

Psychological vulnerability as an integral component of comprehensive vulnerability assessment: informing policy and practice in disaster risk reduction

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Jogia, J. & Wedawatta, G. (2019). Psychological vulnerability as an integral component of comprehensive vulnerability assessment: Informing policy and practice in disaster risk reduction. *International Journal of Work Organisation and Emotion* (In Press)

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Abstract

Science can be utilized to mitigate risk and vulnerability throughout the disaster management cycle. The risk of a disaster depends not only on the hazard but also on the psychological, social and environmental vulnerability of exposed communities. Through a review of existing knowledge on evidence-based methods for assessing vulnerability in communities, it was found that psychological vulnerability is seldom considered in such assessments. We argue that psychological aspects play a key role in how people and communities perceive and respond to disaster events. Building infrastructure to assess vulnerability in a comprehensive manner is essential to inform policy and practice in disaster risk reduction. Better understanding of these complex relationships and the role of psychological vulnerability in reducing risk and building the resilience of nations and communities to disasters requires interdisciplinary approaches cutting across fields such as science, psychology, health, environment, economics, engineering and technology.

Keywords: risk reduction, resilience, disaster management, engineering and environment, psychological impacts, disaster management mental health, vulnerability, assessment, socio-economic

Introduction

Understanding disaster risk has been suggested as the top priority by the Sendai Framework for Disaster Risk Reduction 2015–2030 (Aitsi-Selmi et al., 2015). Disasters represent a major challenge worldwide and a serious threat to sustainable development. Their impacts are complex and multifaceted, comprising fatality, injury and health issues, loss of or damage to resources (property), environment and infrastructure, and socio-economic issues. Disasters are not limited to those due to natural hazards; environmental and technological disasters are also common. However, over the 20 year period between 1995 and 2015, an overwhelming majority (90%) of disasters were due to flooding, storms, heatwaves and other weather-related events (CRED and UNISDR, 2015). In total, 6,457 weather-related disasters were recorded worldwide in the Emergency Events Database (EM-DAT) maintained by the Centre for Research on the Epidemiology of Disaster (CRED). During this period, weather-related disasters have resulted in 606,000 mortalities, averaging over 30,000 lives per annum, and have left a further 4.1 billion people injured worldwide, left out of their homes or in need of urgent emergency relief (CRED and UNISDR, 2015). Recent figures, according to EM-DAT, report that there were 346 disasters in

2015 alone, amounting to US\$66.5 billion in economic damage affecting 98.6 million people and causing 22,773 deaths (EM-DAT, 2016).

The cyclical nature of disasters has also warranted attention, for example, the increased occurrence of flash flood disasters seen in the Middle East and North Africa (MENA) region over the past few years triggered by heavy rain and storms have caused loss of life and social disturbance, and have had a negative economic impact, disrupting business activity and affecting private and public assets (Ismail-Zadeh, 2014). The aforementioned disasters worldwide also have more implicit secondary impacts: namely, dramatic oscillations in insurance premiums (personal and asset), as well as extensive devaluation and accumulation within the (re)insurance industry (Johnson, 2015). Assessment of vulnerability is therefore essential for effective disaster risk reduction.

Knowledge relating to what makes people and places vulnerable to environmental threats has significantly advanced over the years and various vulnerability assessment methods have been developed and are being used. It is argued that psychological issues need to be considered as part of vulnerability assessments if a holistic picture is to be obtained because psychological issues play a crucial role in human well-being and also act as a moderating factor in how people view disaster risk. A better understanding relating to whether psychological aspects feature in current vulnerability assessments, and to what extent, will help gauge whether improvements to current methods of assessing vulnerability are required.

Here, we examine existing vulnerability assessments and discuss directions for future research and practice in disaster risk reduction.

Disaster management cycle

The traditional disaster management cycle consists of a pre- and a post-disaster stage. Within each stage there are two phases: firstly prevention/mitigation and preparedness in the pre-disaster stage. In the post-disaster stage, there are response and recovery phases (Reaves et al., 2014). Taking appropriate action and implementing measures based on the concept of disaster risk management in each phase of the disaster management cycle can reduce the overall disaster risk.

In the pre-disaster stage of the disaster management cycle, the disaster risk 'mitigation' (prevention) phase focuses on minimizing the effects of disasters. Typical activities undertaken include vulnerability analysis and public education. Identifying vulnerability in this phase is the first step in understanding risk. The next phase of the disaster management cycle is 'preparedness', in which response strategies are planned. Here, response plans are drawn up and emergency exercises/training undertaken. In the post-disaster stage, the 'response' phase

includes responding to a disaster even by means of undertaking search and rescue operations and providing emergency relief. The next phase of the post-disaster stage is 'recovery', in which the focus is on returning the affected community back to normal as soon as possible. Activities undertaken in this phase include temporary housing, grants and permanent housing. Khan et al. (2008) further divides this recovery phase into two more phases: 'rehabilitation' and 'reconstruction'. Khan et al. (2008) define rehabilitation as restoration of basic services and functions, whereas reconstruction is defined as full resumption of services which collectively contribute to recovery of the affected community. The recovery phase will lead to mitigation for future events, thereby continuing the cycle.

The finance and time spent on disaster response and recovery could, it is argued, be spent to greater effect in terms of saving lives and livelihoods through disaster risk reduction measures in the mitigation and preparedness phases. In addition, responses to disasters when they happen would be better in many ways if people were better prepared to manage the necessary responses (Mercer, 2010). Therefore, disaster risk reduction has been highlighted as a systematic method to identifying, assessing and reducing the risks of disasters by governments, policymakers and global disaster agencies worldwide (UNISDR, 2004). Disaster risk reduction's central objective is to mitigate risk related to disasters by the assessment of socio-economic and environmental vulnerabilities to disaster, as well as by dealing with the environmental and other hazards that trigger them (UNISDR, 2015). Here, we will focus only on the identification of vulnerabilities to disaster in the pre-disaster stage.

Vulnerabilities to disaster

Recently there has been a call for a move away from the quantification and analysis of hazards and instead there is a greater impetus on identification, assessment and analysis of vulnerability in the disaster risk management discourse (Joseph, 2013). Vulnerability is defined as the conditions determined by the physical extended to the psychological, social, economic and environmental factors or processes, which make a community more susceptible to the impact of hazards (UNISDR, 2005). From the existing body of research examining disaster vulnerability, broad categories of vulnerability, including environmental, socio-economic and psychological vulnerability, can be identified.

Environmental vulnerability

As discussed previously, disaster events are often triggered by natural hazards such as cyclones, tsunamis or flooding. As such, many of the early assessments of vulnerability have focused on the environmental issues. Whilst acknowledging that understanding vulnerability requires diverse methodological approaches due to it being multifaceted, Boruff and Cutter (2007) stress a spatial perspective incorporating the particularities of place as being essential, as vulnerability manifests itself geographically. Some form of indicators that measure the vulnerability of the

environment be it the natural environment, built environment or both is therefore integrated into various vulnerability assessment schemes. For example, these indicators include susceptibility to environmental events and hazards (Atkins et al., 2001), physical susceptibility (Cardona, 2005), event characteristics (such as frequency, duration and intensity) and antecedent conditions, including natural systems and built environment (Cutter et al., 2008). Other indicators used to assess the environmental vulnerability include infrastructure and lifeline indicators and building structural and occupancy indicators (de Ruiter et al., 2017). Considering that a broad range of issues falls under the umbrella of 'environmental' factors, including features of the disaster event itself, the physical protection measures available and the nature of the built and natural environment all significantly affect the vulnerability of a place to a particular disaster. These indicators feature prominently in most vulnerability assessment methods.

Socio-economic vulnerability

Disaster-prone developing countries, small developing island states, landlocked developing countries and African countries, as well as middle-income countries all show higher vulnerability and elevated risk levels to disasters (Pelling and Uitto, 2001). This would suggest the benefit of using a sociocultural approach to assess disaster vulnerability. Age and cultural diversity also influence vulnerability to the impacts of natural disasters. The elderly are an exceedingly high-risk group affected by displacement and damage to property. Cultural factors such as social values, traditions and attachment to a location have been associated with disaster vulnerability (Jogia et al., 2014). Socio-economic data has been used to examine social vulnerability, identifying the impact of specific contributors comprising rural character, development (urbanization) and economic status (Zhou et al., 2014). Furthermore, a household's socio-economic status is suggested to be the main determinant of social vulnerability. More wealth is positively associated with the greater possibilities to prepare for disasters and recover from losses by means of insurance, social safety nets and entitlement programmes (Koks et al., 2014). Overall, socio-economic indicators are included in current vulnerability assessments.

Psychological vulnerability

Along with personal injury and mortality, the psychological effects of disasters such as post-traumatic stress disorder (PTSD) and major depressive disorder (MDD) are prevalent (Kessler et al., 2005). Whilst PTSD prevalence estimates vary, the majority are in the 20–40% range in disaster-focused research (Bromet et al., 2017). Psychiatric morbidity and functional impairment were examined in Thailand two and a half years after the tsunami in 2004. Incidence of two conditions namely PTSD and MDD was noted as being 36.5% and 28.6%, respectively (Hussain et al., 2011).

Usui et al. (2013) investigated vulnerability and the long-term influence of traumatic stress caused by the Great East Japan Earthquake disaster, which occurred in 2011. They reported that

acute stress related to the earthquake was likely to subside within seven months after the disaster. However, depression-related symptoms increased for more than one year after the disaster. The authors concluded that the long lasting and progression of depressive symptomatology may be a response to chronic stress induced by the fear of radiation due to the subsequent nuclear power disaster (Usui et al., 2013). This suggests that the subsequent effects of natural disasters should be considered where possible in vulnerability assessments. More recently, Inoue et al. (2015) found key differences in vulnerability to traumatic stress between those with and without pre-existing psychological disorders after the Great East Japan Earthquake. Severe vulnerability was observed in patients with neurotic disorders, followed by those with mood disorders, and last of all schizophrenia (Inoue et al., 2015). These studies suggest that more sensitive assessment and monitoring of psychological vulnerability is needed, especially for those with pre-existing mental health conditions.

Current assessments and critique

Beccari (2016) in his review of 106 methodologies or tools of assessing disaster risk, resilience and vulnerability composite indicators analysed the inclusion of indicators measuring different types of environments: that of social, built, economic, natural and disaster. Whilst the social environment was identified as the most dominant aspect included in the methods assessed, disaster environment was also identified as a key feature (see Table 1). Built and natural environments were found to be given relatively less priority in vulnerability assessment. Cumulatively though, the physical environments of disaster environment and built and natural environments were found to contribute to approximately 44% of the variables in each index, thus highlighting the particular significance of environmental vulnerability in overall vulnerability assessment.

Insert Table 1 here.

More recently, de Ruiter et al. (2017), in their review of vulnerability indicators used in various assessments of earthquake and flood vulnerability, categorized the indicators under physical vulnerability and social vulnerability. These were further sub-divided as:

1. Physical vulnerability
 - 1.1. Infrastructure and lifeline indicators
 - 1.2. Building structural and occupancy indicators
 - 1.3. Environmental indicators

2. Social vulnerability
 - 2.1. Demographic indicators
 - 2.2. Awareness indicators

2.3. Socio-economic indicators

2.4. Institutional and political indicators

Whilst the physical, environmental, social and economic issues feature prominently in the vulnerability indicators, psychological aspects do not seem to be widespread among the assessments evaluated. This finding is consistent with the findings from Beccari (2016) discussed above. Whilst a number of the underlying socio-economic conditions that lead to psychological vulnerability are included in some of the assessments (including socio-economic disadvantage, social status, age, etc.), direct issues pertaining to psychological vulnerability are seldom included in many of the assessment tools. There is evidence that disasters can cause a wide range of psychological impacts such as PTSD, MDD, suicidal ideation and anxiety (Choi et al., 2016; Gruebner et al., 2015). However, the extent to which such potential impacts are considered in vulnerability assessments is questionable.

Gruebner et al. (2015) noted that there is a probability for psychological outcomes following a disaster to be different across space or geographic regions. There is a probability for vulnerability and resilience factors linked to post-disaster psychological responses to vary across different geographic regions (Gruebner et al., 2015). This again underlines the importance of examining psychological vulnerability as part of a comprehensive assessment because the level of vulnerability could vary across regions and communities, thus requiring different types and levels of support following a disaster event.

Birkmann (2007) highlighted the importance of viewing vulnerability as a process, and the necessity of measures and instruments which allow the past, current and potential future areas and people at risk or vulnerable to be assessed and defined within this process. This further highlights the need to use the vulnerability index and indicator approaches as a tool to identify priority areas and targets where policy intervention is most needed. It is equally important that all major contributing factors such as space, time and psychological vulnerability be considered in such assessments, in order to obtain a holistic picture of vulnerability and to identify the priority areas and policy interventions required. The lack of inclusion of psychological factors seems to be a major limitation in the current assessment schemes.

Interdisciplinary approach to vulnerability assessment

To date, social sciences have had a relatively limited impact in the area of disaster vulnerability research and policy, compared to physical and environmental sciences. Instead, disaster research has concentrated on familiar, disciplinary approaches with little empirical data existing about the real-world measures of interdisciplinary research or practice (Rhoten, 2004), especially with regard to disaster vulnerability assessment. There is a paucity of social science engagement with global environmental change in especially middle-income and low-income countries, like Brazil, Mexico and Argentina, which do have more than adequate natural and health science research

networks (Lahsen et al., 2010). The social sciences make a distinction between the exposure to threats and the ability to cope with these threats. This is often used to underline the double structure of vulnerability. This double structure suggests the fact that vulnerability is the result of an interaction between exposure to external or environmental stressors and the coping capacity of the affected household, group or society (van Dillen, 2004). Thus, the social sciences have a key role to play in measuring the complex nature of vulnerability, especially in light of the increasing frequency of disasters and the devastating effects on communities.

Moreover, science needs to be coupled with other disciplines to have a surmountable impact on disaster risk research. Interdisciplinary approaches are needed which address the multiple causes of environmental risks, of vulnerability, and of the necessary measures to mitigate risk which will transform scientifically based insights into innovative policy and practice 'on the ground' (Martens et al., 2009). Reducing disaster risk is an issue pertinent to a number of diverse sectors, which requires interdisciplinary approaches with the support of the natural and social sciences. Applied fields such as science, psychology and medicine, along with environment, engineering and technology, have helped improve our ability to predict disasters and alleviate the devastating after-effects of disaster such as flooding. However, over time, population growth, social, economic and natural environmental processes have increased the exposure and susceptibility of communities to disasters (Herlander et al., 2013). Moving away from the predication of threats and examining the person perspective is essential. Vulnerability assessment measures that deduce the seriousness of potential threats based on known hazards and the level of vulnerability of societies and individuals is key (Wisner, 2014). Psychological, social and environmental vulnerability can be assessed using an interdisciplinary approach combining psychology, mental health, socio-economic aspects and the physical environment. Conceptualizing and creating more cohesive frameworks for vulnerability assessment will reduce risk and will build resilience for nations and communities to disasters.

Gruebner et al's (2015) study of post-disaster mental health, among the victims of Hurricane Sandy that affected New York in 2012, concluded that explanatory characteristics may well result in different psychological vulnerability and resilience factors within different geographical and regional contexts. It was highlighted that there is a need to assess vulnerability both during the preparedness stages and in the aftermath to strengthen the psychosocial resources of demographic groups at greatest risk of adverse outcomes, to identify survivors at greatest risk and to plan for targeted interventions to reach them. As such, it is suggested that psychological vulnerability needs to be incorporated within vulnerability in a more comprehensive manner in order to obtain an accurate account of the vulnerability of communities. This is especially important considering the priorities set for 2015–2030 as part of the Sendai Framework for Disaster Risk Reduction. Priority one out of the four priorities set therein was to understand disaster risk. The framework recognises that 'policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment' (UNISDR,

2015). A deeper understanding of the psychological aspects of vulnerability, capacity and exposure is required to achieve this objective. Understanding of how psychological vulnerability changes across communities encompassing psychological comorbidity, functional impairment and pre-existing mental health conditions is essential.

Furthermore, the dynamic interplay of psychological vulnerability with socio-economic and environmental vulnerability needs to be explored. The lack of understanding and holistic consideration of this dynamic interplay of vulnerability hinders decision making, policy and practice for disaster preparedness and response. Two diverging policy and practice approaches can be seen in the UK and Sri Lanka with regards to insurance post disasters. For example, communities largely depend on insurance to cover damage from disasters for their properties and businesses. In the UK, previous research (Wedawatta et al., 2012) has noted that excess values for property insurance tend to increase when renewed following a flood event affecting a property. Whilst the policyholders may act with a false sense of security and expectation from their insurance cover, the real impact of a higher excess will only be realised in the event of a subsequent claim for damages. Conversely, in Sri Lanka, the government has introduced an insurance scheme to cover all properties in the country affected by disasters, up to a limited extent. Such provisions are likely to affect how communities perceive their vulnerability and decide on preparedness strategies. Such issues affect behaviour and emotion towards risk, finance and affordability of insurance pre and post disasters. This is the perfect example of the interplay between psychology, socioeconomics and the environment during natural disasters.

Given that the fourth priority of the Sendai Framework is to enhance ‘disaster preparedness for effective response and to “build back better” in recovery, rehabilitation and reconstruction’, further study is required to better understand how psychological aspects of vulnerability are linked to and transcend other aspects of vulnerability. This understanding is fundamental in order to develop societal resilience to disasters. As elaborated by Paton (2006), the well-established potential of vulnerability factors to increase loss potential in the event of a disaster means that they have a key role to play in estimating risk. Paton (2006) further acknowledges that the presence of vulnerability factors should not be automatically equated to increased risk because these factors tend to coexist with factors that facilitate adaptive capacity; thus building resilience. This argument equally applies to psychological vulnerability factors and shows the need for understanding the complex links that exist between them. For example, Paton et al. (2000) discussed that, rather than assuming that disaster exposure and the experience of pathological reactions or loss are integrally linked, there is a need for accommodating the possibility of positive reactions and growth outcomes in research and in the disaster risk reduction process.

Mainstreaming psychological vulnerability within holistic vulnerability assessment requires a truly interdisciplinary approach to research and practice. Reviewing the need for interdisciplinary research in developing resilience to disasters, Davidson (2015) argued that the topic of resilience could not be fully understood through analysis by any one discipline or by analysis of disciplines

separately. Davidson (2015) proposed that the societal predicament posed by inadequate resilience needs to be resolved by integrating contributions from many disciplines. As such, we propose a two-fold strategy: firstly, the need for further study to understand the complex role of psychological factors in vulnerability and the dynamic interplay with socio-economic and environmental vulnerability; and, secondly, the need for adopting an interdisciplinary approach therein. This interdisciplinary process of vulnerability assessment needs to be an integral component within a coherent disaster risk reduction strategy, informing disaster preparedness, disaster response or relief and post-disaster rehabilitation, as shown in Figure 1.

Insert Figure 1 here.

It is important that all major contributing factors are included in such a vulnerability assessment, in order to obtain a holistic picture of vulnerability and to identify the priority areas and policy interventions required. This includes a comprehensive measure of psychological vulnerability pertaining to the subclinical and clinical symptoms of depression and anxiety. More specifically, a mood rating and social anxiety scale. This assessment should also incorporate an evaluation of resilience, response to stress and perhaps extend to quality of sleep and activities of daily living. We suggest a composite measure of general mental health and well-being, along with an evaluation of an individual's functioning and capacity to cope, provides the basis for identifying at-risk individuals and providing support. This support can be within the community, be it from an immediate social network or a community mental health team and could be provided as a targeted intervention.

Another idea could be to provide those at risk with psychological training and workshops on disaster risk and resilience or to use a psycho-educational approach. Psychoeducation is an evidence-based intervention in the form of relevant factual information to help patients better understand and cope with potential or actual illness or life events. We suggest that if psychological vulnerability is adequately assessed then such early intervention strategies can be employed, and the post-disaster psychological effects can then be minimized for those at risk.

When psychological vulnerability is assessed as part of a comprehensive assessment, this will provide the basis for pre-disaster mitigation and preparedness (the prevention and preparedness phases respectively, as per Reaves et al., [2014]). For example, education programmes can be used to provide accurate information, negate unnecessary fears and address major concerns identified. If and when a disaster strikes, response actions can be taken to address the pre-identified issues using suitable interventions (the response phase, as per Reaves et al., [2014]). Having a greater understanding of vulnerabilities will help design and implement appropriate rehabilitation strategies (for the recovery phase, as per Reaves et al., [2014]), targeting short, medium and long-term requirements. For example, psychological assistance as part of an immediate short-term post-disaster treatment plan for the wounded/those who have not been physically wounded, and medium and long-term psychological therapeutic support for affected

communities, etc. can be designed based on the vulnerability assessments undertaken and the impacts of a disaster. Evidence suggests that the support available to disaster-affected communities fades away with time after a disaster. Whilst support for reconstruction may be available in the medium term, the long-term support available is limited. Similarly, communities may also need psychological support in the long term, even after reconstruction. Ongoing support would then lead to a better understanding of vulnerability and preparedness for a future event. As demonstrated above, psychological vulnerability assessment can thus be incorporated into the four phases of the traditional disaster management cycle.

Obtaining a better understanding of underlying psychological issues will help design more tailored, effective preparedness, response and rehabilitation strategies throughout the disaster management cycle. Kulatunga et al. (2014) discussed how vulnerability factors are inherently intertwined with complex root causes and origins. As such, neither psychological issues nor other types of vulnerability can be treated in isolation, but in an all-encompassing, comprehensive way, grounded and tailored to address the requirements of specific communities, groups and individuals (figure 1).

Conclusion

Vulnerability assessment is becoming a crucial component of disaster risk mitigation and preparedness, allowing us to monitor vulnerability and to identify those target communities where practical measures and policies are needed. Our ability to assess a population's vulnerability and to use this information in the policy and decision-making sphere would be made easier if we could develop indicators or indices to encapsulate the multifaceted notion of vulnerability (Birkmann, 2007).

In disaster risk reduction, vulnerability assessment is emerging as one of the major challenges facing scientific and policy communities. Its inherent complexity will ultimately require a much more integrated response scientifically to better understand multiple causes and impacts. At the scientific policy and practice interface, new forms of engagement between multiple disciplines, policymakers and wider stakeholder communities can make a valuable contribution to more informed disaster risk reduction. The current research highlights the need to use the vulnerability index and indicator approaches as a tool to identify priority areas and targets where policy intervention is most needed. Whilst the physical, environmental, social and economic indicators are central in vulnerability assessment, psychological aspects are absent among our current assessments.

We propose that a more comprehensive understanding of disaster risk in all its dimensions of vulnerability is required. This equates to exploring all aspects of psychological vulnerability, capacity and exposure. Understanding of how psychological vulnerability adapts across communities comprising psychological comorbidity, functional impairment and pre-existing

mental health conditions is crucial. Furthermore, we suggest that there is an unexplored interaction between exposure to external or environmental and socio-economic stressors and psychological vulnerability inclusive of the perception of vulnerability or coping capacity and resilience of the affected community. This lack of understanding and holistic consideration of vulnerability impedes decision making, policy and practice for disaster mitigation, preparedness and response. Of course, vulnerability assessments need to be valid and reliable. To advance the field of disaster management, psychology and science can and should play an important role in reducing risk and building the resilience of nations and communities to disasters. It is integral that an approach be adopted which utilizes interdisciplinary research, including social sciences such as psychology, to further elucidate the conditions under which different types of vulnerability can be identified. This scientific information can then be incorporated into new vulnerability assessments and effectively brought to bear on decision making and policy frameworks (Lahsen et al., 2010).

We suggest that the aim should be to bring together the full diversity of the science and environmental community, policymakers, practitioners and researchers from different geographical regions, at local, national and international levels. It is imperative to share state of the art research and discuss how the science community will best support the implementation of a holistic assessment of disaster vulnerability that is inclusive of psychological, environmental and socio-economic factors. We suggest future research should focus on creating and testing a comprehensive measure of psychological vulnerability that includes mental health (focusing on depression and anxiety) and well-being, along with an evaluation of an individual's functioning and capacity to cope. Psychological health not only plays a critical role in human well-being; it can also act as a moderating factor in how people view disaster risk. Identifying those at risk and identifying resilience factors in communities needs to be a core component of future research on disaster risk reduction. Disaster risk reduction and resilience are central tenets for governments, policymakers and global disaster agencies the world over. Therefore, more comprehensive vulnerability assessments will provide a strong scientific basis for investment in disaster risk reduction and building disaster resilience in communities. This should be at the core of disaster risk assessment and planning and an essential component of the disaster management risk cycle.

References

- Aitsi-Selmi, A., Egawa, S., Sasaki, E.H., Wannous, C. and Murray, V. (2015) 'The Sendai Framework for Disaster Risk Reduction: Renewing the Global Commitment to People's Resilience, Health, and Well-being', *International Journal of Disaster Risk Science*, Vol. 6, No.2, pp.164–176.
- Atkins, J.P., Mazzi, S. and Easter, C.D. (2001) Small States: A Composite Vulnerability Index. In Peretz D, Faruqi R and Kisanga E. (eds.), *Small States in the Global Economy*, Commonwealth Secretariat, London.
- Beccari, B. (2016) 'A Comparative Analysis of Disaster Risk, Vulnerability and Resilience Composite Indicators'. *PLOS Currents Disasters*, Vol. 8.
- Birkmann, J. (2007) 'Risk and vulnerability indicators at different scales: Applicability, usefulness and policy implications', *Environmental Hazards*, Vol. 7, No.1, pp.20-31.
- Boruff, B.J. and Cutter, S.L. (2007) 'The environmental vulnerability of Caribbean Island nations', *Geographical Review*, Vol. 97, No.1, pp.24-45.
- Bromet, E.J., Atwoli, L., Kawakami, N., Navarro-Mateu, F., Piotrowski, P., King, A.J., Aguilar-Gaxiola, S., Alonso, J., Bunting, B., Demyttenaere, K., Florescu, S., de Girolamo, G., Gluzman, S., Haro, J.M., de Jonge, P., Karam, E.G., Lee, S., Kovess-Masfety, V., Medina-Mora, M.E., Mneimneh, Z., Pennell, B.E., Posada-Villa, J., Salmerón, D., Takeshima, T. and Kessler, R.C. (2017) 'Post-traumatic stress disorder associated with natural and human-made disasters in the World Mental Health Surveys', *Psychological Medicine*, Vol.47, No.2, pp.227-24.
- Cardona, O.D. (2005) Indicators of disaster risk and risk management Program for Latin-America and The Caribbean Trinidad and Tobago IDB. [online] Main technical report. IDB/IDEA Program of Indicators for Disaster Risk Management, National University of Colombia, Manizales. <https://publications.iadb.org/publications/english/document/Indicators-for-Disaster-Risk-and-Risk-Management-Program-for-Latin-America-and-The-Caribbean-Trinidad-and-Tobago.pdf> (Accessed 30 May 2019).
- Centre for Research on the Epidemiology of Disasters (CRED) and The United Nations Office for Disaster Risk Reduction (UNISDR). (2015) The Human Cost of Weather-Related Disasters 1995-2015. [online] The United Nations Office for Disaster Risk Reduction, Geneva. https://www.unisdr.org/files/46796_cop21weatherdisastersreport2015.pdf (Accessed 30 May 2019).
- Choi, K.H., Lim, M.H., Ha, M., Sohn, J.N., Kang, J.W., Choi, Y.H. and Cheong, H.K. (2016) 'Psychological Vulnerability of Residents of Communities Affected by the Hebei Spirit Oil Spill', *Disaster Medicine and Public Health Preparedness*, Vol.10, No.1, pp51-58.

Cutter, S.L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E. and Webb, J. (2008) 'A place-based model for understanding community resilience to natural disasters', *Global Environmental Change*, Vol.18, No.4, pp.598-606.

Davidson, R.A. (2015) 'Integrating disciplinary contributions to achieve community resilience to natural disasters', *Civil Engineering and Environmental Systems*, Vol.32, No.1-2, pp.55-67.

de Ruiter, M.C., Ward, P.J., Daniell, J.E. and Aerts, J.C.J.H. (2017) 'Review Article: A comparison of flood and earthquake vulnerability assessment indicators', *Natural Hazards and Earth System Sciences*, Vol.17, No.7, pp.1231-1251.

Emergency Events Database (EM-DAT), (2016). [online] www.emdat.be (Accessed 30 May 2019).

Gruebner, O., Lowe, S. R., Sampson, L. and Galea, S. (2015) 'The geography of post-disaster mental health: spatial patterning of psychological vulnerability and resilience factors in New York City after Hurricane Sandy', *International Journal of Health Geographics*, Vol.14, No.1, pp.16.

Herlander, M.L., Andreilcy, A.B., Adilson, P., Abel, M.L. and António, A.J. (2013) 'Impacts of natural disasters on environmental and socio-economic systems: what makes the difference?', *Ambiente & Sociedade*, Vol.16, No.3, pp.45-64.

Hussain, A., Weisaeth, L. and Heir, T. (2011) 'Psychiatric disorders and functional impairment among disaster victims after exposure to a natural disaster: A population based study', *Journal of Affect Disorders*, Vol.128, No.1-2, pp.135-41.

Inoue, K., Inoue, K., Suda, S., Shioda, K., Kobayashi, T., Kishi, K. and Kato, S. (2015) 'Differences in vulnerability to traumatic stress among patients with psychiatric disorders: One-year follow-up study after the Great East Japan Earthquake', *Psychiatry and Clinical Neurosciences*, Vol.69, No.9, pp.587-95.

Ismail-Zadeh, A., Urrutia Fucugauchi, J., Kijko, A., Takeuchi, K., and Zaliapin, I. (Eds.). (2014). *Extreme Natural Hazards, Disaster Risks and Societal Implications* (Special Publications of the International Union of Geodesy and Geophysics), Cambridge University Press, Cambridge.

Jogia, J., Kulatunga, U. and Wedawatta, G. (2014) 'Culture and the psychological impacts of natural disasters: Implications for disaster management and disaster mental health', *Built and Human Environment review*, Vol.7, No.1, pp.1- 10.

Johnson, L. (2015) 'Catastrophic fixes: cyclical devaluation and accumulation through climate change impacts', *Environment and Planning A: Economy and Space*, Vol.47, No. 12, pp.2503-2521.

- Joseph, J. (2013) 'Measuring vulnerability to natural hazards: a macro framework', *Disasters*, Vol.37, No.2, pp.185-200.
- Khan, H., Vasilescu, L.G., and Khan, A. (2008) 'Disaster Management CYCLE – a theoretical approach', *Management and Marketing*, Vol.6, No.1, pp.43-50.
- Kessler, R.C., Berglund, P., Demler, O., Jin, R., Merikangas, K.R. and Walters, E.E. (2005) 'Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication', *Archives of General Psychiatry*, Vol.62, No. 6, pp.593–602.
- Koks, E.E., Jongman, B., Husby, T.G. and Botzen, W.J.W. (2014) 'Combining hazard, exposure and social vulnerability to provide lessons for flood risk management', *Environmental Science and Policy*, Vol.47, pp.42–52.
- Kulatunga, U., Wedawatta, G., Amaratunga, D. and Haigh, R. (2014) 'Evaluating vulnerability factors for cyclones: the case of Patuakhali, Bangladesh', *International Journal of Disaster Risk Reduction*, Vol 9, pp. 204-211.
- Lahsen, M., Sanchez-Rodriguez, R., Lankao, P.R., Dube, P., Leemans, R., Gaffney, O., Mirza, M., Pinho, P., Osman-Elasha, B. and Smith, M.S. (2010) 'Impacts, adaptation and vulnerability to global environmental change: challenges and pathways for an action-oriented research agenda for middle-income and low-income countries', *Current Opinion in Environmental Sustainability*, Vol.2, No.5-6, pp.364–374.
- Martens, P., McEvoy, D. and Chang, C. (2009) 'The climate change challenge: linking vulnerability, adaptation, and mitigation', *Current Opinion in Environmental Sustainability*, Vol.1, No. 1, pp.14-18.
- Mercer, J. (2010) 'Disaster risk reduction or climate change adaptation: Are we reinventing the wheel?', *Journal of International development*, Vol.22, No. 2, pp.247–264.
- Paton, D., Smith, L. and Violanti, J. (2000) 'Disaster response: risk, vulnerability and resilience', *Disaster Prevention and Management: An International Journal*, Vol.9 No.3, pp.173-180.
- Paton, D. (2006) Disaster resilience: Integrating individual, community, institutional, and environmental perspectives. In Paton, D. and Johnston, D. (eds). *Disaster resilience – An integrated approach*, Charles Thomas Publisher Ltd, Illinois.
- Pelling, M. and Uitto, J.I. (2001) 'Small island developing states: natural disaster vulnerability and global change', *Global Environmental Change Part B: Environmental Hazards*, Vol.3, No.2, pp.49-62.
- Reaves, E.J., Termini, M. and Burkle, F.M. (2014) 'Reshaping US Navy Pacific response in mitigating disaster risk in South Pacific Island nations: adopting community-based disaster cycle management', *Prehospital and Disaster Medicine*, Vol.29, No.1, pp.60-68.

Rhoten, D. (2004) 'Interdisciplinary research: Trend or transition?' *Items & Issues*, Vol. 5, No. 1-2, pp. 6-11.

UNISDR. (2005) Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. [online] United Nations International Strategy for Disaster Reduction, United Nations Office for Disaster Risk Reduction, Geneva.
<https://www.unisdr.org/2005/wcdr/intergover/official-doc/L-docs/Hyogo-framework-for-action-english.pdf> (Accessed 30 May 2019).

UNISDR. (2004) Living With Risk: A Global Review of Disaster Reduction Initiatives. [online] United Nations Office for Disaster Risk Reduction, Geneva.
<https://www.unisdr.org/we/inform/publications/657> (Accessed 30 May 2019).

UNISDR. (2015) Sendai Framework for disaster Risk Reduction 2015-2030. [online] United Nations Office for Disaster Risk Reduction, Geneva.
<https://www.unisdr.org/we/inform/publications/43291> (Accessed 30 May 2019).

Usui, C., Hatta, K., Aratani, S., Yagishita, N., Nishioka, K., Okamura, S., Itoh, K., Yamano, Y., Nakamura, H., Asukai, N., Nakajima, T. and Nishioka, K. (2013) 'Vulnerability to traumatic stress in fibromyalgia patients: 19 month follow-up after the great East Japan disaster', *Arthritis Research and Therapy*, Vol.15:R13, pp.1-7.

van Dillen, S. (2004) Different Choices: Assessing Vulnerability in a South Indian Village, Studien zur geographischen Entwicklungsforschung, Band 29, Verlag für Entwicklungspolitik, Saarbrücken.

Wedawatta, G., Ingirige, B. and Proverbs, D. (2012) Impacts of Flooding on SMEs and their Relevance to Chartered Surveyors. [online] Royal Institution of Chartered Surveyors, London.
https://www.isurv.com/downloads/download/1742/impacts_of_flooding_on_smes_and_their_relevance_to_chartered_surveyors_ribs (Accessed 30 May 2019).

Wisner, B., Blaikie, P., Cannon, T. and Davis, I. (2014) At Risk: Natural Hazards, People's Vulnerability and Disasters, 2nd ed., Routledge, London.

Zhou, Y., Li, N., Wu, W., Wu, J. and Shi, P. (2014) 'Local spatial and temporal factors influencing population and societal vulnerability to natural disasters', *Risk Analysis*, Vol.34, No.4, pp.614-39.

Table 1: Number of methodologies containing different environments and the average proportion of variables in each index (Source: Beccari, 2016)

Environment	Number of methodologies containing variables in each environment	Average proportion of variables in each index
Social Environment	98	34%
Built Environment	74	13%
Economic Environment	86	20%
Natural Environment	51	6%
Disaster Environment	75	25%
Indices	21	3%

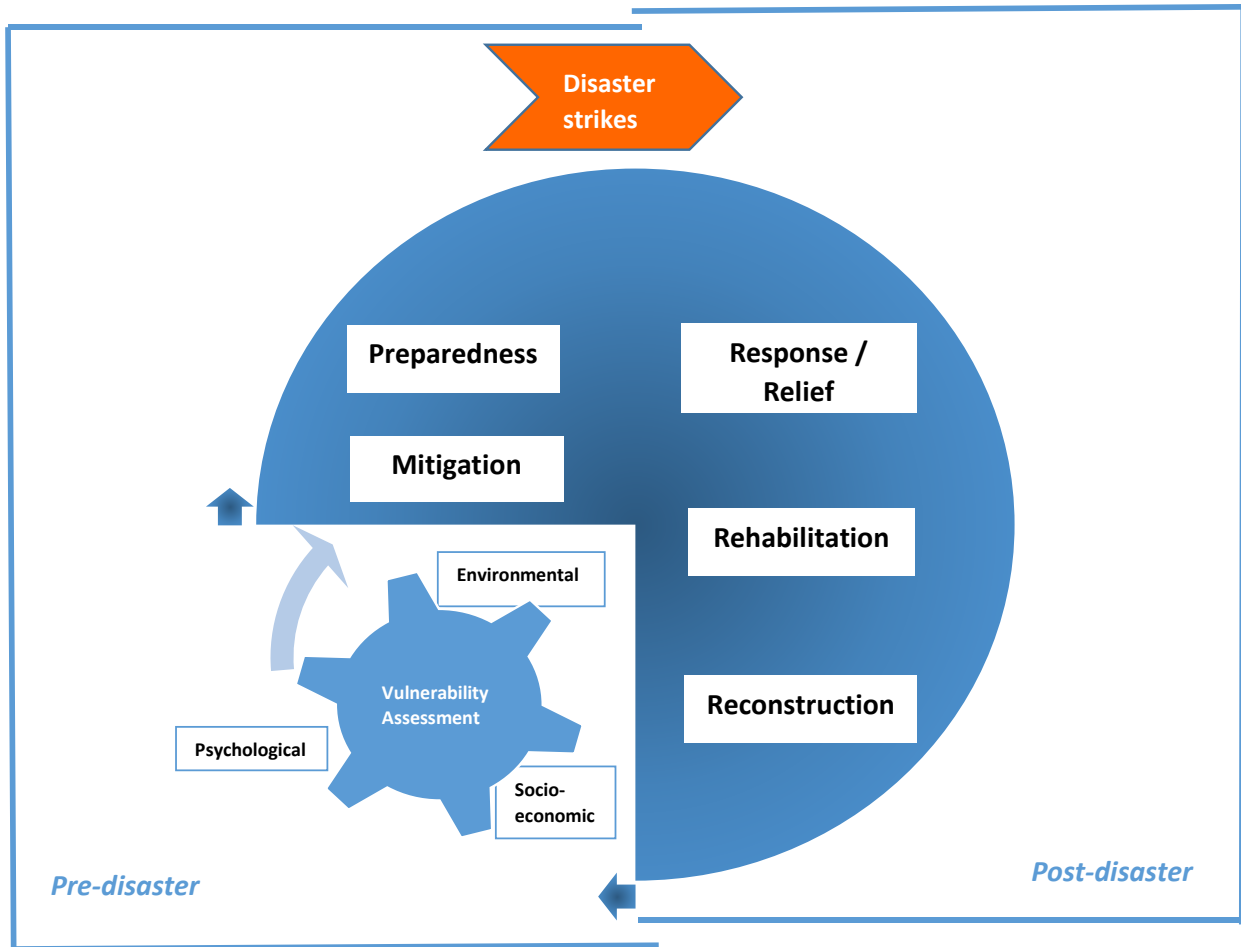


Figure 1: Adaptation of the disaster management cycle: inclusive of psychological vulnerability assessment (Adapted from Khan et al., 2008)