framework is essential to ensure that it works. Ho et al. (2009) confirm that the validation can be achieved in either a controlled environment such as laboratory or un-controlled environment such as the field. In this study, the un-controlled environment is used to validate CRDSA. Furthermore, strong evidence can be gained when a method is validated during a real study (Ho et al., 2009).

Each year, Saudi Arabia receives millions of people from different countries to visit Makkah for the Hajj (pilgrimage) or to visit the holy mosque. Consequently, the Hajj season is chosen as a case study, in coordination with the various authorities in Saudi Arabia, to validate CRDSA. The Hajj is a mass gathering of up to 3 million people visiting the city of Makkah within a 6-day period. Furthermore, it involves a large number of activities in a confined area. The pilgrim of various ethnicities and speaking different languages travel from all over the world.

The extreme overcrowding at the Hajj can increase disease transmission (Shafi et al., 2008). In 2013, there was a fear that Middle East respiratory syndrome coronavirus (MERS-CoV), which infects the respiratory tract to cause severe pulmonary disease in humans (Chan et al., 2013), could be came as an epidemic (i.e. a biological disaster). MERS-CoV is among of a large family of viruses termed coronaviruses.

7.1.1 What is MERS-CoV

MERS-CoV has clinical signs consisting of fever, cough, acute respiratory distress syndrome and, in some cases, accompanying renal failure, and are very similar to those caused by SARS-CoV (Al-Tawfiq et al., 2013, Assiri et al., 2013, Chan et al., 2013).

However, the new coronavirus differs from SARS-CoV in genomic sequence (Assiri et al., 2013, Geng and Tan, 2013).

In 2012, MERS-CoV was first recognised in Saudi Arabia (Al-Tawfiq et al., 2013, Assiri et al., 2013) and, by mid-September 2013 132 cases of MERS-CoV infection were reported globally by the World Health Organization (WHO) (Al-Tawfiq et al., 2013). Several studies have confirmed its transmission from person to person (Al-Tawfiq et al., 2013), which could be as a result of exposure to infected respiratory droplets, direct or indirect contact (Assiri et al., 2013).

Several studies emphasis that human-to-human transmission of MERS-CoV can be increased as result of many reasons such as its modification and unknown intermediate hosts which may produce a global pandemic like the one caused by SARS-CoV in 2003 (Lu et al., 2013).

7.2 The case study location

Makkah city is located 73 kilometres east of Jeddah (SGS, 2012a). It is the holiest city on earth for Muslims. Its population is estimated by the Ministry of Municipal and Rural Affairs (2010) at 1,534,731 (SGS, 2012a). It is the second largest city in the region, and the third largest in the country. Climatic conditions in Makkah are characterised by long hot summers and short mild winters, with average temperatures ranging between a summer maximum of 45°C and a winter minimum of 15°C (Hajj, 2011). The Holy City is served by a seaport and an international airport at Jeddah (Hajj, 2011).

7.2.1 Identification of Hajj

Hajj is pilgrimage to Makkah, in Saudi Arabia, and is the fifth and final pillar of Islam. It is the biggest annual mass gathering event on earth (Shafi et al., 2008). The pilgrims come from all over of the world in response to a command from God in the (Qur'an): "And proclaim to the people the Hajj; they will come to you on foot and on every lean camel; they will come from every distant pass" (The Qur'an 22: 27).

{وَأَذِّن فِي ٱلنَّاسِ بِٱلْحَجِّ يَأْتُوكَ رِجَالًا وَعَلَىٰ كُلِّ ضَامِرٍ يَأْتِينَ مِن كُلِّ فَجٍّ عَمِيقٍ ﴿٢٧﴾} سورة الحج

According to the Qur'an, all Muslims who are physically and financially able must make this journey at least once in a lifetime. "Pilgrimage thereto is a duty men owe to God——those who can afford the journey" (The Qur'an 3: 97).

{وَلِلَّهِ عَلَى ٱلنَّاسِ حِجُّ ٱلْبَيْتِ مَنِ ٱسْتَطَاعَ إِلَيْهِ سَبِيلًا} ﴿٩٧﴾ سورة آل عمران

The Hajj occurs during the twelfth month of the Islamic calendar called *Du al-Hijja*; it also called the month of pilgrimage.

Figure 7-1: The Area of Movement of Pilgrims during the Hajj
Source: Google Earth (2013).

The area of movement during the Hajj is between Holy mosque, Mina, Muzdalifah and Arafat (see Figure 7-1). On arrival at Makkah, pilgrims make seven circumambulations, which called *Tawaf* around the Ka'aba (the building Muslims consider as the house of God). Then leave to Mina to spend the rest of the day there, a so-called Day *Tarwiyah*. In the next day, which is the most important rite of the Hajj, all pilgrims move to Arafat, a few miles east of Makkah, where the Hajj culminates in the "Day of Standing". Pilgrims spend all day in Arafat in prayer and supplication, and can visit the Mountain of Mercy, although this is not required. Directly after sunset on this day, all pilgrims have to leave Arafat for Mozdalifah (a distance of about 8 kms from Arafat), where some spend the night. Some pilgrims (e.g. elderly, women and people with special needs), stop in Muzdalifah for a short time to pray, and then continue to Mina.

By early in the morning of the tenth day, all pilgrims are back in Mina where each undertakes the following:

- throws seven pebbles at the third pillar of the Jamarat, (Jamarat are three places in Mina, each has a pillar representing a symbol of the devil (Shaitan);
- sacrifices an animal (usually by proxy), as thanks for an accepted Hajj; and

- then shears or shortens the hair on his/her head.

In 1434 AH, the Hajj took place from 6th to 18th of October 2013. The Hajj pilgrimage brings about 3 million pilgrims from over 180 countries (see Figure 7-2). However, in 2013, the number of the pilgrims was reduced by 20% from abroad and by 50% from Saudi Arabia due to construction projects including the expansion of the Grand Holy Mosque in Makkah. Therefore, the total of pilgrims was 1,980,249. The reduction is temporary until the completion of the expansionist projects (Figure 7-3).

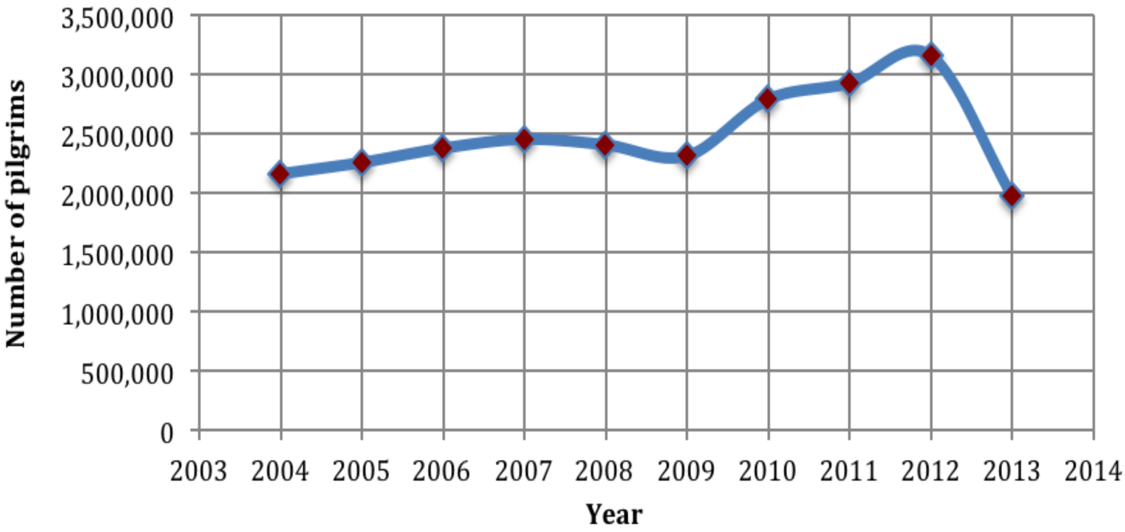


Figure 7-2: Annual Count of Pilgrims to the Hajj, 2004 to 2013

Figure 7-3: Construction Projects Expanding the Area of the Grand Holy Mosque. Researcher's photographs (2013).

6.1.4 Risks of disaster at the Hajj

This mass gathering, in a confined area and short period, leads to physical, environmental and health difficulties for pilgrims which can increase health risks for pilgrims (Shafi et al., 2008, Ahmed et al., 2006), through either communicable or non-communicable disease (Memish et al., 2003). For instance, extreme physical stressors such as extreme heat, inadequately prepared or stored food, sun exposure, crowding, traffic congestion, steep inclines and rough ground underfoot increase the risk of communicable diseases (Ahmed et al., 2006). Moreover, elderly pilgrims face an increase in morbidity and mortality risks (Memish, 2002). In such a mass gathering infectious diseases have the potential to rapidly turn into epidemics such as the Neisseria meningitidis W135 outbreak in Hajj 2000–01 (Wilder-Smith et al., 2002, Ahmed et al., 2006).

For each Hajj, authorities implement a number of requirements one year in advance such as the coordination of all government sectors, implementation of extensive planning, and the use of vast resources (Memish, 2002, Memish, 2010). Consequently, the preparedness of the 2013 event started at the end of the 2012 Hajj.

Saudi Arabia provides all services that are needed by pilgrims, such as free health care services, security services, and transportation, for which the country mobilizes all the necessary human and financial capacities. For example, in 2013, approximately 95,000 people from different sectors and organisations, in addition to the Ministries of Defence and the National Guard assisted with the event according to HRH Prince Mohammed bin Naïf, the Saudi interior minister (Dickinson, 2013). Thus, during the interview, Commander of Hajj Civil Defence said, during the interview, “the officers of civil defence have trained to deal with possible risks in various sites in Makkah to ensure the highest level of safety for this season".

There are many risks in the Hajj including fire, stampedes and disease, which can threaten the safety and security of the pilgrims. Moreover, in the 2013 Hajj season, there was the fear of the additional threat from MERS-CoV (Gautret et al., 2013). This fear was based on the spread of many respiratory diseases in previous Hajj such as Neisseria meningitis (Gautret et al., 2013). Furthermore, the pilgrims may transfer these diseases infections to their home countries after their return from the pilgrimage (Gautret et al., 2013, Memish et al., 2013a).

7.3 Methodology

In order to achieve the aim of this research, a case study approach is used. Therefore, the current study is conducted using face-to-face and telephone interviews with decision makers directly involved in the Hajj event and with a number of the pilgrims who were at risk from MERS-CoV in Makkah along with observation (as has been described in Chapter 3 section3.4). The researcher used a car and helicopter from which to undertake crowd movement and space occupation patterns observation (Figure 7-4).The proposed methodology is framed to answer the following research questions:

- ***RQ. What is the level of community resilience of the Hajj community under the epidemic threat of MERS-CoV?***
- ***RQ. Can the proposed resilience to disaster framework inform improved management of mass gathering events such the one of Hajj?***

Figure 7-4: Tools of observation (the researcher in the field study, Makkah, researcher's camera 2013).

7.4 Results and Discussion

The CRDSA framework was examined during the 2013 Hajj under the fear of MERS-CoV threat epidemic and other potential risks such as "floods, landslides, falling rocks, storms or strong winds, and risks of hustle and scramble" to quote the Director General of Civil Defence (Hajj, 2013). As the Hajj season is one of the world's largest mass gatherings of people (Memish et al., 2012), it presents the reseracher with a good opportunity to validate the framework's ability to assess the resilience of the community to this type of disaster in a real-world setting.

According to the methods discussed above, this section presents the results and the analysis that were performed for each dimension of the CRDSA framework (Figure 1). Assessment and scoring of each criterion of the framework dimensions was informed by fieldwork results as well as available documentation. The score of each criterion are totalled to give the score for the dimension concerned, while summing the scores for all six dimensions determines the level of community resilience (Alshehri et al., 2015b). The latter is measured through 5 possible grades: very low (<20), low (≥20 and <40), fair (≥40 and <60), high (≥60 and <80), outstanding (≥80). Scoring of each criterion involved consensus and consistency checking values (Harris and BROWN, 2010).

7.4.1 Social dimension (S)

Data for this dimension were collected from the pilgrims by using a short and closed interview style that raises questions requiring precise answers as illustrated in Table 7-1. As mentioned above the total of 334 pilgrims were interviewed but only 279 interviews deemed exploitable due to data incompleteness.

Several studies indicate that communities in which elderly people are a smaller proportion of the population are more resilient to disaster (Manyena, 2006, Cutter et al., 2010). Moreover, according to (Taglioni et al., 2013), it has been evidenced that young people looked the most active in terms of prevention of epidemic 8 times more than elderly people.

Although MERS-CoV has not reached the stage of the epidemic (Memish et al., 2013a), the Saudi authorities recommended pilgrims most at risk, such as the elderly or those with chronic diseases, to delay their participation in the 2013 Hajj (Gautret et al., 2013). This step was taken to protect the pilgrims and to prevent the worldwide spread of MERS-CoV (Gautret et al., 2013). In this study, the vast majority of the pilgrims' participants are below of 60 years. The majority of respondents (57%) were aged 21 to 40 while 35% were between 41 and 60. The rest of participants (6%) were above 60, and 2% were 20 or younger (as seen in Figure7-5).

It has been pointed out that female can be more vulnerable to the respiratory mortality than males (Davie et al., 2007). Furthermore, females are more susceptible to respiratory infections such as SARS than males (Nishiura et al., 2005). In current study, the proportion of males (82%) was higher than females (18%) among the respondents. This was due in part to the difficulty in approaching directly females (as seen in Figure7-5). It is worth noting that about 60% of the pilgrims in 2013 were male. According to (CDSI, 2014), the proportion of males (59%) attending the Hajj in 2013 was higher than females (41%). Hence, the demographic criterion (S10) is positively in Hajj community.

From an educational perspective, it has been highlighted that educated people are more resilient to disasters and can also help in improving the community planning (Jafari et al., 2011b). In the current study, the most respondents of pilgrims are educated; more than half (51%) of the respondents have University degrees or postgraduate qualifications (as seen in Figure7-5). About 43% are educated to either primary or high school level and the rest of participants have no education. Hence, criterion S9 (education levels) is available which assists to change their behaviour according to the virulent of the epidemic (Taglioni et al., 2013).

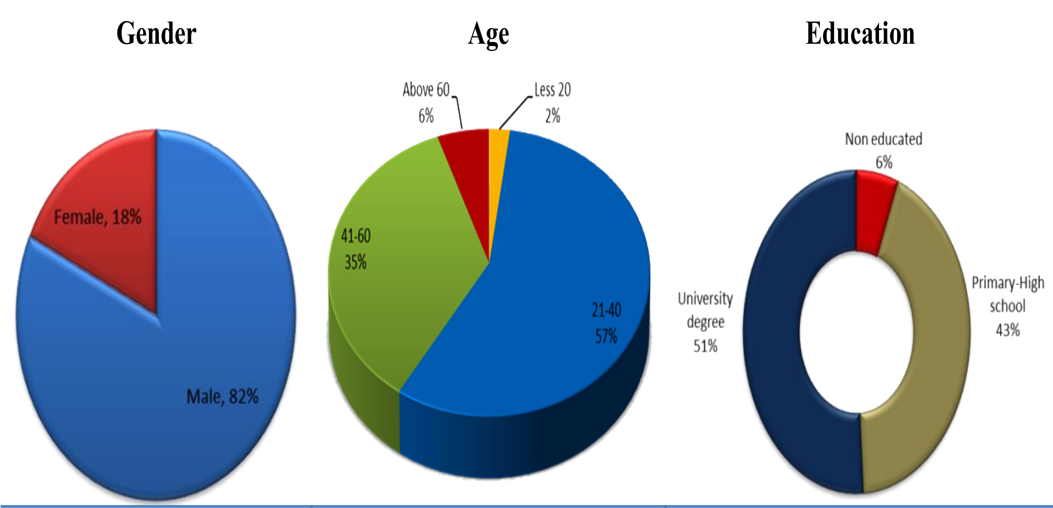


Figure 7-5: Some criteria of Social dimension

On the other hand, two criteria were not present with high score under this dimension; (S6) previous experience and (S11) national language. In relation to S6, more than half of the responders had no previous experience of biological threats such as H1N1 or MERS-CoV, as these had not become epidemics (Memish et al., 2013a). S11 has low scoring as the pilgrims come from more than 180 countries; however, about 25% of pilgrims of this year can speak Arabic (CDSI, 2014). Moreover, about 30% of the pilgrims this year came from in Saudi Arabia both Saudi and non-Saudi (CDSI, 2014). Thus, language barriers are a significant problem when it comes to helping the pilgrims (Mohandes, 2008). Nevertheless, the Saudi government provides health education and publications on the risks at the Hajj for all the pilgrims in various languages. The Director General of Civil Defence in Hajj and Director-General of the MOH Health Emergency General Department, and the Head of the Emergency and Field Medicine Committee confirmed that thousands of these publications are distributed to Hajj establishments in other countries and in the holy sites. Additionally, the researcher observed posters to raise awareness of MERS-CoV (as seen in Figure 7-6).

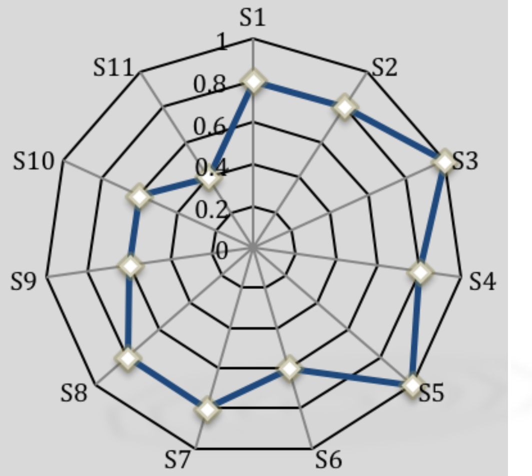
Figure 7-6: Posters to raise awareness of MERS-CoV

Therefore, in the current study more than 80% of respondents were aware of the risks associated with the Hajj risks including the MERS-CoV threat, which validates the S1 criterion. This result is consistent with the results of a study in France, which showed that most of the respondents were aware of an on-going MERS-CoV threat in Saudi Arabia before travelling to Hajj 2013 (Gautret et al., 2013). Moreover, Devi et, al, 2014 indicate that the Ministry of Health (MOH) in Malaysia provided the pilgrims with an alert card containing information such as the symptoms of MERS-CoV infection (Devi et al., 2014).

The rest of the questions involved binary (Yes / No) answers as summarized in Table (7-1) alongside the obtained scores for each criterion through a “spider” diagram.

Table 7-1: Scoring of the Criteria of the social Dimension

Dimension	*Criteria*	Questions	Means of testing
Social	**S1**	Are you aware of:: -Risks involved in Hajj? -Evacuation and emergency plans?	Pilgrims interview
	S2	Do you think that this region could be affected by disasters?	Pilgrims interview
	S3	Are you concerned about your community issues, respect for and service to others?	Pilgrims interview
	S4	Do you have responsibility to help others?	Pilgrims interview
	S5	Do you comply with all instructions from government authorities?	Pilgrims interview
	S6	Have you heard of epidemics such as H1N1 and MERS-CoV?	Pilgrims interview
	S7	Do you have people from your family or close friends with you?	Pilgrims interview
	S8	Do you comply with all instructions from faith organisations?	Pilgrims interview
	S9	- Primary - High school - University degree	Pilgrims interview
	S10	Gender: M / F Age: Less 20; 21-40; 41-60; Above 60	Pilgrims interview
	S11	Nationality, Do you understand the local language (Arabic)?	Pilgrims interview

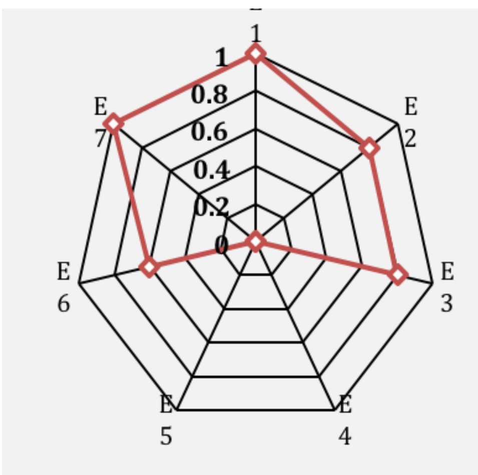


7.4.2 Economic (E)

The role of economic capital in community resilience is important in that it raises the capacity of the community to cope with the impact of disasters (Mayunga, 2007). (E) dimension has got the lowest score (60%) in total; however, in this study, most of its criteria have been reached the valeted score. The scoring of the criteria under the Economic dimension relied mainly on interviews with the decision makers and pilgrims. There was difficulty in assessing some of the criteria of this dimension. Criteria E4 (insurance coverage) and E5 (home ownership status) did not apply to this study, given the transient dimension of the studied population. Table 7-2 illustrates the resulting scores of the economic dimension.

Table 7-2: Presence of the Criteria of the Economic Dimension

Dimension	*Criteria*	Respondents	Score
Economic	E1	Decision makers	**1**
	E2	Decision makers	**0.8**
	E3	Decision makers	**0.8**
	E4	Pilgrims	**N/A**
	E5	Pilgrims	**N/A**
	E6	Pilgrims	**0.6**
	E7	Decision makers	**1**



7.4.3 Physical and environmental (PE)

Observation and interviews with government officials informed the scoring of the criteria of this dimension. However, 'management of waste created by natural hazards' (PE6) was not observed as a result of absence of natural disaster during the study's period. The location of the site (PE8) is vulnerable to the risk of disasters given the record of past disasters and the intense overcrowding of this mass event. Table7-3 illustrates the scores of this dimension which is supported by some pictures (as seen in Figures 7-7 – 7-10)

Table 7-3: Presence of the Criteria of Physical and Environmental Dimension

Dimension	*Criteria*	Respondents
Physical and environmental	PE1	Decision makers / Observation
	PE2	Decision makers / Observation
	PE3	Decision makers / Observation
	PE4	Decision makers
	PE5	Decision makers / Observation
	PE6	Decision makers
	PE7	Decision makers / Observation
	PE8	Decision makers
	PE9	Decision makers / Observation

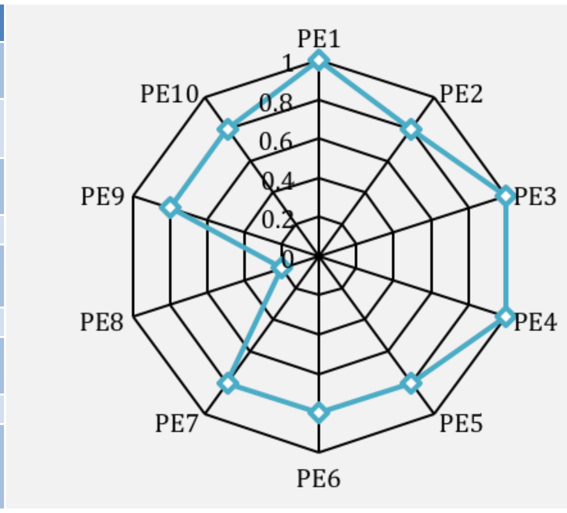


Figure 7-7: The availability of PE criteria (researcher's camera 2013)

Figure 7-8: The availability of PE criteria (researcher's camera 2013)

Figure 7-9: The availability of PE criteria (researcher's camera 2013)

Figure 7-10: The availability of PE criteria (researcher's camera 2013)

An appropriate infrastructure is important in reducing impacts of disasters (Perera et al., 2010). Additionally, one of the most critical criteria to increase the resilience of community is 'lessons learnt from previous disasters' (McDaniels et al., 2008, Litman, 2006). The Saudi government has faced biological threats previously such as that of H1N1 during the 2009 Hajj. As a result, several steps were able to be put in place to face the new challenge of MERS-CoV (these steps are discussed in the following section). In this context, the Director General of Civil Defence in Hajj (2013) confirmed that plans were in place to evacuate the pilgrims for any reasons to shelters such as schools, which were prepared for any emergency. This plan confirmed the presence of criterion PE4. However, the location of case study area is vulnerable to various types of life threatening hazards (Shehata and Koshak, 2007). Moreover, the extreme overcrowding at the Hajj in specific area can increase (MERS-CoV) transmission; hence, criterion (PE8), which is "*The location of built environment*", has not been validated.

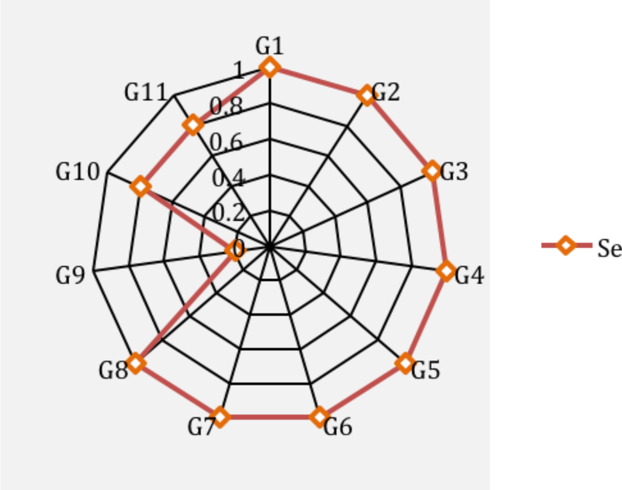
7.4.4 Governance dimension (G)

According to the UNDP: "There is a need for institutional systems and administrative arrangements that link public, private and civil society sectors and build vertical ties between local, district, national and global scale actors" (Pelling et al., 2004).

Interviews with government officials informed the scoring of the criteria of this dimension as illustrated in Table (7-4). It is worth noting that all criteria have achieved high score with the exception of G9 (participation of community members through volunteerism) as most of the structures in place are government led.

Table 7-4: Scoring of the Criteria of Governance Dimension

Dimension	*Criteria*	Respondents	Score
Governance	G1	Decision makers	**1**
	G2	Decision makers	**1**
	G3	Decision makers	**1**
	G4	Decision makers Observation	**1**
	G5	Decision makers	**1**
	G6	Decision makers	**1**
	G7	Decision makers	**1**
	G8	Decision makers	**0.8**
	G9	Decision makers	**0.2**
	G10	Decision makers	**0.8**
	G11	Decision makers	**0.8**



In 2013, the Saudi government faced a potentially huge challenge in coping with the threat from MERS-CoV; although, the disease had not yet become an epidemic (Memish et al., 2013a). Nevertheless, the Saudi authorities started to prepare for the 2013 Hajj one year previously. The main element in preparedness plans in Saudi Arabia is strong cooperation between the public health and emergency services under the supervision of the MOH and Civil Defence (Ebrahim et al., 2009). In addition, all authorised organizations are involved in this plan (e.g. Ministry of Hajj and Ministry of Municipal and Rural Affairs). Moreover, the Saudi National Guard and the Ministry of Defence and Aviation are involved in the provision of free medical care (Memish, 2010), which is offered to all pilgrims who require medical care (Ebrahim et al., 2009, Memish et al., 2013a).

Most of criteria of the G dimension were observed during the preparation stage with the exception of G9 as a result of the lack of available data. For example, vast majority of decision makers agreed that the participation of women and children is limited in Hajj. This can be as result of customs and traditions in Saudi Arabia recruiting female participate is quite difficult (Zabin, 2010).

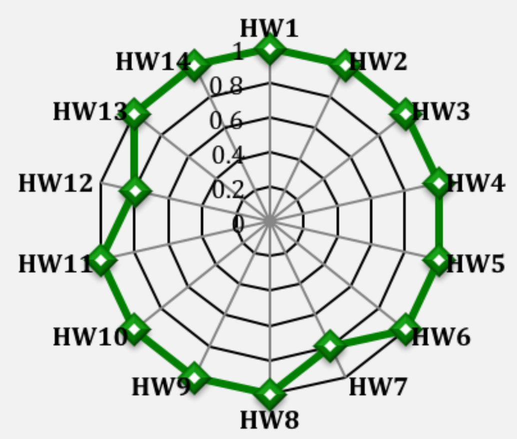
The current study confirmed that coordination was effected between local organisations such as the Saudi Red Crescent Authority and international organisations such as WHO and CDC (Qureshi, 2009, Memish, 2010, Memish et al., 2013a). Likewise, in 2012 the Global Centre for Mass Gathering Medicine was established by the MOH (Memish et al., 2014). According to Memish et al., this centre is "an essential research network of UK academic and public health institutions in partnership with the WHO Collaborating Centre on Mass Gatherings Medicine and WHO Global Capacity Alert and Response" (Memish et al., 2014, p.2080). Furthermore, WHO was invited by the MOH in Saudi Arabia to observe and to provide any required technical assistance during the 2013 Hajj. These factors all reflect international coordination, thereby validating criteria G11.

7.4.5 Health and well-being dimension (HW)

The health and well-being dimension is the most important in relation to the threat of MERS-CoV. All criteria have been achieved high scores (see Table 7-5 which is supported by some pictures as seen in Figures 7-11 – 7-15), including immunisation programmes (HW8) that are very important in Hajj season. All pilgrims are obliged to take vaccines for other illnesses, such as influenza and meningitis; however, the absence of a vaccine against MERS-CoV is acknowledged.

Table 7-5: Presence of the Criteria of Health Dimension

Dimension	*Criteria*	Respondents	Score
Health and Wellbeing	HW1	Pilgrims / Observation	**1**
	HW2	Decision makers / Observation	**1**
	HW3	Decision makers / Observation	**1**
	HW4	Decision makers / Observation	**1**
	HW5	Decision makers	**1**
	HW6	Decision makers	**1**
	HW7	Decision makers / Observation	**0.8**
	HW8	Pilgrims Decision / makers	**1**
	HW9	Decision makers	**1**
	HW10	Decision makers	**1**
	HW11	Decision makers	**1**
	HW12	Decision makers	**0.8**
	HW13	Decision makers	**1**
	HW14	Decision makers	**1**



According to the World Health Organization (WHO), mass gatherings can be defined as "events attended by a sufficient number of people to strain the planning and response resources of a community, state or nation"(WHO, 2008). Several studies (Memish et al., 2013a, Locoh-Donou et al., 2013, Dye, 2014) point out that mass gathering is a potentially important epidemiological event that may increase the occurrence of infectious diseases. Since 2002, Saudi Arabia has faced major challenges such as Rift Valley fever, SARS, bird flu (H5N1), swine flu (H1N1), and finally MERS-CoV.

Saudi Arabia provides all services that are needed by pilgrims such as security, free health care, and transportation; it also organises the country's human and financial capacities for this season (Almalki, 2012). Thus, considerable sums of money are allocated by the Saudi government to establish comprehensive and integrated services to the pilgrims (Eltahir, 2000). For instance Saudi government spent about $800 million on constructing an efficient network of covered roads for buses and shaded lanes for pilgrims (Eltahir, 2000).

A number of criteria are critical in reducing the transmission of disease (Jafari et al., 2011b). For example, access to clean water and adequate sanitation (HW1), which is supplied during the Hajj by the Saudi government. In 2013, the Saudi authorities provided clean desalinated water for the pilgrims in Makkah. The Director General of the General Organization for Water Desalination noted that the amount of clean water provided was 9.5 million cubic metres, with a daily average of more than 677,000 cubic meters (Sabaq, 2013).

Moreover, food security (HW2) is one of the most important criteria in mass gathering management (Jafari et al., 2011b) and as precaution way of MERS-CoV(Ababa, 2014) . In this study, HW2 was observed during the field study. The Saudi government seeks to ensure the safety of pilgrims; therefore, there were inspections to places producing food and places storing food as well as inspections to ensure that all food workers have the appropriate health certificates.

Due to the importance of HW7, hygiene, as an effective method of preventing the spread of respiratory infection such as MERS-CoV, the MOH, provided sanitation and hygiene advice to all pilgrims including guidance on ensuring effective hand washing, adhering to cough etiquette, wearing face masks in the crowded areas, and more generally maintaining good personal hygiene (Memish et al., 2013b). (Gautret et al.,

2013) Pointed out that most pilgrims were willing to apply hygiene methods including facemasks, hand hygiene and social distancing before coming to the 2013 Hajj.

During the event, criterion HW4 was validated because Saudi Arabia provides 25 hospitals with a total of 5250 acute clinical care beds including: 4200 specialised, 500 critical care, and 550 emergency beds as part of the routine Hajj programme (Memish et al., 2013a). In addition, Director-General of the MOH Health Emergency highlighted that18 field medical teams were prepared in order to work at the health emergency points.

In relation to the validation of HW3, availability of trained health workers, (Qureshi, 2009) points out that emergency (EM) training in Saudi Arabia started in 2000. It involved mass gathering casualty care and disaster preparedness (Qureshi, 2009). (Memish et al., 2013b) highlight that more than 22,500 health practitioners and MOH staff participated in the entire Hajj period. To that effect, Director-General of the MOH Health Emergency emphasised that health practitioners were subjected to intensive training courses to cope with any emergency cases.

In 2013, greater precautionary methods were established to prevent the spread of MERS-CoV. However, there is no vaccine against MERS-CoV at present, therefore, Saudi Arabia was unable to issue Hajj visas that had a proof of vaccination certificate against respiratory infections (Qureshi, 2009). Therefore, the Saudi authorise decided that "all pilgrims with acute respiratory symptoms suggestive of pneumonia requiring intensive care will be isolated and tested for MERS-CoV" (Memish et al., 2013a)

One of the most important criteria under the HW dimension is HW10, disease surveillance, (Alshehri et al., 2015b). Assiri et al (Assiri et al., 2013) point out that "surveillance and infection-control measures are critical to a global public health response" (2013. p.3). In this context, the Director-General of the MOH Health Emergency General Department stated that there is a system of surveillance in place for gathering information from all medical clinics to follow up on suspected cases. This result is consistent with a study which point outs that increased surveillance during 2013 Hajj was achieved in relation to MERS-CoV (Memish et al., 2014); therefore, HW10 was validated.

Additionally Saudi Arabia advised all countries to strengthen their surveillance systems to ensure early detection of any possible cases among returning pilgrims (Memish et al., 2013a). Importantly, there were no cases of MERS-CoV infection detected or reported after pilgrims returned home related to the 2013 Hajj (Memish et al., 2014, Devi et al., 2014).

The availability of laboratory services during the Hajj is important that help to speed up the diagnosis and detection of disease, including MERS-CoV (Devi et al., 2014). In 2013, in order to examine the suspected cases of MERS-CoV, the MOH established a new laboratory unit at Mina Al Wadi Hospital in addition to the existing laboratories at Jeddah and Medina (WHO, 2013). In order to meet the strictest biosafety standards, the Director-General of the MOH Health Emergency General Department confirmed that MOH provided information that assists laboratories in implementing proper biosafety procedures when handling samples containing MERS-CoV. It also monitors all laboratories to ensure appropriate facilities, equipment, policies, security precautions and occupational health programs. Therefore, the criterion HW9, effective bio-security and bio-safety systems, which is an essential of both globally and locally health security (Bakanidze et al., 2010), is validated by reaching high score.

Figure 7-11: The availability of HW criteria (researcher's camera 2013)

Figure 7-12:The availability of HW criteria (researcher's camera 2013)

Figure 7-13: Availability of clean water (researcher's camera 2013)

Figure 7-14: Management of waste (researcher's camera 2013).

Figure 7-15: Air ventilation (researcher's camera 2013).

Figure 7-16: Health workers training (researcher's camera 2013).

Figure 7-17: Hygiene kits were provided by some agencies (researcher's camera 2013)\

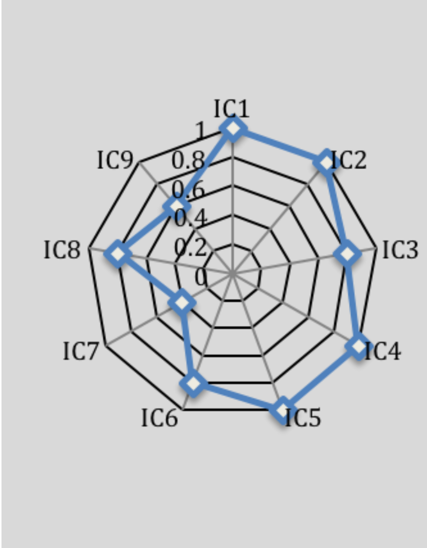
Figure 7-18: Using face mask

7.4.6 Information and communication dimension (IC)

Rating of the criteria under this dimension is informed by observation, decision makers' views and supporting evidence, and pilgrims' perceptions as illustrated in Table 7-6. Visual alerting systems (IC7) was only observed in a few places while ability to cascade information from international through regional to local communities (IC9) was partly satisfied through gathered evidence.

Table 7-6: Presence of the Criteria of Information and Communication Dimension

Dimension	*Criteria*	Respondents	Score
Information and communication	IC1	Decision makers Observation	**1**
	IC2	Decision makers Observation	**1**
	IC3	Pilgrims	**0.8**
	IC4	Decision makers	**1**
	IC5	Decision makers Observation	**1**
	IC6	Decision makers Observation	**0.8**
	IC7	Decision makers Observation	**0.4**
	IC8	Decision makers	**0.8**
	IC9	Decision makers	**0.6**



(Channa and Ahmed, 2010) emphasise that the availability of information and communication services is one of the most important aspects of disaster management. The researcher of this study recommends the importance of using social media to create a relationship and method of communication between official organizations and the public (Alshehri et al., 2013). Accordingly, in 2013, during the period of the Hajj, the MOH conducted a Twitter account and tweeted the Ministry's website in several languages to raise awareness and to respond to enquiries about the health risks in the pilgrimage, including MERS- CoV (MOH, 2013). Furthermore, it was observed that both Civil Defence and the MOH sent text alerts during the Hajj through mobile phones. As a result, criterion IC8 'ability to exploit social media' was validated (see Figures 7-19 and 7-20).

Figure 7-19: Ability to exploit social media such as website and Twitter sours MOH and Civil Defense.

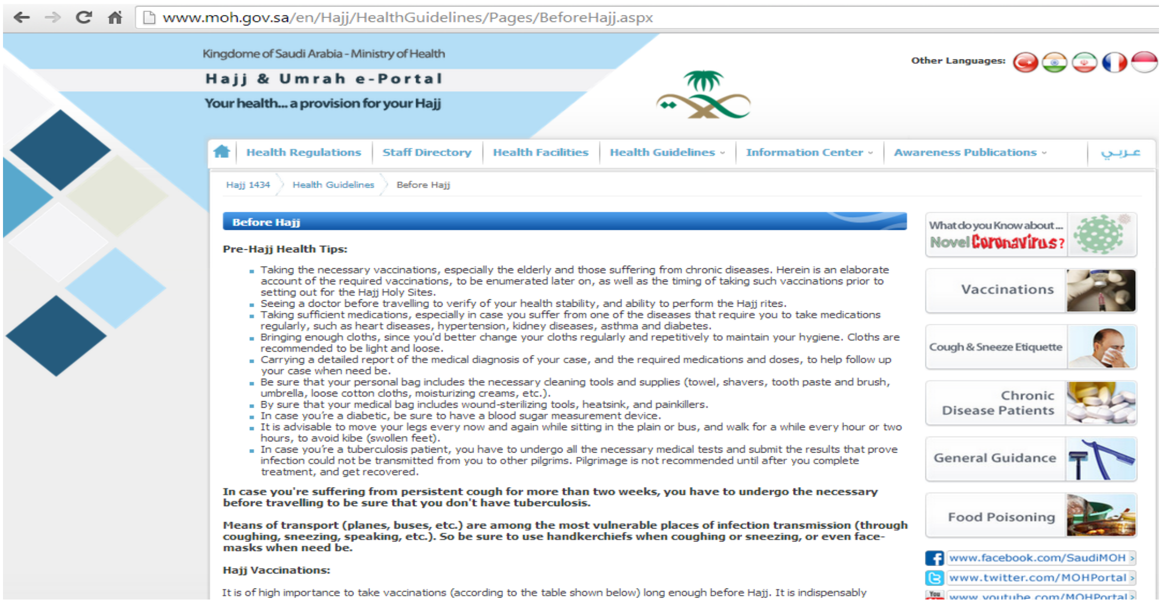


Figure 7-20: Ability to exploit social media such as website and Twitter sours MOH and Civil Defence.

Moreover, in 2013, the MOH launched 50 small, new ambulances specially equipped with the latest medical devices. For example, the Director-General of the MOH Health Emergency General Department, and the Head of the Emergency and Field Medicine Committee noted, during the interview, that all the ambulances have wireless communication means and location-pinpointing devices, GPS; in order to ensure efficient communications and the directing of ambulances to the locations where the cases exist. This method of communication was established for the first time in 2013, which validated IC2. Furthermore, the information technology system used validates criteria such as IC1, IC2, IC4 and HW14 (Memish et al., 2014) (see Figure 7-21).

Figure 7-21: The availability of IC2 (researcher's camera 2013)

The current study validates the presence of early warning (IC1) of MERS-CoV as a result of several factors. For instance, the presence of HW10, disease surveillance, and high-tech labs, which can examine samples and provide results quickly. Also, social media has become a part of daily life. Therefore, criteria IC8 can be used to warn the pilgrims to avoid crowded areas and to increase the awareness and precautions. These results are consistent with other studies that emphasise the increasing use of social media during disasters to provide new information from the authorities, which may increase disaster situation awareness (Yin et al., 2012).

Figure 7-22: Visual alerting systems (researcher's camera 2013)

Using social media by government officials such as Civil Defence and MOH may increase IC3 'trusted sources of information' (Kavanaugh et al., 2012). IC3 is one of the main criteria under IC dimension (Alshehri et al., 2015a); it has been proven that people will ignore early warnings if they do not trust the source of the information (Haynes et al., 2008, Mayhorn and McLaughlin, 2014). In the current study, a number of the responsible authorities held a daily press conference directly through television and translated into English in order to clarify the status of pilgrims' health.

Figure 7-23 Trusted sources of information (sours Saudi's TV)

7.5 Overall Resilience Rating

The overall resilience of the hajj community is computed, using the formulas listed earlier in chapter 3, based on the values of the 62 criteria under the six dimensions. An overall rating of 83% is achieved as illustrated in spider diagram in Table 7-7. This is considered as outstanding based on the proposed benchmark (Table7-8), and reflects a high resilience of the Hajj community in the majority of criteria.

Table 7-7: CRDSA in Hajj community

Dimension	AHP Weight	New weight (WD)
Health and wellbeing (HW)	25%	24%
Governance (G)	18%	16%
Physical and Environmental (PE)	17%	14%
Economic (E)	16%	10%
Information and communication (IC)	14%	12%
Social (S)	10%	8%
Total	100%	83%

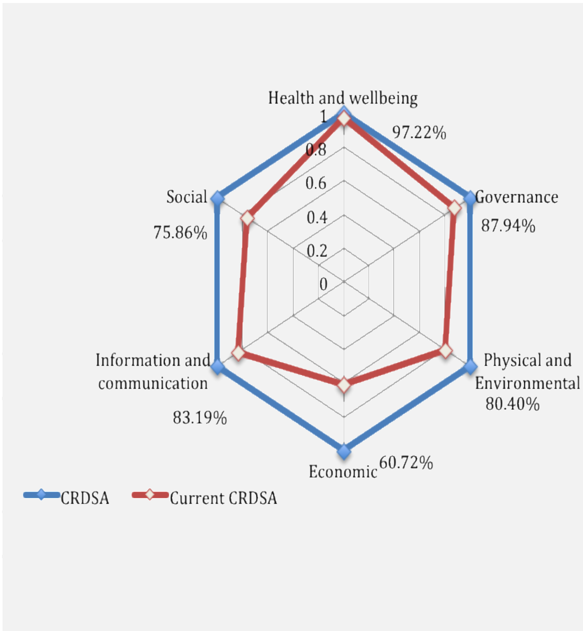


Table 7-8: High resilience of the Hajj community in the majority of criteria

Dimension	AHP weight	New weight
Health and wellbeing	25%	24%
Governance	18%	16%
Physical and Environmental	17%	14%
Economic	16%	10%
Information and communication	14%	12%
Social	10%	8%
Total	100%	82%

HW

	0	0.2	0.4	0.6	0.8	1
HW1	0.00%	0.38%	0.76%	1.15%	1.53%	1.91%
HW2	0.00%	0.38%	0.76%	1.13%	1.51%	1.89%
HW3	0.00%	0.36%	0.72%	1.08%	1.44%	1.80%
HW4	0.00%	0.36%	0.72%	1.07%	1.43%	1.79%
HW5	0.00%	0.36%	0.72%	1.07%	1.43%	1.79%
HW6	0.00%	0.35%	0.70%	1.06%	1.41%	1.76%
HW7	0.00%	0.35%	0.70%	1.06%	1.41%	1.76%
HW8	0.00%	0.35%	0.70%	1.05%	1.40%	1.75%
HW9	0.00%	0.35%	0.70%	1.04%	1.39%	1.74%
HW10	0.00%	0.35%	0.70%	1.04%	1.39%	1.74%
HW11	0.00%	0.33%	0.66%	1.00%	1.33%	1.66%
HW12	0.00%	0.33%	0.66%	0.99%	1.32%	1.65%
HW13	0.00%	0.33%	0.66%	0.98%	1.31%	1.64%
HW14	0.00%	0.33%	0.65%	0.98%	1.30%	1.63%
25%						

G

	0	0.2	0.4	0.6	0.8	1
G1	0.00%	0.36%	0.73%	1.09%	1.46%	1.82%
G2	0.00%	0.35%	0.70%	1.04%	1.39%	1.74%
G3	0.00%	0.34%	0.68%	1.02%	1.36%	1.70%
G4	0.00%	0.34%	0.67%	1.01%	1.34%	1.68%
G5	0.00%	0.33%	0.66%	0.98%	1.31%	1.64%
G6	0.00%	0.33%	0.65%	0.98%	1.30%	1.63%
G7	0.00%	0.32%	0.65%	0.97%	1.30%	1.62%
G8	0.00%	0.32%	0.64%	0.97%	1.29%	1.61%
G9	0.00%	0.31%	0.62%	0.94%	1.25%	1.56%
G10	0.00%	0.31%	0.62%	0.92%	1.23%	1.54%
G11	0.00%	0.29%	0.58%	0.88%	1.17%	1.46%
18%						

PE

	0	0.2	0.4	0.6	0.8	1
PE1	0.00%	0.38%	0.76%	1.14%	1.52%	1.90%
PE2	0.00%	0.37%	0.74%	1.10%	1.47%	1.84%
PE3	0.00%	0.36%	0.73%	1.09%	1.46%	1.82%
PE4	0.00%	0.36%	0.72%	1.07%	1.43%	1.79%
PE5	0.00%	0.36%	0.71%	1.07%	1.42%	1.78%
PE6	0.00%	0.35%	0.70%	1.04%	1.39%	1.74%
PE7	0.00%	0.35%	0.69%	1.04%	1.38%	1.73%
PE8	0.00%	0.34%	0.69%	1.03%	1.38%	1.72%
PE9	0.00%	0.34%	0.67%	1.01%	1.34%	1.68%
PE10	0.00%	0.28%	0.56%	0.84%	1.12%	1.40%
17%						

E

	0	0.2	0.4	0.6	0.8	1
E1	0.00%	0.53%	1.07%	1.60%	2.14%	2.67%
E2	0.00%	0.47%	0.94%	1.41%	1.88%	2.35%
E3	0.00%	0.46%	0.93%	1.39%	1.86%	2.32%
E4	0.00%	0.45%	0.91%	1.36%	1.82%	2.27%
E5	0.00%	0.43%	0.87%	1.30%	1.74%	2.17%
E6	0.00%	0.43%	0.87%	1.30%	1.74%	2.17%
E7	0.00%	0.39%	0.78%	1.16%	1.55%	1.94%
16%						

IC

	0	0.2	0.4	0.6	0.8	1
IC1	0.00%	0.36%	0.72%	1.09%	1.45%	1.81%
IC2	0.00%	0.34%	0.68%	1.01%	1.35%	1.69%
IC3	0.00%	0.33%	0.67%	1.00%	1.34%	1.67%
IC4	0.00%	0.32%	0.65%	0.97%	1.30%	1.62%
IC5	0.00%	0.32%	0.63%	0.95%	1.26%	1.58%
IC6	0.00%	0.31%	0.62%	0.92%	1.23%	1.54%
IC7	0.00%	0.30%	0.60%	0.90%	1.20%	1.50%
IC8	0.00%	0.29%	0.59%	0.88%	1.18%	1.47%
IC9	0.00%	0.28%	0.57%	0.85%	1.14%	1.42%
14%						

S

	0	0.2	0.4	0.6	0.8	1
S1	0.00%	0.20%	0.41%	0.61%	0.82%	1.02%
S2	0.00%	0.20%	0.39%	0.59%	0.78%	0.98%
S3	0.00%	0.19%	0.39%	0.58%	0.78%	0.97%
S4	0.00%	0.19%	0.38%	0.58%	0.77%	0.96%
S5	0.00%	0.19%	0.38%	0.57%	0.76%	0.95%
S6	0.00%	0.19%	0.38%	0.56%	0.75%	0.94%
S7	0.00%	0.18%	0.36%	0.55%	0.73%	0.91%
S8	0.00%	0.18%	0.35%	0.53%	0.70%	0.88%
S9	0.00%	0.16%	0.31%	0.47%	0.62%	0.78%
S10	0.00%	0.15%	0.31%	0.46%	0.62%	0.77%
S11	0.00%	0.15%	0.30%	0.44%	0.59%	0.74%
10%						

As result of the presence of the majority of criteria of the CRDSA framework, the Minster of Health in Saudi Arabia announced that 2013 Hajj has not reported any cases of MERS-CoV. This result was confirmed by studies such as (Memish et al., 2014) and (Devi et al., 2014) which also emphasised that no cases of MERS-CoV infection were detected or reported after pilgrims returned home from the 2013 Hajj. Thus, the assessment of community resilience to disaster in Makkah during the Hajj period determines that community of Hajj is well prepared for risks of disasters such as the MERS-CoV threat.

7.6 Software for measuring community resilience to disasters according to CRDSA methodology.

The approach has been implemented in software as has been menstioned in chapter 3. A case study of Hajj (2013), under threat of the MERS-CoV, has been used to demonstrate the applicability of the established software.

Submission the input data from users is controlled by a username account with email address as password (as seen in Fig 7-3). The input data required by the program are all six dimensions with all their criteria. The test assesses all data that have been entered (as shown in Figures 7-24 - 7-26).

Figure 7-24:The interface of CRDSA software.

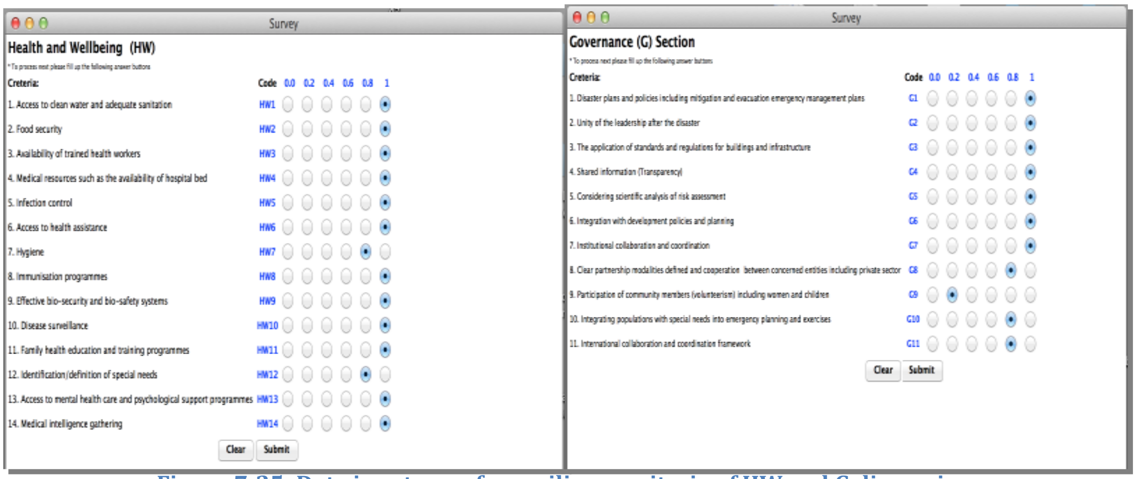


Figure 7-25: Data input page for resilience criteria of HW and G dimensions

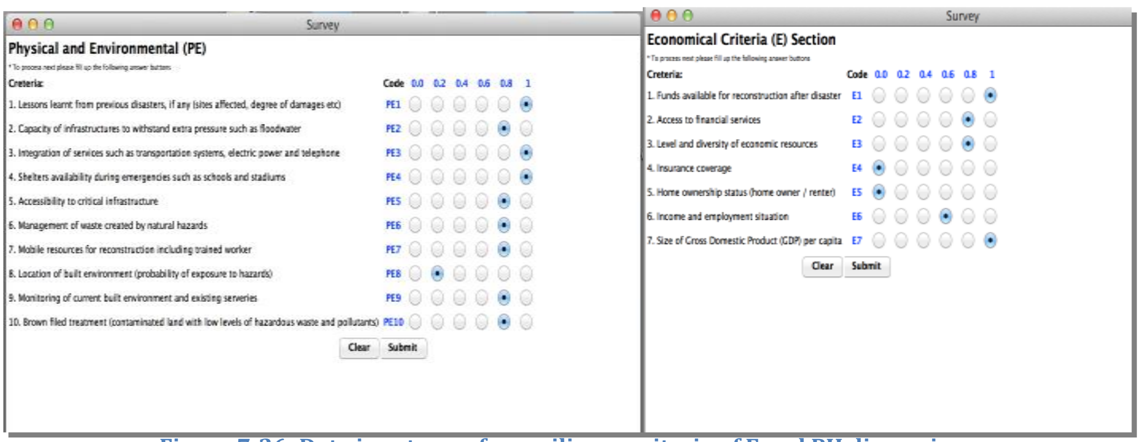


Figure 7-26: Data input page for resilience criteria of E and PH dimensions

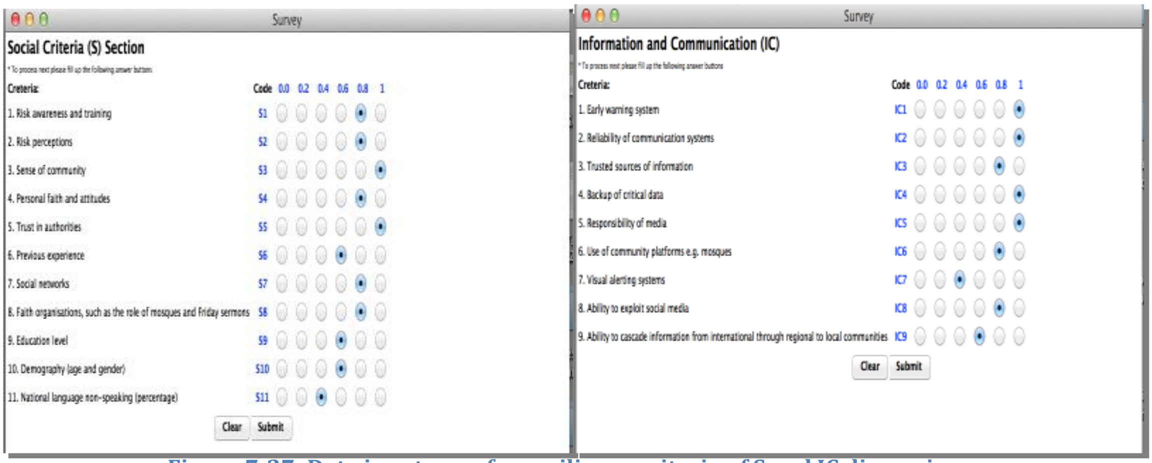


Figure 7-27: Data input page for resilience criteria of S and IC dimensions

It was found the following results, the level of resilicne in Hajj community is about (83%), that are illustrated in Fig.(7-27) below identically with the results that have been presented in Fig (7-21) by using excel sheet. This finding points out that CRDSA framework is validated.

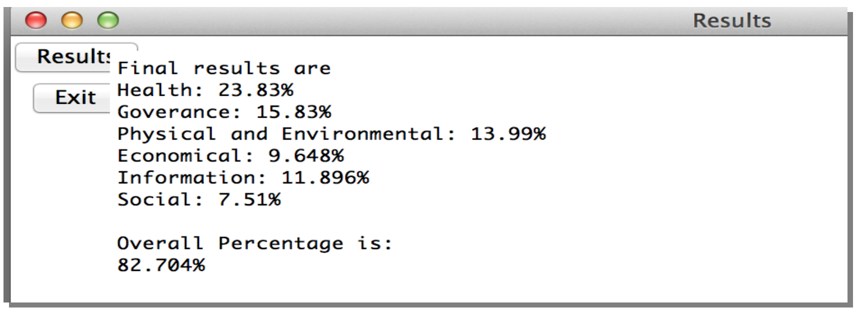


Figure 7-28: The result of Hajj community resilience level.

A physical website is a good opportunity for users to discuss, realize and practice the prototype as it is planned. Therefor, the researcher had collaboration with the developer and programmer of the software to design the web site with an interactive chart, on the Cardiff University's server, (as seen in Figures 7-29 and 7-30) that intended for explanatory visualization work. It allows user to browse all six dimensions of CRDSA and the level of community.

Figure 7-29:The Hajj's resilience level on the website

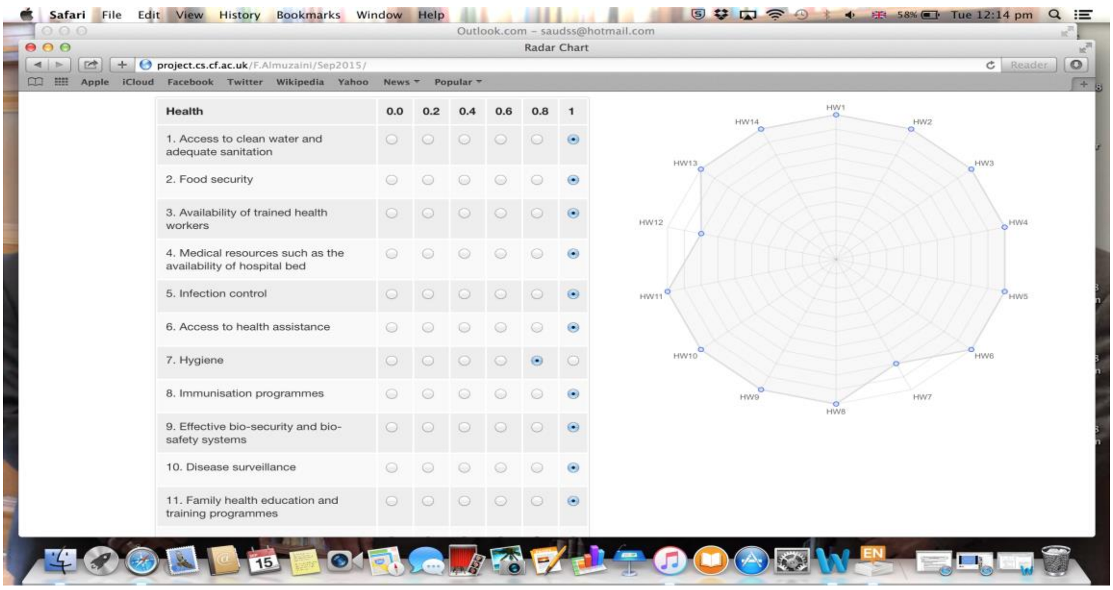


Figure 7-30: An example of dimension at the website

7.7 Summary

The proposed CRDSA framework was validated by a real case of mass gathering (the 2013 Hajj). Saudi Arabia starts to prepare for this event one year in advance and all the relevant authorities are involved in the preparedness plan. Moreover, the Saudi government expands its capabilities to keep all pilgrims safe and to ensure the Hajj season remain clear from accidents or epidemics. Therefore, the Hajj was a good opportunity to validate the developed CRDSA framework.

Evidence from the validation work suggests that the vast majority of the criteria of the proposed CRDSA framework are valuable and can be used to build community resilience to disaster, despite the difficulty of measuring some of the criteria. CRDSA can also indicate the criteria that need to be improved to increase the resilience of the community.

An interesting finding is the importance of lessons learnt from previous experiences in improving resilience to disasters. In particular, local authorities have gained considerable experience in facing H1N1 in 2009. In addition, a number of instruments were introduced in 2013 for the first time, such as the use of social media (e.g. Twitter and Instagram), wireless communication means, location-pinpointing devices, GPS, a new laboratory unit, 18 field medical teams, and a new standard of biosafety for all laboratories.

Morover, this chapter display that a software of CRDSA to measure the community resilience was created. It also has been tested by using data of real study of mass gathering (Hajj).

The researcher believes that the CRDSA framework can be used as an assessment tool for transient and permanent community resilience. The framework is scalable to other contexts through expert adaptation.

Chpter:8 Conclusion

Introduction

This study aims to establish the applicable community resilience framework needed to building the community resilience to disaster, including biological disaster, in the Saudi Arabian context. This general aim translates into the following research questions:

- *RQ1- What are the Saudi's public attitudes towards the risk of disaster in general and biological disaster in particular?*
- *RQ2- What specific cultural and demographics factors (such as faith, age, and gender) affect the Saudi public's perception of disaster in general and biological disaster in specific?*
- *RQ3- What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?*
- *RQ4- Which adapted resilience assessment weighting system that best conveys community resilience measurement in the context of Saudi Arabia?*
- *RQ5- To what extent do the dimensions and criteria of the proposed community resilience to disasters in Saudi Arabia (CRDSA) determine the measureable outcomes of community resilience?*
- *RQ6-What is the level of community resilience of the Hajj community under the epidemic threat of MERS-CoV?*

As considered in chapter one, the foundation for the study stems from the need to enhance the community resilience to disaster, including biological disaster, in the Saudi Arabian context. This study contributes to the literature about public perception of disasters by identifying and analysing the public's perception of the risks of disaster in a developing economy, namely Saudi Arabia. Additionally, it provides the first milestone towards the process of building community resilience to disaster, including biological disasters, in Saudi Arabia by proposing the CRDSA framework.

The current chapter summarizes the work and findings of the thesis, identifies limitations of current research, and provides recommendations for future research. As such, this chapter is structured into the following sections: addressing the research questions (8-1); contribution to knowledge (8-2); limitations of the current work (8-3); and recommendations for future research (8-4).

8.1 Addressing the research questions

Following an in-depth review of the literature, the research questions have been answered in three different phases using different approaches as elaborated in the methodology section.

The first phase focused on the investigation of public perception of the risk of disaster. The second phase was split into two parts to establish a Community Resilience Framework. In the first part, the Delphi consensus-based consultation is employed. All dimensions and their corresponding criteria were presented to an experts' panel to determine the level of importance and consensus for each dimension and criterion in relation to community resilience to disaster management in Saudi Arabia. In the second part, the researcher used Analytic Hierarchy Process (AHP) and a calculation method to establish the weights for each dimension and criterion. The final phase focused on the validation of CRDSA.

The answer to each formulated research question is elaborated below.

RQ1-

What are the Saudi public's attitudes towards the risk of disaster in general and biological disaster in particular?

The answer to this research question is discussed in detail in chapter 4. The public's perception to disasters was surveyed in order to highlight the public's attitudes towards the risk of disaster in general, as well as to biological disaster. A number of factors were identified that can inform the development of an adapted community resilience strategy across the region. These factors included 'Faith', 'Education level', 'Risk perception', 'Access to sources' and 'Willingness and responsibility'. However, other important factors, such as lack of 'Raising awareness', 'Training', and 'Knowledge regarding information on official websites', which can decrease community resilience, are also evident from the survey.

Based on the survey results, the researcher believes that the Saudi government should focus on addressing these areas and use the identified factors to inform the development of adapted resilience strategies in disaster management. This can be achieved through public education and training, building on cooperation between official organisations (including the Ministry of Health, Civil Defence and the Ministry of Education) to increase public awareness, knowledge and skills around this problem. Furthermore, the Ministry of Health should develop its website and investigate the reasons behind the currently limited public usage and distrust of the site. Furthermore, it should take into account that it can use faith, knowledge and Islamic teachings to create a stronger incentive and improve risk reduction in a post-disaster environment.

RQ2-

What specific cultural and demographics factors (such as faith, age, and gender) affect their perception of disaster in general and biological disaster in specific?

The cultural and demographics factors highlighted in the public perception survey that affect the public's perception include 'Faith', 'Education level', 'Economics', 'Risk perception', 'Access to sources', and 'Willingness and responsibility'. Therefore, the primary results reveal that age, gender, education and faith are positively related to the perception of biological risk. The results of this survey show that the complex socio-cultural environment of Saudi Arabia at the local and regional level is exacerbated by a lack of resilience in several areas such as 'Awareness raising', 'Training' and 'Access to timely and relevant information' and 'Knowledge related to disasters'. Moreover, the willingness and responsibility of most respondents to engage with disaster mitigation presents significant opportunities to engage community members in the preparation of response to disasters and to encourage informed action.

This study determines that the development of adapted resilience strategies in disaster management can be achieved through public education and training. This would involve cooperation between official organisations and religious authorities in the country in order to increase public awareness, knowledge and skills in mitigating biological threats.

RQ3 -

What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?

This research question was addressed through a survey based on the Delphi method (as discussed in Chapter 5). The Delphi method provides a valuable framework for tapping experts' experience and knowledge in relation to community resilience. Forty experts completed three rounds of a Delphi consultation process.

The use of the Delphi technique was significant in reaching consensus around the CRDSA framework for decision-makers in the country. Based on this consultation, the study proposes a framework focused on six resilience dimensions: a) social; b) economic; c) physical and environmental; d) governance; e) health and wellbeing; and f) information and communication. It also provides 62 criteria in total to be employed, with each dimension comprising between 7 and 14 criteria.

These dimensions and their criteria can be summarised as follows:

- **Health and Wellbeing Dimension:**

A clear consensus was achieved, in this study, that health should be a separate dimension with its own criteria, which can be used in the process of building community resilience to disasters. These criteria covered both mental and physical health issues. Importantly, a number of factors are included that have not been raised in previous community resilience frameworks, such as ‘effective bio-security and bio-safety systems’, ‘family health education and training programmes’, and ‘medical intelligence gathering’. Moreover, the ability to respond effectively to high-consequence disasters requires surge capacity and capability through the availability of trained health workers and medical resources such as the availability of hospital beds.

- **Governance Dimension:**

The consensus of the experts on the criteria of this dimension was reached. These criteria include ‘participation of community members (volunteerism) including women and children’ and ‘integrating populations with special needs into emergency planning and exercises’, ‘clear partnership modalities defined and cooperation between concerned entities including private sector’, ‘institutional collaboration and coordination’, ‘international collaboration and coordination’, ‘unity of the leadership after the disaster’, ‘disaster plans and policies, including mitigation and evacuation emergency management plans', 'the application of standards and regulations for buildings and infrastructure', and 'integration with development policies and planning'. Both criteria 'shared information (transparency)' and 'considering scientific analysis of risk assessment' are vital in this context.

- **Physical and Environmental Dimension:**

Under this dimension, there are criteria that increase the ability of the community to mitigate disaster. These criteria are 'lessons learnt from previous disasters', 'capacity of infrastructures to withstand extra pressure', 'integration of services', 'the availability of shelters', 'mobile resources for reconstruction', 'monitoring of current built environment and existing services', 'management of waste' and 'brown field treatment (contaminated land with low levels of hazardous waste and pollutants)'.

- **Economic Dimension:**

The indicators proposed for this dimension are 'funds available for reconstruction after disaster', 'access to financial services', 'level and diversity of economic resources', 'insurance coverage', 'home ownership status (home owner/renter)', 'income and employment situation' and 'size of gross domestic product (GDP) per capita'.

- **Information and Communication Dimension:**

The criteria in this dimension include 'the availability of early warning and visual alerting systems', 'trusted sources of information', 'reliable communication systems', 'responsibility of media', 'the ability to exploit social media' and 'the use of community platforms such as mosques'.

- **Social Dimension:**

This study extracted a number of criteria that can contribute to increasing the resilience of the community in this dimension, as follows: 'risk awareness and training'; 'faith organisations, such as the role of mosques and Friday sermons'; 'personal faith and attitudes'; 'sense of community'; 'social networks'; 'trust in authorities'; 'previous experience'; 'education level'; 'demography (age and gender)'; and 'risk perceptions'.

RQ4-

Which adapted resilience assessment weighting system best conveys community resilience measurement in the context of Saudi Arabia?

Using the AHP approach, this research question is answered and discussed in depth in Chapter 6. The best adapted resilience assessment is derived through an adapted weighting system for CRDSA that assesses the community resilience in the context of Saudi Arabia. This study presents the dimensions and criteria of CRDSA collected through the Delphi method. The researcher then used AHP as a systematic methodology of acquiring knowledge from human experts through group decision-making for building the analytical framework.

A weighting system for each dimension and criteria is proposed using AHP along with a method of calculation. In this study, the AHP was developed and 16 experts participated (who were also involved in the Delphi surveys in order to avoid inconsistency). The weights and ranking of the six dimensions are derived using Expert Choice software from the pair-wise comparison matrices.

These six dimensions have 62 criteria (7 to 14 per dimension), all of which were developed by consensus within the expert panel in the Delphi method. The researcher used equations as discussed in Chapter 3 to determine the weights for each criterion in the six dimensions. He combined the results of means, which were obtained under the Delphi method with AHP results. Thus, the proportions of each criterion (p) against its dimension in the third hierarchy level and weights allocations of criteria (wc) were determined. When the new weight of each dimension is obtained then the total assessment of community resilience to disasters is reached by summing up the new weights.

RQ5-

To what extent do dimensions and criteria of the proposed community resilience to disasters (CRDSA) determine measureable outcomes of community resilience?

The fifth research question is answered by providing the first assessment tool to measure and grade the level of resilience to disaster of a given community in Saudi Arabia (see Chapter 6). The dimensions and criteria of the CRDSA can determine measurable outcomes of community resilience based on this tool and the Benchmark Resilience Scores.

In this study, CRDSA provides an assessment system, with each criterion weighted to evaluate the level of the community resilience to cope with future disasters. This tool creates resilience scores for each of the six dimensions, as well as an overall score. Hence, it can be used to improve the resilience of community by implementing the proposed criteria. The overview of the final outcome of creating the measurement resilience tool for the CRDSA has been obtaind (as seen in Chpater 6). To facilitate the computational process and to obtain results it is assumed that the total weight of each dimension is equal to one. The result obtained from the Measurement Resilience tool of CRDSA can be displayed on a spider diagram that illustrates the relative importance of criteria of resilience under all six dimensions.

The proposed community resilience framework (CRDSA) is the first milestone towards the process of building community resilience to disaster in Saudi Arabia. This framework is the result of contributions from international experts that complement solicited local experts.

This study reviews numerous studies to determine ranges of resilience scores according to the outcome of the measurement tool of CRDSA. Therefore, benchmark resilience scores for the CRDSA framework were identified to evaluate the resilience of a community in the context of Saudi Arabia. This scale indicates the relative resilience scores of a community, using the six dimensions and 62 criteria of CRDSA, and can be used for evaluating the resilience weaknesses and strengths for each dimension.

This study suggests a Benchmark Resilience Scores as: the score 0 is considered as “Absence” which means there is no resilience and the community is vulnerable to disasters. A community that scores below 21 will be considered “Very low”, while the community that scores between 21 and 40 will be considered as “Low”; a community evaluated between 41 and 60 will be considered as “Fair”; a community assessed between 61 and 80 will be considered as “High”; and finally a community scored between 81 and 100 will be considered as ‘‘Very High’’.

RQ6-

What is the level of community resilience of the Hajj community under the epidemic threat of MERS-CoV?

The proposed framework was validated during the 2013 Hajj pilgrimage period under the epidemic threat of MERS-CoV as discussed in Chapter 7. The validation approach involved a field study investigation, including interviews and observations during the 2013 Hajj to (a) determine community resilience level at the Hajj, (b) inform mass gathering management for protection from MERS-CoV, and (c) validate the CRDSA in a real mass gathering situation with a transient community.

Evidence from the validation work suggests that the vast majority of the criteria of the proposed CRDSA framework are valuable and can be used to assist in community resilience planning and preparedness. The results reveal that the level of community resilience of the Hajj community to disaster is high (83%) as evidenced by the absence of any reported epidemic case. The local authorities fully exploited the valuable experience gained from the H1N1 epidemic in 2009. They also benefited from the widespread use of an effective prevention and communication campaign reflected by: the effective adoption and deployment of social media, the use of wireless communications, and location-pinpointing devices; trained field medical teams; and stringent biosafety standards for all laboratories.

Thus, the study confirms that the proposed CRDSA framework can be used as an assessment tool to build community resilience to disasters in permanent and transient/temporary communities. In addition, the framework is scalable to other contexts through expert adaptation. Furthermore, a prototype software of CRDSA to measure the community resilience was created. It was also tested by using data at the mass gathering (Hajj). It found that the level of resilience in Hajj community is 82%, which is identical to the result presented by using Excel. This confirms that the CRDSA framework is validated.

8.2 Contribution to Knowledge

The study makes a number of important contributions to knowledge. First, the researcher provides a new classification of biological disasters as discussed in chapter 2 (Figure 2-2). This contribution is important in disaster management research.

Second, one of the most important contributions of this study is that it considers the issue of public perception of the risk of disasters, including biological threats, in Saudi Arabia. As far as the researcher is aware this is the first study of its kind conducted in Saudi Arabia.

Third, the study provides a new framework of CRDSA, which can be used to reduce the risk of biological threats. The results of this study will add further to the understanding of the nature of disaster management in the Saudi context and can be used by decision-makers in the development of community resilience to disasters in the future.

Fourth, it provides a weighting system obtained through a quantitative and qualitative assessment tool to measure community resilience to disasters in Saudi Arabia and also beyond based on the Benchmark Resilience Scores for the CRDSA.

Finally, a web-based prototype that implements the methodology that underpins CRDSA to measure community resilience was developed.

8.3 Limitations of the Research

The researcher has identified several limitations as elaborated below:

- The distribution of a survey in a country such as Saudi Arabia is very difficult in practice, given its large area. Therefore, an online survey was used to conduct the questionnaire. The key limitation is that the survey was conducted among people who have access to computers and e-mail, thus not allowing access to those who do not.
- The percentage of female respondents, who participated in the national survey, was relatively low as result of the customs and traditions in Saudi Arabia. Nevertheless, it is worth noting that the return was higher than initially expected.
- The researcher faced problems in recruiting experts to participate in the Delphi consultation. A number of local experts refused to participate in the research citing a lack of knowledge of Delphi method or lack of expertise in community resilience. The researcher has provided full explanation related to this issue.
- Pair-wise comparisons of all criteria were more difficult and time consuming as they involve 62 criteria, which could require 303 comparisons.
- Concerning the validation of the CRDSA framework, the researcher acknowledges that it was difficult to assess every single criterion included within the proposed framework. Therefore, the credit achieved has been divided

into five points as described in Chapter Seven given the fact that not every criterion can be measured on the ground accurately.

8.4 Recommendation for Future Research

Although the resulting findings, analyses and methodologies have revealed the effectiveness of CRDSA, further improvements may still be achieved. Therefore, this section briefly formulates a number of research areas that are worth considering further:

- The extension of public perception of risks of disasters to other regions in Saudi Arabia, mainly those regions that have a low number of participants in the current study, is important. Research also needs to include people who have no Internet access.
- The CRDSA should be evaluated in different regions in the Kingdom in order to examine the resilience level which, in turn, can identify the absence or lack of the availability of criteria to measure the CRDSA.
- Future research could design policies to implement CRDSA within the Saudi Arabia in terms of a timescale and roadmap.
- The CRDSA should be tested in other situations in Saudi Arabia that are vulnerable to disaster in order to formulate effective regulation that builds community resilience to cope with future disasters.
- This study provides a quantitative and qualitative assessment tool to measure community resilience to disasters in Saudi Arabia. However, as the surrounding region shares similar social and cultural characteristics, further research could be extended countries such as Gulf Cooperation Council (GCC) member states.

8.5 Summary

The researcher argues that this research is one of the most important studies on resilience in Saudi Arabia, as it reveals public perceptions about the risks of disasters, including biological disasters. It also has achieved its objective of establishing the framework of CRDSA that can be used to reduce the impact of biological risks. Moreover, it contributes to the body of knowledge through a new classification of biological disasters.

A number of recommendations for future work are provided in order to develop CRDSA. It is expected that such studies will be of use in decision-making and the application of guidelines that are applicable in the context of Saudi Arabia for disaster management in the future. It is hoped that this study will be the starting point of further research for the development of disaster management in general and particularly in biological disasters, in the context of Saudi Arabia and beyond.

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Appendix

Appendix A
Public perception Survey

1. Public perception of disaster in Saudi Arabia التصور العام للكوارث في المم...

أخي/أختي/ الفاضل/ـة
السلام عليكم ورحمة الله وبركاته
يموج عالمنا في السنوات الاخيرة بتغيرات كونية نتج عنها كوارث طبيعية
مثل الزلازل والفيضانات والأمراض الوبائية , وكوارث تقنية مثل الحروب
وقد يكون للانسان دور في تخفيف اثارها او زيادة خسائرها البشرية والمادية
ونحن في المملكة العربية السعودية جزء لا يتجزء من العالم وقد تعرضنا بالفعل
الي احداث عدة من هذه الكوارث ولا ادل على ذلك مما حدث في جدة من السيول
وماحدث من إنتشار لمرض الوادي المتصدع ومرض انفلونزا الخنازير في السنوات القليلة الماضية
لذا
ورغبة في الوصول الي أفضل الطرق لمعرفة امكانية التعامل مع تلكم الكوارث
او تخفيف اثارها والخروج باقل الخسائر ان حدثت لا سمح الله
فانه يسرني ان اضع بين ايديكم الأسئلة التالية
لمعرفة التصور العام للكوارث في المملكة العربية السعودية
. وهي جزء من دراستي لدرجة الدكتوراه
حيث تحتوي على ثلاثة أجزاء , الاول يتعلق بالصفات الديموغرافية للشخص
والثاني يتعلق بالمعرفة عن مخاطر الكوارث والاخير عن كيفية استقاء المعلومات عن الكوارث
. وكيفية رفع مستوى إدارة الكوارث
, ارجو ان تمنحني جزء من وقتك لتعبئة هذا الاستبانه, لأستنير بعلمك ومعرفتك
وتسهم بإضافة لبنة
.الي لبنات العلم وتحقيقا الي ما من شأنه رفع سلامة هذا البلد
.علما بأن هذه المعلومات لن تستخدم إلا للأغراض البحثية فقط
شاكر لكم حسن تعاونكم
ولمزيد من الاستفسار يمكن التواصل عبر العناوين المدونة أدناه
والله ولي التوفيق

أخوكم سعود بن علي الشهري
طالب / درجة الدكتوراه
جامعة كارديف
المملكة المتحدة

Saud Alshehri
Cardiff University
Alshehris1@cardiff.ac.uk
saudss@hotmail.com
00447955373612 (U.K)
00966505483586 (SAUDI)
CF14 5EQ
Cardiff
United Kingdom

2. Persoanl Information

***1. AGE العمر**

- ◯ Less than 18 أقل من 18
- ◯ 18 - 30
- ◯ 31 – 50
- ◯ 50+

***2. Genderالجنس**

- ◯ MALE ذكر
- ◯ FEMALE أنثى

***3. Marital Status الحالة الاجتماعية**

- ◯ MARRIED متزوج
- ◯ SINGLE أعزب

***4. Number of children under 16 years of age in the household**
كم عدد الأبناء أقل من 16 سنه في المنزل

- ◯ None لايوجد
- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4 or more أو أكثر 4
- ◯ Refused رفض

***5. Where do you live in Saudi Arabia?**
اين تعيش في المملكة العربية السعودية؟

Region المنطقة

Please specify your city يرجى تحديد المدينة

***6. What type of house do you live in? ماهو نوع المنزل الذي تعيش فيه؟**

- ◯ Apartment شقة
- ◯ House بيت
- ◯ Villa فيلا
- ◯ Other أخرى

please specify- (يرجى التحديد)

***7. What is the highest level of education you have completed?**

ماهو أعلى مستوى تعليمي حصلت عليه؟

- Primary school إبتدائي
- Intermediate school متوسط
- High school ثانوي
- Diploma دبلوم
- Advanced Diploma دبلوم عالي
- University Degree شهادة جامعية
- Postgraduate Qualification دراسات عليا
- Other أخرى

please specify:- (يرجى التحديد)

8. What is your occupation?

ماهي وظيفتك؟

نوع الوظيفة

Other please specify (يرجى التحديد) أخرى

9. Your income is

ماهو مستوى الدخل المالي ؟

Income الدخل

3. Knowledge and perception questions of hazards

***10. Which of the following do you think can generate a Disaster? (You may choose as many as you like).**
أيا من النقاط التالية تعتقد أنها تسبب الكوارث؟ (يمكنك أن تختار ما تستطيع).

- [ ] Earthquake الزلازل
- [ ] Flood الفيضانات
- [ ] Epidemic الأمراض الوبائية
- [ ] Volcanic eruption البراكين
- [ ] Tornado الأعاصير
- [ ] Landslide الانزلاقات الأرضية
- [ ] Tsunami تسونامي
- [ ] conflicts الحروب والنزاعات

***11. Do you think the region where you live could be affected by Disaster?**
هل تعتقد أن المنطقة التي تعيش فيها يمكن ان تتعرض للكوارث؟

○ Yes نعم ○ No لا ○ Don't know لا أعلم

***12. How concerned, if at all, are you about Disasters?**
كيف تصف قلقك من الكوارث؟

○ Very concerned قلق جدا
○ Fairly concerned قلق نوعا ما
○ Neither agree nor disagree محايد
○ Not very concerned لست قلق جدا
○ Not at all concerned لست قلق نهائيا
○ Don't know لا أعلم

***13. To what extent do you agree or disagree with each of the following statements about Disasters related to you faith?ما مدى إعتقادك او عدم إعتقادك بالجمل التالية ذات الصله بحدوث الكوارث**

	Completely agree أوافق بشدة	Mostly agree أوافق	Neither agree Nor disagree محايد	Mostly disagree لاأوافق	Completely disagree لاأوافق بشدة	Don't know لاأعلم
God is in control of every that happens in the world. أن الله سبحانه وتعالى هو المتحكم في كل ما يحدث في العالم	○	○	○	○	○	○
Disasters such as earthquakes, floods, epidemic other natural disasters are sign from God. أن الكوارث مثل الزلازل, الفيضانات, الأمراض الوبائية والكوارث الطبيعية الاخرى هي من علامات الله	○	○	○	○	○	○
Disasters such as earthquakes, floods, epidemic other natural disasters are God's way of testing our faith. أن الكوارث مثل الزلازل, الفيضانات, الأمراض الوبائية والكوارث الطبيعية الاخرى هي إختبار من الله لإيماننا	○	○	○	○	○	○
Disasters such as earthquakes, floods, epidemic other natural disasters are punishments from God for the sins of some people. أن الكوارث مثل الزلازل, الفيضانات, الأمراض الوبائية والكوارث الطبيعية الاخرى هي عقاب من الله	○	○	○	○	○	○

***14. 15. Thinking about the causes of Disasters, which, if any, of the following best describes your opinion?**
أيا من الفقرات التاليه توضح رأيك عن اسباب حدوث الكوارث؟

- ☐ Disasters are completely caused by natural processes تحدث الكوارث نتيجة للعمليات الطبيعية
- ☐ Disasters are partly caused by natural processes and partly caused by human activity تحدث الكوارث نتيجة لنشاطات طبيعية وبشرية
- ☐ Disasters are caused by human activity تحدث الكوارث بسبب النشاطات البشرية
- ☐ Don't know لا أعلم
- ☐ No opinion ليس لدي رأي

***15. Do you know when the last Disaster affected Saudi Arabia?**
هل تعلم متى كانت اخر كارثة حدثت في المملكة العربية السعودية؟

○ Yes نعم ○ No لا

If yes, where— اذا كانت اجابتك نعم أين

***16. Have you ever experienced a natural disaster?**
هل تعرضت شخصيا لاي كارثة؟

○ Yes نعم
○ No لا

4.

17. What was the nature of the disaster and in approximately what year did the event take place?

ماذا كان نوع الكارثة وفي اي سنه تقريبا حدثت؟

***18. Do you think a Disaster affecting Saudi Arabia could have the following effects? (Put the following points in the order please the most important takes 1-- less important takes 8).**

ماهي الآثار التي تعتقد انها قد تحدث نتيجة كارثة تحدث في المملكة لاسمح الله (ضعها بالترتيب حسب الاهمية من 1 الي 8على الا يتكرر الرقم لوسمحت).

	Please DON'T repeat choice رجاء عدم تكرار الرقم
Death and injury of people وفيات وإصابات للناس	
Damage and destruction to homes and Factoriesالأضرار والدمار للمنازل والمصانع	
Damage and destruction to critical lifelines e.g. water, electricity الضرر والدمار لشرايين الحياة الهامة على سبيل المثال المياه والكهرباء	
Damage and destruction to infrastructure such as communication networks and transport networksالضرر والدمار للبنية التحتية مثل شبكات الاتصالات وشبكات الطرق	
Impacts on agriculture أثر على الزراعة	
Impacts on export of Oil أثر على تصدير النفط	
Impacts on Religious tourism (Hajj, Umrah)التأثيرات على السياحة الدينية (الحج والعمرة وزيارة المسجد النبوي)	
Impacts on Environment أثر على البيئة	

Other (please specify) أخرى يرجى تحديدها

*** 19. To what extent do you agree or disagree with each of the following statements about Disasters relating to your knowledge and opinions?**
ما مدى موافقتك او عدم موافقتك مع الجمل التالية المرتبطة برأيك ومعرفتك الشخصية عن الكوارث؟

	Completely agree أوافق بشدة	Mostly agree أوافق	Neither agree Nor disagree محايد	Mostly disagree لا أوافق	Completely disagree لاأوافق بشدة	Don't know لاأعلم
I am uncertain that Disasters are really happening أنا لست متأكد من حقيقة حدوث كوارث	○	○	○	○	○	○
There are risks to people in Saudi Arabia from Disasters أن هناك مخاطر على السكان في المملكة العربية السعودية نتيجة الكوارث لاسمح الله	○	○	○	○	○	○
I have mixed feelings about Disasters لدي مشاعر مختلطة تجاه الكوارث	○	○	○	○	○	○
I have strong opinions about Disasters لدي آراء قوية عن الكوارث	○	○	○	○	○	○
My emotions relating to Disasters strong لدي مشاعر قوية مرتبطة بالكوارث	○	○	○	○	○	○
I trust Saudi Government to take appropriate action against Disasters أنا لدي ثقة بأن الحكومة السعودية لديها القدرة على التعامل مع تلك الكوارث	○	○	○	○	○	○
The seriousness of Disasters are exaggerated أن جدية الكوارث مبالغ فيها	○	○	○	○	○	○
Most scientists agree that humans are causing Disasters أن غالبية العلماء يرون أن البشر يتسببون في الكوارث	○	○	○	○	○	○
It is uncertain what the effects of Disasters will be من غير المؤكد ماهي الآثار التي ستحدث نتيجة الكوارث	○	○	○	○	○	○
Any type of Disaster could strike my community حدوث أي نوع من أنواع الكوارث في مجتمعي أمر محتمل	○	○	○	○	○	○
Disasters will mostly affect areas that are far away from my region أن الكوارث تؤثر بشكل كبير على المناطق البعيدة عن منطقتي	○	○	○	○	○	○
Disasters will mostly affect developing countries الكوارث سوف تؤثر في الدول النامية	○	○	○	○	○	○
Disasters are likely to have a big impact on people like me إحتمال أن يكون هناك تأثيرات كبيرة للكوارث على السكان مثلي	○	○	○	○	○	○

***20. To what extent do you agree or disagree with each of the following statements about Disasters relating to responsibility?**

ما مدى موافقتك او عدم موافقتك مع الجمل التالية المرتبطة بالمسئوليات خلال الكوارث؟

	Completely agree أوافق بشدة	Mostly agree أوافق	Neither agree Nor disagree محايد	Mostly disagree لا أوافق	Completely disagree لاأوافق بشدة	Don't know لاأعلم
I know Disaster's risks انا اعرف مخاطر الكوارث	○	○	○	○	○	○
I can help my family and helping others during a disaster أستطيع مساعدة عائلتي والأخرين خلال الكوارث	○	○	○	○	○	○
I know what to do in the event of a Disaster أنا اعرف ماذا افعل خلال الكارثة	○	○	○	○	○	○
I can personally contribute to reduce the risks of Disaster استطيع المشاركة شخصيا في تخفيف مخاطر الكوارث	○	○	○	○	○	○
I am aware of the emergency procedures I need to follow if a Disaster warning is issued أنا على وعي بإجراءات الطوارئ المفترض اتباعها بعد صدور انذار الكارثة	○	○	○	○	○	○
I will comply with the evacuation of any circumstances سوف التزم بخطة الإخلاء في كل الظروف	○	○	○	○	○	○

***21. As you might know, there were Epidemics last decade in the world or in Saudi Arabia such as Rift Valley fever (RVF) Severe Acute Respiratory Syndrome(SARS), Avian Flu (H5N1) and Swine Flu(H1N1), therefore, Do you think**

كما تعلم ،أنه ظهر عدد من الأمراض الوبائية في العالم او في المملكة في العقد الماضي مثل

مرض الوادي المتصدع(RVF)

مرض الالتهاب الرئوي الحاد (SARS)

ومرض انفلونزا الطيور(H5N1)

ومرض أنفلونزا الخنازير (H1N1)

وبالتالي ، هل تعتقد أن ،

	Yes نعم	No لا	Don't know لاأعلم
SARS is a communicable disease مرض الالتهاب الرئوي الحاد (السارس) هو مرض معدي	○	○	○
Avian Flu (H5N1) is a communicable disease أنفلونزا الطيورهو مرض معدي	○	○	○
People can die of an infection with a new flu virus يمكن ان يموت الناس نتيجة للإصابة بفيروس انفلونزا جديد	○	○	○
The impact of a new communicable disease as a threat to the community أثار ظهورمرض معدي جديد يعتبر تهديد للمجتمع	○	○	○

***22. In general, do you think that people can take actions to prevent getting a new disease in case of an outbreak in such as Flu, Malaria , Dung Fever and etc. in Saudi Arabia?**
بشكل عام ، هل تعتقد أن الناس يمكن أن تتخذ إجراءات لمنع الاصابة بمرض جديد في حال أنتشاره مثل حمى الضنك، الملاريا اوالانفلونزا ، وغيرها. في المملكة العربية السعودية؟

- ◯ Completely agree أوافق بشدة
- ◯ Mostly agree أوافق
- ◯ Neither agree Nor disagree محايد
- ◯ Mostly disagree لا أوافق
- ◯ Completely disagree لا أوافق بشدة
- ◯ Don't know/ refused لا أعلم/ارفض

***23. How confident are you that you yourself can prevent a new disease in case of an outbreak in such as Flu, Malaria, Dung Fever and etc.. in Saudi Arabia?**
الي اي مستوى تثق بأنك يمكن أن تحمي نفسك من الاصابة بالأمراض الجديدة في حالة تفشيها مثل الملاريا,الانفلونزا , حمى الضنك ، وغيرها. في المملكة العربية السعودية؟

- ◯ Very confident واثق جدا
- ◯ Quite confident واثق
- ◯ Somewhat confident واثق الي حدا ما
- ◯ Neutral محايد
- ◯ Not confident لست واثق
- ◯ Don't know/ refused لاأعلم/ارفض

***24. How much have you heard about Epidemic after Disasters?**
ماهي كمية المعلومات التي سمعتها عن الامراض الوبائية بعد الكوارث؟

- ◯ Nothing لاشي
- ◯ Little قليل
- ◯ Some much نوعا ما
- ◯ Much كثير
- ◯ Very much كثير جدا
- ◯ Don't know/ Refused لا أعلم /رفض

***25. Which of the following do you think can increase diseases after Disasters? (Put the following points in the order please the most important takes 1-- less important takes 9)**

أي من الفقرات التالية تعتقد أنها ترفع مستوى الأمراض بعد الكوارث؟ (رتبها حسب الاهمية حيث يأخذ 1 الاهم ويبدء بالتنازل الي 9 في الاهمية دون تكرار الرقم لو سمحت).

	Please DON'T repeat choice الرجاء عدم تكرار الرقم
Crowded Living المعيشة المزدحمة	
Population Displacement تشرد السكان	
Lack of protective infrastructure (Lack of shelter) نقص في البنية التحتية الحماية مثل نقص الملاجئ	
Lack of sanitary water نقص المياه النظيفة	
Poor Waste management ضعف امكانية التخلص من النفايات	
Malnutrition due to food shortage سوء التغذية نتيجة نقص الغذاء	
Personal Hygiene نقص النظافة الشخصية	
Lack of adequate immunization and medical service نقص تقديم التطعيمات والخدمة الطبية	
Physical ability (القدرة الجسدية/الاستطاعة على التحرك)	

***26. To what extent do you agree or disagree with the following statement about Disasters?**

ما مدى موافقتك او عدم موافقتك مع الجملة التالية؟

	Completely agree أوافق بشدة	Mostly agree أوافق	Neither agree Nor disagree محايد	Mostly disagree لاأوافق	Completely disagree لاأوافق بشدة	Don't know لاأعلم
Dead bodies transmit diseases after disasters/ الجثث تنقل الامراض بعد الكوارث	○	○	○	○	○	○

5. Use of hazard information available through various media sources

***27. To what extent do you agree or disagree with each of the following statements about Disasters related to hazard information?**

الي اي مدى توافق او لا توافق على الجمل التالية المتعلقة بالمعلومات عن مخاطر الكوارث

	Completely agree أوافق بشدة	Mostly agree أوافق	Neither agree Nor disagree محايد	Mostly disagree لا أوافق	Completely disagree لاأوافق بشدة	Don't know لاأعلم
I like to read and think about Disasters أحب القراءة عن الكوارث	○	○	○	○	○	○
Disasters get me thinking about lots of other related topics and issues الكوارث تجعلني افكر في الكثير من المواضيع الاخرى ذات العلاقة	○	○	○	○	○	○
I don't give information about Disasters my full thought and attention لا أشغل كامل تفكيري وأهتمامي بالمعلومات عن الكوارث	○	○	○	○	○	○
I tend to skip over or skim read any information I get on Disasters أميل الى تجاوز قراءة أي معلومات أحصل عليها بشأن الكوارث او أقرأها بشكل سريع	○	○	○	○	○	○

***28. Have you followed discussions in the media about natural hazards connected to Saudi Arabia?**

هل تتابع المناقشات عن المخاطر الطبيعية المتصلة بالمملكة العربية السعودية من خلال وسائل الإعلام؟

○ Yesنعم ○ Noلا

6.

29. From what forms of media do you access this information? من اي المصادر التالية تحصل على تلك المعلومات؟ (اختر ما تشاء) -

- [ ] Newspaper الصحف
- [ ] Radio المذياع
- [ ] Television التلفزيون
- [ ] Internet الانترنت
- [ ] Information Brochures (المطويات)المنشورات
- [ ] Books الكتب
- [ ] Mobile phone (SMS, Whats App) (الجوال مثل(الرسائل النصية, الواتس أب

***30. Would you like to be more active in taking steps to protect your family and home from the effects of a disaster?**
هل تريد أن تكون أكثر نشاطا في اتخاذ خطوات لحماية الأسرة والمنزل من آثار الكوارث

- ( ) Yes نعم
- ( ) No لا

***31. Please check the two best methods to deliver disaster safety advice to you?**
يرجى إختيار افضل وسيلتين لتقديم المشورة في مجال السلامة من الكوارث بالنسبة لك

- [ ] Radio
- [ ] Television
- [ ] Newspaper
- [ ] Internet
- [ ] Educational Seminar
- [ ] Mobile phone (SMS, Whats App)
- [ ] Friends/Family
- [ ] Word of mouth

Other (please specify) أخرى (أرجو تحديد ذلك)

***32. Did you take part in the evacuation exercise inside or outside of Saudi Arabia about Disasters? Why/why not?**

هل سبق وان شاركت في دورات للإخلاء داخل المملكة او خارج المملكة في مجال الكوارث / ولماذا؟

- Yes نعم
- No لا

السبب

***33. Were you, or anyone else you know, reluctant to take part in the exercise with Civil Defense about Disasters? Why?**

هل سبق لك او لاي شخص آخر تعرفه ، الإحجام (الامتناع) عن المشاركة في التمارين او الدورات مع الدفاع المدني في مجال الكوارث؟ لماذا؟

- Yes نعم
- No لا

السبب

***34. How often do you have to use the follwing websites or any other websites for hazard information**

كم مرة تدخل للمواقع التالية او مواقع ذات صلة , للحصول معلومات عن المخاطر سواء البيئية او الطبية

	Once per Day مرة في اليوم	Once per Week مرة في الأسبوع	Once per Month مرة في الشهر	N/A لاادخل
Civil Defense الدفاع المدني				
Environmental Protection Standards الهيئة العامة للارصاد وحماية البيئة				
Ministry of Health website or other medical websites for Epidemic diseases information وزارة الصحة او مواقع طبية أخرى للحصول على معلومات عن الأمراض الوبائية				
Other websites مواقع اخرى ذات صلة بالمخاطر				

Other (please specify) أخرى حدد لو سمحت

***35. Which of the following do you think can reduce the risk of Disasters?(Put the following points in the order please the most important takes 1– less important takes 5)**

أياً من الفقرات التالية تعتقد انها تساهم في تقليل مخاطر الكوارث(رجاءً ترتيبها حسب الاولوية من1- 5 مع عدم تكرار الرقم لو سمحت)

	Please DON'T repeat choice رجاءعدم تكرار الرقم
Rise of awareness of disaster's risk رفع مستوى الوعي بمخاطر الكوارث	
Early warning system وجود نظام إنذار مبكر	
Disaster management وجود خطة إدارة الكوارث	
Evacuation plan وجود خطة إخلاء	
Prosocial behavior during disasters (volunteer, helping others) السلوك الايجابي خلال الكوارث(التطوع, مساعدة الاخرين, تقديم الدعم)	

Other (please specify) أخرى (أرجو تحديد ذلك)

Appendix B
Delphi surveys

Community resilience to disasters in Saudi Arabia(First Round:

Introduction

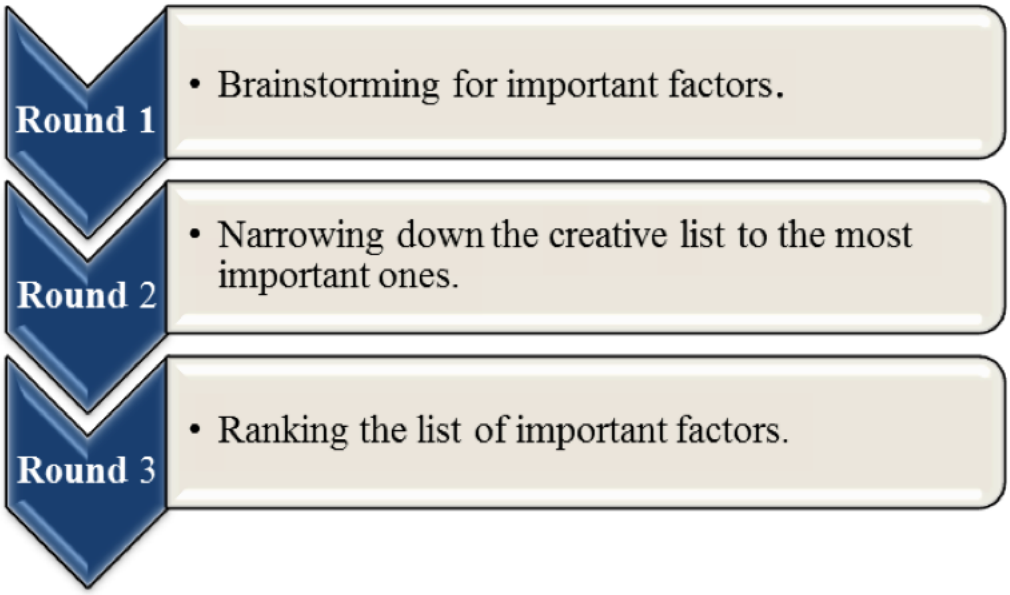
Dear expert
First, I would like to express my sincere thanks and gratitude for your participation in this research consultation. Your contribution is essential for the success of this consultation.
In the last ten years, Saudi Arabia has been subjected to a wide range and increasing occurrence of natural disasters, including flooding, epidemics and dust storms. There is a need to promote community resilience to disasters in various regions and cities of the country to address uncertain future scenarios. The research aims at identifying and building consensus around a set of dimensions and underpinning factors that can provide detailed accounts and assessment of the capacity of resilience of a community to natural or man-made hazards.

Community resilience to disasters in Saudi Arabia(First Round:

Delphi technique

Delphi technique will be used in this consultation via a questionnaire method. The questionnaire will involve three rounds to reach consensus around community resilience dimensions and factors in Saudi Arabia. The first round of Delphi involves approving and extending a set of factors drawn from the literature in the field. The second round will synthesize results from the first round with the view of reaching consensus on a set of agreed factors. The third and final round will involve ranking the list of factors by levels of importance.

Delphi rounds (adpted from Okoli and Pawlowski (2004))



Community resilience to disasters in Saudi Arabia(First Round:

Personal Information

***1. Please provide the following information**

Name:	
Organisation	
Position	
Country:	
Email Address:	
Phone Number:	

Community resilience to disasters in Saudi Arabia(First Round:

1- Social Dimension

This dimension includes aspects related to the human community in managing disasters. Initiatives to increase the population's level of education, rising awareness of the risk of disasters and participation in decision making would help community prepare for future disasters.

***1. Please indicate the level of importance of the assessment criteria for community resilience to disasters in Saudi Arabia.**

	1- Not applicable	2- Not important	3- Less important	4- Important	5- Very important
• Education Level.	○	○	○	○	○
• Trust in authorities.	○	○	○	○	○
• Personal faith and Attitudes.	○	○	○	○	○
• Risk Awareness and Training	○	○	○	○	○
• Risk perceptions.	○	○	○	○	○
• Sense of community.	○	○	○	○	○
• Social networks.	○	○	○	○	○

If you indicate Not Applicable for any criterion above, Please indicate the criterion and justify briefly your opinion

2. Please list further criteria of Social which not covered above that consider important for community resilience to disasters in Saudi Arabia.

1

2

3

4

Community resilience to disasters in Saudi Arabia(First Round:

2- Economical Dimension

The economic dimension is important as it increases the ability of communities to absorb disaster impacts and speed up the recovery process. It can be measured through income and employment.

***1. Please indicate the level of importance of the assessment criteria for community resilience to disasters in Saudi Arabia.**

	1- Not applicable	2- Not important	3- Less important	4- Important	5- Very importanr
• Level and diversity of economic resources.	◯	◯	◯	◯	◯
• Income and employment situation.	◯	◯	◯	◯	◯
• Access to financial services.	◯	◯	◯	◯	◯

If you indicate Not Applicable for any criterion above, Please indicate the criterion and justify briefly your opinion

2. Please list further criteria of Economical which not covered above that consider important for community resilience to disasters in Saudi Arabia.

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3

4

Community resilience to disasters in Saudi Arabia(First Round:

3- Physical and Environmental Dimension

Community resilience can also be achieved through better management of the built environment, i.e. the resilience of residential housing, public buildings and shelters. Further examples of physical capital include lifelines such as electric power, water, and transportation systems.

***1. Please indicate the level of importance of the assessment criteria for community resilience to disasters in Saudi Arabia.**

	1- Not applicable	2- Not important	3- Less important	4- Important	5- Very important
• Integration of services such as transportation systems, electric power and telephone.	○	○	○	○	○
• Management of waste created by natural hazards.	○	○	○	○	○
. Location of built environment (probability of exposure to the hazards).	○	○	○	○	○
• Shelters availability during emergencies such as evacuation time.	○	○	○	○	○
• Critical infrastructure, accessibility.	○	○	○	○	○

If you indicate Not Applicable for any criterion above, Please indicate the criterion and justify briefly your opinion

2. Please list further criteria of Physical and Environmental Dimension which not covered above that consider important for community resilience to disasters in Saudi Arabia.

1

2

3

4

Community resilience to disasters in Saudi Arabia(First Round:

4- Governance Dimension

The governance dimension is the most important. Planning, regulation, integration, institutional systems, partnerships and accountability are significant to everyone because they are issues likely to increase community resilience to cope with such disasters.

***1. Please indicate the level of importance of the assessment criteria for community resilience to disasters in Saudi Arabia**

	1- Not applicable	2- Not Important	3- Less Important	4- Important	5- Very Important
• Mitigation and evacuation plan.	○	○	○	○	○
• Disaster plans and policies.	○	○	○	○	○
• Emergency management plans.	○	○	○	○	○
• The application of standards and regulations.	○	○	○	○	○
• Shared information.	○	○	○	○	○
• Institutional collaboration and coordination.	○	○	○	○	○
• Integration with development policies and planning.	○	○	○	○	○
• Integration with emergency response and recovery.	○	○	○	○	○

If you indicate Not Applicable for any criterion above, Please indicate the criterion and justify briefly your opinion

2. Please list further criteria of governance dimension which not covered above that consider important for community resilience to disasters in Saudi Arabia

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2

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4

Community resilience to disasters in Saudi Arabia(First Round:

5- Health and wellbeing Dimension

This dimension contributes to making community members more able to cope with disasters. It can also protect them from disease as a result of the spread of epidemics after disasters.

***1. Please indicate the level of importance of the assessment criteria for community resilience to disasters in Saudi Arabia.**

	1- Not applicable	2- Not Important	3- Less Important	4- Important	5- Very Important
• Food security.	○	○	○	○	○
• Safe water and adequate sanitation.	○	○	○	○	○
• Personal hygiene.	○	○	○	○	○
• Infection control.	○	○	○	○	○
• Surveillance.	○	○	○	○	○
• Trained Health workers.	○	○	○	○	○
• Immunisation programme.	○	○	○	○	○
• Medical services such as availability of beds.	○	○	○	○	○
• Access to health assistance.	○	○	○	○	○

If you indicate Not Applicable for any criterion above, Please indicate the criterion and justify briefly your opinion

2. Please list further criteria of Health and wellbeing which not covered above that consider important for community resilience to disasters in Saudi Arabia.

1

2

3

4

Community resilience to disasters in Saudi Arabia(First Round:

6- Information and Communication Dimension

It is important to reduce the impacts of risks of disasters and support the saving of lives and property by delivering the right information at the right time. This includes implementing an early warning system, warning members of the community and communicating through the media and trusted sources of information.

***1. Please indicate the level of importance of the assessment criteria for community resilience to disasters in Saudi Arabia.**

	1- Not applicable	2- Not Important	3- Less Important	4- Important	5- Very Important
• Warning system.	◯	◯	◯	◯	◯
• Trusted sources of information.	◯	◯	◯	◯	◯
• Responsibility of media.	◯	◯	◯	◯	◯
• Communication system.	◯	◯	◯	◯	◯

If you indicate Not Applicable for any criterion above, Please indicate the criterion and justify briefly your opinion

2. Please list further criteria of Information and Communication which not covered above that consider important for community resilience to disasters in Saudi Arabia.

1

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4

Community resilience to disasters in Saudi Arabia(First Round:

Building community resilience to disasters

There are varieties of activities that can be implemented (or are already being implemented) by communities to build resilience to cope with disasters according to specific local needs.

***1. Please indicate the level of importance of the action should be taken for building community resilience to disasters in Saudi Arabia.**

	1- Not important	2- Less Important	3- Modrate important	4- Important	5- Very important
Encourage better knowledge on disaster risks and improve access to information.	○	○	○	○	○
Encourage social inclusion.	○	○	○	○	○
Encourage investment in disaster risk reduction.	○	○	○	○	○

2. Please list further criteria which not covered above that consider important for building of community resilience to disasters In Saudi Arabia.

1

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4

Community resilience to disasters in Saudi Arabia (Second Round)

Introduction

Dear Expert

I would like to thank you very much for your time and effort in completing the web-based questionnaire (round 1) and for your excellent comments.
For your information I have presented the results based on your and other experts' responses to the questionnaire. These include the criteria that the experts agreed should be included and the new criteria for each of the proposed dimensions of community resilience to disaster in Saudi Arabia.
I would like to invite you to participate in the second-round of the Delphi survey which asks you to review the dimensions and criteria that achieved consensus during the first round, and to assess the new criteria.
Yours sincerely

***1. Please type your full name**

Name:

Community resilience to disasters in Saudi Arabia (Second Round)

1- Social Dimension

***1. Feedback & Revision:**

There is consensus on the following criteria. Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disasters in Saudi Arabia.

	Not important	Less Important	Important	Very important	Extremely important
Education level	○	○	○	○	○
Trust in authorities	○	○	○	○	○
Personal faith and attitudes	○	○	○	○	○
Risk awareness and training	○	○	○	○	○
Risk perceptions	○	○	○	○	○
Sense of community	○	○	○	○	○
Social networks	○	○	○	○	○

***2. Further criteria**

The criteria below were recommended by the experts for inclusion under social dimension. Please indicate your opinion about these suggested criteria?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
National language nonspeaking (percentage).	○	○	○	○	○
Faith organisations, such as the role of mosques and Friday sermons.	○	○	○	○	○
Demography (age and gender).	○	○	○	○	○
Previous experience.	○	○	○	○	○

Comments

Community resilience to disasters in Saudi Arabia (Second Round)

2- Economical Dimension

***1. Feedback & Revision:**

There is consensus on the following criteria. Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disasters in Saudi Arabia.

	Not important	Less Important	Important	Very important	Extremely important
Level and diversity of economic resources.	○	○	○	○	○
Income and employment situation.	○	○	○	○	○
Access to financial services.	○	○	○	○	○

***2. Further criteria**

The criteria below were recommended by the experts for inclusion under economical dimension. Please indicate your opinion about these suggested criteria?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Home ownership status (home owner / renter).	○	○	○	○	○
Funds available for reconstruction after disaster.	○	○	○	○	○
Insurance coverage.	○	○	○	○	○
Size of Gross Domestic Product (GDP) per capita.	○	○	○	○	○

Comments

Community resilience to disasters in Saudi Arabia (Second Round)

3- Physical and Environmental Dimension

***1. Feedback & Revision:**
There is consensus on the following criteria. Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disasters in Saudi Arabia.

	Not important	Less Important	Important	Very important	Extremely important
Integration of services such as transportation systems, electric power and telephone.	◯	◯	◯	◯	◯
Management of waste created by natural hazards.	◯	◯	◯	◯	◯
Location of built environment (probability of exposure to the hazards).	◯	◯	◯	◯	◯
Shelters availability during emergencies such schools and stadiums.	◯	◯	◯	◯	◯
Accessibility to critical infrastructure.	◯	◯	◯	◯	◯

***2. Further criteria**
The criteria below were recommended by the experts for inclusion under physical and environmental dimension. Please indicate your opinion about these suggested criteria?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Lessons learnt from previous disasters, if any (sites affected, degree of damages etc).	◯	◯	◯	◯	◯
Capacity of infrastructures to withstand extra pressure such as floodwater.	◯	◯	◯	◯	◯
Mobile sources for reconstruction including trained worker.	◯	◯	◯	◯	◯
Monitoring of current built environment and existing serveries.	◯	◯	◯	◯	◯
Brownfiled treatment (land has contaminated with low levels of hazardous waste and pollutants).	◯	◯	◯	◯	◯

Comments

Community resilience to disasters in Saudi Arabia (Second Round)

4- Governance Dimension

***1. Feedback & Revision:**

There is consensus on the following criteria. Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disasters in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely important
Disaster plans and policies including mitigation and evacuation emergency management plans	◯	◯	◯	◯	◯
The application of standards and regulations for buildings and infrastructure.	◯	◯	◯	◯	◯
Shared information (Transparency).	◯	◯	◯	◯	◯
Institutional collaboration and coordination.	◯	◯	◯	◯	◯
Integration with development policies and planning.	◯	◯	◯	◯	◯

***2. Further criteria**

The criteria below were recommended by the experts for inclusion under governance dimension. Please indicate your opinion about these suggested criteria?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Unity of the leadership after the disaster.	◯	◯	◯	◯	◯
Clear partnership modalities defined and cooperation between concerned entities including private sector.	◯	◯	◯	◯	◯
Considering scientific analysis of risk assessment.	◯	◯	◯	◯	◯
International collaboration and coordination framework.	◯	◯	◯	◯	◯
Participation of community members including women and children,volunteerism.	◯	◯	◯	◯	◯
Integrating special needs populations into emergency planning and Exercises.	◯	◯	◯	◯	◯

Comments

Community resilience to disasters in Saudi Arabia (Second Round)

5- Health and wellbeing Dimension

***1. Feedback & Revision:**

There is consensus on the following criteria. Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disasters in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely important
Food security.	◯	◯	◯	◯	◯
Access to clean water and adequate sanitation.	◯	◯	◯	◯	◯
Hygiene.	◯	◯	◯	◯	◯
Infection control.	◯	◯	◯	◯	◯
Disease surveillance.	◯	◯	◯	◯	◯
Availability of trained health workers.	◯	◯	◯	◯	◯
Immunisation programmes.	◯	◯	◯	◯	◯
Medical resources such as the availability of beds.	◯	◯	◯	◯	◯
Access to health assistance.	◯	◯	◯	◯	◯

***2. Further criteria**

The criteria below were recommended by the experts for inclusion under health and well-being dimension. Please indicate your opinion about these suggested criteria?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Effective bio-security and bio-safety systems.	◯	◯	◯	◯	◯
Family health education and training programmes.	◯	◯	◯	◯	◯
Identification/definition of special needs.	◯	◯	◯	◯	◯
Medical intelligence gathering.	◯	◯	◯	◯	◯
Access to mental health care and psychological support programmes.	◯	◯	◯	◯	◯

Comments

Community resilience to disasters in Saudi Arabia (Second Round)

6- Information and Communication Dimension

***1. Feedback & Revision:**

There is consensus on the following criteria. Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disasters in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely important
Early warning system.	○	○	○	○	○
Trusted sources of information.	○	○	○	○	○
Responsibility of media.	○	○	○	○	○
Communication systems.	○	○	○	○	○

***2. Further criteria**

The criteria below were recommended by the experts for inclusion under governance information and communication dimension. Please indicate your opinion about these suggested criteria?

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
Ability to cascade information from international through regional to local communities.	○	○	○	○	○
Use of community platforms e.g mosques.	○	○	○	○	○
Ability to exploit social media.	○	○	○	○	○
Backup of critical data.	○	○	○	○	○
Visual alerting systems.	○	○	○	○	○

Comments

Community resilience to disasters in Saudi Arabia (Second Round)

Building community resilience to disasters in Saudi Arabia

***1. This framework has six dimensions. Could you please indicate how much you agree or disagree with each of the following dimensions?**

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
SOCIAL DIMENSION.	○	○	○	○	○
ECONOMICAL DIMENSION.	○	○	○	○	○
PHYSICAL AND ENVIRONMENTAL DIMENSION.	○	○	○	○	○
GOVERNANCE DIMENSION.	○	○	○	○	○
HEALTH AND WELLBEING DIMENSION.	○	○	○	○	○
INFORMATION AND COMMUNICATION DIMENSION.	○	○	○	○	○

Comments

Community resilience to disasters in Saudi Arabia (Third Round)

1. Introduction

Dear Expert

I would like to thank you very much for your time and effort in completing the web-based questionnaire (round 2) and for your excellent comments.
For your information I have presented the results based on your and other experts' responses to the questionnaire. The results are presented as chart, each criterion is evaluated and reflected to you as statistical data (Mean:the average rating of 43 Experts). The average rating is based on a 5-point Likert scale, where 5 means extremely important and 1 not important.
I would like to invite you to participate in the final-round of the Delphi survey which asks you to review and to give the final rating for each of the proposed dimensions and criteria of community resilience to disaster in Saudi Arabia,that achieved consensus during the first and second rounds.

Your time and effort are highly appreciated.
Yours sincerely

***Please provide the following information**

Name:

Community resilience to disasters in Saudi Arabia (Third Round)

2. Social Dimension

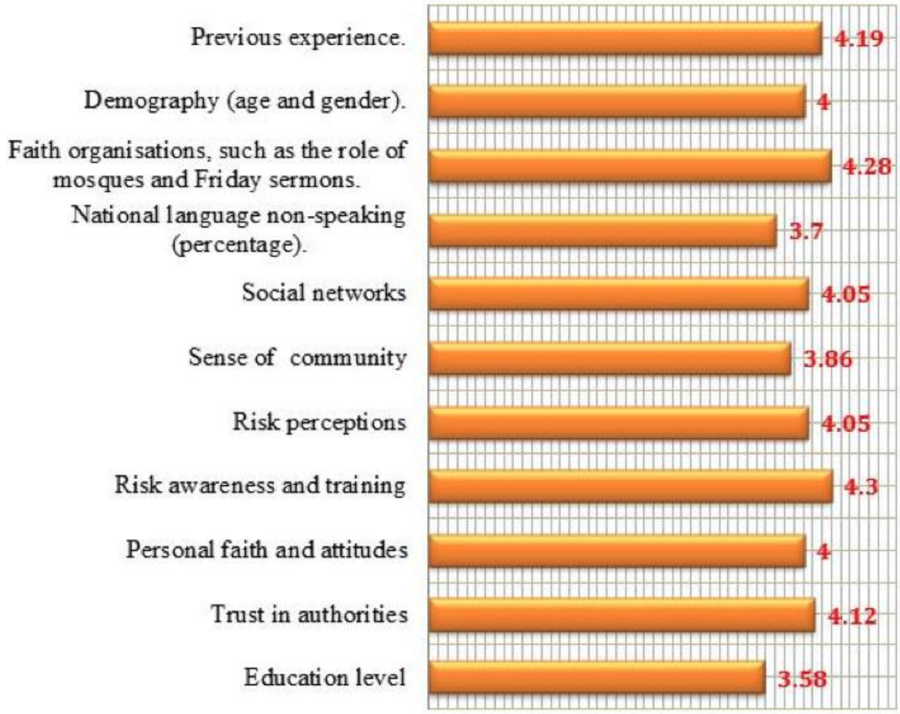
***Feedback & Revision:**

There is consensus on the following criteria (see the chart). Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disaster in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely importar
Previous experience.	○	○	○	○	○
Demography (age and gender).	○	○	○	○	○
Faith organisations, such as the role of mosques and Friday sermons.	○	○	○	○	○
National language non-speaking (percentage).	○	○	○	○	○
Social networks.	○	○	○	○	○
Sense of community.	○	○	○	○	○
Risk perceptions.	○	○	○	○	○
Risk awareness and training.	○	○	○	○	○
Personal faith and attitudes.	○	○	○	○	○
Trust in authorities	○	○	○	○	○
Education level.	○	○	○	○	○

Comments

Community resilience to disasters in Saudi Arabia (Third Round)



Community resilience to disasters in Saudi Arabia (Third Round)

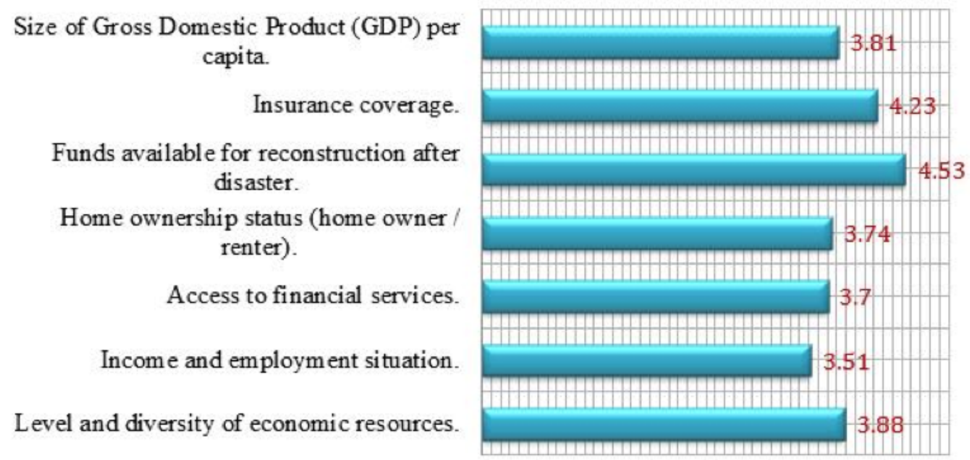
3. Economical Dimension

***Feedback & Revision:**

There is consensus on the following criteria (see the chart). Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disaster in Saudi Arabia.

	Not important	Less important	Important	Very important	Extreme importan
Size of Gross Domestic Product (GDP) per capita.	○	○	○	○	○
Insurance coverage.	○	○	○	○	○
Funds available for reconstruction after disaster.	○	○	○	○	○
Home ownership status (home owner / renter).	○	○	○	○	○
Access to financial services.	○	○	○	○	○
Income and employment situation.	○	○	○	○	○
Level and diversity of economic resources.	○	○	○	○	○

Comments



Community resilience to disasters in Saudi Arabia (Third Round)

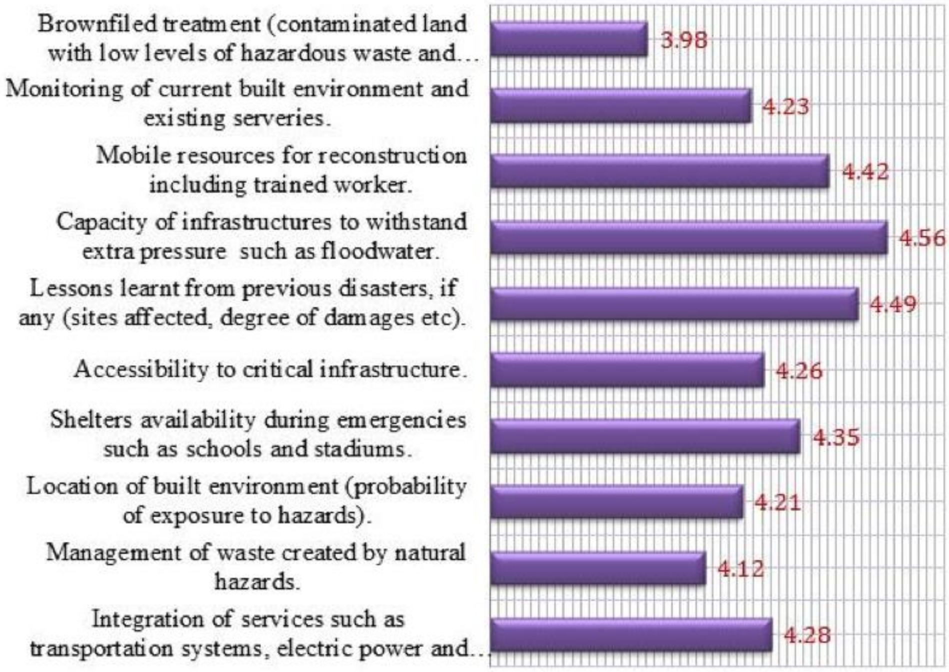
4. Physical and Environmental Dimension

***Feedback & Revision:**
There is consensus on the following criteria (see the chart). Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disaster in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely important
Brown filed treatment (contaminated land with low levels of hazardous waste and pollutants).	◯	◯	◯	◯	◯
Monitoring of current built environment and existing serveries.	◯	◯	◯	◯	◯
Mobile resources for reconstruction including trained worker.	◯	◯	◯	◯	◯
Capacity of infrastructures to withstand extra pressure such as floodwater.	◯	◯	◯	◯	◯
Lessons learnt from previous disasters, if any (sites affected, degree of damages etc).	◯	◯	◯	◯	◯
Accessibility to critical infrastructure.	◯	◯	◯	◯	◯
Shelters availability during emergencies such as schools and stadiums.	◯	◯	◯	◯	◯
Location of built environment (probability of exposure to hazards).	◯	◯	◯	◯	◯
Management of waste created by natural hazards.	◯	◯	◯	◯	◯
Integration of services such as transportation systems, electric power and telephone.	◯	◯	◯	◯	◯

Comments

Community resilience to disasters in Saudi Arabia (Third Round)



Community resilience to disasters in Saudi Arabia (Third Round)

5. Governance Dimension

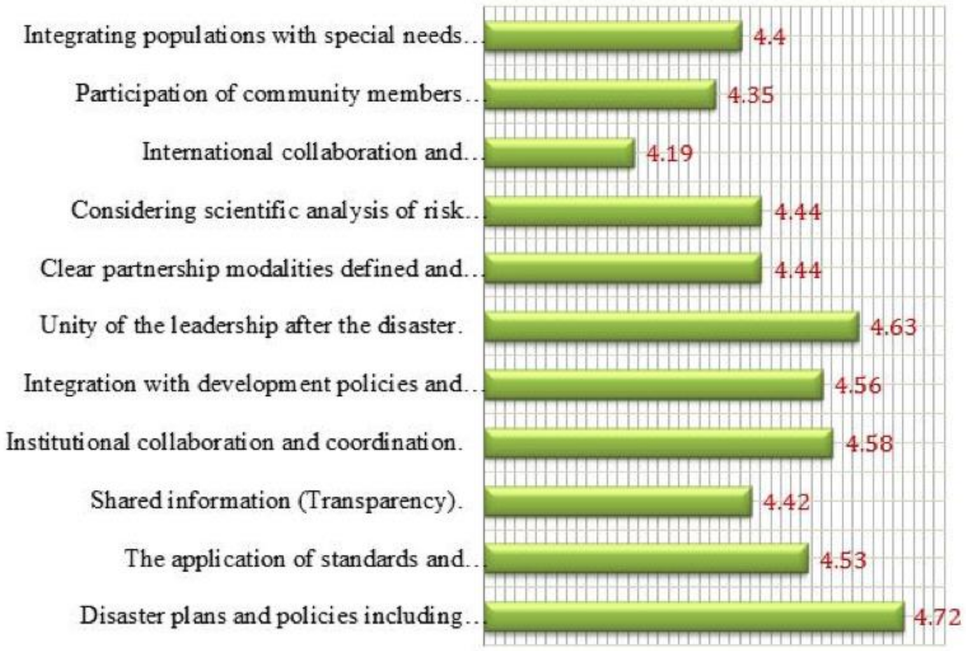
***Feedback & Revision:**

There is consensus on the following criteria (see the chart). Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disaster in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely important
Integrating populations with special needs into emergency planning and exercises.	○	○	○	○	○
Participation of community members (volunteerism) including women and children.	○	○	○	○	○
International collaboration and coordination framework.	○	○	○	○	○
Considering scientific analysis of risk assessment.	○	○	○	○	○
Clear partnership modalities defined and cooperation between concerned entities including private sector.	○	○	○	○	○
Unity of the leadership after the disaster.	○	○	○	○	○
Integration with development policies and planning.	○	○	○	○	○
Institutional collaboration and coordination.	○	○	○	○	○
Shared information (Transparency).	○	○	○	○	○
The application of standards and regulations for buildings and infrastructure.	○	○	○	○	○
Disaster plans and policies including mitigation and evacuation emergency management plans.	○	○	○	○	○

Comments

Community resilience to disasters in Saudi Arabia (Third Round)



Community resilience to disasters in Saudi Arabia (Third Round)

6. Health and wellbeing Dimension

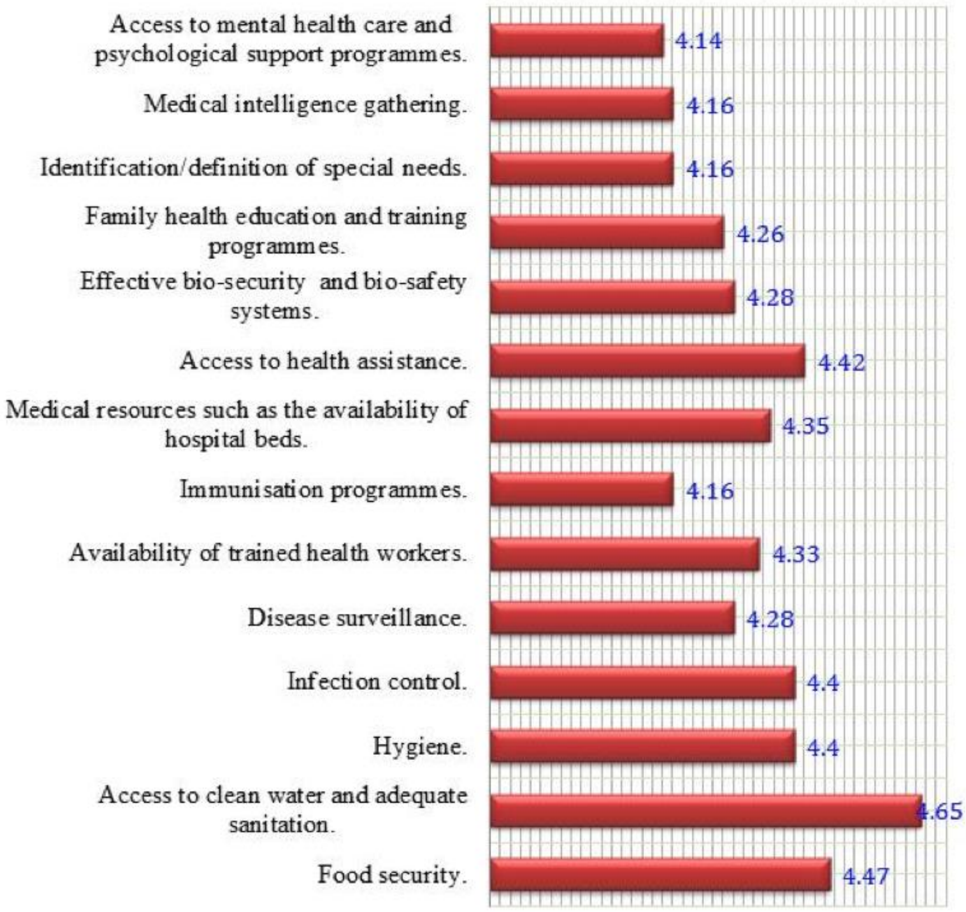
***Feedback & Revision:**

There is consensus on the following criteria (see the chart). Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disaster in Saudi Arabia.

	Not important	Less important	Important	Very important	Extreme importar
Access to mental health care and psychological support programmes.	◯	◯	◯	◯	◯
Medical intelligence gathering.	◯	◯	◯	◯	◯
Identification/definition of special needs.	◯	◯	◯	◯	◯
Family health education and training programmes.	◯	◯	◯	◯	◯
Effective bio-security and bio-safety systems.	◯	◯	◯	◯	◯
Access to health assistance.	◯	◯	◯	◯	◯
Medical resources such as the availability of hospital beds.	◯	◯	◯	◯	◯
Immunisation programmes.	◯	◯	◯	◯	◯
Availability of trained health workers.	◯	◯	◯	◯	◯
Disease surveillance.	◯	◯	◯	◯	◯
Infection control.	◯	◯	◯	◯	◯
Hygiene.	◯	◯	◯	◯	◯
Access to clean water and adequate sanitation.	◯	◯	◯	◯	◯
Food security.	◯	◯	◯	◯	◯

Comments

Community resilience to disasters in Saudi Arabia (Third Round)



Community resilience to disasters in Saudi Arabia (Third Round)

7. Information and communication

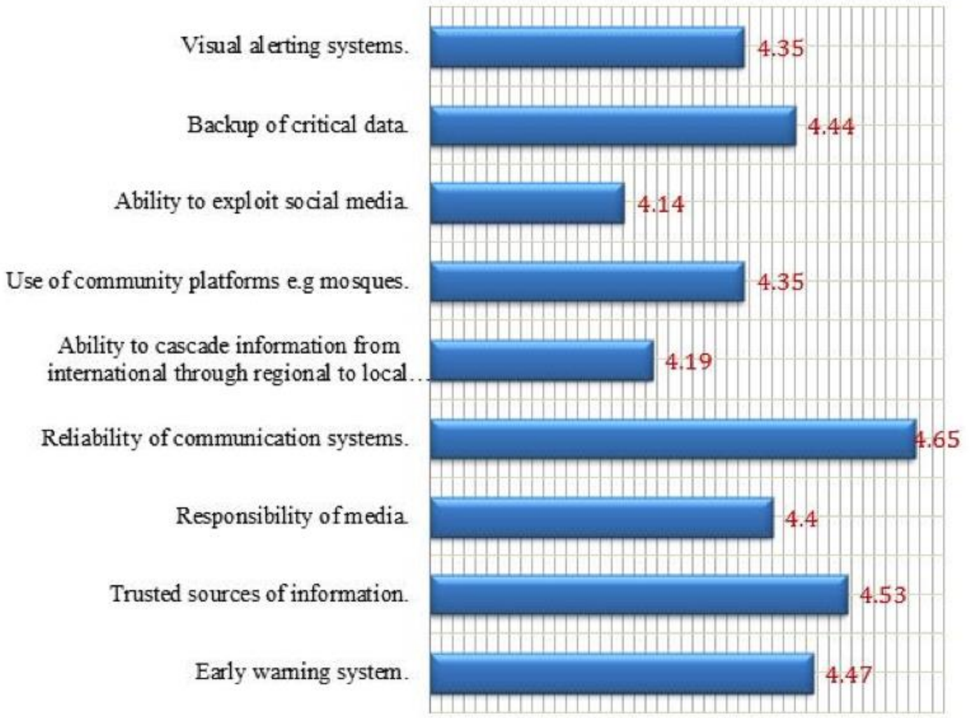
***Feedback & Revision:**

There is consensus on the following criteria (see the chart). Thus, please indicate the level of importance you attach to the assessment of criteria for community resilience to disaster in Saudi Arabia.

	Not important	Less important	Important	Very important	Extremely important
Visual alerting systems.	◯	◯	◯	◯	◯
Backup of critical data.	◯	◯	◯	◯	◯
Ability to exploit social media.	◯	◯	◯	◯	◯
Use of community platforms e.g. mosques.	◯	◯	◯	◯	◯
Ability to cascade information from international through regional to local communities.	◯	◯	◯	◯	◯
Reliability of communication systems.	◯	◯	◯	◯	◯
Responsibility of media.	◯	◯	◯	◯	◯
Trusted sources of information.	◯	◯	◯	◯	◯
Early warning system.	◯	◯	◯	◯	◯

Comments

Community resilience to disasters in Saudi Arabia (Third Round)



Appendix C
AHP survey

Questionnaires: Pair-wise Comparisons

Dear expert,

First of all, I would like to express my appreciation for your time and efforts in completing the web-based questionnaires (three rounds) of Delphi survey and for your extremely useful comments. The Delphi survey established the consensus on the framework of community resilience to disaster in Saudi Arabia, which includes 6 key dimensions, as illustrated in Figs.1&2. I would like to conclude my consultation by carrying out a pairwise comparison approach via the present questionnaire to evaluate the relative importance of these dimensions.

I would like to invite you to participate to this questionnaire, where you are kindly requested to (a) compare pairs of dimensions, (b) decide which of the two is more important, and (c) quantify the intensity of importance. This round is a very important and involves the use of Analytical Hierarchy Process (AHP) to elicit the weights and priorities of the dimensions.

Your time and effort are highly appreciated.

Yours sincerely

Saud Alshehri

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Questionnaires: Pair-wise Comparisons

Figure 1 Framework of community resilience to disaster in Saudi Arabia

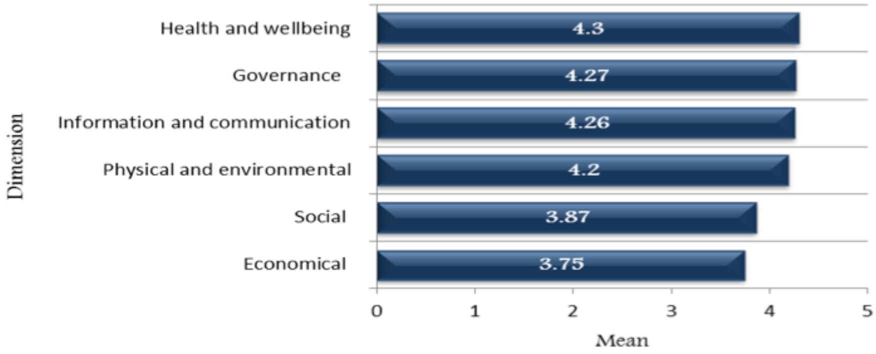

Figure 2 Consensus on all dimensions (40 experts)

Personal Information

Please type your flowing information

Name	
Position	
Country	

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Questionnaires: Pair-wise Comparisons

In this questionnaire, you will be asked to perform relative comparison of importance of the applicable dimensions for community resilience to disaster in Saudi Arabia. Each row in the relative comparison tables includes two dimensions and their rating boxes at the middle. Therefore, please choose the appropriate number using a pair-wise comparison scale (1-9 scale) as shown Table 1 below:

1. Explanation

Intensity of importance	Definition and explanation
1	Equally Important
2	Equally to moderate more important
3	Moderately important
4	Moderate to strong more important
5	Strongly important
6	Strong to very strong more important
7	Very strongly important
8	Very to extremely strongly more important
9	Extremely more important

Table1 Pair wise comparison scale source: Saaty (1980)

Examples:

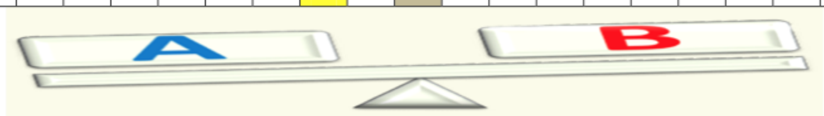
The aim of this concept is to determine the weighting for each dimension by conducting pair-wise comparison.

✓ If your decision is that the weight of "**A**" & "**B**" are ***equally important,*** then your response will be:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
A									●									**B**

✓ If your decision is that the weight of "**A**" is ***moderate important*** than "**B**", then your response will be:

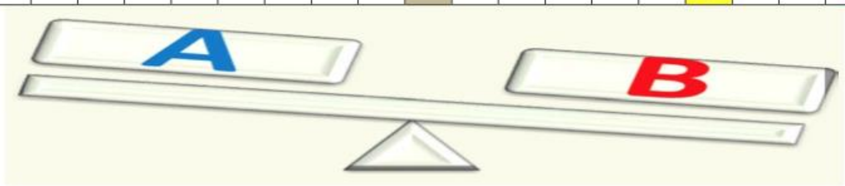
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
A							●											**B**



Questionnaires: Pair-wise Comparisons

✓ If your decision is that the weight of "B" is ***very strongly important*** than "A", then your response will be:

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
A															●			B



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Questionnaires: Pair-wise Comparisons

2. Pair-wise Comparisons of the framework:

Could you please perform the followings **pair-wise comparison**, to determine the applicable weighting system for Saudi context?

1. **Please perform pair-wise Comparisons of "Health and wellbeing" with other dimensions**

9 = Extreme **7** = Very strong **5** = Strong **3** = Moderate **1** = **Equal** **3** = Moderate **5** = Strong **7** = Very strong **9** = Extreme

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Health and wellbeing																		Governance
Health and wellbeing																		Information and Communication
Health and wellbeing																		Physical and Environmental
Health and wellbeing																		Social
Health and wellbeing																		Economical

2. **Please perform pair-wise Comparisons of "Governance" with other dimensions**

9 = Extreme **7** = Very strong **5** = Strong **3** = Moderate **1** = **Equal** **3** = Moderate **5** = Strong **7** = Very strong **9** = Extreme

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Governance																		Information and Communication
Governance																		Physical and Environmental
Governance																		Social
Governance																		Economical

3. **Please perform pair-wise Comparisons of "Information and Communication" with other dimensions**

9 = Extreme **7** = Very strong **5** = Strong **3** = Moderate **1** = **Equal** **3** = Moderate **5** = Strong **7** = Very strong **9** = Extreme

	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Information and Communication																		Physical and Environmental
Information and Communication																		Social
Information and Communication																		Economical

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Questionnaires: Pair-wise Comparisons

4. **Please perform pair-wise Comparisons of "Physical and Environmental" with other dimensions**

9 = Extreme 7 = Very strong 5 = Strong 3 = Moderate 1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme																		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Physical and Environmental	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Social
Physical and Environmental	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Economical

5. **Please perform pair-wise Comparisons of "Social" with other dimension**

9 = Extreme 7 = Very strong 5 = Strong 3 = Moderate 1 = Equal 3 = Moderate 5 = Strong 7 = Very strong 9 = Extreme																		
	9	8	7	6	5	4	3	2	1	2	3	4	5	6	7	8	9	
Social	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	Economical

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