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ORIGINAL PAPER

Delphi-based consensus study into a framework of community resilience to disaster

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Abstract Disasters cannot be prevented but their impacts can be mitigated through adapted disaster management strategies. Several studies confirm that community resilience is a significant factor in disaster management. Saudi Arabia is (a) increasingly exposed to disasters, as reflected in recent events, and (b) lacks a credible disaster management strategy. This paper aims to develop a framework of community resilience to disaster in Saudi Arabia. A three-round Delphi study is conducted using a local and an international panel of experts with in-depth knowledge in the wide field of disaster management. General dimensions and criteria for consideration are derived from the academic literature. The latter are used by the expert panel as a starting point to achieve consensus on a framework of community resilience to disasters, focused on six resilience dimensions: social; economic; physical and environmental; governance; health and well-being; and information and communication. A total of 62 criteria are identified. Fifty-seven of these criteria achieved consensus in Round 2. An additional five criteria reached consensus in the third round. The resulting community resilience framework involves seven to fourteen criteria in each of the six identified dimensions.

Keywords Saudi Arabia · Community resilience · Disaster management · Delphi

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1 Introduction

The impacts of disasters have increased in recent years (Neumayer and Barthel 2011; Gaillard and Texier 2010). These disasters have a far-reaching impact on the lives of those affected and can also result in considerable economic losses (Jafari et al. 2011; Becken and Ren 2012).

Despite the presence of volcanic and seismic areas, Saudi Arabia is not recognized for either natural or man-made disasters (Alshehri et al. 2013; Al-Saud 2010). However, in 2009, more than 30,000 tremors struck the province of Harrat Lunayyir in north-west Saudi Arabia resulting in the evacuation of 4,000 people (Pallister et al. 2010). Furthermore, the scale and significance of disasters in the past decade are 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 (EM-DAT 2014). Two of these disasters were of a biological nature: H1N1 (AlMazroa et al. 2010) and MERS-Corona (WHO 2014; MOH 2014), while the rest were attributed to flooding (Fig. 1).

Other types of hazards include Ramadan and Hajj, which are two important events in 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). These include the potential for stampedes and outbreaks of infectious diseases, such as meningococcal disease and respiratory tract infections, which have been frequently reported during and following the Hajj (Memish 2010). Additionally, Saudi Arabia has in recent years suffered from several terrorist attacks, such as the Riyadh and Khobar bombings (Hegghammer 2008).

As a result of these challenges, 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

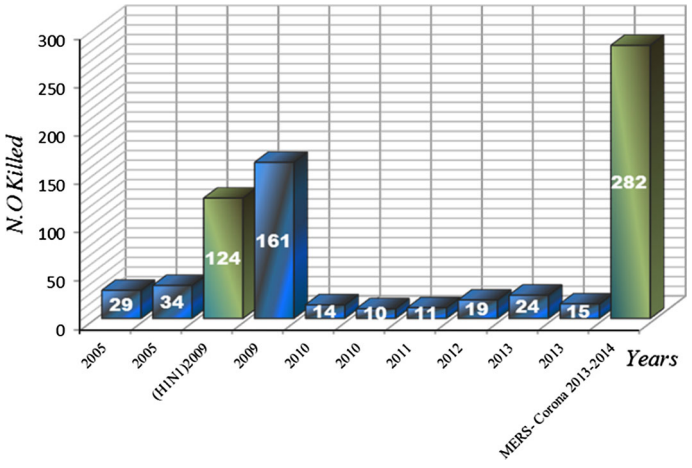


Fig. 1 Disasters in Saudi Arabia 2005–2014

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 paper proposes a 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. The article is structured into six sections. Following this introduction, a brief overview of community resilience and related frameworks is given. This is followed by the methodology that underpins the research (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 chapter provides concluding remarks.

2 Background

The impact of disasters, such as earthquakes on poorly constructed buildings and infrastructure, can be exacerbated by a lack of community resilience (Sungay et al. 2009). Nowadays, 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). The term 'resilience' is the antithesis of 'vulnerability', but both are related terms (Twigg 2007).

The importance of the entrance of the concept of 'resilience' into disaster discourse was confirmed at the 2005 World Conference on Disaster Reduction (WCDR) and gave birth to a new culture of disaster response (Cimellaro et al. 2010). 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 as a result of communities lacking resilience, for 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). The following subsections elaborate further on (a) the concept of resilience in disaster management and (b) the need for adapted frameworks to assess and build community resilience.

2.1 Resilience

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). Dalziell and McManus (2004) note that the major challenge

with the definition of resilience relates to its use by researchers in different ways across various research fields.

Manyena (2006) states that increased resilience is a significant goal 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'. Godschalk (2003) proposes two further reasons why importance should be attributed to resilience. First, 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. Second, 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 regard 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.

Several researchers and system theorists explain that resilience requires combinations of efficiency and redundancy, diversity and interdependence, strength and flexibility, dependence and collaboration, and preparation and adaptability (Godschalk 2003).

2.2 Community resilience frameworks

Resilience can operate at various levels, e.g. individual, community and state (Longstaff et al. 2010; Wilson 2012). 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 essentially required for hazard mitigation, planning and recovery. Moreover, Chandra et al. (2010) emphasis that building community resilience is a basis for national health security.

Furthermore, several studies posit a link between individual resilience and community activities (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, such as floods, 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).

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.

Communities are always the 'first responders' to disasters; consequently, several dimensions such as economic, social and physical are critical to assess 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). Therefore, 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 using the following proposed indicators:

- Social capital, such as social structure, trust, norms and social networks.
- Economic capital (financial resources that people use to achieve and maintain their livelihoods), including savings, income, investments and credit.
- Physical capital, which refers to the built environment, such as public buildings, business/industry, dams and levees, and shelters.
- Human capital, such as education, health, skills and knowledge.
- Natural capital, such as resources, stocks, land and water, and the ecosystem (Mayunga 2007).

Cutter et al. (2008) propose the 'disaster resilience of place' (DROP) model to describe the relationship between vulnerability and resilience. This model relies on six dimensions: ecological; social; economic; infrastructural; institutional; and community components. Each of these dimensions has several indicators that can be used to measure disaster resilience at the community level (Cutter et al. 2008).

Conversely, in their multivariate analysis, Burton (2012) identifies six dimensions, which although named slightly differently are in fact similar: environmental systems; social; economic; infrastructure; institutional; and community capacity. Moreover, they identified 41 variables that they consider suitable for measuring disaster recovery based on their analytical soundness and statistical significance of their parameter estimations.

In contrast, Orencio and Fujii (2013) recognized criteria and elements that can be used to reduce the vulnerability 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.

Furthermore, the Hyogo Framework for Action (Innocenti and Albrito 2011) argues both the need for and ways to build resilient communities by (a) integrating disaster risk reduction (DRR) 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. 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. Meanwhile, 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) used to quantify a measure of resilience, whereas Stewart et al. (2009) propose a framework to improve the community resilience during disaster through partnership (Stewart et al. 2009).

3 Methodology

The research methodology is designed to answer the research question 'What are the applicable community resilience criteria needed to manage disasters in the Saudi Arabian context?'

Saudi Arabia has little history with disasters (Alshehri et al. 2013; Al-Saud 2010). However, their increasing frequency in recent years justifies the need for the present study and the reliance on experts' views and experiences to devise adapted response strategies. One method of obtaining this expertize is through the Delphi technique, a multi-round survey of experts that 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 to be an important data collection method for gathering information from experts on a topic of interest (Hsu and Sandford 2007). Keeney et al. (2006) argue that a Delphi survey is an appropriate method to establish consensus or obtain a judgement on an issue, because of the possibility of using iterations and feedback (De Villiers et al. 2005). The Delphi method has thus been selected for the present study.

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 15 April to 15 June 2013.

3.1 Delphi method

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 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 organized feedback; and (d) allows statistical analysis of the experts' responses (De Vet et al. 2005; Pill 1971; Bailie 2011).

3.2 Panel selection

An important component in the Delphi method is the selection of experts as the results rely on their judgement (Woudenberg 1991). Four 'expertize' 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

expertize 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, with at least 5 years of experience in disaster management and a relevant degree.

It is recommended to involve experts with various expertize and geographic locations in 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 ensuring a more holistic, objective and positivist grounding of the resulting framework (Jeste et al. 2010). Therefore, the experts in our study were recruited from a variety of disciplines in disaster management, locally and internationally, with an in-depth understanding of local and wider issues as illustrated in Table 1. 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. 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. 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 and 50 (Endacott cited in Jirwe et al. 2009). 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 2 weeks, non-responders received 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.

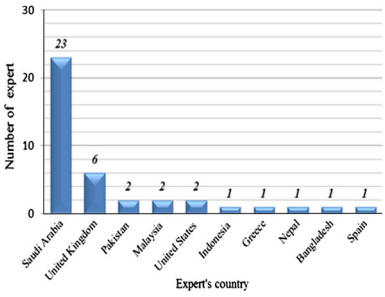
3.3 Delphi rounds

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

According to Burton (2012), numerous studies agree that the concept of resilience involves the following categories: social, economic, institutional, infrastructural, community and natural/ecological. Moreover, most of these dimensions are used in several frameworks as the main aspects for community resilience (Twigg 2007; Cutter et al. 2008; Norris et al. 2008; Ainuddin 2012; Mayunga 2007; Burton 2012). The initial phase of our community resilience framework development is informed by all these efforts with a view of delivering a comprehensive set of categories and criteria drawn from the literature. Hence, six dimensions have been 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 authors in Saudi Arabia

Table 1 Background of experts' panel

Expert	Organization	Experts distribution
International	International Red Cross Red Crescent Climate Centre/German Red Cross Leeds City Council (UK) NHS Commissioning Board (UK) Earthquake Reconstruction and Rehabilitation Authority (Pakistan) Muhammadiyah movement (Indonesia) Humanitarian Futures Programme (Malaysia/UK) Mahila Partnership (USA) Crowd Modelling Ltd (UK) Asian Disaster Preparedness Centre (Bangladesh) Caribbean Emergency Responder's Training Academy (USA) Experts (Independent Consultant) from other countries (Greece, Nepal and Spain)	 
Government official	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 (Saudi Arabia) University Putra Malaysia (Malaysia) University College London (UK) King Khalid University Umm Al-Qura University (Saudi Arabia) Naif Arab University for Security Sciences (Saudi Arabia)	
Medical	Prince Sultan Military Medical City (PSMMC) (Saudi Arabia) NHS South (UK) King Abdulaziz University Hospital (Saudi Arabia) King Saud University for Health Sciences (Saudi Arabia)	
Industry	Saudi Basic Industries Corporation (SABIC)	

(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; Innocenti and Albrito 2011).

In a second stage, all dimensions and their corresponding criteria were presented to the experts' panel in the first round of Delphi in order to determine the 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

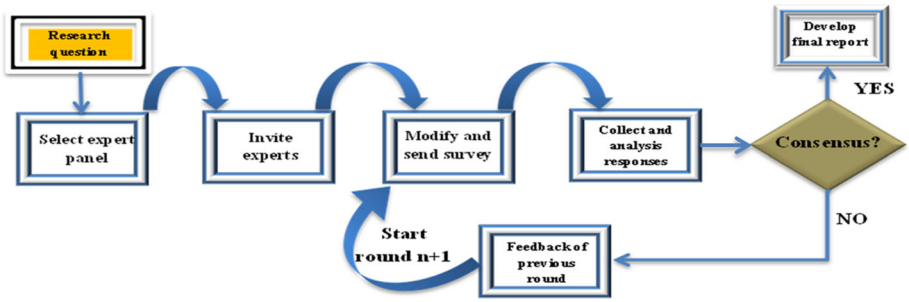


Fig. 2 Summary of the planned Delphi method

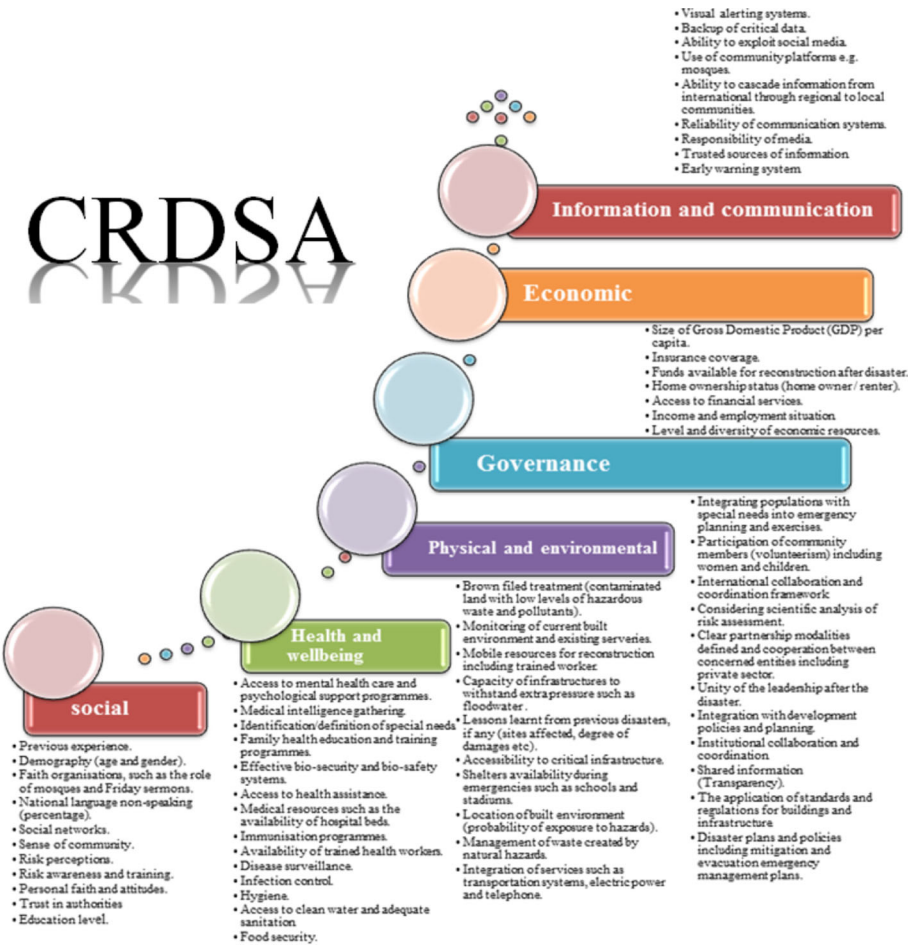


Fig. 3 The framework of community resilience to disasters in Saudi Arabia

(1 = not applicable, 5 = very important). In addition, the experts were, as part of the Delphi consultation process, asked to provide further criteria that they consider 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.

According to several studies, experts' panel has the opportunity to revise their judgments to change their answers for achieving the required consensus as the Delphi process is iterative and incremental (De Vet et al. 2005; Pill 1971; Bailie 2011). 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 have 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 our consultation.

3.4 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 other statistical methods (Murphy et al. 1998), was used for each criterion and all dimensions beginning with second round. Rayens and Hahn (2000) consider that 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. The criteria with a standard deviation close to 0 indicate 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 means of understanding the panel's judgment on the importance of the criteria (Greatorex and Dexter 2000). The criteria were considered to be important if $\geq$60 % of the respondents were in agreement (Mundt and Connors 1999).

4 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 whether consensus was reached in relation to the importance of community resilience criteria to disasters in Saudi Arabia across the six dimensions.

4.1 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

Table 2 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 well-being	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
	Immunization programme	49	4.41
	Food security	49	4.45
	Access to health assistance	49	4.61
Information and communication	Warning system	49	4.55
	Trusted sources of information	49	4.69
	Responsibility of media	49	4.41
	Communication system	49	4.63

resilience to disasters. Figure 3 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.

Table 3 Total criteria reaching consensus in rounds 2 and 3

Dimension	Round 2			Round 3		
	Total criteria	Meet consensus criteria	%	Total criteria	Meet 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 well-being	14	13	93	14	14	100
Information and communication	9	9	100	9	9	100
Total	62	57	92	62	62	100

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 2.

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. The answers were analysed first to determine the degree of perceived importance (mean) and 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 3). The five criteria ($IQR = 2$) were as follows: 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.

Forty experts completed round 3, in which all 62 criteria under the six dimensions received means between 3.20 and 4.85 (see Figs. 4, 5, 6, 7, 8, 9), 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.

4.2 Social dimension

Figure 4 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 $\leq$1, while

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

Fig. 4 Social criteria consensuses round 3, *(IQR): interquartile range

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	3.58
Income and employment situation.	0.873	1	3.58
Size of Gross Domestic Product (GDP) per capita.	0.790	1	3.2

Fig. 5 Economic criteria consensuses round 3, *(IQR): interquartile range

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.

4.3 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 equal to 1 (see Fig. 5). 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.

4.4 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 Fig. 6). 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'.

4.5 Governance dimension

Figure 7 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.

Physical and Environmental	Round 2		
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

Fig. 6 Physical and environmental criteria consensuses round 3, *(IQR): interquartile range

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

Fig. 7 Governance's criteria consensuses round 3, *(IQR): interquartile range

4.6 Health and well-being 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 well-being dimension (see Fig. 8).

4.7 Information and communication dimension

Figure 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 Fig. 9).

4.8 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 10 displays the status of consensus from the final Delphi round, which

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

Fig. 8 Health and well-being's criteria consensuses round 3, *(IQR): interquartile range

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

Fig. 9 Information and communication's criteria consensuses round 3, *(IQR): interquartile range

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.

5 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.

Table 4 Comparison between the current study and other frameworks

DROP (Cutter et al. 2008)	Multivariate analysis (Burton 2012)	AHP (Orencio and 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 well-being

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 4).

However, our framework differs in two dimensions, namely 'information and communication' and 'health and well-being', which 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 well-being 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 well-being' as one of their framework's dimensions. 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 well-being' dimension, with standard deviations (0.214) and mean value (4.3), is ranked as the highest dimension in our framework, as illustrated in Fig. 10.

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 well-being dimension. Several key issues appear from this study as elaborated below.

5.1 Health and well-being 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.

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

Fig. 10 Dimensions of the framework consensus round 3, *(IQR): interquartile range

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.

5.2 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 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 essential 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.

5.3 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 paper emphasizes 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' 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 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 as follows: '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 emphasized as part of the process of building community resilience.

5.5 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 organizations, 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'.

5.6 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 as follows: '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 the 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 was 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 analytic hierarchy process (AHP) 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 pairwise 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-day 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.

6 Conclusion

Saudi Arabia has been prone to an increasing rate of disasters in recent years as reported earlier in the paper. However, its disaster management preparedness lacks effective response and recovery (Abosuliman et al. 2013). 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.

The authors believe 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. Moreover, the validation and stress-testing of the proposed community resilience framework are essential. The authors have identified and are in the process of delivering this validation component using the Hajj (pilgrimage) event. The research is commissioned and supported by Saudi authorities who will assist and endeavour to delivering and implementing the resulting community resilience framework across the country.

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