

A critical review of social resilience assessment frameworks in disaster management

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ABSTRACT

The role of social resilience in disaster management continues to gain increasing attention and interest from both researchers and practitioners. This paper critically reviews existing frameworks and methods to understand their application in a disaster context, to highlight key challenges and future directions for developing robust social resilience assessment frameworks. The analysis revealed a lack of consistency in key concepts used to measure social resilience to disasters. This results in significant confusion in the way key concepts are understood, interpreted, and applied. Due to the multi-faceted nature of social resilience concepts, there are pronounced theoretical and practical difficulties in carrying out a rapid, but rational, accurate, and meaningful assessment of social resilience to disasters. Many of the key process-oriented indicators are not included in the existent social resilience frameworks, since they are not easy to operationalise due to their dynamic nature. Therefore, a comprehensive social resilience framework that can be adapted to different contexts and integrated with specific measurement tools and guidelines is necessary. Such a comprehensive framework can make resilience measurement consistent across geographies by adapting it with context specific resilience characteristics.

1. Introduction

The concept of resilience has been studied and applied across many diverse disciplines, including ecology, social-ecological systems, social science, and psychology [1–4]. Specifically, social resilience has been broadly studied in natural resource management, social change and development, and disaster management [5]. The emphasis on social resilience to disasters has been growing in the last two decades [6], as a result of the large number of major disaster events across the world and a recognition that disasters have a significant social dimension due to its increasingly devastating impacts on local communities [7]. Rapid urbanization and poor development planning have increased the exposure of communities to disasters globally, generating new risks or exacerbating existing risks that have led to a sharp increase in disaster related losses [8]. Communities need to proactively and consistently prepare for and mitigate risks in order to build resilience so as to reduce the severity of disaster impacts and recover more rapidly from disaster losses. However, the speed and extent of recovery from disasters often differ significantly across communities [9] depending on a range of complex factors such as their socio-economic status, extent of external

support and aid provision, past experience of disasters, and the nature and severity of the disaster.

There is an urgent need to identify the underlying social resilient characteristics/capabilities of communities so as to help them to better prepare for and recover from disasters. There is often a mismatch between community expectations and government actions that is underpinned by an assumption that governments need to take a lead role and are responsible for meeting people's needs following disasters [10]. In reality, many past disaster situations have demonstrated that this notion is neither effective nor sustainable, and have highlighted the important role of existing social systems in responding to, and aiding communities to recover effectively from disasters.

While there is a large body of work on social resilience in a disaster context, there is a lack of clarity and consistency on how the concept of social resilience is defined, understood and applied across different communities or disaster contexts. This is problematic as a robust social resilience measurement is difficult to formulate and there is no uniformity to guide the comparison of the resilience status of two communities to make appropriate resilience investment decisions. Hence, consistent and reliable resilience measurement approaches that are

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grounded in theoretical and practical understanding of social resilience features are required [2,11], so as to reduce the complexity and confusion in its use and application in a disaster context.

Social resilience is defined in this study as the ability of social entities and social mechanisms to effectively anticipate, mitigate and cope with disasters and implement recovery activities that minimize social disruptions and reduce the impact of future disasters [12]. This definition is adopted so as to consider the abilities of both, social entities and social mechanisms, along the different phases of a disaster, i.e. ex-ante, disturbance, and ex-post.

The primary aim of this paper is to critically review existent social resilience frameworks in order to derive a detailed understanding of social resilience in the disaster context. In this critical review, an in-depth analysis of social resilience characteristics and indicators used in existing social resilience frameworks developed over the past decade are presented. This review has a specific objective to examine the merits and limitations of existing social resilience frameworks and to discuss future conceptualisation of social resilience frameworks in disaster management. Further, this paper also critically reviews current social resilience assessment methods and highlights key challenges in existent methods. The critical knowledge developed in this study will be useful for policymakers, practitioners and researchers to guide effective operationalisation of social resilience frameworks in a disaster context.

2. Methodology

A systematic literature review was conducted to critically analyse current social resilience frameworks in disaster context. In selecting literature for inclusion in the review, social resilience frameworks developed since 2005 in the disaster management sector were identified. The selected frameworks were developed during the time period of the Hyogo Framework for Action (HFA) implementation, which was the global guiding framework for disaster risk reduction efforts since 2005. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses – PRISMA [13] method was used to select social resilience frameworks for a detailed review as shown in Fig. 1. PRISMA is an established method for guiding systematic review of academic literature, and is based on four steps: Identification, Screening, Eligibility, and Inclusion.

Key steps of the PRISMA method is explained below:

Step 1 - Identification stage: The keywords, “Social” OR “Community” AND “Resilience” were used in the search to identify all potential peer-reviewed research articles on social resilience. The initial literature search was done using the Scopus database, which is a comprehensive research database for peer-reviewed literature, for the period of ten years since 2005 in Title, Abstract, and Keywords [14]. This resulted in the identification of 12,121 research articles.

Step 2 - Screening stage: In this stage, search limiters on relevant disaster related disciplines, such as social science, environmental science, and multidisciplinary studies were used. Journals that are not relevant to disaster research and in languages other than English were excluded. Consequently, 1,194 relevant research articles were selected.

Step 3 – Eligibility check: In this step, the titles of the selected 1,194 research articles were screened to narrow down the search for the most relevant articles on social resilience to disasters. The title and abstracts of articles that do not relate to social/community resilience in any natural disaster context were excluded. Finally, 172 research articles were selected for detailed review of abstracts.

Step 4 – Inclusion step: Based on the review of the abstracts of the 172 articles, 16 social resilience frameworks were selected. Using the snowball technique, 15 additional articles were included. Accordingly, a total of 31 different social resilience frameworks were selected for detailed analysis.

3. Social resilience frameworks in disaster context

Many social resilience frameworks have been developed in a disaster context as a result of different ways of defining and conceptualising social resilience [4,6,15,16]. The understanding of different concepts used to frame social resilience in a disaster context is critical to further advance these frameworks to comprehensively measure social resilience characteristics. The method of selection of social resilience frameworks for analysis was explained in section 2 and details of the 31 selected social resilience frameworks for critical analysis are shown in Table 1.

The 31 social resilience frameworks can be categorised into two main approaches: distinctive single dimensional frameworks and those embedded within multi-dimensional community resilience frameworks. Distinctive single dimensional frameworks consider only one dimension of community resilience e.g. social resilience or economic resilience characteristics. In contrast, embedded social resilience frameworks view community resilience as multi-dimensional using variations of the following five characteristics - social, economic, infrastructure, institutional, and environment. The embedded social resilience framework is part of a broader multi-dimensional framework, whereas a distinct framework is a stand-alone social resilience framework that is not connected to the other four common dimensions of community resilience. The key difference between these approaches are that the focus of multi-dimensional framework is wider with limited depth, whereas distinctive resilience frameworks cover single dimensional resilience characteristics in more detail.

The frameworks were also categorised by the researcher (year), hazard focus and country of development (geographic coverage) along with the method adopted for developing the framework. Table A1 in supplementary information provides details of the social resilience characteristics used in each social resilience framework. For the analysis undertaken in this study, only social resilience characteristics were included from the multi-dimensional disaster resilience frameworks. However, other resilience characteristics that are closely related to social resilience such as social-culture and human capital were also considered in the evaluation.

In the context of social resilience assessment, two recent reviews by Cutter [15] and Sharifi [47] highlighted common features used in disaster resilience frameworks. Their review focused broadly on five commonly used dimensions of community resilience to disasters, i.e. social, economic, infrastructure, institutional, and environment. Though the review by Cutter [15] broadly covered the five key dimensions of community resilience, comprehensive analysis of social resilience characteristics and indicators is limited. The review of resilience assessment frameworks on social dimension undertaken by Sharifi [47], identified social structure, social capital, safety and well-being, equity and diversity, and local culture as five sub-dimensions within the social resilience dimension. The review by Sharifi [47] was confined to the analysis of the characteristics of each of the five sub-dimensions of social resilience and does not include a detailed review of indicators or proxy measures used to operationalise the proposed social resilience characteristics. The currently available reviews have been undertaken within a broader context of multi-dimensional disaster resilience frameworks. Hence, a comprehensive critical review of social resilience is required to identify knowledge gaps and to further advance the research on social resilience measurement in disaster context.

4. Analysis of social resilience frameworks

4.1. Social resilience framework development approaches

The existent social resilience frameworks found in disaster management literature can be primarily categorised as standard or context-specific frameworks. Every framework has its own strengths and limitations and sometimes there are overlaps between multiple categories.

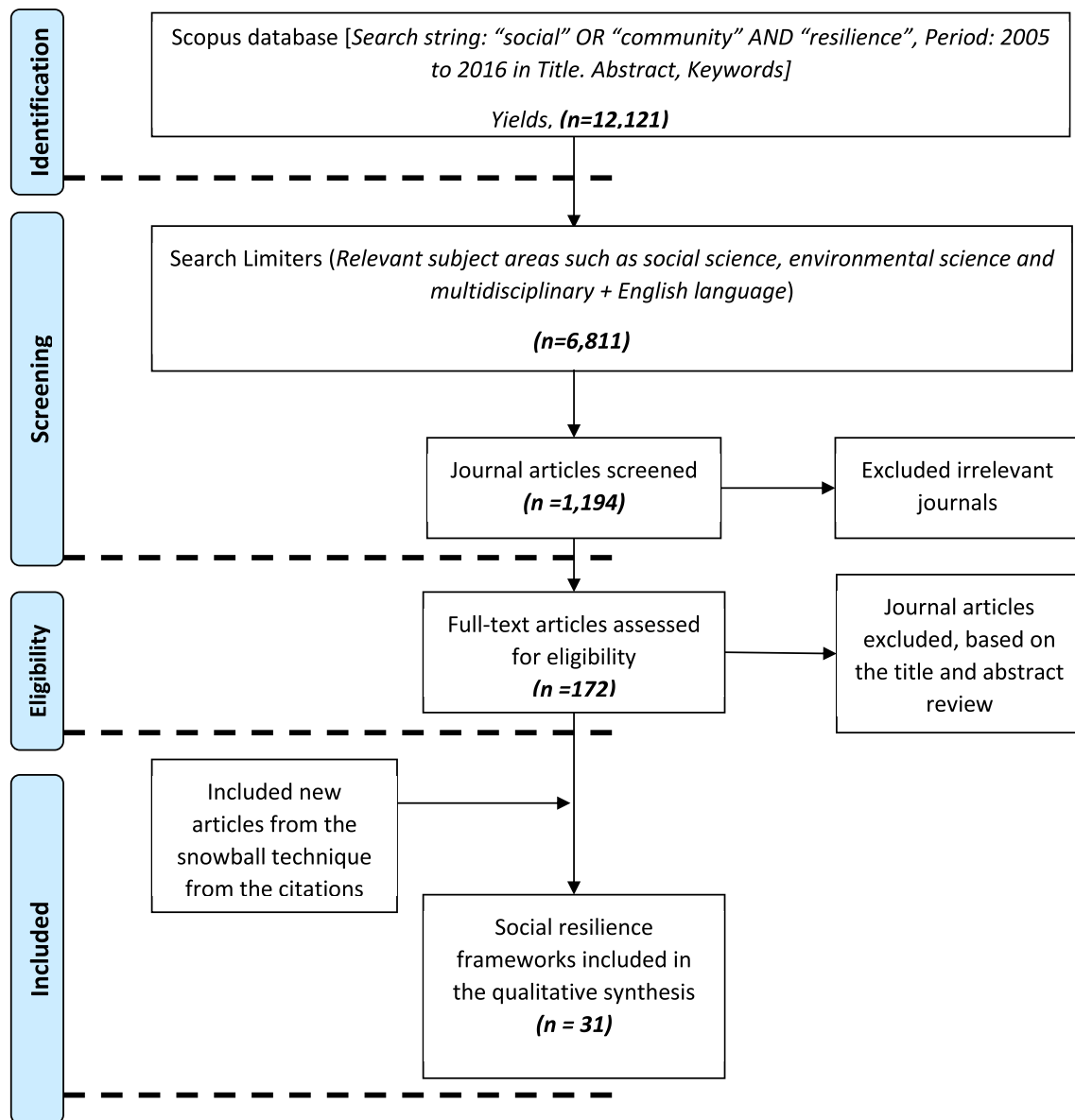


Fig. 1. PRISMA Flow diagram used for selection of social resilience frameworks for analysis.

Standard and context-specific frameworks can be further categorised as hazard-specific, hierarchical level specific, and -geographical scope specific frameworks as illustrated in Fig. 2 (adapted from Winderl [48]). For example, Qasim et al. [49] developed a country and hazard specific multi-dimensional disaster resilience framework for floods in Pakistan. The combination of standard and context-specific measures can help in understanding resilience [48], as standard metrics assist in developing specific contextualised metrics. The main drawback in developing a hazard/context-specific framework for every hazard/geographic location is that it is resource and time intensive, while an adaptable generic framework at national, sub-national or community level can increase the uniformity and comparability of resilience measurements. This process can improve consistency in resilience investment decisions across different locations. The different types of social resilience framework development approaches are discussed below.

4.1.1. Hazard specific frameworks

While there are many common resilience frameworks, some hazard-specific frameworks adopt a targeted approach to one hazard type such as for flood or earthquake, based on the premise that some resilience

characteristics are more relevant to a particular hazard. Though a region can sometimes be prone to multiple hazards, developing a hazard specific framework is a time-consuming task. Therefore, an adaptable framework to multiple hazards can assist in taking into consideration hazard specific resilience phenomena while keeping the framework intact, so that a uniform resilience measurement can be carried out.

Table 2 shows examples of social resilience characteristics in flood and earthquake-specific frameworks developed in Pakistan. These are hazard specific frameworks developed within the same geographical context. There are many similar characteristics common to both frameworks such as, social trust, educational status, population composition, and health status. Yet, two other characteristics, namely, religious beliefs and transportation means, were prioritised in the flood context, while access to health care and public information were priorities in the earthquake context.

4.1.2. Frameworks developed for a specific geographical context

Many frameworks have a geographical focus such as city resilience frameworks, rural resilience frameworks, urban resilience frameworks, and coastal resilience frameworks. These geographic specific

Table 1
Social resilience frameworks evaluated.

(1) Distinctive social resilience frameworks								
#	Author (Year)	Framework	Country	Hazard	Method adapted	Ref.		
1	Kwok et al. (2016)	Social Resilience for New Zealand	New Zealand	Multi hazard	Workshop (Expert Opinion from Researchers, Practitioners, and policy makers)	[17]		
2	Kotzee et al. (2016)	Social-Ecological Flood Resilience Index	Southern Cape of South Africa	Flood	Secondary data from public databases (Census data)	[18]		
3	Kahlil et al. (2015)	Temporal Social Resilience Framework	Australia	Flood	Literature review Case study in 2 locations	[19]		
4	Lorenz (2013)	Social System Resilience	Not specific	Multi hazard	Literature review	[20]		
5	Maguire and Hagan (2007)	Social Resilience Framework	Australia	Common to all disasters	Literature review	[21]		
(2) Social resilience frameworks embedded within the multi-dimensional community resilience frameworks								
#	Author (Year)	Framework	Country	Hazard	Method adapted	Ref.		
6	Parsons et al. (2016)	Australian Natural Disaster Resilience Framework /Index (ANDRI)	Australia	Multi hazard	Literature review	[22]		
7	Yoon (2016)	Community Disaster Resilience Index (CDRI)	Korea	Multi hazard	Index development with secondary data	[23]		
8	Ostadtaghizadeh et al. (2016)	Community Disaster Resilience Framework for Iran	Iran	Multi hazard	Expert opinion through Focus Group Discussions	[24]		
9	Arbon et al. (2016)	Community Resilience Score Card	Australia	Multi hazard	Score card approach	[25]		
10	Qasim et al. (2016)	Social Resilience Index (SRI) (Component Community Resilience Index)	Pakistan	Flood	Questionnaire and secondary data	[26]		
11	Woolf et al. (2016)	Resilience Assessment in Slums	Kenya Slums	Multi hazard	Workshop and case study approach	[27]		
12	Leykin et al. (2016)	Conjoint Community Resiliency Assessment Measure (CCRAM)	Israel-Gaza borders	Security threats	Web-based survey (Longitudinal study)	[28]		
13	Alshehri et al. (2015)	Community Resilience to Disasters in Saudi Arabia (CRDSA)	Saudi Arabia	Multi hazard	Delphi based expert opinion/AHP	[29]		
14	Ainuddin et al. (2015)	Composite Community Resilience Index	Baluchistan, Pakistan	Earthquake	Literature review, Composite index	[30]		
15	Burton (2015)	Disaster Resilience Indicators	Mississippi Gulf Coast in the United States	Hurricane	Case study, secondary data for index development	[9]		
16	Cox and Hamlen (2015)	Rural Resilience Index (RRI)	USA	Multi hazard	Literature review, Pilot study	[7]		
17	Cutter et al. (2015), Cutter et al. (2010)	Baseline Resilience Indicators for Communities (BRIC)	US Counties	Multi hazard	Public and freely accessible data sources, and created dimensional scores	[31,32]		
18	Joerin et al.(2014)	Climate Disaster Resilience Index (GDRI)	Chennai, India	Multi hazard	Literature review, CDRI scores	[33]		
19	Kusumastuti et al. (2014)	Social Dimension Score (Resilience Score)	Indonesia	Multi hazard	In-depth Interviews, Focus Group Discussions	[34]		
20	Frazier et al. (2013)	Baseline Resilience Indicators for Communities (BRIC)	Sarasota County, Florida, USA	Multi hazard	Interviews, plan review, focus group, and spatial analysis	[35]		
21	Chandra et al. (2013)	Community Resilience Framework	Los Angeles, USA	Health focus	Online survey	[36]		
22	Pfefferbaum et al. (2013)	Communities Advancing Resilience Toolkit (CART)	USA	Multi hazard	A toolkit consists of assessment and data collection tools	[37]		
23	Orencio and Fujii (2013)	Disaster Resilience Index	Japan	Coastal hazards	Analytic Hierarchy Process (AHP)	[38]		
24	Norris et al. (2008)	Communities Advancing Resilience Toolkit (CART)	USA	Multi hazard	Web-based survey using expanded version of the CART	[4,39]		
25	Sherrieb et al. (2012)	Community Disaster Resilience Indicators (CDRI)	US Gulf Coast Region	Multi hazard	Results from implementing a project	[40]		
26	Peacock et al. (2010)	Community Resilience Index (CRI)	Mississippi counties	Multi hazard	Index creation (Archival and population data)	[41]		
27	Sempier et al. (2010)	Coastal Community Resilience Index (CCRI)	USA	Multi hazard	Community Self-Assessment Tool (Index)	[42]		
28	Renschler et al. (2010)	PEOPLES Resilience Framework	USA	Multi hazard	Literature Review	[43]		
29	Cutter et al. (2008)	Disaster Resilience of Place (DROP)	USA	Multi hazard	Conceptual model based on literature review	[44]		
30	Hegney et al. (2008)	Building resilience in rural communities toolkit	Australia	Multi hazard	Research/community consultation	[45]		
31	Mayunga (2007)	Capital based Community Disaster Resilience	USA	Multi hazard	Index development with secondary data	[46]		

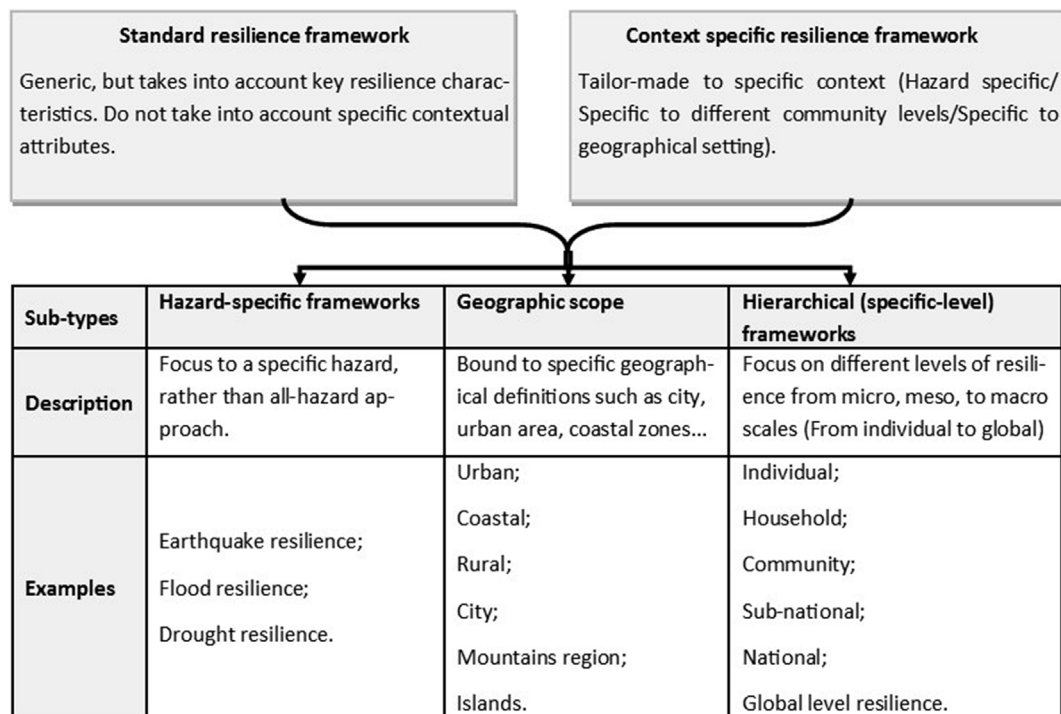


Fig. 2. Types of social resilience framework development approaches.

frameworks are the result of differences in hazards in specific geographic location and context. Table 3 shows examples of frameworks for different geographical contexts such as coastal, rural, and slum areas. Social resilience characteristics such as social networks, civic organizations, social cohesion, community collaboration and support, and faith based engagement are common for all geographic contexts. However, there are different characteristics prioritised in different geographies. For example, in coastal resilience frameworks, business cooperation and working relationships are identified as resilience characteristics, whereas in a rural context, knowledge and skills to manage different disaster phases is prioritised.

4.1.3. Hierarchical frameworks at specific levels

Hierarchical resilience frameworks can be categorised as global, country specific, and community based frameworks. Global frameworks have been developed by multi-national and large funding agencies such as the United Nations [8,50], World Bank [51], IFRC [52], ARUP [53], and the Department for International Development of UK [54]. These frameworks mainly focus on governance, legal, leadership and awareness concepts at the global level. Country specific frameworks have been developed, for example in Australia, South Korea, and Saudi Arabia, in order to operationalise resilience from national to sub-national levels. Table 4 shows the key differences in the type of social resilience characteristics used in five national frameworks evaluated in this study. These frameworks were developed using a multi-hazard approach either using primary data collection and/or tested using case

studies.

It was found that none of the resilience frameworks evaluated in this study have formulated an adaptable structure with the most common and key social resilience indicators. When a framework is applied to a specific geographical location, hazard, timeframe or context, appropriate characteristics could be extracted or removed or even new emerging characteristics can be added using a hierarchical approach [2]. With accurate hierarchical definitions of terms, common resilience attributes may also be scaled-up [2]. Thus, an adaptive social resilience framework comprising basic, but critical characteristics that is flexible enough for adapting to specific conditions at spatial and temporal scales is needed. Developing such an integrated and adaptive framework by bringing together similar/common resilience characteristics that can be adaptable in different contexts or to a specific hazard is still a gap in disaster resilience research.

Further, the Hyogo Framework for Action (HFA) had explicitly given importance to resilience building as one of the five priority actions. However, the alignment of most research-based frameworks analysed in this study with global, regional or national policy agenda on disaster resilience, for example, linkages to the recommendations in the Hyogo Framework (2005–2015) was unclear. This limits the real world application of the frameworks in practice, and result in a lack of lessons learnt and good practices for further improvement of frameworks. In contrast, most practitioner-orientated frameworks are aligned to the global and national disaster resilience agenda. They are largely available in the non-academic literature or in report/toolkit form. Most often

Table 2
Examples of key social resilience characteristics in hazard specific frameworks.

Framework name	Key social resilience characteristics		Author (Year)	Reference
	Similarities	Differences		
Social Resilience Index (SRI) (Component Community Resilience Index) (Flood focus)	Social capital (Societal relationships), Educational status, Age (Dependents), Disability, Health insurance.	Religious beliefs, Transportation means.	Qasim et al. (2016)	[26]
Composite Community Resilience Index (Earthquake focus)	Social Capital (Community trust), Educational level, Population composition, Health status.	Access to resources (Health Care), Public information.	Ainuddin et al. (2015)	[30]

Table 3
Examples of key social resilience characteristics in multi-hazard social resilience frameworks developed for different geographical context.

Framework name	Key types of social resilience characteristics included		Author (Year)	Reference
	Similarities	Differences		
Resilience Assessment in Kenyan Slums	Religion, Community organizations with collaborative/partnership relations, Community cohesion and cooperation	Connections and Information, Services	Woolf et al. (2016)	[27]
Coastal Community Resilience Index (CCRI)	Strong faith based networks, Strong civic organizations, Neighbourhood associations, Support members in times of need, Social systems	Business cooperative or working relationships (industries that employ many residents, Chamber of Commerce), Cultural identity	Sempier et al. (2010)	[42]
Rural Resilience Index (RRI)	Social networks; social networks reach.	Knowledge and skills translatable to disaster preparedness, mitigation, response, recovery, and social determinants of health and disaster vulnerability	Cox and Hamlen (2015)	[7]

the method of development is not reported, which limits detailed analysis from a research point of view.

4.2. Classification of frameworks based on resilience concepts and dimensions

The 31 frameworks identified in section 3 can be alternatively clustered into four dimensions based on different social resilience conceptual foundations: Capital-based dimension; Coping, Adaptive, and Transformative/participative capacities (CAT capacities); Social and interconnected community resilience dimensions; and Structural and cognitive dimensions of social resilience. Fig. 3 shows the schematic overview of the four classifications with examples from the 31 frameworks evaluated in this study. Over the period of time since 2005, no clear trend can be seen in framework development for adapting to a particular social resilience concept. While some frameworks have continued to focus mainly on social capital as key resilience characteristics, some other frameworks included social structure, social equity, and social beliefs. Both of these conceptualisations have used outcome and process related indicators. Another conceptualisation differed from this approach, which categorised resilience as coping, adaptive, and transformative capacities. As highlighted by Hutter and Lorenz [55], social resilience concepts have largely been driven by perceptions, social level studied, and its measurement complexity. However, it is important to progress from simple statistical measures (such as the population age) towards resilience indicators that can be practically dealt with [56].

The advancement of social resilience concepts and measurement frameworks and assessment methods/tools capturing dynamic interactions within and between different social dimensions is not yet evident in the frameworks analysed in this review. This is partly due to difficulty in making the resilience indicators easily measurable that are not outcome oriented, but related to social mechanisms. The lack of a clear body of knowledge on how indicators are related to or dependent on each other constitutes a key research gap and warrants further investigation. New ways of framing social resilience such as using systems thinking need to be explored.

A further discussion on each of the classifications is as follows:

- Capital based dimensions:** These frameworks have a predominant emphasis on social capital and are driven by the concept that different types of social assets can be attributed to key social resilience characteristics. Social capital itself has been framed as a social resilience framework by Peacock et al. [40], Sherrieb et al. [41], and Mayunga [46]. Some other capital based dimensions closely aligned to social capital include human capital [7], social-cultural capital [43], and community capital [35] (Fig. 3a). Social capital is an important community resource that helps community to address disaster related issues. Although social capital can be defined in many different ways, social trust, norms, and networks have been the common aspects emphasized in social capital based social resilience models [57]. Though social capital covers many important social resilience characteristics, the capital based frameworks provide a limited measure of social resilience. Since the proposed measure of social resilience is carried out using a few selected social capital indicators that are measured with secondary data sources, these frameworks provide only a limited measure of social resilience.
- Coping, Adaptive, and Transformative/participative capacities (CAT capacities):** Social resilience framework developed by Parsons et al. [22] was based on coping and adaptive capacities and the framework by Lorenz [20] was based on adaptive, coping, and transformative capacities. This aligned with the way social resilience is defined as coping, adaptive, and transformative capacities. It is helpful to define social resilience using CAT capacities, because they can capture dynamic attributes of social systems at multiple scales

Table 4

Examples of key social resilience characteristics in multi-hazard social resilience frameworks developed at national level.

Framework name	Key types of social resilience characteristics included	Author (Year)	Reference
Australian Natural Disaster Resilience Framework/Index (ANDRI)	Coping capacity: Social character, Emergency services, community capital, information and engagement and Adaptive capacity: Governance, policy and leadership, Social and community engagement	Parsons et al. (2016)	[22]
Community Resilience to Disasters in Saudi Arabia (CRDSA)	Education level, Trust in authorities, Personal faith and attitudes, Risk awareness and training, Risk perceptions, Sense of community, Social networks, Health and well-being, Information and Communication.	Alshehri et al. (2015)	[29]
Social Dimension Score (Resilience Score), Indonesia	Social demography, Social preparedness and social service, Community competence, Understanding of disaster risk and mitigation.	Kusumastuti et al. (2014)	[34]
Community Disaster Resilience, Iran	Social capital, Social security, Psychosocial preparedness, Lifestyle, Community culture and attitude, Knowledge and awareness, Cultural heritage, Religion.	Ostadtaghizadeh et al. (2016)	[24]
Community Disaster Resilience Index (CDRI), South Korea	Registered volunteers, Volunteer organizations, Budget for volunteer organizations, Population over 65 years, Females, Population with less than high school diploma, Population of one person households, Per capita disaster managers.	Yoon et al. (2016)	[23]

with the combination of different capacities and the interaction between capacities to ensure the stability of a system. For example, coping is the ideal strategy to manage disaster risk. However, when the coping capacity is exceeded, the adaptive capacity will be activated [58]. When adaptation is not adequate to overcome the disaster risk, the system will progress towards transformation to sustain system stability [58]. This process can help social systems to achieve the desired resilient status. Yet, the notion of social resilience conceptualised using CAT capacities has led to many debates in academic literature [20] due to large variations in interpretation of CAT capacities.

Further, operationalising social resilience frameworks conceptualised based on CAT capacities is difficult in practice, without formulating CAT capacities in easily understandable social resilience dimensions and characteristics such as in the Australian Natural Disaster Resilience framework developed by Parsons et al. [22] (Fig. 3b).

- c) Social and interconnected community resilience dimensions: This approach views social resilience within holistic multi-dimensional characteristics of community resilience to disasters. From the five-dimensional community resilience concepts, social dimensional characteristics are considered as social resilience characteristics. These types of frameworks are defined as distinctive single dimensional frameworks in this study. However, some resilience frameworks selected for this study have proposed other dimensions that are closely interconnected with social resilience characteristics. Examples include human [23], community competence [44], community capacity [34], health and well-being [29], information and communication [29], and cultural [24] dimensions (Fig. 3c).

The key difference between multi-dimensional and single dimensional frameworks is that the focus of a multi-dimensional framework is wider with limited depth in every dimension, whereas distinctive resilience frameworks cover single dimensional resilience characteristics in detail. For example, the multi-dimensional framework developed by Ainuddin et al. [30] has considered only a limited number of social resilience characteristics such as population composition, social capital, educational level, health status, public information, and access to resources (health care). Similarly, the framework by Qasim et al. [49] included only educational status, age (dependents), health insurance, social capital, disability, transportation means, and religious beliefs. These examples show that the prioritisation and selection of social resilience characteristics is not uniform. Hence, social resilience frameworks within a multi-dimensional framework sometimes lack adequate measure of social resilience for effective decision making.

- d) Structural and cognitive dimensions of social resilience: While structural dimensions are more discrete characteristics, such as people and demographic composition, cognitive dimensions include attitudes, values, and perceptions (Fig. 3d adapted from Ref. [17]).

As opposed to the social resilience frameworks embedded within multi-dimensional resilience frameworks, as discussed in category c above, stand-alone distinctive social resilience frameworks capture a large number of key social resilience characteristics. For example, the social resilience framework developed by Kwok et al. [17] was categorised into structural and cognitive dimensions. Most structural social resilience characteristics are outcome oriented and cognitive characteristics are process oriented. While it is useful to categorise social resilience characteristics in structural and cognitive dimensions, further categorisation is needed for operational replication of the framework in multiple locations and multi-levels.

Since many social resilience frameworks analysed in this study are embedded frameworks within community resilience frameworks, they were categorised as either, capital-based dimensions or interconnected community resilience dimensions (Fig. 3). Distinctive social resilience frameworks were conceptualised either in CAT capacities or structural and cognitive dimensions of social resilience. However, a key challenge is to develop a standard and adaptive social resilience framework that can be operationalised in any contextual setting [9]. A social resilience framework should not be solely limited to easily identifiable social resilience indicators, but instead be comprehensive in nature so as to facilitate a holistic assessment of social resilience.

An important research gap in conceptualising a social resilience framework is to set a basic foundation for the assessment of social resilience in different disaster phases that can guide the selection and proper operationalisation of social resilience characteristics [22]. Further, emerging social resilience concepts and models should focus on wider applicability in divergent geographic contexts [59]. However, due to variations in defining and conceptualising resilience, the assessment of social resilience has become a challenging task [60].

The robust conceptualisation of social resilience needs to overcome the limitations discussed in the above four categories of frameworks and should be an adaptable framework without compromising the quality and adequacy of social resilience measurement required in a specific context. An inclusive and adaptable social resilience framework was proposed by Saja et al. [12], which was developed based on the critical review of existing social resilience frameworks to address this gap. This framework included 16 key social resilience characteristics and 46 indicators in a logical structure organised under five sub-dimensions.

To better understand different ways in conceptualising social resilience and developing social resilience frameworks, a detailed analysis of key components used in the 31 existent frameworks is discussed below.

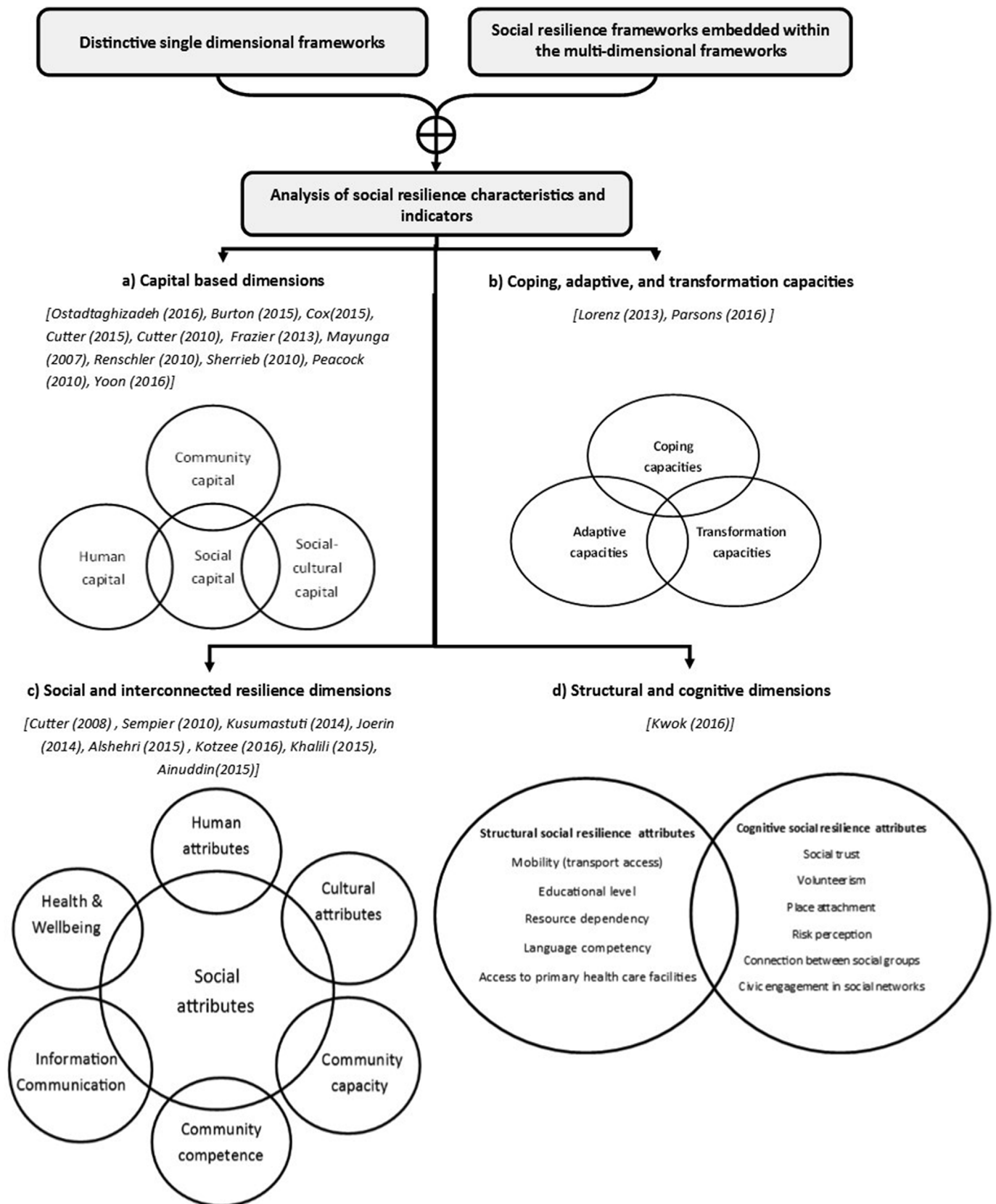


Fig. 3. Classification of social resilience frameworks and examples.

4.3. Analysis of social resilience frameworks

4.3.1. Indicators and layers in a social resilience framework

A set of indicators are needed to characterise social resilience and for the practical application of social resilience frameworks to different types of disasters and for varying context. A resilience indicator is a description of observable or measurable information that is used to identify state or function of social entities [61]. A set of indicators will collectively measure a resilience characteristic. However, at times, the distinction between characteristics and indicators are not rigid [54]. The resilience indicators can be process indicators or outcome indicators. The outcome indicator shows how well certain activities accomplish their proposed results and process indicator is a measure of how well the activities are implemented [62]. Both, process and outcome indicators are important to measure social resilience, because process indicators help to understand the community and sustainability of the community programs, whereas outcome indicators reflect the achievements of community capacity building and empowerment [63].

A lack of agreement and consistency in framing the social resilience characteristics, adds a further degree of complexity to the useful transformation and utilisation of the concept in multiple contexts. For example, around one third of the frameworks only have two layers and do not identify indicators. There is also lack of clarity about characteristics and indicators in some frameworks, and characteristics are sometimes labelled as indicators. Two third of the frameworks analysed had a third layer as indicators, with the exception of a few frameworks that have indicators as the second layer in a sub-dimension. Some frameworks have termed indicators as variables. Most of the social resilience frameworks have adapted the characteristics/indicators based approaches to measure social resilience, because those frameworks can be easily operationalised. Further, systematic structuring of a social resilience framework in logical layers can guide the practitioners to operationalise it uniformly across different communities. Table 5 gives a matrix showing the layers used in each framework and corresponding

term used for each layer.

Social resilience needs to be framed to include characteristics and a set of indicators to operationalise. However, as shown in Table 5, framing the social resilience characteristics and its assessment layers have not been consistently applied in the literature. Similarly, majority of the frameworks have included characteristics as the second layer using different terms such as criteria, attributes, descriptions, elements, variables and sub-components.

Despite these deviations for framing social resilience concepts into layers, it is possible that a logical structure can be used for operationalising the resilience characteristics. All related social resilience characteristics can be clustered in the most appropriate sub-dimension. Further, inadequate information about measurement tools and techniques and lack of clear guidelines for measuring proposed resilience indicators in many frameworks limit the operationalisation of the framework in different contexts [58].

In the absence of robust guidelines accompanying the set of indicators that are proposed to measure resilience, the possibility exists for the misinterpretation of the indicator data that may lead to inaccurate outcomes. The guidance on how to develop resilience indicators and to contextualise them to a specific context is limited in current resilience literature [64]. Therefore, a further knowledge gap in social resilience research is the lack of guidance for developing tools, techniques, and guidelines for measuring indicators required for operationalisation of resilience frameworks for different contexts. Accordingly, based on this critical review, a social resilience framework structure with five layers (Fig. 4) was created to further analyse the characteristics and indicators included in the 31 selected frameworks. A logical framework structure helps to standardise social resilience measurement across different communities, so that a useful comparison can be undertaken for resilience investment decision making.

Table 5
Terms used for different layers in social resilience frameworks analysed in this review.

#	Author/Reference	Sub dimensions	Characteristics	Indicators
1	Kwok et al. [17]	✓	✓	X
2	Kotzee and Reyers [18]	X	✓ (Variables)	✓ (Descriptions)
3	Khalili et al. [19]	X	X	✓
4	Lorenz [20]	✓ (Capacity)	X	X
5	Maguire and Hagan [21]	X	✓ (Indicators)	X
6	Parsons et al. [22]	✓ (Theme)	✓ (Indicator dimension)	✓ (Variables)
7	Yoon et al. [23]	X	X	✓ (/Variables)
8	Ostadtaghizadeh et al. [24]	✓ (Attributes)	✓ (Indicators)	X
9	Arbon et al. [25]	✓ (Concept/Themes)	✓ (Questions)	✓ (Scores)
10	Qasim et al. [26]	X	✓ (Variables)	✓
11	Woolf et al. [27]	✓ (Category)	✓	✓
12	Leykin et al. [28]	X	✓ (Factors)	✓ (measures)
13	Alshehri et al. [29]	X	✓ (Criteria)	X
14	Ainuddin et al. [30]	X	X	✓
15	Burton [9]	X (Type)	X	✓ (Variables)
16	Cox and Hamlen [7]	✓ (Domain)	✓ (Dimensions)	X
17	Cutter et al. [31]/Cutter et al. [32]	✓ (Concepts)	X	✓ (Variables)
18	Joerin et al. [33]	✓ (Parameters)	✓ (Variables)	✓
19	Kusumastuti et al. [34]	✓	✓ (Descriptions)	✓
20	Frazier et al. [35]	X	✓ (Variables)	✓
21	Chandra et al. [36]	✓ (Levers)	✓ (Core components)	X
22	Pfefferbaum et al. [37]	✓ (Domains)	✓ (Process)	X
23	Orencio and Fujii [38]	✓ (Criteria)	✓ (Elements)	✓
24	Norris et al. [4]/Sherrieb et al. [39]	X	✓ (Elements)	✓
25	Peacock et al. [40]	✓ (Components)	✓ (Activity)	✓
26	Sherrieb et al. [41]	X	✓ (Elements)	✓
27	Sempier et al. [42]	X	✓ (Category)	✓
28	Renschler et al. [43]	✓ (Components)	✓ (Sub components)	X
29	Cutter et al. [44]	X	✓ (Variables)	X
30	Hegney et al. [45]	✓ (Concepts)	✓ (Ideas)	X
31	Mayunga [46]	X	✓ (Indicators)	✓

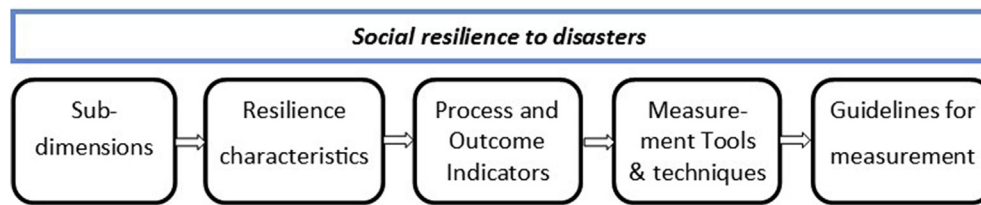


Fig. 4. Five layer framework structure of a social resilience to disasters.

4.3.2. Dominant and variant social resilience sub-dimensions, characteristics, and indicators

As part of the review undertaken, all social resilience characteristics/indicators in each of the 31 selected frameworks were tabulated to create a master list. All the characteristics and indicators in the master list were aggregated and then filtered to remove the characteristics/indicators that were duplicates or similar. This resulted in 80 unique social resilience characteristics and indicators that were analysed in this study (See Table A1 in supplementary information for the complete list of social resilience characteristics/indicators analysed and Fig. A1 for flowchart with analysis steps). These 80 characteristics/indicators were then iteratively categorised by placing them under the most appropriate sub-dimension of social resilience. For categorisation, codes were created to cluster similar resilience characteristics and each characteristic was assigned a unique code (Table A1 in Supplementary information). The iterative process resulted in 20 sub-dimensions (Fig. 5).

Social demography, social networks, and community engagement are found to be the three key common sub-dimensions used in most social resilience frameworks analysed in this review. More than two thirds of the frameworks have not considered key sub-dimensions such as community aspirations, goals and efficacy, social institutions, social safety measures, equity and diversity/inclusiveness, local culture/beliefs/faiths, community processes and education. There is a tendency to prioritise easily measurable outcome oriented resilience characteristics such as social demography and social networks. Process oriented resilience characteristics have received a relatively lower priority due to difficulty in measurement.

Fig. 6 shows the social resilience concept map generated from the analysis of social resilience characteristics/indicators used in the 31 social resilience frameworks using Leximancer V4.5 software. Leximancer is a textual data analytics tool which helps to analyse textual content and to visualise the meaningful concepts emerging from the data [65]. All the characteristics/indicators identified from the 31 frameworks were collated into one document and uploaded as an input for the analysis (The full list is available in Table A1 in the supplementary information). The concepts and theme map was generated as shown in Fig. 6 and social capital (networks and trust), community engagement, community competence (skills, resources, services, and

capacity), education, and health were some of the key concepts identified from Fig. 6. From the analysis of the concepts in Fig. 6 and the indicator matrix in Table A2 in the supplementary information, 13 most commonly used social resilience characteristics were identified from the frameworks analysed as shown in Table 6.

There is lack of consistency in fundamental characteristics of social resilience used in the existing frameworks. The distinctive social resilience frameworks such as that developed by Kwok et al. [17] identified 66 unique social resilience characteristics through initial consultation with disaster management stakeholders in New Zealand. However, Kwok et al. [17] finally proposed 18 key social resilience characteristics by further synthesising them through consultation and consensus building among the stakeholders. In another study, Khalili et al. [19] identified 18 social resilience characteristics from the literature relevant to their context to develop a temporal framework to measure social resilience in Australia. Both frameworks have captured some similar characteristics/indicators, such as leadership and social trust. However, there are differences as well. For example, Khalili et al. [19] used social innovation and learnings from previous disasters as two important social resilience indicators in their framework, which were not prioritised in the framework developed by Kwok et al. [17]. The selection of resilience indicators is largely based on how the measurement of resilience is conceptualised. Fig. 3 explains four different types of conceptualizations. These conceptualizations depended on how resilience is defined by the researcher, either as an ability of social entities/social mechanisms/both or as a Coping, Adaptive, and Transformative capacity. However, there is still a lack of clarity on methodical selection of resilience indicators.

The scale of exclusion of important social resilience characteristics is evident in many frameworks embedded within the five dimensional community resilience frameworks. A key limitation for including all essential characteristics for each dimension in a multi-dimensional framework is that it can become unmanageable for effective operationalisation. This underlines the need to include only critical resilience characteristics in each dimension so that the number of aggregate resilience characteristics are reasonable for practical application. Also, the broader the framework with multi-dimensions, the lesser is the focus on each dimension and vice-versa.

Existing indicators to capture social resilience are inadequate, since

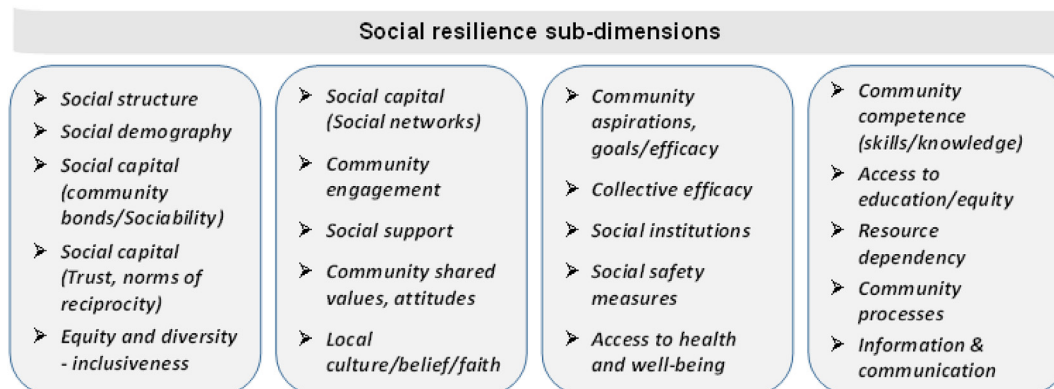


Fig. 5. Sub-dimensions of social resilience extracted from the frameworks analysed.

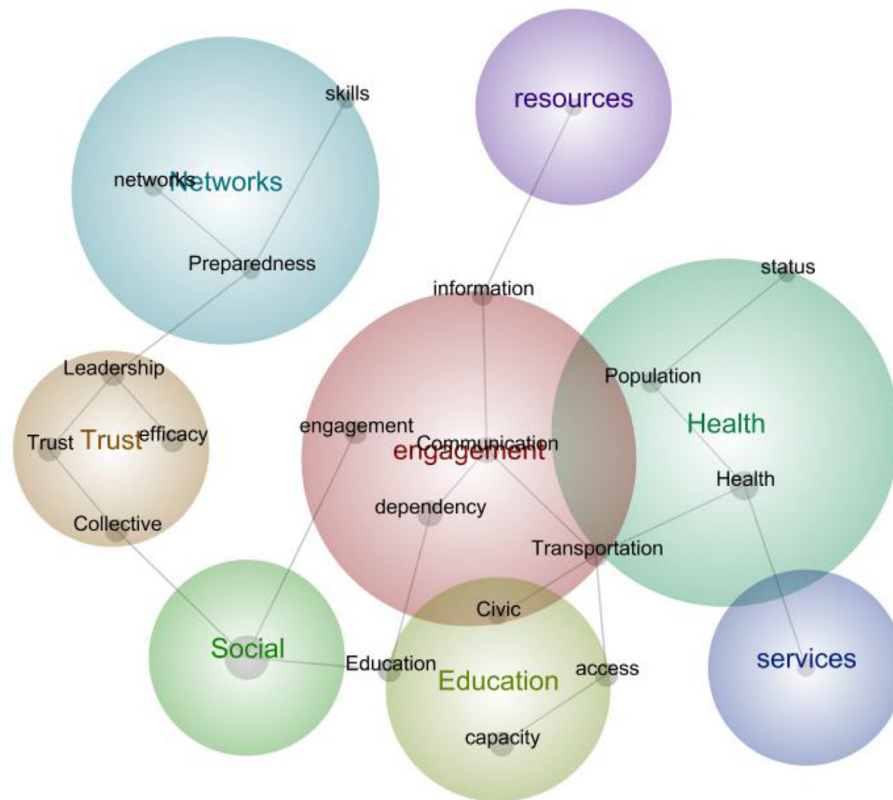


Fig. 6. Social resilience concept/theme map view (Generated by Leximancer 4.5).

Table 6

Most widely used social resilience characteristics/indicators in the frameworks evaluated.

Sub-dimensions	Most commonly used resilience characteristics/indicators
Social demography	1. Age, gender, socioeconomic status (Income), health, historical profile 2. Occupation/Employment 3. Education level/attainment 4. Population with specific/special needs (Elders, Widows, Disables)
Social cohesion/support (Social capital)	5. Social trust 6. Volunteerism
Social networks (Social capital)	7. Civic engagement in social networks 8. Social associations/Societal systems/Connection between groups
Community engagement	9. Religious or faith based engagement 10. Political participation
Community values	11. Place attachment and sense of community and pride/Community connectness
Access to health	12. Access to health services (Primary health care facilities)
Community competence	13. Local understanding/knowledge of risk or perception

resilience characteristics such as social capital, social dynamics and interactions are hard to measure in practice [15]. One common approach in social resilience measurement is to use publicly available and easily accessible data sets such as census data as proxy measures to formulate indicators [15]. The effectiveness of this approach is highly dependent on the accuracy of the data set, and the ability to methodically and accurately characterise social resilience indicators within a broader framework [66,67]. Novel ways are needed to capture key social resilience characteristics with more conceptual clarity when developing frameworks. Future development of social resilience frameworks need to take into account key process-oriented social resilience characteristics that are critical for adequate measurement of social resilience, since they were largely neglected in the existent frameworks.

4.3.3. Challenges in measuring social resilience

“Resilience has proven difficult to measure, and an alternative to estimating resilience directly is to monitor characteristics of systems that are related to the resilience of the system and are measurable” [68]

(p.946). Social resilience to disasters can be measured for many different purposes. These include: (a) measuring the relative level of resilience between two geographic locations; (b) measuring changes in resilience status (trend) over the continuous span of time within a single phase of the disaster; (c) measuring resilience in multiple stages of a community at discrete time intervals such as the changes between different disaster phases (before, during, and after a disaster); (d) measuring hazard-specific resilience of a community; and (e) combination of above scenarios. Numerous methods to measure resilience across different disciplines have also produced various qualitative and quantitative techniques such as participatory assessments, statistical evaluations, modelling, and metrics [2]. In this section, different social resilience measurement methods found in the literature are critically analysed to identify key challenges in adequately measuring social resilience.

Gaillard [69] categorised resilience measurement methods as; quantitative methods (mainly index based measures), qualitative methods such as case studies/life stories/observations, and

Table 7
Social resilience measurement methods and examples of frameworks investigated in the review.

Method	Description	Example frameworks analysed in this study [with reference]
Index/Indices	Numerical value obtained through weighting of different indicators	Community Disaster Resilience Index [23,40,46] Community Resilience Index [41] Socio-Ecological Composite Flood Resilience Index [18] Composite/component Resilience Indices [49] Resilience Factor Index [30] Rural Resilience Index [7] Climate Disaster Resilience Index [33] Resilience Index [34] PEOPLES Resilience Index [43] Coastal Community Disaster Resilience Index [38] Community Resilience Indicator Matrix/index [9] Australian Natural Disaster Resilience Index (ANDRI) [22]
Scores/Score card Indicator ranking/Indicator matrix	Numeric value obtained through qualitative measurement or analysis	Community Resilience score card [70] Coastal Resilience score card/index [42] Resilience assessment score/Resilience Indicator rating [27] Community resilience indicator ranking [35] Conjoint Community Resiliency Assessment Measure (Factor and scores) [28] Social resilience indicator levels and scores for flood [19] Community Resilience scores to disasters [71] Baseline Resilience Indicators for Communities (BRIC) Matrix [31]
Participatory tools/toolkit or Case studies	Tools/techniques guidelines on what and how to measure	Community Advancing Resilience Toolkit (CART) [4,37] Building resilience in rural communities toolkit [45] Community Resilience Toolkit [36]

participatory tools/toolkits (for example, participatory hazard mapping). Cutter [15] identified resilience measurement methods in three other different categories: Index, score cards, and toolkits. Other methods used to measure resilience include indicator ranking, models, and simulations. While there are overlaps in the above two categorisations, it is sometimes difficult to assign methods as a quantitative or qualitative measure. Therefore, social resilience measurement methods identified in this study were broadly categorised into three types; Index based approaches, score cards/ranking methods, and participatory toolkits/case studies. More than half of the 31 social resilience frameworks analysed have used index and similar methods such as indicator scoring, ranking of indicators, and indicator matrix. Table 7 below provides the categorisation of the different type of methods and examples of frameworks analysed in this study.

Quantitative measure of resilience such as an index, as an analytical tool helps to measure the baseline social resilience and estimate the target for improvement in social resilience [35]. An index is helpful to national and local authorities who formulate policies and decisions about projects focusing on building social resilience to address priorities identified at national and sub-national levels [72]. An index is created by combining multiple indicators and assigning proportional weights as appropriate to create a single value [15,47]. Yet, substantial challenges exist in characterizing and quantifying resilience accurately to create a good basis for policy-making in resilience-based disaster management [73]. The key issue with an index is the subjectivity inherent in assigning weights to different indicators which is often based on expert judgment [74] and can result in significant variability.

Score card is another method for measuring disaster resilience. Score card approach can be used by communities themselves to assess their likely scale of resilience to a disaster [70]. Local level resilience measures to disasters are more useful than national resilience quantification metrics for community based disaster risk reduction initiatives as they take into account geographical and other area specific considerations [35]. Score card is an example of how a community itself could measure its own resilience at local level using a set of indicators. A qualitative analysis method used by Woolf et al. [27] is another example to rank and calculate average scores for indicators based on their strengths and weaknesses.

Resilience measurement toolkits provide qualitative measures as opposed to index and scoring methods. Toolkits provide guidelines and

establish step by step procedures on how to measure resilience [15]. For example, the community self-assessment resilience toolkit developed by Sempier et al. [42] was used to assess resilience through a participatory process of engaging multi-stakeholders at community and sub-national levels. Besides, the use of participatory tools to capture qualitative measures other than resilience assessments guided by set of questions used in toolkits can also be used to quantify the resilience measure. Case studies used by Hegney et al. [45] is another example of a qualitative measure of social resilience.

An analysis of existing resilience composite indicator frameworks by Beccari [75] recognizes the problematic nature of current approaches in measuring resilience that are largely customised to specific contexts and not compatible in another geographical setting. Social resilience is also too complex to reduce it to a numeric value [27] and capturing dynamic social resilience characteristics using a static measurement is not easily achievable [76] for effective decision making. Hence, future research needs to focus on innovative methods that are required to solve the inadequacy of measuring social resilience using a single method such as index or score card, which has been a dominant approach to date. A hybrid measure that provides a quantitative value such as index or score card with sufficient qualitative interpretation using participatory tools to reach an acceptable level of resilience measurement for effective decision making needs to be explored.

5. Conclusion, key knowledge gaps and recommendations for further research

This paper presents a critical review of 31 selected social resilience frameworks from a systematic literature review. Based on the analysis of frameworks, the following six key knowledge gaps for future research on social resilience in a disaster context are highlighted. Firstly, the many challenges inherent in adequately measuring social resilience, as highlighted in section 4.3.3, necessitates a well-structured, rigorous, and adaptable framework in the context of disaster management. A comprehensive social resilience framework which considers multiple dimensions of the social resilience concept is a pre-requisite for any detailed assessment of resilience. Social resilience assessment frameworks have largely been developed without consensus on the key characteristics of social resilience and how to robustly measure them. The key question which remains unanswered is the extent to which

existing frameworks can be adapted for different contexts since many of them have been operationalised within a limited context, scale and scope. Developing an integrated and adaptable framework for consistent operationalisation remains an important research gap in social resilience literature. A new integrated and adaptable social resilience framework, for example, the '5S' model proposed by Saja et al. [12] could guide the formulation of a comprehensive measure of social resilience as it can be adapted to different geographic and hazard specific contexts as well as in different governance levels from national to local.

Secondly, further research is needed to identify indicators to measure social resilience in each phase of a disaster – pre disaster, disaster response and post-disaster recovery phases. Such indicators will help to develop strategies to effectively measure social resilience and to execute effective resilience enhancing actions to build a resilient community [19]. Furthermore a detailed analysis is required to understand key social resilience characteristics and particularly, those characteristics that have received minimal attention, but are relevant and important [47]. Such an adaptable social resilience framework needs to be operationalised, to different types of geo-specific communities such as coastal, rural, and urban, for different hazard-specific scenarios ranging from slow-onset to rapid-onset disasters, and at different levels such as at community level, sub-national level, and at the national level. The social resilience framework developed by Saja et al. [12] was adapted by Bustamante [77] with 8 of 16 characteristics relevant in the context of that research study provides a good example of adapting an integrated framework for a certain context. Further, it is important for any framework to align with the relevant policy framework, when it is developed or operationalised. This could be based on the context of its development and operationalisation at the regional, national, sub-national level.

Thirdly, theoretical orientations of social resilience influences the decisions on what should be assessed, for what purpose, and for whom [78]. Most social resilience frameworks have focused on outcome oriented social resilience indicators since they can easily produce social resilience indices. These indices however, have limited value for interpreting the actual resilience status of a community. In contrast, process-oriented indicators are based on dynamic properties which are essential to comprehend social resilience adequately, have been largely neglected. This is mainly because they are difficult to measure due to their dynamic nature. An adequate measurement of social resilience requires both, outcome and process oriented social resilience characteristics that can capture social dynamics and perceptions. Hence, future research needs to find innovative methods using community participatory or multi-stakeholder engagement tools to capture the dynamic nature of social resilience in disaster context. In addition, participatory quantitative measurement techniques, for example preference ranking can be used for creating indices for comparison of resilience status across communities or geographies. A systems thinking approach can help in conceptualising the dynamic and complex nature of social resilience, which will improve resilience measurement.

Fourthly, conceptual frameworks should be translated into practice to help decision-makers to operationalise social resilience measures [79]. Conceptual and measurement complexity and diversity has led to limited agreement on a standard approach to operationalise the resilience concept in disaster management [15,47,80]. The extent to which resilience assessment approaches can be adapted for use in the real world depends on how resilience is understood, assessed and its ease of measurement [2]. Researchers and practitioners who apply the frameworks need to be guided for successful translation to real world application. This requires frameworks to be further extended to include social resilience measurement tools, techniques, and guidelines as to how to measure the proposed social resilience indicators. The proposed five-layer structure (Fig. 4) can be used to develop the standard structure for social resilience frameworks. Further, future research needs to incorporate the identification of specific resilience indicator measurement tools and guidelines.

Fifthly, a research gap still exists in relation to the assessment of the reliability and consistency of resilience measures, when frameworks are operationalised in real-world applications [84]. A novel approach is needed to overcome the limitations in using an index or score card which primarily quantifies the resilience measure without sufficient qualitative interpretations to help design appropriate interventions. Further, methodical steps using indicator selection criteria need to be applied in selecting indicators.

Finally, many existing social resilience frameworks developed in disaster context have applied selected proxy measures in the absence of a methodical process for identifying and selecting the best proxy measures. A detailed review to understand the use of proxy measures in social resilience assessment is limited in the current social resilience literature. Such a review needs to discuss challenges and drawbacks in the use of proxy measures and to identify innovative ways to measure social resilience to disasters. Further, the use of surrogates in lieu of actual parameters could be explored to overcome the challenges in measuring resilience. The potential surrogates also need to be evaluated against a set of key indicator evaluation criteria such as accuracy, cost-effectiveness, and measurement complexity.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ijdr.2019.101096>.

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