University of Huddersfield Repository

Malalgoda, Chamindi, Amaratunga, Dilanthi, Keraminiyage, Kaushal and Haigh, Richard

Knowledge Gaps in the Construction Industry to Increase Societal Resilience: A Local and National Government Perspective

Original Citation

Malalgoda, Chamindi, Amaratunga, Dilanthi, Keraminiyage, Kaushal and Haigh, Richard (2016) Knowledge Gaps in the Construction Industry to Increase Societal Resilience: A Local and National Government Perspective. In: Proceedings of the CIB World Building Congress 2016. Advancing Products and Services, V . Tampere University of Technology. Department of Civil Engineering, Tampere, Finland, pp. 543-556. ISBN 978-952-15-3745-5

This version is available at http://eprints.hud.ac.uk/id/eprint/28483/

The University Repository is a digital collection of the research output of the University, available on Open Access. Copyright and Moral Rights for the items on this site are retained by the individual author and/or other copyright owners. Users may access full items free of charge; copies of full text items generally can be reproduced, displayed or performed and given to third parties in any format or medium for personal research or study, educational or not-for-profit purposes without prior permission or charge, provided:

- The authors, title and full bibliographic details is credited in any copy;
- A hyperlink and/or URL is included for the original metadata page; and
- The content is not changed in any way.

For more information, including our policy and submission procedure, please contact the Repository Team at: E.mailbox@hud.ac.uk.

http://eprints.hud.ac.uk/

CIB World Building Congress 2016

Proceedings of the CIB World Building Congress 2016

Volume V

Advancing products and services

Edited by
Nebil Achour

TAMPERE UNIVERSITY OF TECHNOLOGY

Tampereen teknillinen yliopisto. Rakennustekniikan laitos.
Rakennustuotanto ja -talous. Raportti 18
Tampere University of Technology. Department of Civil Engineering.
Construction Management and Economics. Report 18

Nebil Achour (eds.)

WBC16 Proceedings: Volume V

Advancing Products and Services

Tampere University of Technology. Department of Civil Engineering
Tampere 2016

Copyright © 2016 TUT – Tampere University of Technology

All rights reserved. No part of this publication or the information contained herein may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, by photocopying, recording or otherwise, without written prior permission from the publishers or in the case of individual papers, from the author(s) of that paper.

Although all care is taken to ensure the integrity and quality of this publication and the information herein, no responsibility is assumed by the publishers or the authors of individual papers for any damage to property or persons as a result of operation or use of this publication and/or the information contained herein.

Published by: TUT – Tampere University of Technology

ISBN 978-952-15-3740-0 (set)
ISBN 978-952-15-3741-7 (vol. I)
ISBN 978-952-15-3742-4 (vol. II)
ISBN 978-952-15-3743-1 (vol. III)
ISBN 978-952-15-3744-8 (vol. IV)
ISBN 978-952-15-3745-5 (vol. V)
ISSN 1797-8904

Knowledge Gaps in the Construction Industry to Increase Societal Resilience: A Local and National Government Perspective

Chamindi Malalgoda, Dilanthi Amaratunga, Kaushal Keraminiyage and Richard Haigh

Global Disaster Resilience Centre, University of Huddersfield
Email: c.malalgoda@hud.ac.uk

Abstract

Over the last decade, a series of increasingly devastated natural disasters have been witnessed across the world. The disaster threats were further aggravated due to various social, economic and environmental trends, such as, growing population, urbanisation, inequality and global environmental change. This demanded a more proactive approach to reduce the vulnerability and exposure, and to increase resilience. For proper implementation of resilience measures, various efforts are required from construction practitioners. Accordingly, construction practitioners are expected to play a key role at each stage of the disaster management cycle. However, recent literature concerning disasters has highlighted the inadequate engagement of the construction industry in reducing the risk of disasters. This emphasises the need to engage the construction professionals adequately, in achieving a resilient built environment. Therefore, it is of paramount importance to provide construction industries with the necessary capacity and capability to plan, design, build and operate in such a way that will reduce vulnerability and exposure, and increase resilience. In order to address this challenge, CADRE (Collaborative Action towards Disaster Resilience Education), which is an EU funded research project, intends to develop an innovative professional doctoral programme that addresses the career needs, and upgrade the knowledge and skills, of practising professionals working to make communities more resilient to disasters. Accordingly, the first phase of the research involved, capturing the needs of 5 stakeholder groups associated in disaster resilience and management as well as current and emerging skills and ultimately knowledge gaps, applicable to construction practitioners towards enhancing societal resilience to disasters. In this context, the paper aims to analyse the current and emerging knowledge gaps of construction practitioners as highlighted by the national and local government stakeholders. Accordingly, the paper provides an extensive analysis of knowledge gaps, which were captured via 20 semi-structured interviews with national and local government stakeholders. Knowledge gaps were analysed in relation to social, technological, environmental, economic and institutional factors and property life-cycle stages. Some of the key knowledge gaps identified in the study are, business continuation management; damage assessments and claims; financing, budgeting and estimating; building codes, regulations and planning; resilient buildings and infrastructure; community empowerment; stakeholder management; legal frameworks and compliance; disaster risk assessment; environmental impact assessment and management; and knowledge management.

Keywords: resilience, national and local governments, knowledge gaps, construction, disasters

1. Introduction

There is a growing recognition that those responsible for the built environment have a vital role to play in developing societal resilience to disasters. If construction researchers and practitioners are to be able to contribute to reduce risks through resilient buildings, spaces and places, it is important that capacity is developed for modern design, planning, construction and maintenance that are inclusive, inter-disciplinary, and integrative. In order to address this challenge, EU funded research project, CADRE (Collaborative Action towards Disaster Resilience Education) will identify knowledge gaps, and develop an innovative professional doctoral programme (DProf) that integrates professional and academic knowledge in the construction industry to develop societal resilience to disasters. Through the development of an innovative and timely curricular and learning material, the project seeks to update the knowledge and skills of construction professionals in the industry.

Before developing the proposed DProf programme, it was important to identify the knowledge gaps in the construction industry to develop societal resilience to disasters. Accordingly, the paper aims to present the knowledge gaps that have emerged as part of this research. Capturing knowledge gaps involved, capturing the needs of various stakeholder groups associated in disaster resilience and management, as well as current and emerging skills, applicable to construction practitioners towards enhancing societal resilience to disasters. The primary and secondary data generated a long list of needs and skills. Finally, the identified needs and skills were combined 'like-for-like' to produce broader knowledge gaps. The paper provides an extensive analysis on the knowledge gaps identified through this process.

The paper begins with a literature synthesis on disaster resilience knowledge and skills. The paper then presents the analytical framework of the study. The scope of the paper is limited to findings gathered from one stakeholder group, national and local governments and therefore the paper investigates the role of the government in developing societal resilience to disasters. The paper continues with an analysis of the data gathered through semi-structured interviews based on five resilience dimensions, economic, environmental, institutional, social and technological and concludes with a list of key classifications derived from government stakeholders in enhancing the knowledge and skills of construction practitioners serving them to increase societal resilience to disasters.

2. Disaster resilience knowledge and skills

Hazards cause various disruptions to the built environment. The damage to the built environment accounts for most of the economic losses of disasters and its failure often determine the amount of fatalities (Witt et al., 2014). As such, professionals related to construction sector are expected to play a major role in mitigating such impacts of disasters. At the same time, it is the duty of the professionals attached to the construction sector, to plan, design, construct and operate necessary risk reduction infrastructure and other services to

protect the communities exposed to hazards (Malalgoda et al, 2015). As such built environment should be planned, designed, built and operated in such a way that it can withstand at a time of a disaster. Therefore it is clear that the construction industry and the built environment professions play an important role in contributing to society's improved resilience (Haigh and Amaratunga, 2010). Max Lock Centre (2009) developed a guide to demonstrate the value of using construction professionals in disaster risk reduction and response. This guide shows how the relevant professional skills and expertise can be applied at all stages of disaster management. Some of the key activities highlighted in this guide are, risk and vulnerability assessment; disaster risk reduction (DRR) and mitigation; emergency water supply and sanitation; logistical planning; relief and transitional shelters; project planning and management; design, construction and monitoring; physical condition surveys and audits; compensation packages; resource mapping; housing need assessment; land survey and acquisitions; physical planning; infrastructure planning and implementation; property rights and claims; financial planning and management; and advice on regulations and codes. Especially, poor urban planning and poorly regulated building codes have aggravated exposure to hazards (Bosher, 2014; Malalgoda et al, 2014) and as such utilising construction practices, building codes and technology that can withstand the exposure is of paramount importance (Ireni-Saban, 2012). As such it is clear that construction practitioners have a key role in DRR and management and their professional skills and expertise need to be deployed in disaster risk reduction and management. In addition to these, Norman and Binka (2015) highlighted the importance of soft skills such as leadership in building disaster resilience and response. A study conducted in Sub-Saharan Africa revealed that leadership capacities need to be strengthened through continual professional developments and formal education in order to build resilience and to improve response. It is important to understand that the disaster resilience requires efforts of various stakeholders and would require a multi-sectoral and inter-disciplinary approach (Haigh and Amaratunga, 2010). As such collaborative actions are required for a better resilience outcome (Ireni-Saban, 2012), which highlights the importance of knowledge and skills, related to collaborative working and community interactions.

Indigenous knowledge is another important aspect when it comes to DRR and resilience. According to Ireni-Saban (2012) local knowledge places a greater importance, including understanding communities at risk, including their practices, traditions, customs and beliefs. By understanding the indigenous knowledge, such as local skills and materials and how it can be successfully used and its success in coping with disasters over time (UNISDR, 2008) would undoubtedly benefit in the preparation for future disasters. However, according to Gaillard and Mercer (2012) there is a gap in integrating local and scientific knowledge because of the lack of trust between stakeholders operating at different level. As a result, contributions of local communities are often disregarded which lead to gaps between policy development at the national level and the practice at the local level. This emphasises the need of multi stakeholder approach, inclusion and empowerment.

As discussed above, various knowledge and skills are required to better perform the tasks associated with risk reduction. As such, knowledge plays a major role in disaster risk reduction and resilience (Weichselgartner and Pigeon, 2015). As a result of prominent gaps in knowledge,

Sendai Framework for Disaster Risk Reduction (2015-2030) has identified the need of enhancing the capacities of relevant stakeholders and industries. The Framework provides recommendations regarding the creation and dissemination of knowledge (Weichselgartner and Pigeon, 2015). Accordingly, the framework suggest to "build the knowledge of government officials at all levels, civil society, communities and volunteers, as well as the private sector, through sharing experiences, lessons learned, good practices and training and education on disaster risk reduction, including the use of existing training and education mechanisms and peer learning" (UNISDR, 2015). Professionals attached to construction sector play an important role in disaster resilience and management. As such, construction professionals require continuous update of knowledge and education in order to effectively contribute to disaster management (Thayaparan et al, 2014). It is therefore important to design educational and training courses to enable them to successfully fulfil this role (Witt et al., 2014). Therefore as argued by Bosher et al. (2007), risk and hazard awareness training needs to be integrated systematically into the professional training of architects, planners, engineers, developers, etc. The next section presents the analytical framework and methodology of the study.

3. Analytical Framework and methodology

The initial framework of the study is a three dimensional framework consisting of the following parameters:

Built environment stakeholders: National and local government organisations; Community; NGOs, INGOs and other international agencies; Academia and research organisations; and Private sector.

Dimensions of resilience: Economic Resilience; Environmental Resilience; Institutional Resilience; Social Resilience and Technological Resilience

Stages of property lifecycle: Preparation Stage (PS); Design Stage (DS); Pre-Construction Stage (PCS); Construction Stage (CS) and Use Stage (US)

The framework was developed through an extensive consultation process with project partners and was refined throughout the first year of the project with the emerging literature findings and the opinion of stakeholders who has been interviewed to capture the labour market demands in construction industry to increase societal resilience to disasters.

The research discussed in this paper is focussed on analysing the market demands of one of the stakeholders, national and local governments. Accordingly, the paper analyses the semi-structured interviews conducted with national and local government organisations. Semi-structured interviews were conducted with a total of twenty respondents from the "national and local government" stakeholder group across different countries and continents. The respondents identified and interviewed in this category were individuals that were attached to national and local government institutions, involved in various activities related to disaster resilience and management. The interviews were aimed at capturing the needs as well as skills, applicable to

construction professionals towards enhancing societal resilience to disasters. During the interviews, special interest and focus was given on the needs of national and local government organisations engaged in disaster resilience and management and the skills required from construction industry professionals serving them. Accordingly, the interviews were more of a discourse structured around the stages of disaster management cycle. The analysis was done using NVivo (version 10). The themes were presented under two main headings i.e. Needs and Skills. The category "Needs" covers the stakeholder requirements that emerged from the interviews as well as the demands specifically made by interviewees. Also, what the interviewees believe should be in place while professionals relate with them to enhance societal resilience were categorized under the heading "Needs" in the analysis. During the interviews, some set of skills were emerged; some were displayed by professionals while serving to reduce the threats posed by natural and human induced hazards and some that are desired by interviewees. These set of skills were categorized under the heading "Skills". All needs as well as skills were categorized into five dimensions of resilience (Social, Economic, Institutional, Environmental, Technological) and each of the dimensions of resilience is sub-headed with the five stages of property lifecycle, Preparation, Design, Pre-construction, Construction and Use stage. The interviews generated a long list of needs and skills with respect to the property lifecycle stages under the respective dimensions of resilience. Finally, the identified needs and skills were combined 'like-for-like' to produce broader level of knowledge gaps (themes).

3.1 Government as a stakeholder

A number of parties are involved in the process of increasing societal resilience to disasters, including community and citizens' groups, local governments, the private/corporate sector, the national government, civil society organisations, external actors, professional groups and the media. There should be adequate coordination among the interested parties in order to overcome the challenges posed by a disaster, successfully. Between these stakeholders, a government of a country plays a predominant role. All activities related to disaster management are usually centred at governmental level, and hence, governments can be identified as the principal stakeholder in disaster management (Moe and Pathranarakul, 2006). Usually the government assigns the responsibility for each task to different ministries or may form new authorities or committees and assign the responsibility for different tasks to these authorities or committees (Wolensky and Wolensky, 1991). To be successful, proper partnerships and cooperation are essential between local and national governments and civil society in order to reduce the costs of risk reduction, ensure local acceptance and build social capital (UN-ISDR, 2010). Recent literature highlight administrative shortcomings that prevent affected communities recovering from disasters (Ireni-Saban, 2012). In overcoming these challenges, government require professional services from the construction professionals to prevent, mitigate, prepare and recover from disasters. According to Bosher (2014) number of structural and operational obstacles does exist in making the built environment resilient to disasters and lack of knowledge and skills were key among others especially in developing country context (Malalgoda et al, 2014). Thus, it is very important to identify the knowledge gaps and develop educational programmes to cater the identified knowledge gaps. The next section analyses the data gathered through semi-structured interviews.

4. Data analysis and discussion

4.1 Economic Resilience

According to Seneviratne et al (2010) economic factors are two-fold, economic planning measures and financial measures. Aspects relating to production, distribution and consumption of goods and services are considered as economic planning measures and aspects relating to money and management of monitory assets are considered under financial measures. In terms of economic resilience, most of the interviewees identified the gaps in business continuity management. Some of the key highlights within this theme were business continuation strategies and business continuation plans. Having a business continuation strategy/plan is of paramount importance in order to make sure that business is up and running after a disaster. Local authorities have a responsibility to promote business continuity to businesses and the interviewees considered this as a key knowledge area within the domain of disaster resilience. Financing, budgeting and estimating was another key theme identified under economic resilience. This covers number of sub-themes such as, sourcing of funds, investment appraisals, construction budgets, cost control, contingency management, financial management relation to disaster resilience and, transparency and accountability. Damage assessments and claims is another important theme highlighted by the interviewees. Under this theme, interviewees highlighted the importance of knowledge and skills related to, property insurance, damage assessments, valuation, and compensation for damages. This include, assessing what damage has the disaster caused and what works need to be done to get back to pre-disaster condition and what further work could be done to prevent or reduce the risk of happening it again. Process and quality management was also categorised under economic resilience as it highlighted the importance of resource management and prioritising work. In particular, prioritisation of work is very much relevant in the context of disaster resilience due to the restricted budgets. Thus, identifying the most critical activities and prioritising projects is very important in implementing DRR projects. Resource management and prioritisation also has a link to the next theme, which is social and cultural awareness. Interviewees highlighted the importance of the use of local knowledge, skills and materials and emphasised the necessity of deploying economically feasible and socially acceptable solutions that would enhance societal resilience to disasters. Another theme was the contracts and procurement. Interviewees argued the importance of knowledge and skills with regard to different procurement strategies which facilitate rapid restoration; different forms of contracts such as nec3 option G which allows instructing task orders during incidents; framework contracts for incident management works; and rapid response of supply chain. All these are formed under the theme, contracts and procurement. Table 1 highlights all themes derived in relation to economic resilience and their relevance to different stages of property life cycle.

Table 1: Themes for economic resilience

		Property lifecycle stages				
No.	*Classifications*	*PS*	*DS*	*PCS*	*CS*	*US*
1	*Business continuation management*	*x*	*x*		*x*	*x*
2	*Financing, budgeting and estimating*	*x*	*x*	*x*	*x*	*x*

3	*Damage assessment and claims*	*x*			*x*	*x*
4	*Process and quality management*	*x*	*x*	*x*	*x*	*x*
5	*Social and cultural awareness*	*x*	*x*	*x*	*x*	*x*
6	*Contracts and procurement*			*x*		
7	*Construction and project management*	*x*	*x*	*x*	*x*	*x*
8	*Consultancy services in relation to constructions*	*x*	*x*	*x*	*x*	*x*
9	*Resilient buildings and infrastructure*	*x*	*x*		*x*	*x*
10	*Disaster management and planning*	*x*	*x*	*x*	*x*	*x*
11	*Disaster risk and need assessment*	*x*	*x*	*x*	*x*	*x*
12	*Knowledge management*	*x*	*x*	*x*	*x*	*x*
13	*Time management*	*x*	*x*	*x*	*x*	

4.2 Environmental Resilience

Factors relating to environment, ecology and sustainability were considered under environmental resilience. Similarly, analysis of semi-structured interviews facilitated deriving number of themes for environmental resilience. Each of these themes was derived from various needs and skills identified by the interviewees. One of the key themes identified under this category was the risk and need assessment. This theme was identified as a result of sub themes such as, preventive structures, identifying vulnerable population and properties, hazard and risk mapping, identifying suitable places for relocation and, forecasting and warning. In doing so, it is very important that community know that they are at risk, so that they will be more engaged and will be willing to take action. For an instance, they can equip with property level protection, for an example, in the case of floods, they can install floodgates for their doors and windows and flaps for inlets and vents into their houses. The theme, knowledge management arise based on interviewees arguments on the need for, access to related data and information and access to required software and technology such as GIS. Lack of data and information is a prevailing issue especially for more remote areas. These include, lack of hazard and risk maps, water tables, soil types, rainfall data, geological data etc. Under environmental management, interviewees highlighted the need of understanding and managing the environmental impacts, which trigger disasters, forecasting, early warning, weather and climate change, use of resilient designs, materials and construction techniques, environmental impact assessments and local topography. Materials and resource management also plays a role in environmental resilience. Accordingly, interviewees highlighted the importance of having the knowledge of resilient and environmentally friendly materials and other resources in order to enhance the environmental resilience. For an example, one interviewee highlighted the importance of selecting materials to match the location, climate, and soil types while another highlighted the importance of resource management to reduce the wastage. Sustainability and resilience is yet another important theme identified under environmental resilience. It covers number of sub themes such as, sustainable design solutions, selection and use of sustainable materials and technologies and ensuring sustainability of resilient solutions. Table 2 highlights all themes derived in relation to environmental resilience and their relevance to different stages of property life cycle.

Table 2: Themes for environmental resilience

No.	Classifications	Property lifecycle stages				
		PS	DS	PCS	CS	US
1	Disaster risk and need assessment	x	x	x	x	x
2	Knowledge management	x	x	x	x	x
3	Environmental impact assessment and management	x	x		x	x
4	Materials and resource management	x	x	x	x	
5	Sustainability and resilience	x	x	x	x	x
6	Building codes, regulations and planning	x	x	x	x	x
7	Resilient buildings and infrastructure	x	x		x	x
8	Disaster management and planning	x	x	x	x	x
9	Health and safety	x	x		x	x
10	Process and quality management	x	x	x	x	x
11	Social and cultural awareness	x	x	x	x	x
12	Teaching and research on disaster resilience and management	x	x	x	x	x
13	Time management	x	x	x	x	
14	Town and country planning	x				

4.3 Institutional resilience

Institutional resilience, as defined in this paper refers to the political, legal and institutional factors. Aspects relating to government and policies are considered as political factors; aspects relating to law, accepted rules and regulations in managing disasters are considered under legal factors; aspects relating to an organisation linked to disaster management are considered under institutional factors (Seneviratne et al, 2010). As shown in Table 3, various themes were identified in relation to enhancing institutional resilience. One of the key themes identified was stakeholder management. Stakeholder management was derived from a combination of responses given by the interviewees. Some of these include, multi stakeholder engagement, appropriate institutional arrangements, clear definitions of roles and responsibilities, coordination between different organisations, collaborative working, relationship with other stakeholders and communities, commitment to disaster management and resilience. This theme further incorporated the interviewees' responses such as communication skills, team working and management and leadership skills. Legal frameworks and compliance is another key theme under institutional resilience. This theme incorporated sub themes such as, policies, plans and legal frameworks for disaster resilience, disaster risk reduction strategies, knowledge on prevailing laws and implementation of laws and regulations. Leadership and people management has been identified as a separate theme as it was a concern for most of the respondents. However, this has a close link to the theme, stakeholder management, and include, sub themes such as multi stakeholder engagement, understanding community needs, engaging communities, collaborative working, conflict management, leadership skills, people management skills, commitment for disaster risk reduction and proactive thinking. Governance is yet another important theme classified under institutional resilience. The theme was derived from number of sub themes, such as, institutional arrangements for disaster resilience;

commitment to disaster risk reduction; coordination between stakeholders; and policies, plans and legal frameworks for disaster resilience.

Table 3: Themes for institutional resilience

No.	Classifications	Property lifecycle stages				
		PS	DS	PCS	CS	US
1	Stakeholder management	x	x	x	x	x
2	Legal frameworks and compliance	x	x	x	x	x
3	Leadership and people management	x	x	x	x	x
4	Governance	x	x	x	x	
5	Building codes, regulations and planning	x	x	x	x	x
6	Business continuation management	x	x		x	x
7	Communication	x	x	x	x	x
8	Contracts and procurement			x		
9	Damage assessment and claims	x			x	x
10	Knowledge management	x	x	x	x	x
11	Resilient buildings and infrastructure	x	x		x	x
12	Disaster management and planning	x	x	x	x	x
13	Disaster risk and need assessment	x	x	x	x	x
14	Environmental impact assessment and management	x	x		x	x
15	Human resource management	x	x	x	x	x
16	Process and quality management	x	x	x	x	x
17	Project and construction management	x	x	x	x	x
18	Teaching and research on disaster resilience and management	x	x	x	x	x
19	Team working	x	x	x	x	x
20	Time management	x	x	x	x	
21	Town and country planning	x				
22	Transparency and accountability	x	x	x	x	x

4.4 Social resilience

Social resilience was defined based on Cacioppo et al (2011) definition for social resilience, which is revealed by capacities of individuals, or groups, to foster, engage in, and sustain positive social relationships and to endure and recover from disasters. Similar to previously identified resilience dimensions, number of themes was also derived under social resilience dimension. Community empowerment is the most noted theme under social resilience. In terms of community empowerment, interviewees highlighted the importance of community engagement and participation, maintaining or re-establishment of community relationships, working with the community, understanding community needs, empowering community and social cohesion. Especially in multi-cultural societies, communities aren't always engaged or integrated, however after an incident community relationship grow stronger and participate more willingly. Team working is also an important theme identified under social dimension which includes, collaborative working, working with the community, understanding community needs, effective involvement of the community and team working. Communication was classified as a separate theme due to the importance placed by the interviewees on communication. Communication skills are especially required when dealing with disaster-

affected communities, to understand their emotional and psychological conditions and to avoid any further harm. Sometimes it is difficult to convince the vulnerable population to take preventive action due to cost, time and other constraints. As such, good communication skills are of paramount importance to ensure that they understand the risk and act upon to reduce it. Another important theme derived under social dimension is the social and cultural awareness. This incorporated interviewees' responses such as the importance of the use of local knowledge and skills, use of local businesses for repairs and reconstructions, and selection of approaches suitable to local context. Table 4 highlights all themes derived in relation to social resilience and their relevance to different stages of property life cycle.

Table 4: Themes for social resilience

		Property lifecycle stages				
No.	*Classifications*	*PS*	*DS*	*PCS*	*CS*	*US*
1	*Community empowerment*	*x*	*x*		*x*	*x*
2	*Team working*	*x*	*x*	*x*	*x*	*x*
3	*Communication*	*x*	*x*	*x*	*x*	*x*
4	*Social and cultural awareness*	*x*	*x*	*x*	*x*	*x*
5	*Building codes, regulations and planning*	*x*	*x*	*x*	*x*	*x*
6	*Business continuation management*	*x*	*x*		*x*	*x*
7	*Consultancy services in relation to constructions*	*x*	*x*	*x*	*x*	*x*
8	*Damage assessment and claims*	*x*			*x*	*x*
9	*Resilient buildings and infrastructure*	*x*	*x*	*x*	*x*	*x*
10	*Disaster management and planning*	*x*	*x*	*x*	*x*	*x*
11	*Disaster risk and need assessment*	*x*	*x*	*x*	*x*	*x*
12	*Emergency shelter management*	*x*	*x*		*x*	*x*
13	*Environmental impact assessment and management*	*x*	*x*		*x*	*x*
14	*Financing, budgeting and estimating*	*x*	*x*	*x*	*x*	*x*
15	*Health and safety*	*x*	*x*		*x*	*x*
16	*Knowledge management*	*x*	*x*	*x*	*x*	*x*
17	*Leadership and people management*	*x*	*x*		*x*	*x*
18	*Legal frameworks and compliance*	*x*	*x*	*x*	*x*	*x*
19	*Post project audits*		*x*		*x*	
20	*Process and quality management*	*x*	*x*	*x*	*x*	
21	*Stakeholder management*	*x*	*x*	*x*	*x*	*x*
22	*Sustainability and resilience*	*x*	*x*	*x*	*x*	*x*
23	*Teaching and research on disaster resilience and management*	*x*	*x*	*x*	*x*	*x*
24	*Time management*	*x*	*x*	*x*	*x*	

4.5 Technological resilience

The final dimension of resilience was about technological resilience. This includes "application of scientific advances including any tool, technique, product, process and method to benefit disaster management" (Seneviratne et al, 2010). In terms of technological resilience, number of themes was identified and this section highlights the key themes identified under this dimension of resilience. The first theme identified was building codes, regulations and planning. This was derived from the sub themes, awareness of property related regulations and policy, knowledge

of construction codes for different properties, knowledge on planning and building regulations and knowledge of planning permissions. In supporting this, one of the interviewees stated, "one of the things that put people and businesses at more risk than anything is permitted developments within flood plains and close to rivers". Land next to rivers and next to water causes or flood plains are relatively cheaper, however, it is important to influence planners and decision makers to not to allow any developments within flood plains. The next theme identified under this was the resilient buildings and infrastructure. This theme covered a variety of sub themes such as, resilience planning, designing and construction, advice and guidance on design and construction of resilient structures, monitoring and supervising the construction and operation of resilient structures, use of resilient construction processes and techniques, development of resilient transport networks, identifying vulnerable population and properties, understanding impacts of disasters on the built environment, addressing disaster resilience in preparation and design stages, proactive approaches to disaster risk reduction or pre-disaster management, build back better and development of preventive structures and methods. There are so much that can be done to prevent or mitigate disasters, for an example, to manage flood risk, some of the things that can be done are, flood walls, embankments, storage areas and flood gates and vent protection to protect individual properties. Project and construction management is a combination of sub themes such as knowledge and experience of construction technology, knowledge of construction codes for different properties, resource management and monitoring and supervising the construction and operation of resilient structures. Table 5 highlights all themes derived in relation to technological resilience and their relevance to different stages of property life cycle.

Table 5: Themes for technological resilience

No.	*Classifications*	*Property lifecycle stages*				
		PS	*DS*	*PCS*	*CS*	*US*
1	*Building codes, regulations and planning*	*x*	*x*	*x*	*x*	*x*
2	*Resilient buildings and infrastructure*	*x*	*x*	*x*	*x*	*x*
3	*Project and construction management*	*x*	*x*	*x*	*x*	*x*
4	*Knowledge management*	*x*	*x*	*x*	*x*	*x*
5	*Disaster management and planning*	*x*	*x*	*x*	*x*	*x*
6	*Disaster risk and need assessment*	*x*	*x*	*x*	*x*	*x*
7	*Emergency shelter management*	*x*	*x*		*x*	*x*
8	*Environmental impact assessment and management*	*x*	*x*		*x*	*x*
9	*Materials and resource management*	*x*	*x*	*x*	*x*	
10	*Process and quality management*	*x*	*x*	*x*	*x*	
11	*Social and cultural awareness*	*x*	*x*	*x*	*x*	*x*
12	Sustainability and resilience	x	x	x	x	x
13	Teaching and research on disaster resilience and management	x	x	x	x	x

5. Conclusions

A number of needs and skills were identified in respect to various resilience factors and property life-cycle stages. Finally, labour market needs and skills with respect to resilience

dimensions across property life stages were filtered to generate a total list of 33 knowledge gaps. 13 (out of 33) gaps emanated from labour market needs and skills under economic resilience with their respective property lifecycle stage. 14 (out of 33) gaps originated from labour market needs and skills under environmental resilience. 22 (out of 33) gaps emanated under institutional resilience. 24 (out of 33) gaps derived under social resilience, and 13 (out of 33) gaps produced under technological resilience. It is evident that more gaps were derived from social resilience, followed by institutional resilience. The paper analysed the knowledge gaps in the construction industry to develop societal resilience to disasters from the perspective of national and local government stakeholders. The paper was based on an EU funded project, CADRE (Collaborative Action towards Disaster Resilience Education) and as part of the project similar studies were conducted to obtain the views of other stakeholders, such as community, private sector, academia and non governmental organisations. Finding of all stakeholders were collated to derive a comprehensive list of knowledge gaps and at the next phase of the research it is expected to validate these findings through stakeholder seminars. Finally, it is intend to develop a professional doctorate to cater the identified knowledge gaps.

6. Acknowledgements

CADRE research project has been funded with support from the European Commission. This publication reflects the views only of the authors, and the Commission cannot be held responsible for any use, which may be made of the information contained therein.

References

Bosher L, Dainty A, Carrillo P, Glass J. and Price A. (2007) "Integrating disaster risk management into construction: a UK perspective." *Building Research and Information*, **35**: 163-177.

Bosher L (2014) "Built-in resilience through disaster risk reduction: operational issues." *Building Research and Information* **42(2)**: 240-254.

Cacioppo J.T, Harry T.R and Zautra A.J (2011) "Social resilience: The Value of Social Fitness with an Application to the Military." *American Psychologist* **66**: 43-51.

Gaillard J.C and Mercer J (2012) "From knowledge to action: Briding gaps in disaster risk reduction", *Progress in Human Geography* 1-22.

Haigh R. and Amaratunga, D. (2010) "An integrative review of the built environment discipline's role in the development of society's resilience to disasters." *International Journal of Disaster Resilience in the Built Environment*, **1(1)**: 11-24.

Ireni-Saban L (2012) "Challenging disaster administration: towards community-based disaster resilience." *Administration & Society* **45(6)**: 651-673.

Malalgoda C, Amaratunga D and Haigh R (2014) "Challenges in creating a disaster resilient built environment", *Proceedings of the fourth International Conference on Building resilience*, 8-10 September 2014, Salford Quays, UK.

Malalgoda C, Keraminiyage K, Amaratunga D, Haigh R, Perera S and Adeniyi O (2015) "Professional doctorates: applicability to the construction industry in increasing societal resilience to disasters", In: Mackee, J., Giggins, H. & Gajendran, T. (eds.) 5th International Conference on Building Resilience, Newcastle, Australia.

Max Lock Centre (2009) *The Built Environment Professions in Disaster Risk Reduction and Response - A guide for humanitarian agencies*, Westminster, UK.

Moe T.L and Pathranarakul P (2006) "An integrated approach to natural disaster management-public project management and its critical success factors", *Disaster prevention and management* **15(3)**: 396-413.

Norman I.D and Binka F.N (2015) "Leadership abilities, skills and knowledge in building disaster resilience and response", *Issues in Business Management and Economics* **3(3)**: 45-58.

Seneviratne K, Amaratunga D, Haigh R and Pathirage, C (2010) "Knowledge management for disaster resilience: identification of key success factors" *Proceedings of the CIB World Congress 2010*, 10-13 May 2010, Salford, United Kingdom.

Thayaparan M, Malalgoda C, Keraminiyage K, Amaratunga D (2014) "Disaster Management education through Higher Education – Industry Collaboration in the Built Environment", *Proceedings of the fourth International Conference on Building resilience*, 8-10 September 2014, Salford Quays, UK.

UNISDR (2008) *Ingenious knowledge for disaster risk reduction: Good practices and lessons learned from Experience in the Asia Pacific Region*, Bangkok, UNISDR.

UN-ISDR (2010) *Local governments and disaster risk reduction***,** (available online http://www.unisdr.org/preventionweb/files/13627_LocalGovernmentsandDisasterRiskRedu.pdf [accessed on 28/04/2010]).

UNISDR (2015) *Sendai Framework for Disaster Risk Reduction 2015 – 2030*, Geneva, Switzerland: UNISDR.

Witt E, Bach C, Lill I, Palliyaguru R, Perdikou S and Ozmen F (2014) "Determining Demand for Disaster Resilience Education through Capacity Analysis of European Public Authorities", *CIB INTERNATIONAL CONFERENCE 2014: W55/65/89/92/96/102/117 & TG72/74/81/83 Construction in a Changing World*, Kandalama, Sri Lanka.

WeichselgartnerR.P and Wolensky K.C (1991) "American local government and the disaster management problem." *Local Government Studies* **17(2)**: 15-32.

Wolensky J and Pigeon P (2015) “The role of knowledge in disaster risk reduction.” *International Journal of Disaster Risk Science* **6(2)**: 107-116.