Developing maturity levels for flood resilience of businesses using built environment flood resilience capability areas

Abstract

The inability of organisations to adequately assess climate risk, understand and execute necessary actions contribute significantly to the increase in economic loss from disasters. This is a threat to business resilience and sustainability of the society. Hence, resilience capabilities of organisations need to be improved, and there should be a way of assessing these capabilities. This paper focuses on the methodology adopted and the maturity model produced by utilising Capability Maturity Model (CMM) concept to develop a capability maturity assessment method for built environment flood resilience of micro, small and medium-sized enterprises (MSMEs). Capability areas obtained from literature were refined and carefully mapped to maturity level characteristics obtained from studies on capability maturity, and a conceptual model was produced. The conceptual model was subsequently refined and validated via expert forum and case studies. The study produced a maturity model for assessing flood resilience capability maturity of businesses, and technically provides an outline of steps for improving flood resilience of business premises.

Introduction

Generally, sustainability aims to ensure the satisfaction of the needs of the current generation as well as the next generation by protecting natural and built environment and taking care of continuity of human beings and natural resources (Osso *et. al*., 1996). Sustainability is a multi-dimensional system which aims to enhance peoples' quality of life and the condition of nature. This is done by ensuring valuable bonds among people through cooperation and social support, preservation of economic status and effective use of natural resources (Hoúkara, 2007; Oktay, 2005). These targets are often threatened by hazards such as flood leading to a disruption in the social, economic and environmental wellbeing of individuals and organisations. To mitigate the disruption, one of the goals of organisations should be the successful management and survival of crises (Grewal & Tansuhaj, 2001; Lalonde, 2011; O'Regan & Ghobadian, 2004). Towards achieving goals, specific sets of capabilities are required for coordinating a set of activities (Yen-Tsang, Csillag, and Siegler, 2012). These capabilities are combination of competencies, skills, resources, strengths, and societal networks used to coordinate a set of activities to achieve particular goals (UNISDR, 2009; Yen-Tsang *et al.*, 2012), which includes disaster resilience. UNISDR (2009) submitted that capacity can also be referred to as capability. Khan, Vasilescu, and Khan (2008) defined capacity as resources, means and strengths which enable a system to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster. In the context of natural disasters and property flood resilience, these capabilities include structural measures, non-structural measures, knowledge base, skills, facilities, and networks among others (UNISDR, 2009). The effective utilisation of these capabilities will reduce damage to the built environment from disasters by ensuring better resistance to flood hazard among others and faster return to operation of businesses, that is, enhance resilience. This will surely help the economic, social and environmental condition of organisations. It should be noted that the resilient ability of a system, property, or facility is beyond the physical characteristics of the facility alone but also the use, users, management and the attributes of external stakeholders (Labaka, Hernantes, & Sarriegi, 2015). Bosher (2008) and UN ESCAP and AIT (2012) underpins the above submission by declaring the need to build capabilities for property resilience beyond physical attributes of the property (Micro, small and medium-sized enterprises - MSMEs inclusive).

Currently, the loss resulting from flood damage to premises and stocks of MSMEs is alarming. In 2012 alone, flooding affected about 8,000 properties in the United Kingdom (RICS, 2015); and insurers paid

out a sum of £373 million in claims for flood damage to business properties and paid business interruption claims to the value of £40 million (ABI, 2013). Interestingly, climate change has been projected to lead to an increase in riverine flooding across the whole of Europe (Kundzewicz *et al.*, 2010). To forestall further damage and loss, it is important to build flood resilience capability around all the factors influencing built environment flood resilience. Early warning systems have proved reasonably helpful in reducing mortality rate from natural disasters, since it ensures a timely movement of people from an area when disaster is imminent. However, since the built environment or properties cannot be entirely moved away before a disaster strikes, early warning systems are less effective. According to Lawrence and Low (1990) the built environment is an abstract concept that describes the results of human building activity, which includes any physical alteration to the natural environment. The term "built environment" refers to the premises of businesses in this study. As a result of the growing need for a reduction in the impact of flood disasters, researchers have discussed mitigation measures (Asgary, Anjum, & Azimi, 2012; Bhattacharya-Mis & Lamond, 2014; CIRIA, 2010; Crichton, 2006, 2008; Ingirige, Wedawatta, & Amaratunga, 2010; Kulatunga, Wedawatta, Amaratunga, Parvez, & Biswas, 2012; Lamond & Proverbs, 2009). Stephenson (2010) and Stephenson, Vargo & Seville (2010) identified general principles for organisation resilience; White, O'Hare, Lawson, Garvin & Connelly (2013) outlined some steps to property flood resilience; Marjaba & Chidiac (2016) conducted a review on sustainability and resiliency of buildings and Kontokosta and Malik (2018) focused on benchmarking of neighbourhood resilience. Interestingly, none of these studies adopted capability maturity modelling concept and none focused on businesses and built environment flood resilience. Capability maturity models (CMM) are useful for capability maturity assessment, benchmarking and improvement (Babatunde, Perera, & Zhou, 2016; Eadie, Perera, & Heaney, 2012; Macgillivray, Sharp, Strutt, Hamilton, & Pollard, 2007; Paulk, Curtis, Chrissis, & Weber, 1993; Sarshar *et al.*, 2000; Yeo & Ren, 2009). The concept has been considered for process improvement in some fields and organisations. This study concentrates on the methodology for developing a capability maturity assessment model for built environment flood resilience at the organisation level with a focus on micro, small and medium-sized enterprises (MSMEs). The focus on MSMEs is based on its significance to the economy and its importance to societal and environmental resilience.

Literature review

Flooding, MSMEs, and flood resilience capability areas

Flood is a hazard that has resulted in huge damage to MSMEs (Woodman, 2008). According to DEFRA (2014) cited in RICS (2015) flood refers to water entering a property at the ground, below or above ground level from an external source. Water entering from above the ground level must have part of its body at ground level (RICS, 2015). The Royal Institute of British Architects identified six mechanisms of flooding (RICS, 2015), namely, tidal, fluvial, ground water, pluvial, flooding from sewers, and flooding from human-made infrastructures. Tidal flood is experienced when flood barriers are breached due to sea level rise (Dahl *et al*, 2017). Similarly, river flood is occasioned by rise in river level and low water absorption of the ground (Barredo, 2007) while fluvial flooding occurs when the capacity of a watercourse is exceeded because of occurrences such as rainfall, snow, and ice melt (RICS, 2015). A groundwater-related flood occurs when there is a rise in groundwater level while pluvial flooding, also called surface water flooding occurs when rainwater runs off on lands with a low rate of absorption (RICS, 2015). Pluvial flooding accounts for over half of the flooding experienced in the UK annually (RICS, 2015); while other flooding mechanisms are largely responsible for flooding in some other locations also (Penning-Rowsell *et al.*, 2005). Contents and buildings insurance policy have been a defence option from flooding for businesses, but the recent spate of disasters is stressing the insurance industry. There is also a problem of insurance penetration in some countries (Mahul & Gurenko, 2006).

Recent policy changes in the insurance industry as well as increase in premium rates, is a source of concern to property owners (RICS, 2015). Due to the above difficulties, it is imperative to support and build flood disaster resilience. This will reduce the pressure on the insurance industry and aid the mitigation of loss from flood events.

According to CSES (2012) and Ward & Rhodes (2014), micro-businesses are business organisations with 0-9 employees; small-sized enterprises are businesses with 10 – 49 employees; medium-sized enterprises are businesses with 50 – 249 employees; and large businesses are those with more than 250 employees. MSMEs make up 99.8% of private sector business enterprises and provided about 67.1% of private sector jobs in Europe (European Commission, 2008). In 2014, 5.2 million MSMEs (MSMEs – 0 to 250 employees) and 5 million micro-businesses were estimated to be in the UK, and this resulted in MSMEs accounting for 99% of UK businesses and about 60.1% of employment (Ward & Rhodes, 2014). MSMEs are largely essential to the well-being of several economies; and obviously, their failure will have a huge impact on these economies. MSMEs are large employers of labour and their activities feed into the broader market (Dalberg, 2011 cited in UNISDR, 2013). Currently, MSMEs are regarded to be highly vulnerable to disruptions because of the limited human and financial resources available to them and limited risk management capability (Bannock, 2005; UNISDR, 2013). While some organisations have identified the need to build resilience, the inadequate in-house capacity to assess and understand risks, and after that implement essential measures is still a challenge (PwC, 2013; Sapountzaki, 2005). There is, therefore, a need for a maturity model for built environment flood resilience capability assessment, benchmarking and improvement. This will provide a methodic guide for self-assessment of capabilities, flood resilience planning and decision making in organisations, and guide the implementation of essential flood resilience enhancement measures.

To achieve the aim of this study, twenty-six capability areas were identified from literature on organisation resilience, infrastructure resilience, flood risk management, extreme weather events, organisation assets, business continuity management among others. The capabilities were subjected to a multi-stage assessment and verification exercise. The verification exercise involved flood risk management experts, property-level flood resilience experts, insurance experts among others. The full list of capabilities and the details of the verification process are presented in a separate work (Adeniyi, 2017) while the consolidated list (used in developing the capability maturity model in this study) is presented in Table 1. The capabilities cover necessary knowledge base, skills, networks, structural and non-structural requirements for enhancing flood resilience.

<<<Table 1 Strategic Capability Areas for enhancing built environment flood resilience (Adeniyi, 2017)>>>

A review of the capability maturity model concept which was adopted in this study is presented in the next section.

Capability maturity model (CMM) concept

The maturity of a process is defined as "the extent to which a specific process is explicitly defined, managed, measured, controlled, and effective" (Paulk *et al.*, 1993). It is ideal to submit that the degree of effectiveness of the steps in a process determines the suitability of the result. Dooley, Subra, and Anderson (2001) defined the maturity of a process as “the extent to which the process is explicitly

defined, managed, measured, and continuously improved". Basically, 'capability maturity' is simply the extent to which capabilities or abilities on specific tasks in a process is defined, managed, measured, controlled, and effective. The concept of 'Capability Maturity Model (CMM)' was coined by Paulk *et al.*, (1993), the study describes five stages of growth involved in software development process. The stages of growth are referred to as maturity levels. Subsequently, the act of carving maturity levels in line with the template of Paulk *et al.*, (1993) is being called capability maturity modelling. The concept of maturity modelling has been deployed by a number of previous researchers and their works have been used in organisations and published in reputable referred journals as well as conferences (Babatunde *et al.,* 2016*;* Eadie *et al.,* 2012, MacGillivray *et al.,* 2007; OGC, 2004, Paulk *et al.,* 1993; Sarshar *et al*., 2000; Yeo & Ren, 2009). The previous areas of application include project management, facilities mangement, e-sourcing, people management among others. Saleh and Alshawi (2005) stated that there are two types of normative models (i.e. Models that can be used to evaluate performance, they provide a standard on the appropriate mode of executing a task or attaining a status). The types are maturity based normative model and non-maturity based normative model. Examples of maturity based normative models are CMM, People-CMM, Trillium among others while examples of non-maturity-based ones are ISO standards for process consolidation and certification and Balanced Scorecard (Saleh and Alshawi, 2005). Summarily, a Capability maturity model outlines the key practices that describe the respective successive levels of maturity in the context for which it was developed. It reveals improvement strategies and helps to describe current capabilities and performance improvement options (Yeo & Ren, 2009).

The Capability Maturity Model (CMM) developed by Paulk *et al.* (1993) eventually metamorphosed to Capability Maturity Model Integration (CMMI) (SEI, 2010). The CMMI emerged because of complications encountered in applying multiple models across an organisation. The complications include the need for training on several maturity models, overlaps, and some sort of confusions resulting from duplications (SEI, 2010). The CMM remains theoretically viable and therefore valid for deployment for research or other purposes. CMMI provides a stepwise evaluation of the status of an organisation as well as guidelines for improvement (SEI, 2010). CMMI has been adopted by a number of researchers in various fields (e.g., Eadie, Perera, & Heaney, 2011; Eadie *et al.*, 2012; Keraminiyage, Amaratunga, & Haigh, 2007a; Sarshar *et al.*, 2000; Sun, Vidalakis, & Oza, 2009).

CMMI covers 22 process areas that are a cluster of related practices classified into four categories – process, project management, engineering and support (SEI, 2010). Each process area consists of related practices and these practices are directed towards fulfilling the desired goal (SE1, 2010). Some basic features, such as a commitment, ability, the performance of activities, measurement/evaluation and analysis, and verification, describe the implementation of key process areas (SE1, 2010). The CMMI comprises of maturity levels presented in a progressive manner containing process improvement criteria across the levels (Eadie *et al.,* 2012; Perera and Rodrigo, 2017; SEI, 2010). There are five maturity levels presented in a stepwise progressive manner and labelled as 1 to 5, where 1 represents 'Initial', 2 represents 'Managed', 3 represents 'Defined', 4 represents 'Quantitatively managed', and 5 represents 'Optimising'. In summary, the CMMI contains four categories made up of 22 process areas, each of which has a purpose and is characterised by generic goals and generic practices as well as specific goals and specific practices (SE1, 2010). The CMMI and the original CMM were utilised in naming the maturity levels and defining the capability level characteristics of each maturity level in this study. The generic and specific goals and practices in the CMM/CMMI were carefully mapped in the context of flood resilience to the verified capability areas for enhancing flood resilience.

A brief description of capability maturity levels is presented below; and the details of maturity level characteristics are presented in Table 2 to Table 6.

- Level 1 – Adhoc (referred to as 'Initial' in CMMI) - The process is best described as ad hoc and it is occasionally chaotic. Only a few processes are defined and success depends on individual effort (Paulk et al., 1993; Yeo & Ren, 2009).

- Level 2 – Repeatable (referred to as 'Managed' in CMMI) - This level is named repeatable, there are project management processes to track cost, schedule and functionality. There are process disciplines aimed at assisting a repeat of success on similar projects (Paulk et al., 1993; Yeo & Ren, 2009).

- Level 3 – Defined (referred to as 'Defined' in CMMI) - At this level, activities are standardised, documented, moulded into a standard process. The standard organisation processes are applied on all projects (Paulk *et al*., 1993; Yeo & Ren, 2009).

- Level 4 – Managed (referred to as 'Quantitatively managed' in CMMI) - Process and product quality are measured and documented; they are well understood and controlled in quantitative terms (Paulk *et al*., 1993; Yeo & Ren, 2009).

- Level 5 – Optimizing (referred to as 'Optimizing' in CMMI) - The processes are improved continuously using quantitative feedbacks and innovative skills. Concepts and best practices are embedded in all legal and operational frameworks (Paulk *et al.*, 1993; Yeo & Ren, 2009). In this study, efforts were made to extract only the characteristics of maturity levels that are relevant to the maturity definitions for built environment resilience capability. The code ML1In/C1 reads "Maturity level 1, Adhoc, Capability 1" and ML2Re/C2 reads "Maturity level 2, Repeatable, Capability 2" and so on.

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Table 2. Characteristics of maturity level 1 – Ad-hoc

Table 3 Characteristics of maturity level 2 – Repeatable

Table 4 Characteristics of maturity level 3 – Defined

Table 5 Characteristics of maturity level 4 – Managed

Table 6 Characteristics of maturity level 5 – Optimizing

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How the extracted characteristics (<<<<<<<<<<<<<

Table 2 to Table 6) were used is discussed in the research method section. The summary provided by Alshawi *et al.,* (2005) provides a guide to requirements for progression through the maturity levels. Alshawi's submissions are adapted for this study and presented as follows. Progression from Level 1 (Ad hoc) to Level 2 (Repeatable) requires achieving some specific goals and undertaking basic practices. Movement from Level 2 to Level 3 (Managed) requires the institutionalisation of some managed process and activities, which includes planning, provision of resources, training provision, the involvement of relevant stakeholders, monitoring and control and evaluation of adherence among others. Similarly, moving from level 3 to Level 4 (Defined) requires the institutionalisation of defined processes, which includes the collection of improvement information. Progression from Level 4 to Level 5 (Optimizing) requires quantitative management, stabilisation of procedure, and continuous

improvement of process or capability. It is clear from the explanations above that the sophistication expected for progression increases from each lower to a higher level. The maturity level definitions will allow an organisation to identify its current status and a view of the characteristics in a succeeding level reveals the steps required for attaining that higher maturity level. Practically, what is needed for progression to a succeeding level is the accomplishment of the characteristics listed in that specific succeeding maturity level.

Research method

Case study and expert forum strategies were adopted in this study. The case study and expert forum strategies permit deep inquiry into the phenomenon being researched. Multiple case studies of MSMEs were undertaken, and case study interviews were adopted as the data collection method. Compared to the single case study method, multiple case studies enhance the generalizability and reliability of a research study (Flick, 2014; Yin, 2014). This study commenced by utilising a set of capabilities for enhancing the flood resilience of the built environment to develop a conceptual capability maturity model. A conceptual model graphically describes the constructs and variables as well as the relationship between them in a proposed research; and it could be rudimentary, elaborative or common-sensical, theory-driven, literature-driven, descriptive or even casual (Miles & Huberman, 1994; Yin (2003)). Miles and Huberman (1994) further argued that the development of a conceptual structure is iterative and it is sure to be re-examined and updated. In this study, a conceptual model was developed by mapping/aligning the maturity level characteristics of the capability maturity model (<<<<<<<<<<<<<

Table 2 to Table 6) with the identified capability areas (Table 1). The concept of mapping the characteristics of maturity levels of an existing capability maturity model to process areas or capability areas have been adopted by some previous researchers (Babatunde, Perera, & Zhou, 2016; Macgillivray *et al.*, 2007). The mapping process involves the alignment of capability maturity level characteristics of existing maturity model(s) (Table 2 to Table 6) with defined capability areas in a new area (Table 1) to form capability maturity level characteristics in that new area (Table 10), this is referred to as a mapping exercise. The mapping exercise is about crafting expressions known as maturity level definitions using maturity level characteristics existing in the literature to describe each of the five levels of maturity in the context of capability areas for built environment flood resilience. The excerpt below was crafted as the conceptual maturity level definitions for maturity level 1 of a capability area named 'Understanding of flood risk'.

"Organisation is yet to recognise the strategic importance of climate information and flooding projection in the area ML1Ad/C4. No formal processes are applied as there is no stable environment to support them ML1Ad/C8. No attempt to identify the benefit ML1Ad/C12. No understanding of principles ML1Ad/C13. No knowledge of relevant tools or database ML1Ad/C14. Unaware of the need ML1Ad/C16."

Similar descriptions were crafted for all the capability areas on all the maturity levels. Each code links each statement (maturity level definition) with the originating maturity level characteristics (Table 2 to Table 6). The codes were removed from the final version of the model. The mapping exercise, a tedious activity (Macgillivray *et al.*, 2007; Sarshar *et al.* (2000), was used to produce the conceptual capability maturity assessment model as earlier mentioned. The conceptual model was reviewed and refined by an expert panel, which consisted of built environment and disaster resilience practitioners, business owner, property owners, and researchers. The involvement of experts allows the acquisition of in-depth knowledge when well managed (Babatunde *et al.*, 2016; Eadie, 2009). The expert panel review conducted in this study was a qualitative review supported by verbal and email interactions and

clarifications. The expert panel made suggestions for improving the conceptual model via a well-documented qualitative feedback. The rounds of review by the experts was stopped when all previous suggestions have been well accommodated in the model and no new suggestions were made by the panel members.

. The criteria for selecting panel members are:

1. Active contribution to issues relating to flood and the built environment,
2. Knowledge and experience in flooding, flood damage, business premises/built environment preparation and recovery from flood either as a professional or flood victims.
3. Academics/researchers must have carried out extensive research on flooding, communities, household and business recovery.

The direct knowledge of the panel members on flood resilience and the built environment was expected to enable the panel members to furnish high-confidence information and as well add their extensive day-to-day experience. Based on the criteria listed and the appropriateness of purposively selecting study participants (Marshall, 1996), six experts were selected (Table 7). The size of expert review panel (N=6) was considered adequate based on the practices in previous research (e.g., Babatunde et al., 2016; Eadie, 2009), where panel sizes ranging from 5 – 10 have been successfully engaged. Boje and Murnighan (1982) observed no effect of group sizes on decision-making techniques when engaging groups of 3, 7, and 11 members. Moreover, Adler and Ziglio (1996) argued that the composition and quality of a panel matter more than the size especially when the heterogeneity of the panel is not prominent.

<<<<<**Table 7 Composition of the expert panel**>>>>

Immediately after the selected experts agreed to participate in the expert review process, the conceptual model, accompanied by a cover letter, instructions, and capability maturity level characteristics (level 1 to 5) were sent to them via email. Feedbacks were received from the expert team and were used to refine the conceptual model. The revised version of the conceptual model was termed as "intermediate model" which was further verified and refined in four case studies. The case study organisations also used the model to assess their current capability maturity levels on each flood resilience capability area. Some of the general criteria for case selection are criticality of the case, the unusualness of a case, the case being revelatory, or just a selection of cases among some cases that have common characteristics (Amaratunga and Baldry, 2001; Yin, 2014). Apart from the general conditions for case selection, study specific criteria are expected to be set. The main criteria for selecting the cases for this study include:

1. The organisation must be a Micro, Small and or Medium sized enterprise (MSME)
2. The organisation must belong to any of the England property use class orders. The use class order is a framework that specifies the categories of use of properties and lands (National Archives, 2016). The classes considered in this study are A1 - Shops, retail warehouses, A3 - Restaurants and cafés, A4 - Drinking establishments, A5 - Hot food takeaways, C1 - Hotels, boarding and guest houses.
3. It must have suffered flood attack before.
4. Understanding and readiness of the organisation to participate in a flood resilience study.

Yin (2014) recommended the use of two or more case studies in multiple-case designs. It is suggested that 2 – 3 case studies are sufficient if similar results are expected and 4 – 6 case studies if different

patterns are being predicted from the case studies. Based on the criteria mentioned above, four case study organisations participated in the study. Property owners, business owners and staff in the organisations were engaged. The unit of analysis in the case studies is from an individual about an organisation and the method of data collection is case study interviews. Because flood disasters and recovery from flood usually attract considerable attention from the press and always require the involvement of several stakeholders, some notes, written reports of events, news excerpts, as well as articles in mass media and newspapers were available for use in this study. Evidence gathered from these sources was used alongside the findings from other literature, to provide the understanding needed to interpret some of the comments from the expert panel. The evidence also aided the structuring of questions for the case study interviews.

A total of 12 semi-structured interviews (Table 8) were conducted in the four case studies comprising guest house, restaurant, retail shop, and drinking establishment. The stakeholders engaged include property owners, business owners, staff members, and business managers (Table 8). Upon completion of the model verification and refinement exercise in the case studies, the case organisations used the model to evaluate their current capability maturity as an internal validation exercise. Similarly, an external validation exercise was conducted on the model developed.

<<<<<Table 8 Background information of respondents>>>>

The summary of the research process in this study is presented in <<<<<<<Figure 1.

<<<<<<<Figure 1 Research method flowchart>>>>>

Results and discussions

<<<<<Table 8 presents a brief on the case organisations and the stakeholders engaged. The interviewees were key persons involved in the management and operation of the organisations. The verification and refinement of the model was done in the four case studies via semi-structured interviews on the model and review of documentary evidence. The refined model (a sample) is presented in <<<<<<Table 9.

<<<<<<Table 9 Built Environment Flood Resilience Capability Maturity Model (Sample)>>>>

The refined model (a sample shown in <<<<<<Table 9) was used to assess the current capability maturity level of case study organisations on the 19 built environment flood resilience capability areas. The maturity levels range from level 1 – Adhoc to level 5 – Optimising. Within each maturity level (i.e. level 1-5), a set of characteristics/level definitions were provided. The main description describes the main maturity level (Adhoc to Optimising) while the sub-characteristics 1-5 indicates the progress made within the maturity level. Until an organisation can be described to have satisfied each of the five sub-

level definitions in each maturity level, it is not fit to be described as being in the succeeding maturity level on that capability area. Each sub-level definition attracts a score of 0.2, so for example, an organisation that has satisfied all sub-level definitions in maturity level 1 has a score of 2.00 (i.e. Maturity level itself is a score of 1, so, 1 + (0.2 x 5) = 2). Therefore, the organisation is in level 2 on that capability area. This is how the organisations were scored on each capability area. Thus, the model was successfully used for evaluating the built environment flood resilience capability maturity level of the four business organisations. Bay and Skitmore (2006) and Rwelamila and Phungula (2009) utilised a quantitative approach to assessing project management maturity in organisations. Similarly, the model developed in this study was used to quantitatively reveal the built environment flood resilience capability maturity levels of selected case study organisations. The maturity scores of the case study organisations are presented in <<<<<Table 10.

<<<<<Table 10 Maturity score of case organisations>>>>>

Note- Ad hoc: 1.00-1.99; Repeatable: 2.00-2.99; Defined: 3.00-3.99; Managed: 4.00-4.99; Optimising: 5.00; n/a- "not applicable" to the businesses because of a UK law.

<<<<<Table 10 shows the capability maturity levels of the four case organisations on the 19 capability areas for enhancing the flood resilience of the built environment. The result shows that CS1 has a relatively high score on each of the capability areas, with the score ranging from 3.20 (level 3 - defined) to 4.80 (level 4 - managed); CS2 has capability maturity level scores that range from 2.40 (level 2 - repeatable) to 4.60 (level 4 - managed); CS3 has scores ranging from 3.20 (level 3 - defined) to 4.80 (level 4 - managed); and CS4 has capability maturity that ranges from 1.20 (level 1 - Ad hoc) to 3.80 (level 3 - defined). Case study 1 (CS1) which is a guesthouse has a relatively high capability maturity. A review of the scores of the organisation on the respective capability areas shows that CS1 belongs to maturity level 4 (Managed) in nine out of nineteen capability areas. The capability areas where CS1 ranks under maturity level 4 are awareness and understanding of flood risk, review for a flood scheme, survey of property, maintenance and post-flood management, the operation of facilities, and post-event review, analysis and management. The organisation belongs to maturity level 3 (i.e. defined) in nine capability areas. The only remaining capability area was said not to be applicable because of a recent legislation that made insurance unavailable to businesses through FloodRe in the United Kingdom (RICS, 2015). The result implies that CS1 belongs to maturity level 4 (Managed) in 47.36% of the capability areas relevant to achieving disaster resilience of built environment identified in the study. Similarly, CS1 belongs to maturity level 3 (defined) in 47.36% of the capability areas, and a capability area that represents 5.26% of the capability areas identified and used in this study was described as "not applicable". The assessed status of CS1 reveals a relatively high level of maturity from the result. It is reasonable to state that CS1 has an appreciable potential for faster premises recovery after a flood disaster.

Case study 2 (CS2) belongs to maturity level 4 (Managed) in 2 of the 19 capability areas: (1) awareness and understanding of flood risk; and (2) decision making in emergency situations. This implies that CS2 has only reached maturity level 4 on 10.53% of the capability areas. The organisation belongs to maturity level 3 in 68.42% of the capability areas by having a score ranging from 3.00 to 3.99 in thirteen of the total nineteen capability areas. CS2 belongs to maturity level 2 (Repeatable) on the three of the total capability areas, i.e., 15.79% of the capability areas identified in this study. Case study 3 (CS3) belongs to maturity level 4 in nine of the nineteen capability areas, which represents 47.36% of the

capability areas identified in this study. On the remaining capability areas, CS3 belongs to maturity level 3, i.e., the organisation has progressed to maturity level 3 on 52.63% of the capability areas. Similarly, CS4 belongs to maturity level 3 in three capability areas; this represents 15.79% of the entire list of capabilities. CS4 belongs to maturity level 2 (repeatable) on four of the capability areas, which represents 21.05% of 19 capability areas. The case study ranks in maturity level 1(Ad hoc) in eleven out of 19 capability areas; and this represents 57.89% of the capability areas related to achieving flood resilience of the built environment of a business. Obviously, CS4 has low maturity by belonging to maturity level 1 (out of 5) in eleven out of nineteen capability areas.

The previous flooding experiences of CS1, CS2 and CS3 appear to have caused the organisations to beef up capabilities towards successfully managing future flooding experiences. This is evident in the scores of organisations CS1, CS2 and CS3, compared to CS4, which was previously insignificantly affected by flood disaster. The actual scores of each organisation on each of the capability areas have earlier been presented in <<<<<Table 10. <<<Figure 2 is a pictorial representation of the maturity of the four case study organisations on the 19 built environment flood resilience capability areas using the built environment flood resilience capability maturity model developed in this study (<<<<<<Table 9).

<<<Figure 2 Current capability maturity level of case study business organisations>>>

The spider diagram (<<<Figure 2) reveals how the case organisations compare in maturity on the capability areas. Therefore, the quantitative assessment performed with the model provides an avenue for establishing the built environment flood resilience capability maturity of each organisation as well as an avenue for comparison of capability maturity. Thus, the built environment flood resilience capability maturity model presented in this study is suitable for evaluation and comparison of capability maturity towards flood resilience enhancement.

Validation of model

Validation is done to confirm the quality, acceptability and authenticity of a research outcome (Cheung, 2009). It is also a way of confirming the reliability of a model or framework. Validation was carried out in this study to confirm the suitability, adequacy, comprehensiveness, clarity of the structure and presentation of the model. In this study, both internal and external validation exercises were conducted on the Built Environment Flood Resilience Capability Maturity Model developed. Internal validation refers to the application of the model by those who were part of its development while external validation refers to its use by a neutral organisation. The internal validation exercise was done by interviewing top personnel in the four case study organisations engaged in the verification and refinement of the model (Figure 1 and Table 8). This was done to ensure that all significant operational issues have been addressed and the model is suitable for use. Responses from the interviewees in the case organisations showed that they were satisfied with the model. Some of the key opinions are presented as follows:

- A standard and clear concept was engaged in developing the model. The progression of maturity from level 1 (Adhoc) to level 5 (Optimizing) is clearly visible. The model is comprehensive.
- The level characteristics are clear and organisations can be rated on each capability area.
- The progression of maturity is clear and the model is comprehensive. All the capabilities required for enhancing flood resilience of the built environment in an organisation are covered.

Based on the feedback from the four case organisations, all operational and process issues relevant to the model have been adequately considered and the model is suitable for use. To further validate the Built Environment Flood Resilience Capability Maturity Model developed (<<<<<<Table 9), external validation exercises were conducted with a new case study and an expert team. For the expert validation aspect, some potential end users of the model and stakeholders in disaster resilience of the built environment were identified. The validation team includes representatives from the business sector, public sector authority, and academia. The engagement of experts in the validation of the model developed in this study aligns with the approach adopted by previous researchers such as Babatunde *et al.* (2016), Cheung (2009) and Yeung (2007). The experts were asked to evaluate the model based on the degree of comprehensiveness, objectivity, level of practicality, replicability, degree of reliability and overall suitability. These evaluation criteria were also used by Awodele (2012), Babatunde *et al.* (2016), Cheung (2009) and Yeung (2007). The experts that participated in the validation exercise in this study were selected based on:

1. Active contribution to issues relating to flood and the built environment,
2. Knowledge and experience in flooding, flood damage, business premises/built environment preparation and recovery from flood either as a professional or flood victims.
3. Academics/researchers must have carried out extensive research on flooding, communities, household and business recovery.

The questionnaire administered to the experts was divided into two sections: (1) section one elicited details on the background information of respondents; and (2) section two contained the validation questions. The questions require experts to rate the model on a list of criteria using a scale of 1 – 5, where, 1 represents Poor; 2 represents Fair; 3 represents Average; 4 represents Good; and 5 represents Excellent. The background information of the five experts engaged in this aspect of the study is presented in <<<<Table 11. The details of the respondents (Table 11) show that they have adequate experience and understanding to participate in the model validation exercise.

<<<<Table 11 Background information of validating experts>>>>

The result obtained from the expert validation exercise (see Table 13) shows that the experts were pleased with the "comprehensiveness" (the validation criteria had a mean score of 4.80) of the model. The score of the model with respect to its comprehensiveness confirmed the width, depth and the overall elaborateness of the model. Similarly, with respect to "Practicality", the model had a mean score of 3.60, which confirmed the applicability of the model in real situations. With respect to overall suitability for assessing, profiling and benchmarking capabilities for flood resilience, respondents rated the model with an average score of 4.00, which implies that the model is considered suitable for the purpose for which it is meant. All the respondents scored the model satisfactorily on all the validation criteria. Based on the overall outcome of the validation exercise, it can be reasonably concluded that the developed capability maturity model is suitable for assessing the built environment flood resilience capability maturity of MSMEs.

<<<<<<<Table 12 Result of expert validation exercise>>>>>

To further ensure that all operational and process issues have been adequately considered in the model (<<<<<<Table 9), a case study validation exercise was undertaken. A case study business organisation different from the ones earlier engaged in the refinement of the model was purposively selected. The organisation satisfied all the criteria set for the multiple case studies described earlier in this study. The informants in the case study organisation were the Managing Director and a staff member. The case organisation is situated around the Lake District in the United Kingdom. It is a hotel with stylish rooms, en-suite bathroom, restaurant, beautiful terrace and a steam room among other facilities. The hotel has varieties of room types described based on view through the window and the size of the room. Varieties of services ranging from the concierge, luggage storage, meeting, spa and room services are offered by the hotel. A director manages the solely owned hotel as well as the property and the business currently records an annual turnover of six million pounds. The capability maturity model for the evaluation of flood resilience capabilities was used in the validation case study. This was to further confirm the real-life applicability of the maturity model.

Table 13 presents the result of the capability evaluation exercise. The organisation belongs to maturity level 4 in the majority (13 out of 19 capability areas) of the capability areas, maturity level 3 in four capability areas, level 2 in one capability area, and level 5 in one capability area.

<<<<**Table 13 Result of case study validation exercise**>>>>

The result of the validation case study is further graphically presented in Figure 3. The inward depressions in the blue line indicate lower maturity level of the organisation with respect to the corresponding capabilities.

Figure 3 Graphical representation of validation case study result

The successful conduct of the validation case study further confirmed the adequacy and suitability of the model. Respondents in the case organisation also commended the suitability of capability areas and the ability of the model in revealing the Built Environment Flood Resilience Capability Maturity of business organisations. The model was adjudged suitable for profiling, benchmarking and improvement focused assessment of capabilities for built environment flood resilience.

Conclusions

To enhance the capability of organisations in dealing with flood disasters, a Built Environment Flood Resilience Capability Maturity Model was developed in this study. The built environment flood resilience capability areas used in developing the maturity model can be adopted for planning and use by business organisations and can be adopted by researchers for use in subsequent studies. Towards enhancing capabilities in different sectors, researchers have advocated and developed models for capability maturity assessment and improvement. Similarly, this study utilised the identified and verified built environment flood resilience capabilities to develop a capability maturity assessment model for flood resilience of the built environment of business organisation. Currently, such model does not exist; its development is expected to benefit Micro, Small and Medium-sized Enterprises, the government and the society at large. The inability of businesses (MSMEs inclusive) to manage flood hazards makes germane the development of a systematic method of assessing and encouraging the improvement of flood resilience capability maturity of business organisations. The assessments done

on case study organisations using the Built Environment Flood Resilience Capability Maturity Assessment Model show that most of the organisations engaged in this research belong to maturity level 2 (repeatable), maturity level 3 (defined) and maturity level 4 (managed) on many the capability areas. However, one of the organisations belongs to maturity level 1 (Adhoc) on 11 of 19 capability areas and maturity level 2 (repeatable) on four of 19 capability areas for enhancing built environment flood resilience capability maturity. The low maturity on many of the capability areas of one of the organisations was attributed to the fact that the organisation has only experienced insignificant flooding once; thus, no significant effort is being made to enhance its capability for resilience. In addition, the methodology should serve as a guide for a future study on capability maturity assessment and maturity modelling.

Also, the developed model (<<<<<<Table 9) is expected to serve as a reference for drafting, structuring and implementing flood resilience capability enhancement initiatives. This is because the model provides information on capabilities required for enhancing flood resilience at the organisation level, with details on attributes that indicate maturity. It has provided a systematic approach to capability evaluation and enhancement. The model provides an improvement blueprint for business organisations to follow towards improving their capability for readiness, response, and recovery from a flood event thereby reducing loss from flood disasters. The systematic approach can be used to benchmark capability maturity status. Since what each maturity level entails are clear, a benchmark of expected capabilities maturity can be set for MSMEs and targets to achieve can also be set for a specific date in the future. This would be beneficial to business organisations and regulatory bodies. The comprehensiveness and the involvement of experts as well as case study organisations with flooding experience enhanced the reliability and the suitability of the model for its purpose.

Although, the model developed is suitable for purpose, some limitations were identified. One of the limitations is that the study focused on flood only. Although, many of the capabilities are also relevant to other types of disasters. Another limitation is that, there is the tendency of organisations viewing the model as a measurement model alone rather than an evaluation and improvement model; this might affect the sincerity of scoring. Despite these limitations, the model remains a suitable tool for capability maturity assessment. The application of capability maturity model (CMM) methodology in disaster resilience with a focus on the built environment is novel. This study has expanded the boundary of CMM application and has contributed to the body of knowledge on capability enhancement in disaster resilience.

Based on the outcome of this study, it is recommended that relevant government agencies and other stakeholders in disaster resilience should continually undertake a broad flood resilience capability enhancement awareness programme for business organisations. Apparently, special attention needs to be given to organisations that are situated in flood-prone zones but are yet to experience flooding. This is necessary because businesses in this category often have a lesser understanding of flood and lower capability maturity until disaster strikes once. All the organisations engaged in this study confessed to strengthening their flood resilience capabilities after they got affected by flooding. It is important to continuously encourage business organisations to undertake flood resilience capability evaluation and improvement. Also, disaster resilience monitoring agencies should profile business organisations using the model developed in this study; and awareness and support initiatives should be drafted and implemented based on the results. Also, there is need for both public and private sector stakeholders to embed flood resilience capability maturity model urgently as a planning tool and a guide for all disaster resilience initiatives. They should be conscious of the fact that higher flood resilience capability maturity can significantly reduce risk and the magnitude of damage at the organisation level. Clearly,

this study has contributed to knowledge on capability enhancement and flood resilience as well as advancements in research methodology.

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Table 14 Strategic Capability Areas for enhancing built environment flood resilience (Adeniyi, 2017)

Reference code	Description of capability areas
SCA1	Awareness and understanding of flood risk to property
SCA2	Planning or review for a flood resilience scheme
SCA3	Survey of property
SCA4	Acquisition and installation of relevant products
SCA5	Maintenance and Post flood management scheme relationships
SCA6	Operation of acquired facilities
SCA7	Organization of disaster scenario simulations
SCA8	Turn-over, cash flow and customer management
SCA9	Insurance adequacy and management
SCA10	Utility and communication system
SCA11	Record/business data management
SCA12	Management of disruption to production/service/operation
SCA13	Crises Response budget
SCA14	Paper records management

SCA15	Decision making without recourse to superior in emergency situations
SCA16	Definition of roles and responsibilities and how it changes in disaster situations
SCA17	Post event operation, analysis and management
SCA18	Network strength
SCA19	Physical resilience of the fabric and structure of property

Table 15. Characteristics of maturity level 1 – Ad-hoc

Reference code	Characteristic	Literature sources
ML1Ad/C1	Summary of general resilience status - Very poor	Stephenson (2010)
ML1Ad/C2	Organisations are highly reactive	Stephenson (2010)
ML1Ad/C3	Engage in very little planning	Stephenson (2010)
ML1Ad/C4	Yet to recognize/identify /task/process/resilience as strategically important	Stephenson (2010); Virtual Corporation (2005)
ML1Ad/C5	No centrally coordinated support function	Virtual Corporation (2005)
ML1Ad/C6	If policy exists, it is not enforced	Virtual Corporation (2005)
ML1Ad/C7	Processes or related activities are generally chaotic	Backlund, Chronéer, and Sundqvist (2014); Kaur (2014) ; Keraminiyage, Amaratunga, and Haigh (2007b) ; Niazi, Wilson, and Zowghi (2005) ; PRINCE 2 (2012); SEI (2010); Sun *et al.* (2009)
ML1Ad/C8	There are no formal processes as there is no stable environment to support them. No standardised procedures.	AXELOS (2013); Batica, Gourbesville, and Tessier (2013); SEI (2010); Kaur (2014)
ML1Ad/C9	Organisation pays lip service to the activity or process	Yeo and Yen (2009)
ML1Ad/C10	Existing processes are abandoned in times of crises. Successes cannot be sustained.	OGC (2010a) ; PRINCE 2 (2012) ; SEI (2010)
ML1Ad/C11	Success depends on individuals' efforts. Individuals act, no institutional coordination	AXELOS (2013); Batica *et al.* (2013) ; Keraminiyage *et al.* (2007b) ; Kwak and Ibbs (2002); OGC (2010a) ; PRINCE 2 (2012) ; Sun *et al.* (2009)
ML1Ad/C12	No attempt to identify the benefit of the activity or process	APSC (2012); Yeo and Yen (2009)
ML1Ad/C13	No understanding of principles/task/process	Batica *et al.* (2013); Yeo and Yen (2009)
ML1Ad/C14	No tools or databases relevant to the process are in use.	APSC (2012) ; (OGC, 2010a) Yeo and Yen (2009)
ML1Ad/C15	Budgets and schedules documented in plans are usually exceeded.	OGC (2010) ; PRINCE 2 (2012) ; Sun *et al.* (2009)
ML1Ad/C16	Unaware of the need for tasks to be undertaken.	Yeo and Yen (2009)
ML1Ad/C17	Short-term focused strategies	Batica *et al.* (2013)
ML1Ad/C18	Approaches/methods are applied on case-by-case basis	Batica *et al.* (2013)
ML1Ad/C19	No monitoring or reporting	Batica *et al.* (2013)
ML1Ad/C20	Use of basic and narrow range technology. Single and simpler products.	APSC (2012)

Table 16 Characteristics of maturity level 2 – Repeatable

Ref. code	Characteristic	Literature sources
ML2Re/C1	Summary of general resilience status - poor	Stephenson (2010)
ML2Re/C2	Organisations are reactive	Stephenson (2010)
ML2Re/C3	Individuals or departments or function do have personal plans in place but they are not shared	Stephenson (2010)
ML2Re/C4	Senior manager/Owner may recognise the importance of resilience but resources are not allocated to it	Stephenson (2010)
ML2Re/C5	Organisations experiment on processes planned, introduced and executed in line with policy	Kaur (2014); Keraminiyage *et al.* (2007); Kwak and Ibbs (2002); OGC (2010) ; Paulk *et al.* (1993); PRINCE 2 (2012); SEI, 2010; Yeo and Yen (2009)
ML2Re/C6	Weak ability as a team, weak orientation, better at repetitive works. Individuals act with limited coordination	Batica *et al.* (2013); Kwak and Ibbs (2002); Lianying, Jing, and Xinxing (2012) ; Paulk *et al.* (1993); Yeo and Yen (2009)
ML2Re/C7	Stakeholders' responsibilities/commitments are revised with time, through training and updates.	OGC (2010) ; SEI (2010) ; PRINCE 2 (2012) ; Lianying *et al.* (2012)
ML2Re/C8	Appropriate stakeholders are engaged	Paulk *et al.* (1993); SEI (2010)
ML2Re/C9	Roles are clear and achievable, with measurement strategies.	APSC (2012); Lianying *et al.* (2012)
ML2Re/C10	Simple tools and templates are used for some activities	Yeo and Yen (2009)
ML2Re/C11	Deliverables or successes can be seen/Pockets of good practices	Crawford (2006); OGC (2010) ; PRINCE 2 (2012)
ML2Re/C12	There are skilled people who can produce controlled outputs. Key individuals demonstrate track record with hopes of repeating earlier success.	AXELOS (2013) ; Paulk *et al.* (1993); PRINCE 2 (2012) ; SEI, (2010)
ML2Re/C13	The importance of tasks/procedures is recognised. They are communicated verbally (within the team(s)).	APSC (2012)
ML2Re/C14	Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions.	PRINCE 2 (2012) ; SEI (2010) ; Sun *et al.* (2009) ; Lianying *et al.* (2012)
ML2Re/C15	Knowledge of specific risks	Batica *et al.* (2013)
ML2Re/C16	Heavy reliance on knowledge of individuals	Batica *et al.* (2013)
ML2Re/C17	Large dependence on historical practice	Batica *et al.* (2013)
ML2Re/C18	Basic processes exist, basic generic training	AXELOS (2013)
ML2Re/C19	Some training exists	Yeo & Yen (2009)
ML2Re/C20	Mid-level proven technology. Mid-range products.	Yeo & Yen (2009)

Table 17 Characteristics of maturity level 3 – Defined

Ref. code	Characteristic	Literature sources
ML3De/C1	Summary of general resilience status - Fair	Stephenson (2010)
ML3De/C2	Importance of resilience or importance of the task/process being undertaken towards resilience is recognised	APSC (2012); Stephenson (2010)
ML3De/C3	They engage in planning. Formal planning.	Stephenson (2010); Yeo and Yen (2009)
ML3De/C4	A visible level of adaptive capacity/ability exists	Stephenson (2010)
ML3De/C5	Processes are described/documented in standards, procedures and are well understood	APSC (2012); Curtis, Hefley, and Miller (1995) ; Kaur (2014); OGC (2010); PRINCE 2 (2012)
ML3De/C6	Strong support to the process/task being undertaken by management	AXELOS (2013); Kaur (2014) ; Sun *et al.* (2009)

ML3De/C7	More proactively managed rigorous process exists. Proactive behaviour.	APSC (2012); Kwak and Ibbs (2002); OGC (2010) ; Paulk *et al.* (1993); PRINCE 2 (2012); Sun *et al.* (2009); Yeo and Yen (2009)
ML3De/C8	Processes have defined purpose, inputs, verification steps, and outputs	Kaur (2014) ; OGC (2010) ; PRINCE 2 (2012)
ML3De/C9	Reasonably high teamwork ability or orientation	Yeo and Yen (2009)
ML3De/C10	Tools, templates and relevant database are available	APSC (2012) ; Batica, Gourbesville *et al.* (2013) ; Yeo and Yen (2009)
ML3De/C11	Standard processes are established and improved overtime	APSC (2012) ; AXELOS (2013); PRINCE 2 (2012); SEI (2010)
ML3De/C12	Pockets of best practices can be seen.	APSC (2012); Yeo and Yen (2009)
ML3De/C13	Standard processes are used to achieve consistency across the organisation.	APSC (2012); Kaur (2014); OGC (2010); PRINCE 2 (2012); Sun *et al.* (2009)
ML3De/C14	Mid-term focused plans	Batica *et al.* (2013)
ML3De/C15	Policies and procedures are partially implemented; implementation is limited to few stakeholders	Batica *et al.* (2013)
ML3De/C16	Insurance scheme is available	Batica *et al.* (2013)
ML3De/C17	Relevant actions are coordinated with stakeholders (government and others)	Batica *et al.* (2013)
ML3De/C18	Training programme for capacity development exists	AXELOS (2013)
ML3De/C19	Effective management of known or predictable risks	Yeo and Yen (2009)
ML3De/C20	Mainly inward looking	Yeo and Yen (2009)
ML3De/C21	More advanced but proven technology. Use major assembles, complex products	Yeo and Yen (2009)

Table 18 Characteristics of maturity level 4 – Managed

Ref. code	**Characteristic**	**Literature sources**
ML4Ma/C1	Summary of general resilience status - Good	Stephenson (2010)
ML4Ma/C2	Recognise importance of resilience (Higher recognition)	Stephenson (2010)
ML4Ma/C3	Manage a variety of resilience activities and programmes	Stephenson (2010)
ML4Ma/C4	Staff are involved and engaged in planning	Stephenson (2010)
ML4Ma/C5	Organisations adaptive capacity is related to the creativity, innovation and autonomy of its staff	Stephenson (2010))
ML4Ma/C6	Processes are formally reviewed by relevant stakeholders on regular basis. Post event reviews are done.	Yeo and Yen (2009)
ML4Ma/C7	Processes and tasks are in line with organisation's objectives and identified priorities	Kwak and Ibbs (2002); OGC (2010) PRINCE 2 (2012)
ML4Ma/C8	Flexible and willing for change with adaptive style of leadership and management	APSC (2012); Yeo and Yen (2009)
ML4Ma/C9	The need for processes/tasks are highly recognised and supported with stated means of improvement.	APSC (2012)
ML4Ma/C10	Post project/task reviews are done and performances are reported.	OGC (2010) ; PRINCE 2 (2012)
ML4Ma/C11	Measures of performance are statistically/technically analysed	Crawford (2006); PRINCE 2 (2012) ; SEI (2010)

ML4Ma/C12	Projections and forecast are partially made on statistical/numerical analysis. Improved predictability of performance.	AXELOS (2013); Curtis *et al.* (2002) ; Crawford (2006); PRINCE 2 (2012) SEI (2010)
ML4Ma/C13	Quantitative objectives are established for managing quality and process performance	AXELOS (2013); Curtis *et al.* (2002); Kwak and Ibbs (2002); Lianying *et al.* (2012）; OGC (2010) ; Paulk *et al.* (1993); PRINCE 2 (2012)
ML4Ma/C14	Tools, database and records are available for analysis (statistics and others) and management	APSC (2012); Stephenson (2010); SEI (2010)
ML4Ma/C15	Strong teamwork with internal and external parties/partners. Network/Coalition building.	APSC (2012); Kwak and Ibbs (2002); Yeo and Yen (2009)
ML4Ma/C16	Strong project-driven attribute	APSC (2012); Kwak and Ibbs (2002); Yeo and Yen (2009)
ML4Ma/C17	Risk is identified	Stephenson (2010)
ML4Ma/C18	Best practice is incorporated	Stephenson (2010)
ML4Ma/C19	Human capacity building is high	Stephenson (2010)
ML4Ma/C20	Insurance scheme exists (More robust)	Stephenson (2010)
ML4Ma/C21	Capable of managing predictable and non-predictable eventualities	Yeo and Yen (2009)
ML4Ma/C22	Consistent and systematic approach to process/task	Yeo and Yen (2009)
ML4Ma/C23	Advanced but proven technology, it requires complex assembly and integration. Complex product systems.	Yeo and Yen (2009)

Table 19 Characteristics of maturity level 5 – Optimizing

Ref. code	**Characteristic**	**Literature sources**
ML5Op/C1	Summary of general resilience status - Excellent	Stephenson (2010)
ML5Op/C2	Operating environment is well understood	Stephenson (2010)
ML5Op/C3	They take the lead in establishing visionary cultures, processes, and practices.	Stephenson (2010)
ML5Op/C4	They anticipate and respond to uncertainty	Stephenson (2010)
ML5Op/C5	They include resilience in their day to day decision making	Stephenson (2010)
ML5Op/C6	Quantitative approaches are used to understand the variation in processes (internal and external).	AXELOS (2013) ; Curtis *et al*. (2002) ; Paulk *et al.* (1993); PRINCE 2 (2012) ; SEI, (2010)
ML5Op/C7	There is focus on continual improvement of process performance through innovation and technological advancements.	APSC (2012); Crawford (2006); Kaur (2014) ; Kwak and Ibbs (2002); Keraminiyage *et al.* (2007); OGC (2010); Paulk *et al.* (1993); SEI (2010)
ML5Op/C8	Quality and process performance are stated and recurrently revised	Kaur (2014) ; SEI (2010)
ML5Op/C9	Quantitative techniques are used for measuring improvements.	SEI (2010)
ML5Op/C10	Lessons learnt are captured and fed back into the system.	APSC (2012); AXELOS (2013); Batica *et al.* (2013); OGC (2010) ; PRINCE 2 (2012)
ML5Op/C11	Processes/tasks/records are kept up-to-date	APSC (2012)
ML5Op/C12	Tolerant/open-minded/enlightened/rational leadership and management style exists.	APSC (2012); PRINCE 2 (2012); Yeo and Yen (2009)
ML5Op/C13	Dynamic, flexible and strong project-driven attribute	APSC (2012); Kwak and Ibbs (2002); Lianying *et al.* (2012); Yeo and Yen (2009)

Ref. code	Characteristic	Literature sources
ML5Op/C14	Sound relationship with stakeholders, societal network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements.	Yeo and Yen (2009)
ML5Op/C15	Sophisticated tools or methodologies are available for qualitative and quantitative analyses with proper interpretations.	APSC (2012); Yeo and Yen (2009)
ML5Op/C16	Resilience concepts are integrated within all legal and operational frameworks	Batica *et al.* (2013)
ML5Op/C17	Fully integrated best practices. Top managers are exemplars.	AXELOS (2013); Batica *et al.* (2013)
ML5Op/C18	Insurance scheme exists (Adequate/more robust)	Batica *et al.* (2013)
ML5Op/C19	A real-time system exists (as required). Automation of process/task or techniques	Batica *et al.* (2013)
ML5Op/C20	High level of awareness	Yeo and Yen (2009)
ML5Op/C21	Active use of information	Yeo and Yen (2009)
ML5Op/C22	Strong negotiation ability and influence on others	Yeo and Yen (2009)
ML5Op/C23	Advanced and some innovative technology, involves large-scale multiple complex assemblies and installations. Complex systems and complex products.	Yeo and Yen (2009)

Table 20 Composition of the expert panel

Reference	Designation/Area of Practice
Expert A	Property level resilience practitioner. A current member of a city council resilience team
Expert B	Property/General risk and damage assessment professional. Operations Vice President and Engineering Manager of an insurance firm
Expert C	The owner of a flood affected business. Chair of a Flood Action Group
Expert D	Flood Recovery Coordinator for businesses, household and communities. Project Manager and Construction professional.
Expert E	Policy Officer, Government agency. Worked as the national contact point for property level flood protection scheme.
Expert F	Insurance professional (Business and property risk management).

Table 21 Background information of respondents

Respondent reference	Business type	Stakeholder engaged
Case study 1 (C1R1)	Guest House	Property owner/Business owner
Case study 1 (C1R2)	Guest House	Property owner/Business partner
Case study 1 (C1R3)	Guest House	Staff
Case study 2 (C2R1)	Restaurant	Property owner/Business owner

Case study 2 (C2R2)	Restaurant	Business partner
Case study 2 (C2R3)	Restaurant	Staff
Case study 3 (C3R1)	Retail shop	Property owner/Business owner
Case study 3 (C3R2)	Retail shop	Business partner
Case study 3 (C3R3)	Retail shop	Staff
Case study 4 (C4R1)	Drinking establishment	Manager
Case study 4 (C4R2)	Drinking establishment	Staff
Case study 4 (C4R3)	Drinking establishment	Staff

Table 22 Built Environment Flood Resilience Capability Maturity Model (Sample)

SN	Strategic Capability Areas (SCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
1	Awareness and understanding of flood risk to property	The owner/user slightly or do not recognise the strategic importance of climate and flood projection. The owner or user is unaware of flood risk to property, has little or no understanding of flood risk, with no attempt to understand. 1 2 3 4 5 1. Importance of weather/climate forecast is slightly recognised 2. Slightly aware of type, frequency of flood 3. Barely supportive environment 4. Little attempt to understand the benefit of knowing flood risk and hazard consequences 5. Barely aware of need Overall score	Owner or user may recognise the importance, but resources are not allocated. Individual stakeholder makes an effort to understand but they are not shared, or they are verbally communicated when shared. 1 2 3 4 5 1. Individuals make efforts to understand flood risk 2. Senior personnel or owner understands 3. Little fund is allocated to related activities 4. Importance is recognised 5. Knowledge of individuals is relied upon Overall score	Importance is recognised, and there are standard processes aimed at enhancing the understanding of risk in the organisation. Relevant actions are coordinated with relevant stakeholders. 1 2 3 4 5 1. Standard processes aimed at enhancing understanding exists 2. Processes are improved overtime 3. Relevant actions are coordinated with stakeholders 4. Training or discussions on risks are done 5. Relevant databases, tools and templates are available/accessed Overall score	Importance and need for an understanding of flood risk are highly recognised. Capable of accessing relevant databases and repositories. Risks can be identified, statistically processed and managerially analysed. 1 2 3 4 5 1. High recognition of importance 2. The need for processes/tasks are highly recognised 3. Related processes are supported with stated means of improvement 4. Tools, database and records are available for statistical analysis and managerial decisions 5. Capable of identifying risks Overall score	Very high understanding of flood risk and how it relates to the property. Lessons learnt from related activities are captured and reflected in operations. Quantitative approaches are used to understand internal and external variations 1 2 3 4 5 1. Very high understanding of flood risk 2. Operating environment is well understood 3. Quantitative approaches are used to understand internal and external variations 4. Lessons learnt are captured and reflected in operations 5. High level of awareness, they anticipate and respond Overall score

Table 23 Maturity score of case organisations

Ref. code	Capability areas	Maturity level scores			
		Case 1(CS1)	Case 2 (CS2)	Case 3 (CS3)	Case 4 (CS4)
KCA1	Awareness and understanding of flood risk to property	4.60	4.60	4.20	1.40
KCA2	Review for a flood resilience scheme	4.40	3.20	3.80	1.20
KCA3	Survey of property	4.80	3.60	4.40	1.60
KCA4	Acquisition and installation of relevant products	4.00	3.60	4.40	1.40
KCA5	Maintenance and Post flood management scheme relationships	4.60	2.80	3.80	1.20
KCA6	Operation of acquired flood facilities	4.60	3.80	4.20	1.60
KCA7	Organisation of disaster scenario simulations	3.80	2.80	3.00	1.20
KCA8	Turn-over, cash flow and customer management	3.40	3.60	3.40	3.80
KCA9	Insurance adequacy and management	n/a	n/a	4.80	n/a
KCA10	Utility/communication system	3.80	3.00	4.20	2.80
KCA11	Electronic data management	3.80	3.80	4.20	2.80
KCA12	Management of disruption – (Attitude towards stressors)	4.80	3.20	4.40	2.40
KCA13	Crisis response budget	3.20	3.60	3.20	2.80
KCA14	Paper records management	3.80	3.60	3.60	3.80
KCA15	Decision making in emergency situations	4.20	4.00	3.80	1.60
KCA16	Definition of responsibilities (and how it changes in disaster situations)	3.20	3.40	3.40	1.60
KCA17	Post event review, analysis and management	4.40	2.40	3.20	1.20
KCA18	Network strength	3.80	3.40	4.40	1.40
KCA19	Physical characteristic of the property (fabric, construction, design and waterproof compartment)	3.80	3.00	3.40	3.00

Note- Ad hoc: 1.00-1.99; Repeatable: 2.00-2.99; Defined: 3.00-3.99; Managed: 4.00-4.99; Optimising: 5.00; n/a- "not applicable" to the businesses because of a UK law.

Table 24 Background information of validating experts

SN	Designation	Area/Sector of practice	Qualification	Years of experience	Experience
1	Senior Lecturer	Academia	PhD	10years	Active researcher with expertise in disasters, properties and capability maturity model
2	Policy officer	Public sector	MSc	26 years	Contact person for property and community flood resilience projects.
3	Business/ Commercial property owner	Business/ Property owner	MSc	24 years	Flooded business and property owner with flood recovery and flood risk management experience

4	Lecturer	Academia	PhD	10 years	An active researcher with expertise in property level flood protection and framework/model development.
5	Resilience Team Member	Public sector	MSc	10 years	Member, Business recovery – Government resilience team

Table 25 Result of expert validation exercise

Validation Criteria	Respondents					Mean score
	1	2	3	4	5	
Comprehensiveness	5	5	5	5	4	4.80
Objectivity	4	4	4	4	4	4.00
Practicality	4	3	4	4	3	3.60
Replicability	4	4	5	4	4	4.20
Reliability	4	4	4	4	3	3.80
Overall suitability for assessing, profiling and benchmarking capabilities for flood resilience	4	4	4	4	4	4.00

Table 26 Result of case study validation exercise

Capability area	**Capability areas**	**Score**
KCA1	Awareness and understanding of flood risk to property	3.80
KCA2	Review for a flood resilience scheme	4.80
KCA3	Survey of property	4.80
KCA4	Acquisition and installation of relevant products	4.80
KCA5	Maintenance and Post-flood management scheme relationships	4.40
KCA6	Operation of acquired flood facilities	3.00
KCA7	Disaster scenario simulations	2.60
KCA8	Turn-over, cash flow and customer management	4.80
KCA9	Insurance adequacy and management	4.80
KCA10	Utility/communication	4.80
KCA11	Electronic data management	3.60
KCA12	Management of disruption – (Attitude towards stressors)	4.60
KCA13	Crisis response budget	4.60
KCA14	Paper records management	3.40
KCA15	Decision making in emergency situations	4.80
KCA16	Definition of responsibilities (and how it changes in disaster situations)	5.00
KCA17	Post-event review, analysis and management	4.60

KCA18	Network strength	4.80
KCA19	Physical characteristic of property (fabric, construction, design and waterproof compartment)	4.80

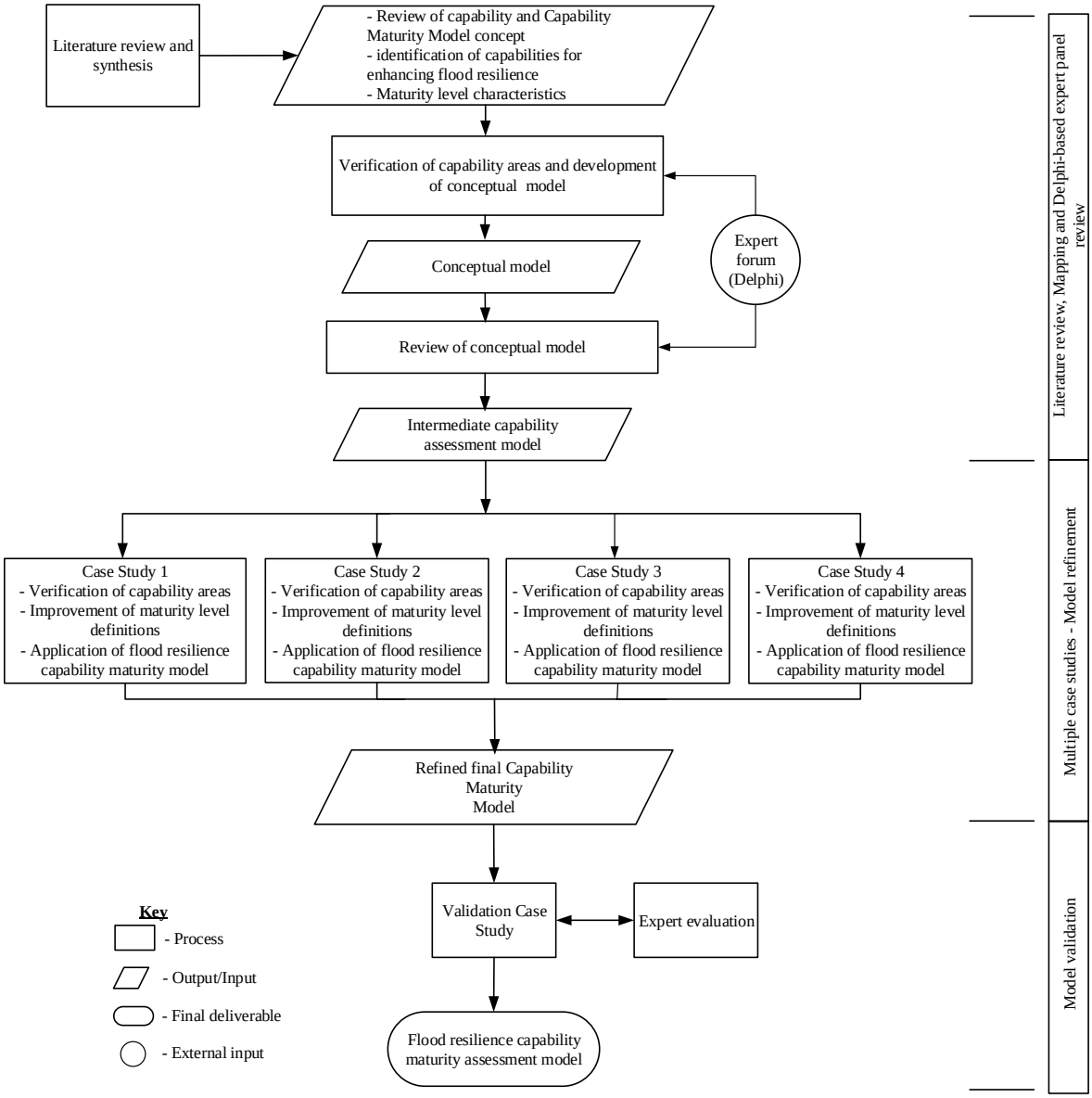

Figure 4 Research method flowchart

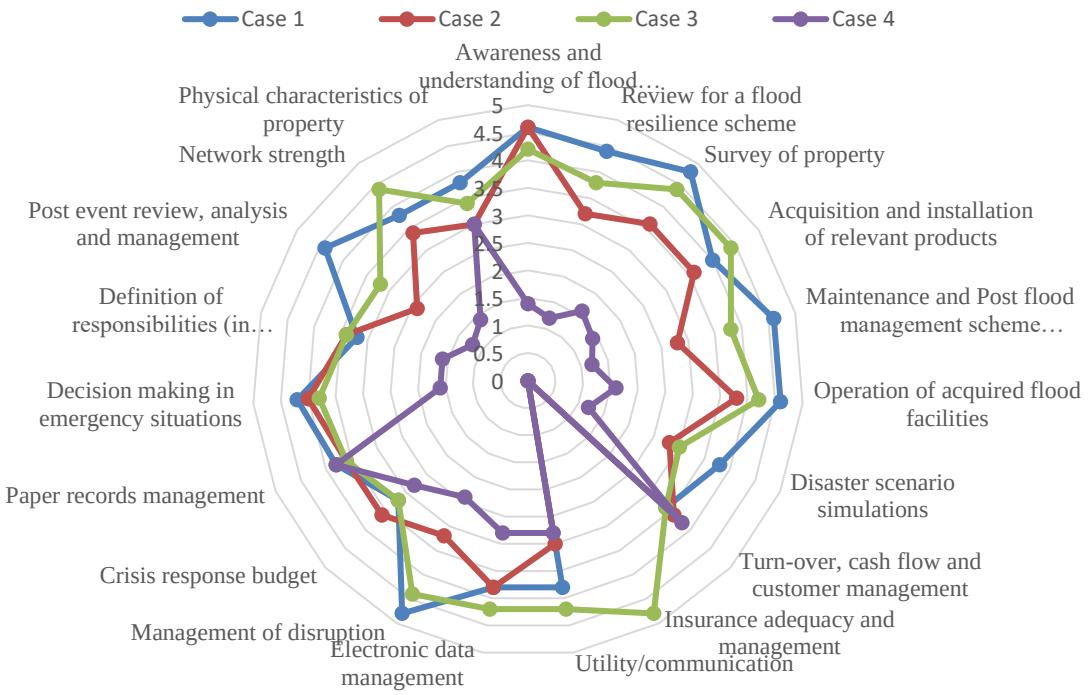

Figure 5 Current capability maturity level of case study business organisations

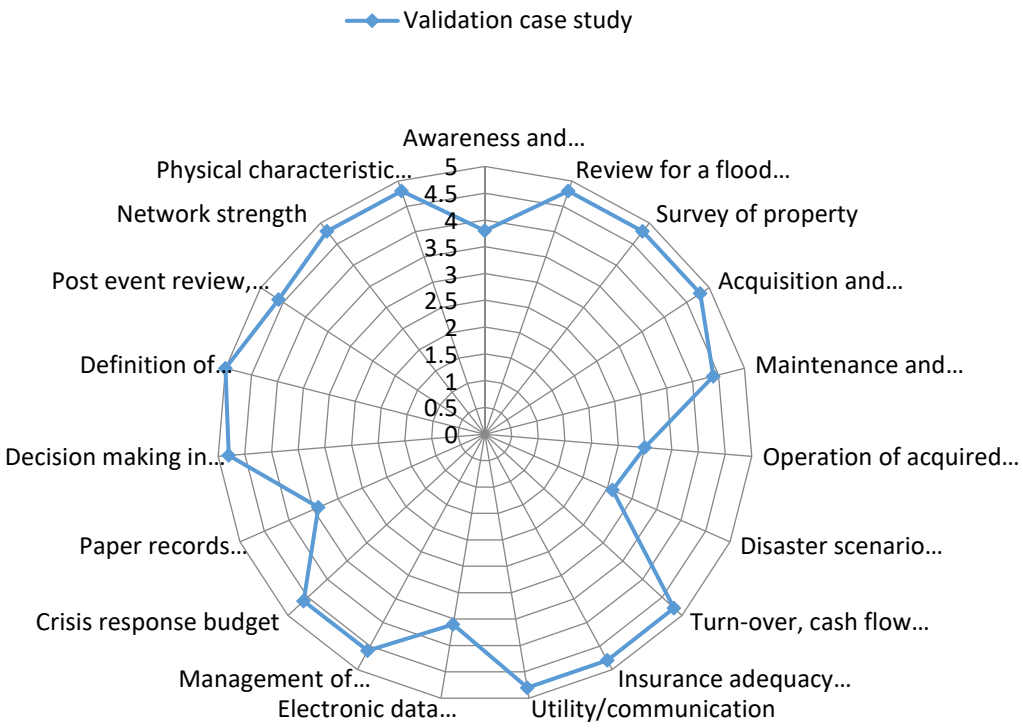

Figure 6 Graphical representation of validation case study result