CAPABILITY MATURITY MODEL FOR ASSESSING FLOOD RESILIENCE CAPABILITIES OF THE BUILT ENVIRONMENT

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CAPABILITY MATURITY MODEL FOR ASSESSING FLOOD RESILIENCE CAPABILITIES OF THE BUILT ENVIRONMENT

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ABSTRACT

Disasters often result in severe socio-economic losses, although there is significant progress in dealing with the social aspect, economic aspect is addressed relatively insufficiently. Therefore, the capabilities of organisations in managing disasters need to be improved, and there should be a way of assessing these capabilities. Hence, this study used capability maturity model (CMM) methodology to develop an assessment method that identifies the built environment flood resilience capabilities of micro, small and medium-sized businesses (MSMEs).

Towards achieving the aim of the study, a conceptual model was developed using the capability areas identified from the literature. The model was then verified and refined by an expert forum. The conceptual model was further improved in case studies, applied in case organisations and after that validated; this resulted in the final model. This study identified 19 capability areas for enhancing built environment flood resilience and developed a capability maturity model that contains maturity level definitions ranging from level 1 (Ad hoc) to level 5 (Optimising).

The outcome of this study provides both theoretical and practical contributions to knowledge. Among the theoretical contributions are the identified and verified built environment flood resilience capability areas for MSMEs. The capability areas can be adopted for use in subsequent studies. Also, the application of capability maturity modelling (CMM) in disaster resilience of the built environment is novel, this has expanded the boundary of CMM application. The practical contributions of the study include the identified capability areas, the capability level definitions and the capability maturity model for profiling MSMEs and benchmarking the capabilities of businesses for built environment flood resilience. The model indicates what needs to be carried out to achieve a higher capability maturity level for flood resilience.

DEDICATION

This thesis is dedicated to the Almighty God, my strength and hope, the giver of knowledge and wisdom, the Lord God of heaven and earth.

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DECLARATION

I declare that the work contained in this thesis is wholly mine and it has not been submitted for any award anywhere.

Name: Onaopepo Adeniyi

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ACRONYMS AND ABBREVIATIONS

ABI – Association of British Insurers

BCM – Business Continuity Management

CCRA – Climate Change Risk Assessment

CMM – Capability Maturity Model (ling)

CMMI – Capability Maturity Model Integration

DEFRA - Department for Environment, Food & Rural Affairs

GCPOE - Global Construction Perspectives and Oxford Economics

MSME – Micro, Small and Medium-sized Enterprises

PPP- Public Private Partnership

RICS – Royal Institution of Chartered Surveyors

UKCIP – United Kingdom Climate Impacts Programme

UK – United Kingdom

UN ESCAP – United Nations Economic and Social Commission for Asia and the Pacific

UNISDR – United Nations International Strategy for Disaster Reduction

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CHAPTER ONE
INTRODUCTION

1.1 Background to the study

Disaster refers to a "serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its resources" (UNISDR, 2009). A disruption caused by a natural phenomenon is a natural disaster. Inferring from Kahn (2005) and Kellenberg and Mobarak (2008), cited in Hallegatte (2013), increasing investments in disaster risk reduction have led to a noticeable reduction in human casualties from disasters, but economic loss is growing at an alarming pace (IRIN, 2005; Ki-Moon, 2013).

Currently, natural disasters result in significant damage to buildings, equipment, goods, stocks, production facilities, homes among others (FEMA, 2003; Kreibich *et al.*, 2010; Scawthorn *et al.*, 2006; UNISDR, 2015). The damage and the consequential economic loss will continue to increase unless drastic control measures are taken (Bouwer *et al.*, 2007; Ki-Moon, 2013; Pielke *et al.*, 2008). Apparently, all categories of stakeholders in the society feel the impact of disasters (Dutta *et al.*, 2003; Hoes & Schuurmans, 2006; Kreibich *et al.*, 2010; Penning-Rowsell *et al.*, 2005; UNISDR, 2015) but the impact on Micro, small and medium-sized enterprises (MSMEs) is not only felt by the MSMEs but many citizens, employees and connected supply chains (Dalberg, 2011 cited in UNISDR, 2013). MSMEs make up 99.8% of private sector business enterprises; it provides about 67.1% of private sector jobs in Europe (European Commission, 2008). In South East Asia, MSMEs make up about 96% of businesses (ASEAN, 2013). The above statistics underline the importance of the need to make the assets of MSMEs disaster resilient.

In the United Kingdom, MSMEs account for 99% of businesses and about 60.1% of employment (Ward & Rhodes, 2014). Leinster (2009) submitted that flooding is a common hazard in the United Kingdom while Woodman (2008) and Heliview Research (2008) claimed that flood impact has been huge on MSMEs. Interestingly, climate change has been projected to lead to an increase in riverine flooding across the whole of Europe (Kundzewicz *et al.*, 2010). According to Norrington and Underwood (2008), damage to property and stock is among the major impacts of flood disasters on Micro, small and medium-sized enterprises (MSMEs). The study emphasised the need for a flood resilient

built environment. In 2012 alone, flooding affected about 8,000 properties in the United Kingdom (RICS, 2015), insurers paid out a sum of £373million in claims for flood damage to business properties and paid business interruption claims to the value of £40million (ABI, 2013). Although some business organisations are making efforts to reduce the impact of disasters, the majority of business organisations including MSMEs are not prepared (Dlugolecki, 2004; Yoshida and Deyle, 2005 and Woodman, 2008).

Even though, several events contribute to economic loss from disasters, among these are damages to premises, damages to stocks, and business disruption, the worth of damages done to the built environment and the ripple effects of the damages are significant (Haigh, 2010; UNDP, 2013a). Lawrence and Low (1990) described the built environment as an abstract concept used to describe the products of human building activity and includes any physical alteration to the natural environment. In this study, the built environment is referring to human-made surroundings and most especially, the premises of a business enterprise i.e. business property. Towards achieving organisational goals which include managing and surviving crises (Grewal & Tansuhaj, 2001; O'Regan & Ghobadian, 2004), Yen-Tsang *et al.* (2012) described the need for capabilities and its importance in coordinating a set of activities to achieve particular goals. The capability of a firm is a combination of competencies, skills, resources, strengths, societal network used to coordinate a set of activities to achieve particular goals (UNISDR, 2009; Yen-Tsang *et al.*, 2012). UNISDR (2009) submitted that capacity can also be referred to as capability.

While making a case for enhancing capacities, Khan *et al.* (2008) defined capacity as resources, means, strengths which enables a system to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster. Some organisations have identified the need to build resilience, but the inadequate in-house capability to assess and understand risks, and after that execute necessary actions is a challenge (PwC, 2013).

To survive a crisis with minimal impact, some capabilities are required by business organisations (Grewal & Tansuhaj, 2001; O'Regan & Ghobadian, 2004). In the context of natural disasters and built environment flood resilience, these capabilities include structural measures, non-structural measures, knowledge base, skills, facilities, and networks among others (UNISDR, 2009). Prominent among the structural measures are the use of resilient construction technologies, building materials and other disaster resilient installations while the non-structural measures include adherence to building

codes, planning and construction considerations, design options among others (Rossetto, 2007; UNDP, 1994). Other capabilities include knowledge base, skills, networks, resources and facilities (Khan *et al.,* 2008; UNISDR, 2009). The effective utilisation of these capabilities is still very low because physical damage to premises remains a major impact of flood disasters (Norrington & Underwood, 2008). UNDP (2013a) stated that it was difficult for the Japanese fishing industry to recover after the Great East Japan Earthquake (GEJE) because of huge physical damage to infrastructure, processing and storage facilities, markets, processing factories, power supply among others. Asgary *et al.* (2012) also identified the significance of damage done to business facilities because of the 2010 flood in Pakistan. Pitt (2008) and Wedawatta (2013) also acknowledged the importance of business premises to continuity after a catastrophe and the significance of the damage currently being experienced. These submissions indicate that only a more disaster resilient built environment can reduce physical damages and in turn reduce the resultant effects of the damages among which is a business interruption. Additional fund is often required to enhance capabilities for disaster resilience (Neumayer *et al.*, 2014; Warhurst, 2006). In this study, a discussion on the funding options available to businesses and other stakeholders in disaster resilience is presented in Chapter 3 alongside other relevant discussions.

As a result of the growing need for a reduction in the impact of flood disasters, researchers have identified mitigation measures (Asgary *et al.*, 2012; Bhattacharya-Mis & Lamond, 2014; CIRIA, 2010; Crichton, 2006, 2008; Ingirige *et al.*, 2010; Kulatunga *et al.*, 2012; Lamond & Proverbs, 2009), each of the studies have various targets. Some other studies also identified general principles for organisation resilience (Stephenson, 2010; Stephenson *et al.*, 2010) and White *et al.* (2013a) outlined six steps to property flood resilience. Based on the definition of capabilities (Khan *et al.*, 2008; UNISDR, 2009; Yen-Tsang *et al.*, 2012) the submissions of all the authors are contributions to the list of capabilities for flood resilience of the built environment of organisations.

It is interesting to note that none of the studies that discussed mitigation measures or identified the need for capacity or capability enhancement developed capability maturity model for flood resilience. Stephenson (2010) considered organisational resilience maturity, but did not focus on flood resilience, and it paid no attention to the built environment and the physical assets of organisations. Researchers have advocated and developed models for capability maturity assessment and improvement (Babatunde *et al.*,

2016; Eadie *et al.*, 2012; Macgillivray *et al.*, 2007; Paulk *et al.*, 1993; Sarshar *et al.*, 2000; Yeo & Ren, 2009), these models have been successfully applied to process and capability improvement in different fields and organisations; the models have been published in reputable refereed journals. It is on this premise that this study is using identified and verified built environment flood resilience capabilities to develop a capability maturity model for flood resilience of the built environment of business organisation. Currently, such model does not exist; its development is expected to benefit MSMEs, the government and the society at large.

1.2 Problem statement

Disasters often result in severe socio-economic losses, although there is significant progress in dealing with the social aspect, economic aspect is addressed relatively insufficiently. The increasing magnitude of loss from disasters was attributed to low level of adherence to disaster resistance and resilience measures (Lamond & Proverbs, 2009), the inadequate in-house capability to assess and understand risks and after that execute necessary actions (PwC, 2013). Capability enhancement for disaster resilience attracts additional costs (Neumayer *et al.*, 2014; Warhurst, 2006). The extra cost is a discouraging factor but since economic loss from disasters is increasing (IRIN, 2005; Ki-Moon, 2013; Kulatunga, 2010a; Neumayer *et al.*, 2014; UNISDR, 2013b) the capabilities for managing disasters need to be enhanced. In the light of this, the capabilities of individual organisations in managing disasters need to be improved, and there should be a way of assessing these capabilities.

In the United Kingdom, flood is a common hazard (Leinster, 2009) and it has resulted in huge damage to MSMEs (Woodman, 2008 and Heliview Research, 2008). Norrington and Underwood (2008) reported that flood is wreaking significant havoc on business properties and stocks; and Crichton (2006) stated that MSMEs are the most vulnerable to disasters in the UK economy. In 2012, flood damages resulted in economic loss to businesses and cost British insurers a whopping £373million and £40million claim payments, for damages to business properties and business interruption respectively (ABI, 2013). The exclusion of businesses and some properties from the FloodRe insurance scheme in the UK (RICS, 2015), significant damage to business properties, projected increase in riverine flooding across the UK (Kundzewicz *et al.*, 2010), low uptake of disaster resistance and resilience measures (Lamond & Proverbs, 2009) as well as inadequate capability of businesses (MSMEs inclusive) to manage flood disasters

(Bannock, 2005; Dlugolecki, 2004; Finch, 2004; PwC, 2013; Yoshida & Deyle, 2005) makes the development of a systematic flood resilience capability enhancement strategy for business organisations germane. This will help MSMEs to manage flood disasters better thereby reducing economic loss; this inspired this study.

In addition, researchers have worked on disaster resilience assessment from a variety of perspectives (Achour *et al.*, 2014; Barker *et al.*, 2013; Cardoso *et al.*, 2015; Faturechi *et al.*, 2014; Holladay, 2012; Lee *et al.*, 2013; Stephenson *et al.*, 2010; UNISDR & GFDRR, 2012). However, none of the previous studies focused on the flood resilience of the built environment of micro, small and medium-sized enterprises (MSMEs), whereas the place of MSMEs in the economy and damages to the built environment of businesses by flood is significant.

In summary, the following gaps inspired this study.

- There are capabilities for enhancing built environment flood resilience of businesses, but previous researchers did not expressly outline these capabilities in the context of built environment flood resilience and individual organisations.
- Capabilities of organisations need to be improved, and there should be a way of assessing these capabilities. Currently, there is no standard method for evaluating and guiding the improvement of these capabilities in the context of built environment and flood resilience.
- There is a need for a methodical approach for encouraging the adoption of flood disaster resilience strategies, strengthening associated capabilities and outlining improvement; this is yet to be done in the context of built environment flood resilience.
- Previous researchers are yet to outline stepwise improvement strategies that can aid organisations commitment to the enhancement of flood resilience capabilities.

Based on the identified gaps, this research proceeded to develop a flood resilience capability maturity model for MSMEs. The research expressly outlined the capabilities required for built environment flood resilience and developed a maturity model for built environment flood resilience capability improvement. The model would be useful for assessing the built environment flood resilience capability maturity level of micro, small, and medium-sized enterprises. It would also guide the continuous improvement of built

environment flood resilience capabilities in business organisations thereby reducing damage to the built environment by flood, business interruption due to premises damage and economic loss. Based on the foregoing, the research questions presented in Section 1.3 are relevant.

1.3 Research questions

Towards achieving the aim of this study, the following questions will be answered.

i. What are capabilities for enhancing built environment flood resilience?
ii. How can the capabilities for enhancing built environment flood resilience be identified?
iii. How can the capability maturity for flood resilience of business organisations be assessed?
iv. How can improvement of capabilities for built environment flood resilience be methodically guided?

1.4 Aim and Objectives

The aim of this research is to develop a flood-related disaster resilience capability maturity model that identifies built environment flood resilience capabilities of micro, small and medium-sized business organisations.

The specific objectives of the study are:

1. To review capability in the context of disaster resilience,
2. To identify and assess key capability areas for enhancing built environment flood resilience of MSMEs,
3. To explore capability maturity model concept towards its application in built environment flood resilience capability assessment,
4. To determine maturity level definitions for capabilities related to built environment flood resilience,
5. To develop a conceptual and intermediate capability maturity model for enhancing capabilities for built environment flood resilience,
6. To refine the built environment flood resilience capability maturity model for businesses; and
7. To validate the capability maturity model developed.

1.5 Research design and methodology used (Indicative methodology)

This study employed a qualitative method of research towards achieving its aim and specific objectives. The procedure includes literature review, expert forum review, and case studies (See Figure 5.5 for details). This study employed a single research choice (i.e. qualitative method) and overcame the possibility of bias and unknown aspects of the research and its result usually attributed to the adoption of a single approach (Bryman, 2006)by adopting multiple round expert reviews and multiple case study strategy. Yin (2014) defined case study as "an empirical inquiry that investigates a contemporary phenomenon within its real-life context". Multiple case studies involve the extraction of data from two or more cases. The data collected is united on the same set of phenomena, thereby eliminating bias through triangulation of data and comparison of results. Beyond the multiplicity of cases in multiple case studies, there was a multiplicity of data sources; data was collected via interviews, documentation, and review of documentation. These provided an adequate base for triangulation. Triangulation involves the use of multiple methods or collection of data from multiple sources for achieving a common purpose (Yazan, 2015). It allows the comparison of responses, data, and results thereby increasing the validity of a research outcome (Love *et al.*, 2002; Saunders *et al.*, 2016; Yin, 2014). Triangulation helps in finding patterns i.e. similarity and differences before discussing and synthesising the meanings and main points of the similarities and differences.

The research methodology flowchart of this study is presented in Figure 5.5. Discussed as follows are the major activities in the research process.

Literature review: Towards achieving objectives one and three and a part of objective two, a comprehensive literature review was undertaken. The extensive review of the literature was carried out to discuss the meaning of capability in the context of disaster resilience (objective one – See Section 4.3) and specifically identify capability areas for enhancing built environment flood resilience (i.e. part of objective 2 – see Table 4.1 and the preceding discussions). Existing maturity models were also identified via literature review, the capability maturity model concept and its applicability in built environment flood resilience was explored. Objective one (i.e. the review of capability in the context of disaster resilience) was meant to expand the researcher's knowledge base on the meaning of capability and its definition by different authors. This was done in preparation for objective two (i.e. the identification and assessment of key capability areas for enhancing built environment flood resilience of MSMEs. Objective two is in two-folds,

the first part is the identification of capabilities from literature and the second part is the assessment of capabilities identified from literature by a team of experts. Objective three was also achieved via literature review; the purpose of objective three is to explore the concept of capability maturity modelling and its applicability in built environment flood resilience (See sections 4.6, 4.7 and 4.8). Efforts toward achieving objective three also led to the identification of existing maturity models as well as identification of capability maturity level characteristics in literature (see section 4.7.1). Data for the literature review were gotten from secondary sources; the literature includes referred journals, conference proceedings, working papers and textbooks.

Expert forum review and mapping exercise: The capability areas for enhancing flood resilience identified in objective two were sent to a team of selected experts for verification (refer to section 5.4.2 and chapter 6 for details), this completed the achievement of objective 2 in full. The characteristics of maturity levels were identified as part of the outputs from objective three. The maturity characteristics identified in objective three were mapped to the capability areas verified in objective 2 (see section 5.4.1.1), and this led to the production of a conceptual model (See section 5.4.1 and Appendix K). A team of experts further developed the conceptual model (see Chapter 7 for details), and this resulted in the development of an intermediate maturity model. The expert panel rigorously reviewed and modified the capability areas identified from literature and the capability level definitions structured around each capability area. The capability maturity levels range from level 1(Ad hoc) to level 5 (Optimising), the definitions of each level are specific characteristics outlined based on the concept of Capability Maturity Model (CMM). A 10-man expert team was constituted to verify the capability areas. The size of the panel aligns with the proof provided by Boje and Murnighan (1982), the study observed no effect of group sizes on decision-making techniques when it engaged groups made up of 3, 7, and 11 members. Also, Adler and Ziglio (1996) submitted that the composition and quality of a panel matter more than the size especially when the heterogeneity of the panel is not prominent. Therefore, the submissions of the expert team and the subsequent case study verifications ensured the reliability of the capabilities identified and the model developed in this study. The expert team members were asked to review and rate their level of agreement and the degree of importance of each of the capability areas with each of the identified capability areas.

The ratings provided by the experts were analysed, the result showed an acceptable level of agreement with the capability areas. Based on the outcome, the research progressed to the next stage. A conceptual model containing the capability areas and the capability level definitions for each capability area was developed. During the review of the conceptual model, the experts were requested to verify and refine the capability areas and capability level definitions prepared for each capability area. There were rounds of communication with the experts and suggested amendments to the model were considered accordingly.

Upon the completion of the expert review process, the model was refined further in case studies. The rounds of expert forum review and the mapping exercise led to the achievement of objectives four and five and the production of an intermediate model, which is the foundation for achieving objectives six and seven.

Case studies: Towards achieving objectives six and seven, which implies the achievement of the goal of this research, case study approach was employed. Case study interview and review of documents were the methods of data collection (Section 5.4.7.1 and 5.4.7.3 respectively) used in the respective case studies. The intermediate maturity model (Table 7.3, see the full version in Appendix L) produced after the expert forum review of conceptual model was modified further in case studies. Four case study business organisations were engaged in the verification of capability areas and the refinement and improvement of the maturity model (Section 5.4.5 and 7.6). Yin (2014) recommended the use of two or more case studies in multiple-case designs; it suggested that two to three case studies are sufficient if similar results are expected and four to six case studies if different patterns are predicted from the case studies. Therefore, a reliable number of case organisations were selected, and they are adequate for all viability and reliability measures. After the refinement of the model and appropriate consideration of feedbacks, the model used in the case studies, and this resulted in the development of the final model.

Validation: Towards validating the model, the model was utilised in a new case study. Alongside the case validation, another set of experts were invited to evaluate the developed Built Environment Flood Resilience Capability Maturity Model. The validation exercises resulted in pleasant feedbacks on the comprehensiveness and suitability of the model. The details of the validation exercise are presented in chapter eight.

1.6 Scope of the study

The study area for this research is the United Kingdom (UK) and the study is limited to flood resilience capabilities of business organisations only. This is because flooding is a frequently occurring natural disaster in the UK and UK businesses are incurring significant losses from flood-related disasters. This study is restricted to capabilities for enhancing the disaster resilience of the built environment of businesses. This is because the ability of the built environment to withstand, resist or absorb the impact of disasters will enhance the quick return of businesses to operation after a catastrophe. The UK was also selected as the study area for this research because of access to suitable built environment flood resilience experts, case study organisations with substantial flood experience, and access to conduct expert review and case study to obtain relevant data. This study is restricted to micro, small, and medium-sized enterprises (MSMEs) because communities and several stakeholders in the society depend on the services provided by MSMEs. In 2014, 5.2 million MSMEs (MSMEs – organisation with 0 to 250 employees) and 5 million micro-businesses were estimated to be in the UK, this resulted in MSMEs accounting for 99% of UK businesses and about 60.1% of employment (Ward and Rhodes, 2014). The above figures underline the importance of the need to make MSMEs disaster resilient. It is believed that achieving a reduction in flood damage to the built environment (i.e. property) will contribute to a reduction in loss to physical assets as well as the consequential effects of damages to business properties.

1.7 Structure of the thesis

Presented in Figure 1.1is the structure of this thesis, it is followed by a summary of the content of each chapter.

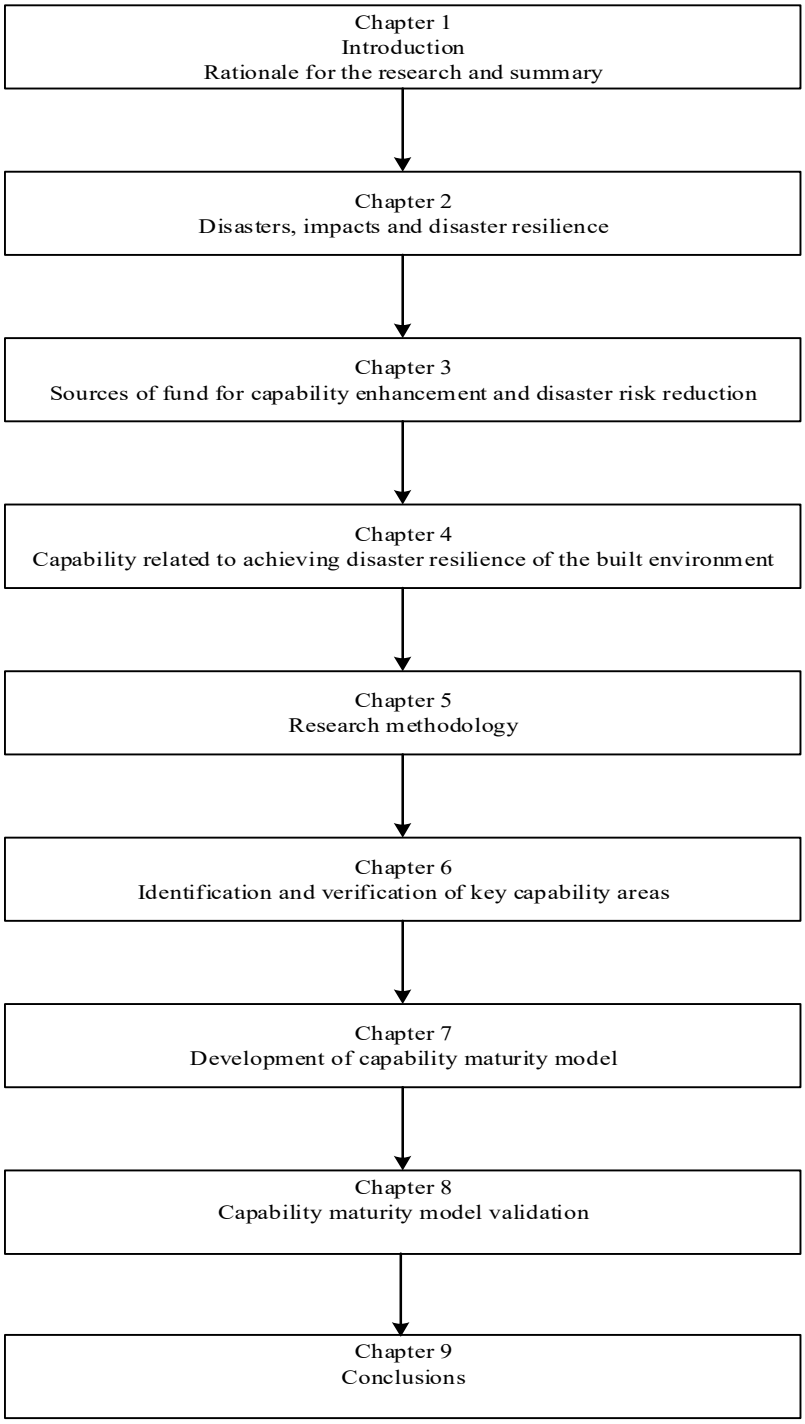

Figure 1.1Structure of the thesis

Chapter 1 presents a discussion on the background information and the rationale for this study. The chapter is presented under the following headings: Background to the study, problem statement, aim and objectives, research methodology and scope of study among others.

Chapter 2 covers discussions on natural hazards and disasters, flooding, impacts of disasters, disaster damages and causes of increase in disaster damage cost, disaster resilience, strategic procedures for building disaster resilience which includes business continuity and corporate social responsibility, disaster resilience in the built environment and frameworks for disaster risk reduction. The chapter provides a general foundation for the focus of this study. The focus of the study is mainly on capabilities for flood resilience of the built environment of an organisation.

Chapter 3 focuses on sources of fund for capability enhancement and disaster risk reduction. The chapter provides a comprehensive discussion on issues relating funding. The discussion in the chapter is necessary because some of the capabilities require financial commitments, so beyond identifying capabilities in this study, channels of funding as might be needed are provided. The chapter is presented under following headings: Disaster risk finance, investment in risk reduction for built environment disaster resilience, barriers and drivers to funding capability enhance and disaster risk reduction efforts, incentives for committing and investing in disaster resilience.

Chapter 4 provides a discussion of capabilities related to achieving flood resilience of the built environment. The discussion covers a review of capability and capacity, capabilities and built environment resilience, assets of an organisation, business assets and organisation resilience, the concept of maturity and capability maturity modelling as well as maturity modelling methodology and disaster resilience among others. The chapter contains a review on some of the key issues on which the aim of this study is strongly anchored.

Chapter 5 presents the research methodology of this study. The discussions in the chapter include research design, which includes research philosophy, research approach, research techniques and procedures, and theories relevant to this study among others. A detailed discussion of the tasks and processes involved towards achieving the aim of this study is presented in this chapter.

Chapter 6 focuses on data analysis and results relating to the identification of the main capability areas for enhancing the flood resilience of the built environment of businesses. Chapter six is the first chapter on data analysis and results.

Chapter 7 is another chapter on data analysis and results. It focuses on all other processes leading to the development of the capability maturity model. This chapter includes a report on the expert review process and multiple case study activities.

Chapter 8 presents the report of the validations exercise conducted on the capability maturity model developed in this study. It covers the rationale for validation, the processes involved and the outcome of the validation exercise.

Chapter 9 is the last chapter of this thesis; it presents the summary of findings from this study in respect of each objective. It also presents the specific contributions of the study as well as conclusions and recommendations. The limitations of this study and suggested areas of further research are also presented. The limitations and areas suggested for further research in this thesis are products of the experiences gathered and discoveries made in this study.

1.8 Chapter Summary

The background to this study has been presented in this chapter. The problems and the specific questions that this study intends to answer have also been discussed. Since all challenges cannot be addressed at once, a technical scope was set for this study and presented in this chapter. The structure of this thesis was also presented to guide readers on how all issues relating to the aim of the study were distributed into chapters. It is believed that a careful read of this chapter by a reader will present a good picture of the aim of this study as well as how the aim and all associated objectives were achieved. Presented in the next chapter is a discussion on disasters, impacts of disasters and issues relevant to disaster resilience. Adequate consideration was given to flooding (the focus of this study) in some sections in the chapter.

CHAPTER TWO
DISASTERS, IMPACTS AND DISASTER RESILIENCE

2.1 Introduction

The background to this study was discussed in chapter 1. The aim of the study was presented, and the procedures leading to the achievement of the aim and its associated objectives were discussed. The discussion in this chapter is meant to provide a broad foundation on a range of issues related to disasters, impacts of disasters and disaster resilience. Since the enhancement of capabilities for flood resilience is the main interest of this study, a clear reference to flooding was made in some sections of this chapter. Among the topics covered are natural hazards and disasters, sustainability impacts of disasters, strategic procedures for building resilience, disaster resilience in the built environment and developments in disaster resilience policies.

2.2 Natural Hazards and Disasters

Disasters affect nations, communities and organisations in different ways and different magnitude; the world has witnessed various types of it in recent times. Some locations are also prone to some specific types of disasters. Literature reveals that several efforts are being made by stakeholders to minimise the impacts of disasters. However, disasters like earthquake, flood, storm, bushfire and landslides among others are still taking a toll on the social, economic, and environmental state of the society (Kulatunga, 2010; UNISDR, 2013).

According to UNISDR (2009), natural hazard is a natural process or phenomenon that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage. Early warning systems can reduce the mortality rate from disasters resulting from natural causes if people are moved out in time, but they are less effective for preventing economic loss since built environment cannot be entirely moved away before disasters strike. The implication of these is an economic loss; there are more disaster events with economic loss than with the human loss of life (Neumayer *et al.*, 2012).

Disasters are caused by the level of people, economic activities, and infrastructure exposure to hazards and the vulnerability of those exposed to hazards (Pitt, 2008). Disaster prevention efforts can reduce vulnerability thereby reducing the impacts of natural disruptive events. Appropriate disaster prevention measures, mitigation and

preparedness, ensure quick restoration of activities after disasters. Regarding the prevalence of disasters on regions, tropical storms, earthquakes, and floods are common in Asia. Floods, volcanoes and tropical storms affect South and Central America while floods, epidemics and droughts mostly affect African countries and the United Kingdom. Disasters of different types have hugely affected communities and the world as a whole in recent times (UNISDR, 2013). Presented in the next section is a review of the literature on the impacts of disasters.

2.3 Impacts of Disasters

GCPOE (2011) estimated project investments in urban areas to rise by 67 percent—i.e. from about US$7.2 trillion in 2011 to around US$12 trillion by 2020. By the year 2020, about US$97.7 trillion is expected to be spent on construction globally thereby bringing the contribution of construction to world GDP to about 13.2 percent (Global Construction Perspectives and Oxford Economics, 2011). However, as significant as the projections appear to be because of its tendency in expanding existing business and creating new ones, the challenge it stands to pose to disaster risk reduction and disaster resilience of the society should remain an issue of utmost concern. This is because much of this development is expected to take place in disaster prone or vulnerable areas and some countries with relatively weak disaster risk management system (IIHS, 2012; Committee on Climate Change, 2012) the developments will also increase the concentration of wealth in some areas. It should be noted that the magnitude of loss from disasters is a function of the wealth of the affected area (Bouwer *et al.*, 2007; Neumayer & Barthel, 2011; Pielke *et al.*, 2008).

According to IIHS (2012) much of the developments in Delhi, India occurred in hazard-prone areas despite the knowledge and awareness of the risks of flood and earthquake. Also, in the United Kingdom, despite the existence of policy frameworks, regulations and monitoring agencies, the number of properties developed on flood plains are still increasing (Committee on Climate Change, 2012). In November 2012, many parts of the country were affected by flooding; this left about 1100 homes damaged or destroyed (AON Benfield, 2012). The flooding was estimated to cost insurers £500 million and estimated to increase annual insured loss in the UK for 2012 to about £1 billion (about USD1.60 billion) (AON Benfield, 2012). The 2012 estimate ranks among the highest regarding claims processed in recent times (AON Benfield, 2012). Also, in Slovenia and Croatia, AON Benfield (2012) reported that excessive rain led to flooding along Drava

and Sava rivers and this resulted in the damage of more than 4, 500 homes and other buildings, this amounted to an economic loss of around EUR209 million (USD265 million). If adequate consideration is given to the need for disaster-resilient infrastructure and properties, and the needed resources are sourced and invested, the expected future development in the built environment will be a great opportunity for achieving a disaster resilient future.

The impacts of disasters can also be examined based on sectors, for instance, the impact of flood in the agricultural sector differs from its impact in the residential or industrial sector. In the agricultural sector, damages are recorded via crops destruction, production facility damage and loss of business (Dutta *et al.*, 2003; Hoes & Schuurmans, 2006). In the residential and housing sector, disasters lead to property damage, equipment and asset damage (Meyer *et al.*, 2013; Penning-Rowsell *et al.*, 2005; UNISDR, 2015). In the industrial and business sector, disasters lead to the damage of building and equipment, goods, stocks, and all other production facilities (FEMA, 2003; Kreibich *et al.,* 2010; Scawthorn *et al.*, 2006, UNISDR, 2015). Disasters also result in other physical infrastructure and intangible/non-physical consequences across other sectors. Meyer *et al.* (2013) conducted a comprehensive review of disaster impacts and categorised the cost of disasters into five, namely: direct cost, business interruption costs, indirect costs, intangible costs and risk mitigation costs. The study highlighted several issues relating to the cost of disasters and assessment approaches; it concluded that all disaster cost and impact evaluation methods had considerable uncertainties and recommended the development of measures to enhance the accuracy of disaster impact assessment methods.

It is believed that disaster impact will keep increasing because of climate change, the rise in living standard, a general increase in population, growth in asset and people concentration in urban areas, industrialisation of risk-prone areas e.g. coastlines and fluvial plains (Neumayer & Barthel, 2011 and Pielke *et al*., 2008). As a result, disasters stand to be a major setback to development. More investments in the built environment and infrastructure are expected over the coming years. If the investments are made with adequate consideration for disaster resilience, the cost of disaster might reduce. Otherwise, the cost especially the economic cost of disasters will keep increasing.

2.4 Impacts of disasters on Micro, Small and Medium-sized Enterprises (MSMEs)

Business organisations are classified based on turnover and number of employees (European Commission, 2008). Until recently, business organisations with less than 250 employees are referred to as SMEs (Ward and Rhodes, 2014). Despite the existence of more detailed definitions, business organisations with 1 – 250 employees are still referred to as SMEs in some reports (CSES, 2012).

CSES (2012) and Ward & Rhodes (2014) defined micro-businesses as business organisations with 0-9 employees, small sized enterprises are businesses with employees between 10 – 49 employees and medium-sized enterprises are businesses with 50 – 249 employees, while large businesses are with staff above 250. Classifying business organisations based on turnover, businesses with ≤ € 2 million are classified as micro businesses while businesses with > € 2 million but ≤ € 10 million are small enterprises. Business organisations with > € 10 million but ≤ € 50 million are medium-sized while those with turnovers > € 50 million turnovers are large business enterprises (CSES, 2012 and Ward & Rhodes, 2014).

MSMEs make up 99.8% of private sector business enterprises; it provides 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; 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 basically because of the limited human and financial resources available to them and limited risk management capability (Bannock, 2005; UNISDR, 2013a).

According to European Union definition, an MSME "is an enterprise which employ fewer than 250 persons and which has an annual turnover not exceeding €50 million, and an annual balance-sheet total not exceeding €43 million" (European Commission, 2006). Although the definition of SMEs and micro business organisations vary across nations

(Hallberg, 1999), the vulnerability and the impacts of disasters on businesses is widely acknowledged (Merz *et al.*, 2010).

Crichton (2006) stated that MSMEs are the most vulnerable to disasters in the UK economy. Similarly, Finch (2004) stated that although large organisations are also affected, MSMEs feel more impact. The fact that MSMEs are often rooted in a local community makes them more vulnerable (Bannock, 2005). On most occasions, MSMEs only operate at a single location, once disaster strikes at that location, the establishment will be out of business and probably the whole of the organisation's asset will be lost (Bannock, 2005). On the contrary, a larger organisation faced with a similar situation can still sustain her business position by controlling operations from another branch. Some authors concluded that MSMEs are not adequately prepared for catastrophes (Dlugolecki, 2004; Yoshida & Deyle, 2005). Woodman (2008) discovered in a study that only 30% of small businesses have a business continuity plan. It is indeed important to work towards enhancing the disaster resilience of these organisations through all possible medium.

Disasters often lead to disruption and damages, towards reducing its occurrence and mitigating its impact, calls have been made for the building of resilient cities and communities (Paton & Johnston, 2006; UNISDR, 2005). Disaster impacts can be physical, social, economic, environmental, and political (UNISDR and GFDRR (2012). Disasters have short and long term effects on regional and sectoral economic performances. Disaster impacts include price increase resulting from supply difficulties, a decrease in stock, trade deficit at least in the short term, loss in sectoral or regional outputs, reduced income for businesses and the government (ECLAC, 2003; Mechler, 2003; Pelling *et al.*, 2002). Larger magnitude of disasters lead to noticeable alterations in economic performance at both micro and macro levels; these changes are noticed in either the occurring year or the year following the occurrence of the disaster (ECLAC, 2003; Mechler, 2003).

Organisations depend on the functionality of built facilities to operate; several stakeholders provide these facilities. On some occasions, the provision of the facilities is localised so as to limit interconnectivity that usually results in a bigger loss once a catastrophe strikes the source. For example, a road network that is destroyed by disaster can isolate a whole community thereby leading to a huge business loss for business organisations and the residents of that community. With the current level of

interconnection of businesses, a business organisation should also labour to assist the resilience of his supply chain. A seemingly interesting paradigm is to establish a cluster of suppliers and vibrant consumer markets that are "hardened" as much as possible, further discussions are needed on this. Local disasters are experienced in some locations, but their impacts are felt from regional to international levels.

Businesses often suffer productivity loss, revenue loss, loss of tangible and intangible assets, and general loss of funds to disasters (Burnham, 2006). Disaster losses result from change in transportation cost, premises repair, loss of operation, supply chain challenges, facility damage, loss of customers, decrease in general demand or some certain goods, staff unavailability due to departure, difficulty in getting to work and/or loss, reduction in competitive advantage, decrease in turnover, increase in operation cost, among others (Bhattacharya-Mis & Lamond, 2014; Burnham, 2006; Heliview Research, 2008; Metcalf & Jenkinson, 2005; RICS, 2015; Wedawatta *et al.*, 2014). Other impacts are a loss of reputation and trust among clients and financiers (Metcalf and Jenkinson, 2005).

Norrington and Underwood (2008) discovered that damage to property, stock and reduction in customer visits is the major impacts of South East of England flood on MSMEs. The study also submitted that damage to property/stock is the main effect of flooding and wind while high and low temperature reduces customers' visit. Staff travel and working condition are also affected (Norrington and Underwood, 2008). Woodman (2008) and Heliview Research (2008) also listed some of the impacts of catastrophes on MSMEs, the studies listed unavailability of staff, flooded premises, disruption of supplies and increase in total cost of operation, decrease in turnover, damage to building and assets as part of the effects of disasters on MSMEs. All the listed impacts are substantial but the discovery of property and stock damage as major impacts of flood disaster by Norrington and Underwood (2008) underlines the importance of flood resilient properties and the protection of stocks to business resilience. A business premises and facilities that can withstand, absorb and resist flood will go a long way in reducing loss from disasters.

The impact of disasters on MSMEs is huge; this is mainly due to their existence in a single location on most occasions, availability of limited resources for business protection, and limited understanding of disaster risks (Bannock, 2005; Dlugolecki, 2004; Finch 2004; and Yoshida & Deyle, 2005). Although some MSMEs are also taking measures aimed at protecting and enhancing their response to and swift recovery from disasters (RICS,

2015). It is important to mention that flooding (the focus of this study) can lead to all of the disaster impacts above.

It is worthy of note that the impacts of disasters on business organisations are enormous (discussed earlier in this section), but a built environment/premises that can withstand, absorb, or resist flood and other types of disasters will prevent the occurrence of the majority of the consequences mentioned above. From the account of Corey and Deitch (2011) cited in UNISDR (2013), physical damage to business premises poses a significant threat to the swift recovery of businesses after disasters. The study reported that businesses spend huge sums on repair of physical damages to premises and facilities and often have to go out of operation during repairs, thereby losing income. It should be noted that the duration of the closure is influenced by the magnitude of damage (Corey and Deitch, 2011 cited in UNISDR, 2013). The account of Corey and Deitch underlines the need for disaster resilient built environment/premises and the significance of the focus of this study (i.e. flood resilience of the built environment of businesses).

2.5 Disaster resilience

Among the several definitions of resilience, the UNISDR (2009) definition of resilience in the context of disasters appears to be among the most popular and perhaps the most acceptable in disaster literatures. Disaster resilience was defined by UNISDR (2009) as "the ability of a system, community or society exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" However, Tainter and Taylor (2014) described disaster resilience as the ability to recover from a setback. Invariably, resilient societies must have the appropriate problem-solving capacity to adjust to setbacks without distortion. As earlier mentioned, the attempt to describe resilience has been greeted with several submissions from authors, this, coupled with the interdisciplinary attribute of resilience is nearly bringing confusion (Twigg, 2009). However, except for the emergence of the principle of "bouncing forward" in the disaster resilience community (Manyena *et al.*, 2011), there is a high level of similarity in the practical implication of almost all previous definitions. The "bounce forward" paradigm still require further development as there is a cloud of ambiguity on the real meaning and boundaries of the bouncing forward of society after a disaster. The authors attached a note of caution, as the 'bounce forward' idea is their conception. Further development on how it will be interpreted by stakeholders – especially

humanitarian intervention providers and intervention beneficiaries is needed (Manyena, 2009).

2.6 Disaster resilience in the built environment

The magnitude of the disaster resilience of the built environment has a strong influence on the volume of risk and the eventual cost of any disaster. Worthy of emphasising is the ability of a disaster resilient built environment in protecting people and other assets from disasters (UN ESCAP and AIT, 2012). Beyond protection, built facilities are supposed to be functional all through the phases of a disaster (McAllister, 2013), this will ensure adequate response and management of shocks caused by the catastrophe. According to Bosher (2008), a disaster resilient built environment is "designed, located, built, operated and maintained in a way that maximises the ability of built assets, associated support systems (physical and institutional) and the people that reside or work within the built assets, to withstand, recover, and mitigate for, the impacts of extreme natural and human-induced hazards". The definition appears to be comprehensive enough that the scope of the definition might paint a thought of how difficult it might be to achieve in one's mind.

Describing the possibilities of achieving a disaster resilient built environment, UNDP (1994), Rossetto (2007) and Lamond *et al.* (2013) provided a list of important considerations. Among the conditions provided are: hazard resilient designs, construction methods, specifications, materials and technologies, consideration for climate change effects, accurate assessment of hazards, alignment of structural designs with hazard levels. According to Lamond *et al.* (2013), one of the major reasons for damage from natural disasters is the structural inadequacy of the built environment. It is indeed reasonable to submit that the level of resilience of a property determines the magnitude of damage that the property will experience from a disaster and also the duration of repair and return to full functionality. Kreibich *et al.* (2005) submitted that the use of precautionary measures is effective in areas with repeated small floods as well as places where extreme floods are experienced.

Similarly, Labaka *et al.* (2015) stated that the resilient ability of a system or facility is not determined by the physical characteristics of the facility alone but also the use, users, management and the attributes of external stakeholders. Previously, Bosher (2008) and UN ESCAP and AIT (2012) had stated that it is necessary to build capabilities for

property resilience beyond physical attributes of the property. Gibberd (2015) made a similar submission on the sustainability of the built environment.

2.7 Flooding and flooding mechanisms

There are different types of disaster, but flooding is being discussed separately in this study because it is the focus of the study. According to CCRA (2012) properties with an annual probability of flooding of 1 in 75 or greater was around 560, 000 in 2012. The figure is expected to rise in the coming years. The annual flood damage to properties was said to be £1.2 billion and might rise to £1.7 - £4.5 billion by 2050 and £2.1 to £6.2 billion by 2080 (CCRA, 2012). Similarly, (RICS, 2015) quoted the Association of British Insurer's description of a flood as a major issue to property owners; the association stated that the 2012 flooding in the United Kingdom resulted to building and content damage of about 400 million pounds on a total of 8, 000 properties.

DEFRA (2014) cited in RICS (2015) defined flood as water entering a property at the ground, below or above ground level from an external source. Water entering from above the ground level has to have part of its body at ground level (RICS, 2015). The Royal Institute of British Architects identified six mechanisms of flooding (RICS, 2015), the mechanisms are tidal, fluvial, ground water, pluvial, flooding from sewers, and flooding from human-made infrastructures. Tidal flood is experienced when river defences are breached by high tides 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). Flooding from sewers result from the exceedance of sewer capacity; this is usually caused by excessive water run-off (RICS, 2015). Flooding due to human-made infrastructure are outcomes of the failure of the reservoir, dam and related infrastructure (RICS, 2015).

Contents and buildings insurance policy have been a defence option from flooding, but the recent spate of disasters is stressing the insurance industry, there is also the problem of insurance penetration in some countries (Mahul & Gurenko, 2006). Recent policy

changes in the insurance industry, as well as increase premium rates, is a source of concern to property owners (RICS, 2015). For instance, it was perceived that securing insurance for some properties might become difficult due to high risk. Therefore, the United Kingdom introduced the FloodRe scheme, a reinsurance scheme that utilises funds from premium and every household insurance policy (RICS, 2015). The main purpose is to ensure affordability of insurance cover. The FloodRe scheme is only available to properties built before 1 January 2009, business premises and buy-to-let dwellings are excluded (RICS, 2015). Also excluded are most blocks of flat, uninsurable homes, properties belonging or occupied by charities, mixed use properties (for example bed and breakfast), and holiday homes that are rented out (RICS, 2015).

With the limits of availability of affordable flood insurance, it becomes imperative to build disaster resilience and support all efforts aimed at building disaster resilience. This will reduce pressure on the insurance industry and mitigate loss from disasters.

2.7.1 Flood damage influencing factors

Flood damage influencing factors are parameters that determine the magnitude of destruction that will result from a flood disaster. Researchers have described and considered these parameters in different flood damage assessments studies. A summary of the factors is presented in Table 2.1.

Table 2.1 Flood damage influencing factors – Adapted from Merz *et al.* (2010)

S/N	Parameter	Brief notes	Literature sources
1	Depth of inundation	Higher inundation depth implies higher buoyancy force and a higher likelihood of damage.	Büchele *et al.* (2006); CIRIA (2007); Citeau (2003); DEFRA (2011); Dutta *et al.* (2003); Hoes and Schuurmans (2006); Kreibich and Thieken (2008); Merz *et al.* (2010); Nicholas *et al.* (2001); Penning-Rowsell *et al.* (2005); Pitt (2008); Thieken *et al.* (2008)
2	Duration of inundation	The amount of time spent by floodwater in a property determines the magnitude of saturation that will be experienced by the property and its contents. This also determines the level of difficulty in drying. Flood duration can be hours, days, or months.	Citeau (2003); DEFRA (2011); Dutta *et al.* (2003); Kato and Torii (2002) cited in Merz *et al.,* (2010); Nicholas, Holt, & Proverbs (2001); Penning-Rowsell et al. (2005)
3	Rate of rising	This refers to the rate at which the floodwater height/depth increases. The potential and magnitude of damage increase as the speed of rising increases.	CIRIA (2010)
4	Flooding frequency	The cumulative effect of frequent flooding of a property increases the magnitude of damage to the property from flood on subsequent occasions. Conversely, frequent flooding of a location can increase preparedness, thereby leading to a reduction in damage.	Elmer *et al.* (2010); Förster *et al.* (2008); Pitt (2008)
5	Velocity of flow	This refers to the speed of flow of flood water in definite directions	DEFRA (2011); Nicholas, Holt, & Proverbs (2001), Pitt (2008)
6	Contamination	The presence of contaminants in floodwater increases damage and the cost of cleaning. Some contaminants might be difficult to remove or require disinfection.	Kreibich and Thieken (2008); Nicholas, Holt, & Proverbs (2001); Thieken *et al.* (2008)
7	Presence of debris and sediments	The presence of debris in floodwater increases the risk of flood damage to properties. The impact of debris on a property can cause both structural and non-structural damage. Sediments can damage surfaces (e.g. floor and wall) as well as equipment; it can also make clean up exercise more challenging.	CIRIA (2010); DEFRA (2011); Kato and Torii (2002) cited in Merz *et al,* (2010), Pitt (2008)
8	Time of occurrence	This refers to the time of the day during which the flood occurred. It is believed that when flooding takes place in the night, there is a higher likelihood of damage to people and properties.	Citeau (2003), Dutta *et al.* (2003)

Table 2.2 continued

S/N	Parameter	Brief notes	Literature sources
9	Construction material, property type and age, and building use	The water absorption rate of the materials used for building the property will influence the extent of damage when it is exposed to water. In addition, the weight of the building will affect the strength of buoyancy force on the property and the likely damage to its foundation. Further, the use of the property often influences the amount of readiness for flood and the amount of protection that can be guaranteed. For instance, property or business with moveable items can move items to higher levels.	FEMA (2003); Kreibich and Thieken (2008); Nicholas et al. (2001); Penning-Rowsell et al. (2005); Scawthorn et al. (2006); Schwarz and Maiwald (2008); Thieken et al. (2008)
10	General preparedness and network strength	This refers to the readiness of the organisation involved. It relates to damage mitigation measures available, such as flood barriers, sump pumps, and other in-house and external response capabilities.	Buchele et al. (2006); Kreibich et al. (2005); Kreibich and Thieken (2008); Penning-Rowsell et al. (2005); Thieken et al. (2008)

2.7.2 Built environment flood resilience policies, standards, and codes

A Development and Flood Risk Planning Policy Statement 25 (PPS25) applies to land use planning in England (Department for Communities and Local Government, 2014). The key objectives of the document are to make certain that flood risks are considered at all stages of planning, strategically support the management of flood risk, and guide sustainable property development in flood risk areas.

The PPS25 clearly requires that a flood risk assessment must accompany planning applications except if the site is not in a known flood risk area (Welsh Government, 2016) Based on the flood risk assessment, recommendations on the reduction of flood risk and the management of residual risk are expected to be made. The incorporation of resistance and resilience option are expected to be considered. The PPS25 was later withdrawn (7 March 2014) and replaced with new planning practice guidance (Department for Communities and Local Government, 2014). The flood risk and coastal change section of the new document also advise on considerations for the risk of flooding and coastal changes while planning (Department for Communities and Local Government, 2014).

The planning policy of Wales 2016 (PPW) guides development in Wales; the document is expected to be read in conjunction with technical advice notes – TANs (Welsh Government, 2016). The policies provide guidance on how developments can be protected from the high risk of flooding i.e. citing of properties and the use of flood resilient and or resistant design considerations.

Similarly, Scottish Planning Policy contains Scottish Government policy on planning and building standards on flood resilience (Scottish Executive, 2014). Also, the planning policy statement of Ireland was introduced in June 2006 (Department for Communities and Local Government, 2014). The Irish policy statement describes government's strong stand against new developments in the flood plain. It emphasises the need for flood risk assessment for developments on "risky" sites. In the United Kingdom, the main regulatory and legislative document is the Flood and Water Management Act 2014, Building Act 1984, the water act 2014 and the Contingency Act 2014; these legislations differ in details across the United Kingdom (RICS, 2015). Policy documents similar to the ones described above also exist in other countries. In general flood risk management,

the points at which flood water can be managed can be divided into three (CIRIA, 2007). The points are the source, pathway and the receptor. Presented in

Table 2.3 below is a breakdown of the components of the source, pathway and receptor.

Table 2.3 Components of source, pathway, and receptor (Defra 2007, page 25) (CIRIA, 2007)

Source	**Pathway**	**Receptor**
Rivers and watercourses	Floodplain	People, dwelling and infrastructure
Groundwater	Ground	
Sea	Beach/embankment	
Drainage system	Pipes/manholes	
Overland flow	Roads/overland	
Infrastructure failure	Overland	

Table 2.4 describes the options available for flood management at the source, pathway and receptor. The strategies for flood management at the source, pathway and receptor points are referred to as source control measures, pathway modifications options and receptor resilience measures respectively. The 'source control measures' refers to measures that reduce the high flow or water levels occurring, the 'pathway modifications' describes the methods that modifies or blocks the pathways of water to a site while the 'receptor resilience' are measures that reduce the vulnerability of receptors (organisations, homes, and people) to flood impact (CIRIA, 2010). The attributes listed under receptor resilience contributed to the capability areas extracted for this study. The descriptions therein and the need to build capability for built environment or property resilience formed the basis of the capability areas identified and adopted in this study.

Table 2.4 General flood risk management strategies (CIRIA, 2010)

Source control	**Pathway modifications**	**Receptor resilience – the properties**
Land use policies	Ground raising	**Business continuity management**
Sustainable drainage • Detention basins • Filter drains/strips • Flow control systems • Infiltration basins/trenches • Permeable paving • Retention bonds • Soakaways/swales • Wetlands • Green roofs/walls	Construction of flood walls and embankments	**Flood risk identification and mapping**
Rainwater harvesting	Construction of diversion channels or tunnels	**Planning policies and development control**

Table 2.4 General flood risk management strategies (continued)

Source control	Pathway modifications	Receptor resilience – the properties
Attenuation reservoirs	Removal or modification of existing structures	**Risk transfer (e.g. flood insurance)**
River regulations	Demountable flood defences	**Flood forecasting and warning**
River restoration and floodplain rehabilitation	Temporary flood defences	**Improved emergency response procedures**
Oversized pipes/attenuation tanks within the drainage network	Designing drainage network for exceedance e.g. overland flow routing	**Improved preparedness**
	Managed realignment to "make space for water."	**Desktop incident management exercise**
	Flood resistance measures (dry-proofing)	**Feedback from lessons identified**
		Flood resilience measures (wet-proofing)

**Bold items are non-structural measures*

The attributes listed under receptor resilience in Table 2.4 (column three) contributed to the capability areas extracted (Table 4.1) and used for model development (see Chapter 6 and Chapter 7) in this study. Note that receptor refers to people, properties, and facilities.

While discussing how to transform disaster resilience principles to practice, Labaka *et al.* (2015) identified nine actions, criteria and policy directions that influence critical infrastructure resilience, the criteria spans internal and external attributes. It also cuts across technical, organisational, economic and social resilience dimensions. The criteria referred to as resilience policy direction relates to design safety and construction, maintenance, data acquisition and monitoring system, crisis response equipment, organisational procedures for resilience, management commitment, crisis response budget, crises manager preparation, operator preparation, external response facilities, trusted network, and situation awareness among others. It is evident from above that the resilience of any physical infrastructure or facility is not only a function of the physical properties of the facility but also the use, users, management and the attributes of external stakeholders. The submission of Labaka *et al.* (2015) is underpinned by Bosher (2008), UN ESCAP and AIT (2012), the studies emphasised the need to build capabilities for property resilience beyond the physical attributes of a property. Gibberd (2015) made a similar submission on the sustainability of the built environment. While collating the

capability areas in this study, adequate attention was also placed on the contributions of other organisation assets to the resilience of the built environment. See section 4.4 for a discussion of business assets and the description of the adapted classification and components in this study.

2.7.3 Flood and the built environment: Impact and resilience techniques

Techniques for achieving built environment resilience are available in the literature. Figure 2.1 presents the approaches for flood resilient designs and construction as recommended by CIRIA (2007). The illustration suggests the approaches for managing designs and construction based on floodwater depth. It suggests mitigation measures suitable for specific water depths. The principle recommends that a water entry strategy (water should be allowed in the property) should be adopted for an anticipated water depth of 0.60metres and above to avoid the risk of structural damage to the property. Whenever water entry strategy is adopted, materials with low permeability and layout that permits easy draining and drying should be adopted. Also, where depths of 0.30 to 0.60metres is anticipated, the first design option is to keep water out of the property in full or part, where structural damage is anticipated, water should be allowed in the property, but if structural damage is anticipated, the approach for depths above 0.60metres should be adopted. For depths below 0.30metres, water exclusion strategy (keeping water out) is recommended, this can be achieved by building with materials with low permeability, land raising or citing the building away from the hazard.

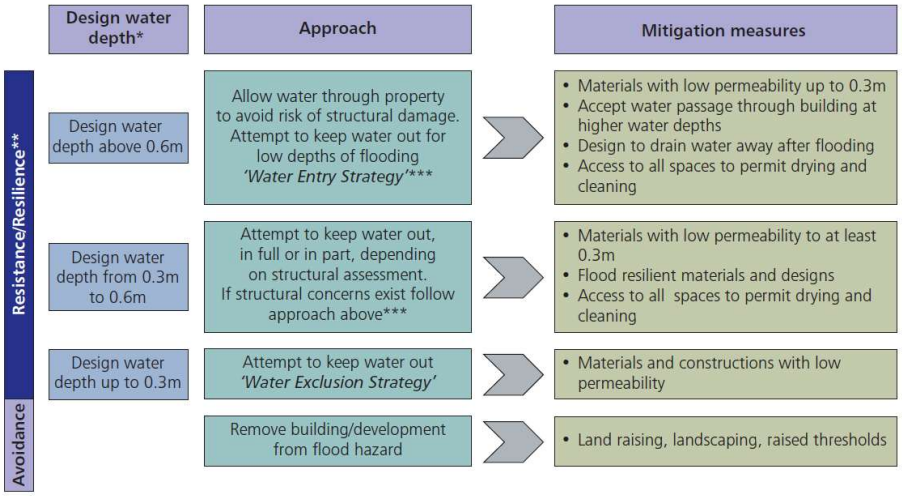

Figure 2.1: Approaches for flood resilient designs and construction (CIRIA, 2007)

*Notes: *Design water depth should be based on assessment of all flood types that can impact on the building; **Resistance/Resilience measures can be used in conjunction with avoidance measures to minimize overall flood risk; ***The water exclusion strategy can be followed for flood water depths up to 0.3m; Flood resilience is about limiting damage, reducing time needed to re-occupy, health and safety issues – disruption to normal life, reduced cost of repair.*

Presented in (Appendix P) are probable failure modes and recommended resistance and resilience measures for the elements of a typical property. The effective use of the detailed recommended structural measures for properties/business premises (Appendix P) alongside other capabilities (Table 4.1 – contains both non-structural and structural measures) as well as the utilisation of available collaborative strategies (section 2.9) is expected to aid disaster resilience of a typical organisation significantly.

2.8 Mitigation of disaster losses

Disasters often result in losses, but losses can sometimes be prevented and or mitigated. However, the private sector and individuals seem to under-invest in disaster preparedness and mitigation measures; this is due to information asymmetry, problems due to collective action and myopic behaviour (DEFRA, 2012; Neumayer *et al.*, 2012). Bhattacharya-Mis and Lamond (2014) perceived the above submissions of Neumayer et al. (2012) and Defra (2011) alongside similar submissions; as a result, an international comparison of barriers to adoption of flood adaptation measures was conducted. Bhattacharya-Mis and Lamond (2014) concluded that informational barriers, emotional, aesthetic and timing issues as well as local circumstances and finance related matters are barriers common among the population considered in the study. Governments can aid the correction of these barriers, also referred to as market failures (Neumayer *et al.*, 2012) but the private sector and individuals also have significant roles to play, no reason is sufficient enough to underinvest in disaster preparedness, not adopting loss mitigation regulations and policies

The magnitude of loss depends on the wealth of the affected area (Bouwer *et al.*, 2007; Neumayer & Barthel, 2011; Pielke *et al.*, 2008) but Neumayer *et al.* (2012) argued that incentives for adoption of mitigation measures should depend on the probability and anticipated magnitude of natural hazards i.e. disaster propensity. That is, where there is high propensity, individuals should have higher incentives to invest in disaster resilience privately. Neumayer et al. (2012) opined that due to market failures, both households and profit-maximizing firms, tend to under-invest in disaster preparedness and damage mitigation, even when disaster propensity is significant. The various impacts of disasters and the specific impacts of disasters on MSMEs have been reviewed in sections 2.3 and 2.4 respectively; the need for a disaster resilient built environment was highlighted in the closing part of section 2.4.

Towards mitigating the impacts of disasters, Kulatunga *et al.* (2012) reviewed disaster risk reduction measures in Bangladesh in the physical, engineering, structural and organisational domains. In the case of flood events, stocks and properties, structural and non-structural measures have been recommended and discussed in literature. Among the recommended measures are flood proofing, building and content insurance, sealing of water entry using barriers and sealants, conduct of risk assessment on property, relocation of stocks to higher floors, protection of electrical facilities and equipment (Asgary, *et al.,* 2012; Bhattacharya-Mis, and Lamond, 2014; Crichton, 2006; Crichton, 2008; Ingirige *et al.,* 2010; Kulatunga *et al.,* 2012; Lamond and Proverbs, 2009; UNISDR, 2013; Wedawatta *et al.,* 2014). Others are the relocation of business records, safety precautions e.g. shutting off electricity and gas, evacuation of employees, etc. (Asgary *et al.,* 2012 and Wedawatta *et al.,* 2014).

The initial consideration and the eventual deployment of these mitigation measures require a level of understanding, some resources, facilities, human knowledge, skills, social relationships, as well as leadership and management among others. These human knowledge, understanding, resources, social relationships, as well as leadership and facilities among others, are referred to as capabilities (UNISDR, 2009). See section 4.2 for a discussion on capability and capacity. It is important to note that no single organisation can possess the entire capabilities required for its disaster resilience. The next section (section 2.9) is a review of how organisations engage internal and external capabilities to build disaster resilience.

2.9 Strategic procedures for building disaster resilience

The points discussed in this section provide a theoretical base for the aim of this study, which is to develop a disaster resilience capability assessment model that identifies built environment flood resilience capabilities of MSMEs (Section 1.4). The points technically describe strategic arrangements and channels through which capabilities can be deployed for building disaster resilience. It should be noted that enhancing the disaster resilience of a single organisation or the society as a whole requires the possession of some attributes, characteristics and facilities within and outside the organisation. Some of the strategies for harnessing capabilities and enhancing the disaster resilience of one's organisation and others is through the disaster resilience efforts delivered via corporate

social responsibility, public-private partnership and business continuity management. See section 2.9.1 - 2.9.3 for details on these strategic principles.

Presented in section 2.9.1 to 2.9.3 are some of the strategies through which organisations undertake disaster resilience activities. The discussion in this section highlights some capabilities that can be deployed as collaborative efforts among organisations towards enhancing their individual or collective disaster resilience.

2.9.1 Corporate social responsibility (CSR)

Corporate social responsibility (CSR) is fast becoming one of the factors that contribute to the development of businesses (Zhao *et al.*, 2012). Moneva *et al.* (2007) submitted that strong corporate structure and commitment to social and ethical values can increase productivity and prevent legal issues, it implies that such commitments will enhance the performance of such companies. ISO (2010) defined corporate social responsibility as the "responsibility of an organisation for the impact of its decisions and activities on society and the environment, through transparent and ethical behaviour". In the area of disaster resilience enhancement, businesses participate beyond the protection of their own human and economic assets at the response phase of a disaster as part of their CSR activities. It is important for organisations to expand their CSR activities beyond response stage, as it is obtainable right now. Currently, much of their activities are about cash donations, debris clearing, use of employees as a volunteer, lending of machinery/equipment, etc. The involvement of organisations in disaster risk reduction is essential as the world is moving towards risk prevention and mitigation rather than response and relief. The paradigm of CSR in disaster resilience should also change as the approach of the world to disaster risk changes.

The Rana Plaza building collapse in Savar, near Dhaka, Bangladesh reportedly has about 1,100 victims; this has led to a shift in the traditional company resilience thinking pattern to global value chain order (Khan & Wichterich, 2015). The incident emphasised the need for attention on the supply chain, especially when developing countries are involved. This is because many of these countries do not have strong disaster management systems and when unpleasant events strike, the whole supply chain will be affected.

Blowfield (2000) while discussing ethical sourcing emphasised the need for a comprehensive set of codes that brings all stakeholders together to address issues that

affect the entire value chain. Similarly, Preuss (2009) examined codes on CSR in the supply chain through the lens of sustainability. It is time to place better attention to the link between disaster resilience and codes on CSR in the supply chain. For example, after the incident in Bangladesh, Primark, a garment sale company, alongside other organisations undertook building safety survey for factories from which it sources garments and became a signatory to the accord on fire and building safety (Goldfingle, 2013; Khan & Wichterich, 2015). It also revised its sourcing policy. Organisations should learn to bear the responsibility of applying best practices in their supply chain through the principle of CSR. Organisations can audit disaster resilience ability of their network of stakeholders for satisfactory performance as part of their CSR (Wieland & Handfield, 2013).

2.9.2 Public-private partnership (PPP)

Public-private partnership (PPP) can be described as a contractual agreement between a public sector organisation and a private sector entity, this contractual agreement allows for an improved private sector involvement in the delivery of public infrastructure projects (Deloitte, 2006). Just several other technical terms, the public-private partnership has been given various definitions by several authors, sometimes based on respective author's context of interest. After considering some definitions, Leiringer (2006) described public-private partnership as "an arrangement between the public sector and private sector investors and businesses whereby the private sector on a non-recourse or limited recourse financial basis provides a service under a concession for a defined period that would otherwise be provided by the public sector." The content of the partnership is practically a function of what the parties to the contract decide to include. It has been argued that the private sector has some qualities and capabilities that are not easily found in government agencies. These qualities can also be exploited in the context of disaster resilience in the built environment through public and private collaboration.

Beyond exploiting the capabilities, the private sector occupies a significant position and stands a good chance of influencing disaster risk accumulation. Worthy of note is the fact that the private sector owns much of a country's infrastructure. For instance, Eighty-five (85) percent of the critical infrastructure in the US is privately owned (Miler, 2013). Therefore, there is the tendency of high loss on the part of the private sector in the event of a disaster. Private sector's readiness to build-in resilience in partnership with the government on the infrastructure it provides is a great opportunity to explore.

Opportunities to enhance disaster resilience through public-private partnership seem under-utilized because building resilience is widely perceived to be a public sector responsibility (PwC, 2013). Zhang and Kumaraswamy (2013) explored PPP as an innovative post-disaster reconstruction approach using a China case study; the study after that emphasised the importance of engaging 'people' in post-disaster reconstruction. Also, Ingirige *et al.* (2015) made a strong case for the full use of public-private partnership (PPP) in the delivery of selected infrastructure projects during post-disaster reconstruction and recovery. The study, however, pointed out some of the merits and demerits noticeable from the application of PPP in the delivery of conventional public infrastructure. It was also clearly stated that PPP or 3P might not be suitable for all disaster risk management/resilience related projects. Many of the demerits and pitfalls can, however, be surmounted by adequately embedding 'People' in the 3P to become 4P through pre-disaster planning.

Public Private Partnerships can help reduce disaster risk and enhance resilience, Johnston (2012) reported on 2010 and 2011 Christ Church Earthquake, New Zealand. The report stated that prior to the earthquake, Christ Church Engineering Lifelines conducted a study to address a range of hazards. As part of the outcome of the study, inter-organisational collaborations emerged and utility companies played significant roles in embedding resilience activities in business practices (Johnston, 2012). As a result, operations resumed few days after at the Port of Littleton, although a level of damage was recorded on the port's commercial buildings and some other physical facilities. Properties built on lands that are susceptible to earthquake impacts were also affected but bridges that were retrofitted as well as telecommunication buildings were not affected, though some were temporarily closed. Johnston's account was also published by UNISDR (2013) as a valuable case study for PPP in disaster resilience.

Further on PPP, the public-private-people partnership (4P) framework presented by Zhang (2012) and Ingirige *et al.* (2015) will serve as an excellent foundation for a structured use of 3P and 4P in disaster resilience and disaster recovery related projects in the built environment. Testing and further developments are very necessary. Legislative changes will, however, be needed to enhance the current approaches and to embed the community effectively. Rotimi *et al.* (2009) discussed the need for legislative changes so as to achieve post-disaster reconstruction effectively. Alongside relevant legislative changes, efficient use of knowledge from previous experiences is essential (Kaklauskas

et al., 2009). In respect of the need for policy changes, the government of England introduced a central government's funding structure for flood and coastal erosion risk management in 2011. Under a scheme called Flood and Coastal Erosion Resilience Partnership Funding, the central government can now fund an array of worthwhile projects rather than bear the full cost of few projects (DEFRA, 2015a). Local communities provide the remaining costs of such projects and environmental agency while administrative responsibilities are handled as agreed. The power of the local authority to carry out risk management works on watercourses remains.

Although the implementation model of public-private partnership may differ a bit between developing countries and developed countries because of peculiarities in the economy, culture, legal and administrative structure of these nations, the underlining principles of PPP remains across the board. The partnership funding scheme in England and the Christchurch's utility companies led intervention that engaged public and private businesses in New Zealand among others are all varieties of partnership. All stakeholders in both developing and developed nations can benefit by exploiting any of the opportunities that relate to the benefits discussed below. Developed countries can lead the implementation of some of the PPP initiatives that are applicable in the developing nation context, for example, Safaricom/GE and Kenyan government's partnership and Swiss Rearrangement in Ethiopia (PwC, 2013). A modified version for application in a developed country context can be an agreement that permits private sector companies to provide resilient materials to homebuilders with defined government support. Another example is an agreement that permits private sector companies to invest in the strengthening or hardening of critical infrastructure in flood prone areas (Environment Agency, 2011).

2.9.3 Business continuity management (BCM)

Business continuity management was identified as a model of strategic collaboration for building disaster resilience in this study. Business Continuity Management and Practice (British Standard Institutions, 2007) alongside other literature provided a foundation on how organisation assets (see section 4.4 and 4.5) contributed to the list of capabilities used in the development of the capability maturity model in this study (Table 7.8). The assets also have relationships with the capabilities (Table 4.1) identified and used for the development of the capability maturity model (Table 7.8).

The British Standards Institution defines BCM as:

> '*A holistic management process that identifies potential threats to an organisation and the impacts to business operations that those threats, if realised, might cause, and which provides a framework for building organisational resilience with the capability for an effective response that safeguards the interests of its key stakeholders, reputation, brand and value-creating activities*.' (British Standard Institutions, 2007).

Tierney (2007) among other authors have clearly discussed the existence of direct and indirect impacts of disasters on businesses. The likelihood of damage to businesses by disaster emphasises the need for protection of business assets, even though providing protection for all assets might not be practical or economical, the assets might still be overwhelmed by a disaster. This underlines the need for business continuity planning and management. Clearly, the fortification of assets, supported with a viable business continuity plan will sustain a business in the face of a disaster.

From the definition of Business Continuity Management (BCM) given above, BCM can be extended beyond the act of ensuring the resilience of an organisation's process, supply chain, customer preservation, and public image to include the immediate premises of an organisation among others. Since an organisation's processes depend on the functionality of infrastructure and business premises, it is reasonable to state that the resilience of infrastructure is a strong influencer of business continuity and disaster loss reduction. Therefore, the significance of the disaster resilience of the built environment in the resilience theme cannot be overemphasised (UNDP, 2013a).

Presented in Figure 2.2 is a pictorial representation of the influence of business continuity planning on the recovery of an organisation. The continuous blue line represents anticipated recovery curve, it indicates the state of the organisation during the full operation mode, the line fell to time-axis as a result of the impact of the disaster, it also indicates a rise after the disaster. The red line indicates recovery curve after implementation of business continuity plan. The red dotted line indicates the permissible limit for operation loss. The blue dotted lines are target recovery times. Call out labelled '1' shows the variance between target recovery time, recovery time and original condition to the initial condition of operation, the call out labelled '2' indicates how BCP can help

recover capacity utilisation within the permissible time. The call out labelled '3' indicates how BCP ensures that the business continues at a level over the permissible limit.

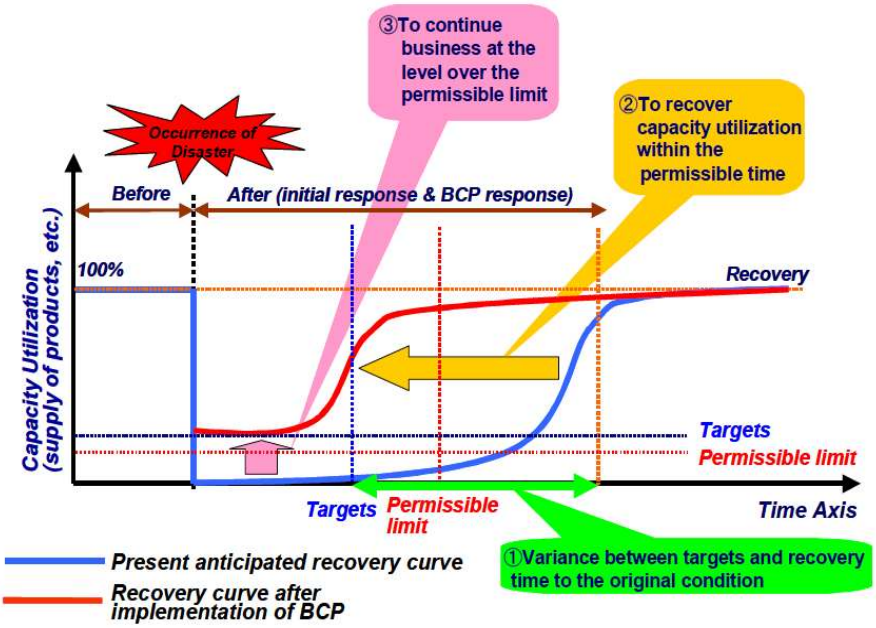

Figure 2.2 The concept of Business Continuity Planning (BCP)

(UNISDR & ADPC, 2007)

Figure 2.3 is a diagrammatic representation of the contents of business continuity plan and good practice. The figure indicates the need for a BCP policy, a plan, exercising and control, provision of education and training, inspection of corrective actions, and review by the management. Listed in the respective boxes are issues relating to the items in the business plan.

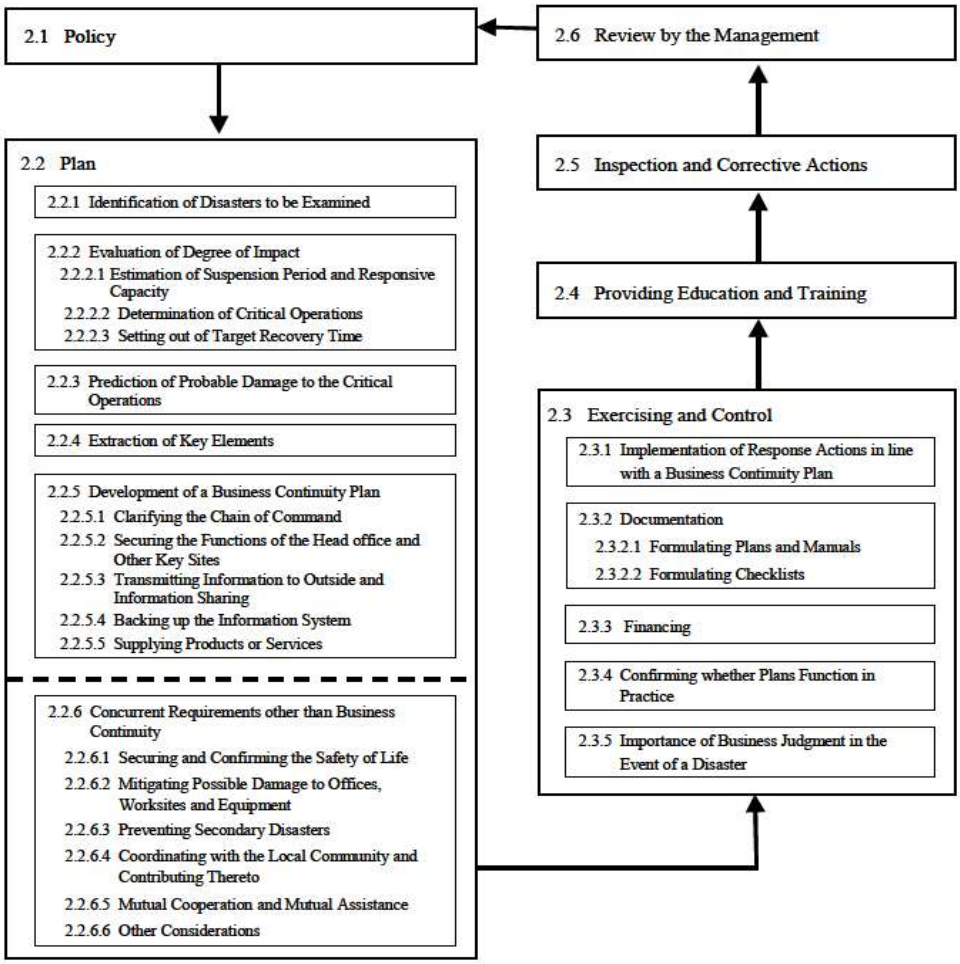

Figure 2.3 Contents of Business Continuity plan and good practice (UNISDR & ADPC, 2007)

As earlier mentioned, achieving disaster resilience requires the joint effort of all stakeholders in the society. Disaster resilience stakeholder groups can be classified into communities, Private sector, non-governmental organisations, government, academia/research institutions (Malalgoda *et al.*, 2016; Malalgoda *et al.*, 2015; Perera *et al.*, 2016; Perera *et al.*, 2015). The classification was used by the studies while discussing the needs and skills for enhancing disaster resilience in the built environment. Each of the stakeholder groups are discussed as follows:

Communities – the capacity of local communities can be deployed to save lives and properties during natural disasters. This can be done by implementing disaster preparedness and mitigation measures that are based on local knowledge. Members of the community play active roles in this regard (Perera *et al.* 2016, Perera *et al.* 2015).

Private sector/Companies/Businesses – All small, medium or large companies are key organisations in the community they are located; it is ideal for them to engage in disaster prevention and mitigation actions. Some companies have understood the need, but the degree to which significant resilience efforts have been taken up is relatively low across board. Disasters can cause the destruction of companies' physical assets, disruption of supply chains, loss of customers to death or displacement (Bhattacharya-Mis, and Lamond, 2014; Burnham, 2008; Heliview Research, 2008; Metcalf and Jenkinson, 2005; RICS, 2015). Convincing a company to make expenditures on disaster mitigation and prevention in a location that is less frequently affected by disasters remains difficult, the argument can be easier for high-risk areas. Under both conditions, it is indeed still necessary to consider the need for disaster resilience while designing the physical assets of business. Some organisations have understood the need and have been actively participating in disaster resilience efforts while some are limited by understanding or resources (PwC, 2013).

Non-governmental/Humanitarian organisations – some organisations have staff and volunteers, who can assist in disaster preparedness efforts of communities, rescue efforts and damage assessment as well as the distribution of relief materials.

Government – Government at all levels are largely relevant to the enhancement of disaster resilience; they contribute by acting as coordinators and regulator of disaster resilience efforts as well as a provider of finance (Malalgoda *et al.*, 2016). **Academia/Research/Educational institutions –** these organisations undertake researches aimed at understanding disaster-related issues and tackling some specific disaster-related problems (Malalgoda *et al.*, 2015).

2.10 Developments in Disaster Resilience

Presented in this section is a discussion on disaster risk reduction policies and frameworks that have emerged, widely accepted, and adopted for disaster risk reduction and disaster management across many nations. The policies guide the interaction of stakeholders in disaster resilience as well as disaster risk reduction and disaster resilience activities.

2.10.1 International Decade for Natural Disaster Reduction (IDNDR)

Towards achieving the resilience of societies, some blueprints and frameworks have been developed over the years. One of such is the International Decade for Natural Disaster

Reduction (IDNDR) is a resolution from a UN assembly. The IDNDR was based on UN General Assembly Resolution 42/169 of 1987, similar to the IDNDR is the Yokohama Strategy and Plan of Action for a Safer World – 1994 (UNISDR, 2004). The International Strategy for Disaster Reduction (ISDR) was launched in the year 1999 and the Millennium Declaration was made in the year 2000 (UNISDR, 2004). This is one of the first and perhaps the first accepted framework for disaster risk reduction. As earlier mentioned, it was fashioned out of the 1987 UN resolution, launched in 1999 but succeeded by Hyogo Framework for Action (HFA) in 2005 (UNISDR, 2005).

2.10.2 Hyogo Framework for Action (HFA)

In the year 2005, the Hyogo Declaration resulted to Hyogo Framework for Action 2005 – 2015. The target of all these actions, declarations and frameworks is to achieve the resilience of nations to disaster. A detailed guideline on how to reduce disaster risks are contained in the Hyogo Framework for Action (HFA), which was sanctioned and adopted by 162 countries in 2005. The Sendai framework – 2015 to 2030, succeeded this. The HFA was expected to ensure a reduction in losses of communities and nations from disasters (UNISDR, 2005). The HFA is simply an international blueprint for disaster risk reduction, which remained valid as an international blueprint till 2015 (UNISDR, 2005).

The HFA has five actions listed as priorities towards achieving its ultimate goal. The priority actions are ensuring that disaster risk reduction (DRR) is a national and a local priority with a sound institutional basis to support implementation - This describes the need to engage in disaster risk management at all levels effectively. The five core priority areas of the HFA are: Identify, assess and monitor disaster risks and enhance early warning – This describes the need for effective monitoring, disaster risk data management and on-time dissemination of information. Others priorities for action are "use knowledge, innovation and education to build a culture of safety and resilience at all levels", "reducing underlying risk factors" and strengthening disaster preparedness for swift and effective response. In an attempt to simplify the HFA, Twigg (2007) divided HFA into five themes. The themes are governance, knowledge and education, risk management and vulnerability reduction, risk assessment, disaster preparedness and response. The study opined that the sub-themes of HFA could simply be described as the attributes of resilient communities. Lists of issues were considered as cross-cutting by the HFA; the issues are expected to be largely considered while pursuing the priority actions. The importance of multi-hazard approach was emphasised, so also gender perspective

and cultural diversity. Community and volunteers' engagement, as well as capacity building and technology transfer, were also among the cross-cutting issues.

The major actors identified by the framework are state governments, regional institutions and organisations as well as international organisations. The ISDR (Inter-Agency Task Force on Disaster Reduction & Secretariat) was expected to oversee all disaster risk reduction in collaboration with the aforementioned actors. Before the expiration of Hyogo framework for action in 2015, a major modification was expected to be made in respect of the major players in the post-2015 edition. This is because, the role of the community, local and international private sector have been identified as significant (Ki-Moon, 2013; UNISDR, 2013b; United Nations, 2013). Prominent among other issues that were expected to be addressed in the post-2015 document are how cross-cutting issues such as gender affect the implementation of existing frameworks. Also, there were claims that some of the issues referred to in the frameworks have been raised in earlier declarations. It is therefore expected to be made clear if the issues are being reaffirmed or the gaps in implementation between the current and previous frameworks are being highlighted. Better execution and follow-up mechanisms were also encouraged (UNISDR, 2013b).

2.10.3 Sendai Framework for Disaster Risk Reduction

The Sendai Framework is the most recent international blueprint for disaster risk reduction; it was endorsed at the Third UN World Conference in Sendai, Japan, on March 18, 2015. Consultations for the framework began in 2012 and negotiations were held between July 2014 and March 2015 (UNISDR, 2015), all inadequacies discovered in HFA and necessary additions to the framework are believed to have been included. The framework is expected to help in substantially reducing disaster risk and losses of communities and nations from disaster. Sendai framework has seven targets which are directly connected to a goal and an expected outcome. The four priorities for action for Sendai framework are understanding disaster risk, strengthening disaster risk governance to manage disaster risk, investing in disaster risk reduction for resilience, and enhancing disaster preparedness for effective response, and to build back better in recovery, rehabilitation and reconstruction(UNISDR, 2015). The framework is expected to last through the year 2030, and it is expected to be implemented under thirteen (13) guiding principles. The Sendai framework is expected to guide all disaster risk reduction for resilience activities at all levels of governance within the specified period.

2.11 Chapter Summary

The discussion in this chapter provides a general base for the aim of this study. Among the topics discussed are natural hazards and disasters, impacts of disasters, strategic procedures for building disaster resilience as well as international frameworks for disaster risk reduction. It is clear that there will not be disasters without hazards and disasters often result in damages. Discussed in a section of the chapter is the rise in the loss from disasters, especially, economic loss. Minimising the impact of disasters is required to achieve a reduction in the economic loss; the availability of some resources, skills, facilities and processes for preparing for and responding to a catastrophe are required (UNISDR, 2009; UNISDR, 2015). The resources, skills, attributes, facilities and processes required for managing disasters are referred to as capabilities by UNISDR (2009), these capabilities consume the additional cost required for building disaster resilience additional costs referred to by Neumayer *et al.* (2014) and Warhurst (2006). Since financial commitments are required for the enhancement of some of the capabilities for dealing with disasters (Neumayer *et al.,* 2014 and Warhurst, 2006) and a request for information and help beyond the development of tools are needed to combat disasters (Ingirige & Russell, 2015) the next chapter (i.e. chapter 3) focuses on the financing options available. It is believed that this will serve as a guide for professionals who give advice and businesses seeking channels of financial supports for enhancing their capabilities. It should be noted that some capabilities are needed at the pre-event stage; some are required at the event stage while others are required at the post-event stage. Therefore, the financing options in the next chapter are also distributed in a similar regard and are available to different levels of administration (i.e. international, national, local government and organisation level).

CHAPTER THREE
SOURCES OF FUND FOR CAPABILITY ENHANCEMENT AND DISASTER RISK REDUCTION

3.1 Introduction

Enhancement of capabilities requires financial commitments; this chapter is dedicated to finance-related discussions. It is meant to provide information on financing options available for organisations to explore. Other topics covered in the chapter are disaster risk financing for built environment disaster resilience, barriers, drivers and benefits for funding capability enhancement and disaster risk reduction.

3.2 Disaster risk financing

Priority Action Four (4) of the HFA is targeted at reducing underlying risks of disaster. One major task under the priority action 4 is to ensure the existence of appropriate risk management systems (UNISDR, 2005). It should be recalled that the ability of the built environment to withstand, absorb and recover from the impact of disaster goes a long way in speeding up the recovery of an entire system from eventualities (Labaka *et al.,* 2015). Therefore, reducing the underlying disaster risk factor in the built environment will go a long way in ensuring the resilience of societies to disasters. Obviously, only little can be done in reducing underlying risks if suitable risk finance mechanisms are not available. Since it is practically impossible to completely insulate the built environment, community, and a nation from natural disasters (DEFRA, 2011), pre-disaster investments made in the right direction coupled with the transfer of risks to the party that can best manage them as well as a reasonable level of post-disaster response capacity is germane. A detailed comparison of the major disaster risk financing mechanisms is summarised in Appendix S. Each of the mechanisms is identified as a prevention funding mechanism (i.e. pre-disaster investment financing), loss financing mechanism (i.e. post-disaster loss management mechanism), loss finance transfers or a combination of prevention and loss financing.

The risk financing options presented in Appendix S have their respective merits and demerits. For instance, prevention funding mechanisms allow for reduction of risks before catastrophes, but on most occasions, it implies that the party that is exposed to the risk bears the risk eventually. Also, the adequacy of investments needed is a function of the accuracy attained in estimating disaster risk; this brings the thought of whether the

investments will prevent, mitigate, or fail to make any impact in the event of a disaster. Examples of prevention funding mechanisms are prevention and mitigation fund, mitigation loans, and prevention loans. Loss financing mechanisms are available for financing losses after a disaster, by implication this financing mechanism are response options. There have been arguments on the logicality and appropriateness of response to disasters rather that prevention and mitigation. Examples of loss financing mechanisms are external borrowing, loan diversion, calamity funds, and state sponsored loss-sharing programmes. The third category referred to as loss financing transfer provides the opportunity for transfer of losses resulting from disasters to a third party; examples are insurance and reinsurance, and insurance for disaster reserves.

The problem of disaster risk financing for resilience is an issue that cuts across both developing and developed nations at similar but different magnitudes. Lack of funds appears not to be the major differentiating factor between developing and developed countries in the context of building disaster resilience. The major issues seem to be a lack of innovativeness, policy frameworks that guide developments and ensure that developments are built in ways that reduce vulnerability and not exacerbate them (Mahul & Gurenko, 2006), and also, the existence of weak disaster risk management system.

Analysing some of the instruments presented in Appendix S in the context of disaster risk financing in developed and developing countries supports the submissions in the last paragraph. For instance, Mahul and Gurenko (2006) mentioned the low level of penetration of insurance in developing countries, but since a nation like Turkey can increase residential catastrophe insurance penetration from 3 to 17% in 3 years, barriers to penetration in developing countries can be surmounted. Some of the common barriers to penetration are over-dependence on aid assistance and the poor state of domestic insurance markets. Insurance remains one of the most popular disaster risk financing instruments for enhancing resilience, although it has its shortcomings too. Micro-insurance is currently a funding option for poorer communities, since it is currently based on informal cooperative systems, a thorough research aimed at bringing a new generation of micro and macro-insurance system seems necessary.

Further, catastrophic bond (CAT bonds) which is also managed by insurance and re-insurance companies is an option available for both developed and developing nations. However, since the insurance market of many developing countries is weak, the ability

of CAT bonds to thrive is slim. Reserve fund is another instrument that provides liquidity after a disaster (Freeman *et al.*, 2003 ; Miller & Keipi, 2005) but since a lot of developing nations do not officially possess enough funds to provide basic amenities, it might be difficult to set funds aside in anticipation for disasters. This finance instrument is currently more useful for wealthier nations; it should be noted that the funds set aside also has a cost (i.e. returns from potential uses of the fund set aside).

External borrowing, loan diversion, emergency loan, reconstruction loans, mitigation loans, prevention loans, reformulation of existing loans are all loans with consequential commitments. Governments usually arrange such loans for citizens. It is useful in both developed and developing nations, though developing countries depend more on loans.

Formal and Informal Risk Coping through Self-Financing, Transfers of Government Budget/budget reallocation, Tax increase and tax exemption reduction, and Government/State sponsored loss sharing and mitigation grants are used more in developed countries. Their use in developing countries is limited perhaps due to the low level of awareness, the rigidity of governance system, which hardly brings about tax change, as well as the usually acclaimed low level of wealth in developing nation. Above all, many of these finance mechanisms have a long history of existence; it is time to develop new generation disaster finance systems that are country specific and focuses more on mitigation and prevention rather than loss finance and even loss finance transfer.

3.3 Private investments and disaster resilience in the built environment

Towards building disaster resilience, the private sector can function in so many ways, among the ways are disaster risk identification, awareness creation, capacity building, making financial and professional commitments, collection and storage of disaster-related knowledge. ADPC (2013) and United Nations (2013) stated that the private sector, investment banks and insurance companies could play a major part in the quest for mitigating disaster-related losses and building disaster resilience. The participation of these organisations in enhancing disaster resilience of the built environment can be based on the type of services they offer to asset owners. For example, investment banks can establish a scheme through which property owners can obtain loans at a reduced interest rate to enhance the disaster resilience of their properties. Also, insurance companies can charge a premium based on the level of a property's disaster resilience. Figure 3.1 describes the different levels of private sector (SMEs) involvement in building disaster

resilience. Organisations engaging in building resilience outside their own premises should perceive such actions as corporate social responsibility and not philanthropy.

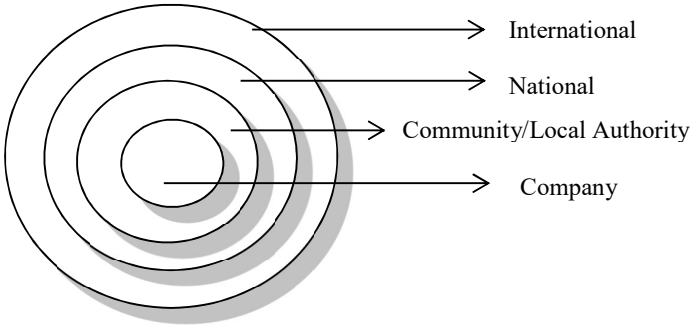

Figure 3.1 Levels investment or involvement in building disaster resilience

Property destruction as a result of disaster shock leads to direct financial loss, expenditure on repair and business interruption (See Figure 3.2). It should be noted that a disaster will strike the built environment first before every other entity within the built environment gets distorted. Therefore, the importance of the resilience of the built environment in the overall resilience agenda cannot be overemphasised (UNDP, 2013a).

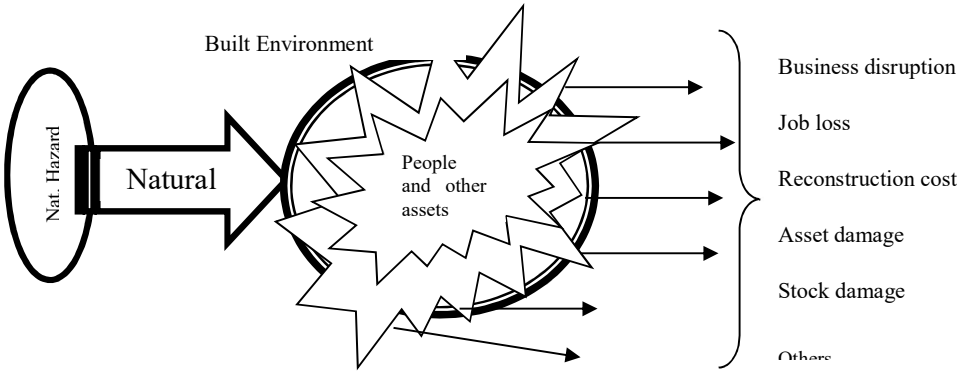

Figure 3.2 Economic impact of disasters on Micro, Small and Medium Enterprises

According to Neumayer *et al.* (2014), two main strategies can be adopted by private individuals to reduce the expected cost or impact of disasters. They can avoid settling, operating in high-risk areas, or construct buildings of little or no probability of being damaged when known hazards strike. On most occasions, high-risk areas have economic advantages, so, there is an opportunity cost for not settling or operating in such areas (Neumayer *et al.,* 2014). Likewise, there are additional costs for putting up disaster-proof

structures. While continuity of operations remains a key concern after disasters, governments do not have the adequate financial strength to offset the cost of disaster impacts, the need for private sector involvement in protecting assets becomes necessary. Kreibich *et al.* (2005) submitted that data on the effects of precautionary measures are scant and the efficiency of those measures is unclear. Similarly, Wedawatta (2013) stated that disaster costs are seemingly being underestimated and this is negatively affecting the Cost-Benefit Analysis (CBA) of disaster resilience and Disaster Risk Reduction (DRR) measures. However, emerging submissions in respect of the superiority of benefit to the cost of disaster risk reduction and disaster resilience enhancement seem encouraging. UNISDR (2013a) reported that the New Zealand Company Orion, invested US$ 6 million on seismic protection; consequently, the investment saved the business up to US$ 65million. Towards protecting buildings and structures (built environment), that cannot be adequately made disaster-proof individually as well as enhancing the economic value of investments, joint and collective investments in resilience can be considered.

Private sector under-invests in disaster preparedness and mitigation measures, due to information asymmetry, problems due to collective action, myopic behaviour, emphasis on cost cutting, short term targets of organisations among others(Neumayer *et al.*, 2014; Warhurst, 2006). Neumayer *et al.* (2014) described the factors above as "market failures" causing the sector to under- invest in disaster preparedness and damage mitigation, even if disaster propensity is significant. Governments can correct these market failures, but they also face incentives to under-invest in expensive disaster preparedness policies and loss mitigation regulations (Neumayer *et al.*, 2014). Since the magnitude of loss depends on the wealth of the affected area (Bouwer *et al.*, 2007; Neumayer & Barthel, 2011; Pielke *et al.*, 2008), Neumayer *et al.* (2014) called for investment incentives that is based on the probability and anticipated magnitude of natural hazards i.e. Disaster propensity. Where there is high propensity, individuals should have higher incentives to invest in disaster resilience privately.

Several channels of engagement of the private sector and related discussion have been presented in this section, for the sake of emphasis, this study focuses on the innermost layer of Figure 3.1 i.e. company/organisation level. Presented in the next section is a discussion on finance and investment efforts towards enhancing the disaster resilience of organisations, the focus is on built environment disaster resilience.

3.4 Investments in risk reduction for built environment resilience across sectors

Before the 1995 earthquake, the port of Kobe in Japan, was among the busiest ports in the world. After the earthquake, the port which used to rank 6th in the world fell to 17th place in 1997 after two years of reconstruction (Chang, 2000); in the year 2000, it became 23rd, and by 2013 it fell to 52nd place (Containerisation International, 2013). The business disruption experienced by the port as a result of the earthquake remains the major reason for the sharp slip in performance. Business did not return to the level it used to be despite several efforts and incentives made available to port users. Among the efforts are a reduction of harbour dues, land rental fees, and 24-hour operation. This is obviously an example of the implication of damage to business premises/built environment by disasters on a typical system. The Kobe loss and delay in recovery could have been significantly reduced if necessary investments on infrastructure strengthening and business continuity practices have been made. A sample of investments in risk reduction for built environment resilience across sectors is presented below.

3.4.1 Education

The term "hardening" is another term used for resilience building or the act of increasing the ability of infrastructure to withstand stress from hazards. In 1996, a middle school in Wisconsin, one of the 180 structures damaged by a tornado that struck the community was later "hardened". After the tornado incident, the need for the disaster resilience of infrastructure was clearer, and this led to the school being rebuilt to withstand 150-mph wind as against the 88-mph stipulated in the public building code for Wisconsin. This was however achieved at a significantly higher cost, the internal walls were hardened, and the roof was bolted to wall supports. The investment made in strengthening the school amounted to $207, 260; the larger part of the amount spent was obtained from mitigation fund (WDEM, 2001). This gave the school the ability to endure twice the wind that most others are built to endure thereby giving a greater sense of safety and security. The school can also serve as a community shelter in the event of another tornado.

3.4.2 Health

Hospitals are critical to post-disaster relief and recovery, damages to hospital structures, hospital equipment and surrounding facilities can lead to a significant setback to the relief and recovery process. Geroy and Pesigan (2011) concluded that there is a gap in hospital infrastructure, emergency equipment and capacity in the face of disaster emergencies. The study emphasised the need to enhance the resilience of health facilities. Also, in a

study conducted by Rautela *et al.* (2011) on seismic vulnerability of health infrastructure in India, it was found that 80 percent of the health facilities in one of the study areas is very likely to be non-functional in a post-earthquake situation as a result of damages. The study suggested improvement health facility's post-disaster capacity through investment in retrofitting. Towards enhancing facilities' capacity, some organisations e.g. Pan American Health Organization (PAHO) developed a series of guidelines for assessing the probable response of hospital structure, equipment, and surrounding facilities to disasters (Rossetto, 2007). Hurricane Ivan that struck Grenada in 2004 resulted in a major loss for schools and hospitals. Only two of the about 75 primary and secondary schools experienced minimal damage; the largest hospital on the Island experienced about 70 percent damage. The second largest hospital was also physically damaged and was not suitable for use; worthy of note is that the two schools that were left standing after the disaster were retrofitted before the disaster through a World Bank initiative (Rossetto, 2007). On a contrary case, Kobe general hospital in Kobe, Japan survived the 1995 earthquake; the hospital was still barely functional as a result of the collapse of the bridge linking it with the mainland. Beyond hardening or strengthening of infrastructure, adequately considering the possible impact of hazards in the design and siting of the main facilities and the infrastructure serving them can largely improve their disaster resilience and post-disaster functionality.

3.4.3 Hospitality

To ensure a suitable level of resilience, UNISDR and Global Initiative for Disaster Risk Management are about to commence a hotel disaster resilience level certification programme (Edo *et al.*, 2014). This is to ensure a reduction in risk to premises, business risk, and as well provide a satisfactory safety guarantee to all stakeholders.

3.4.4 Housing

In the United Kingdom, as time went by, the need for households and individuals to protect their properties against flooding became more important (Pitt, 2008). Eventually, organisation and household led flood risk management gained more prominence as opposed to the traditional state-centred approach (Johnson & Priest, 2008). To encourage investment, the Department for Environment, Food and Rural Affairs in England introduced a £5.5 million grant scheme called Property Level Flood Protection Grant Scheme in December 2008. Under this scheme, local councils were expected to apply for funding and after that subsidise the cost of resistance and resilience installations for

interested property owners (Environment Agency, 2011). The scheme ended in 2011, but the government, for Property Level Flood Protection in 2011 – 2012, allocated an additional sum of £3.4m. A promise of future support to the scheme was made under the succeeding Flood and Coastal Resilience Partnership Funding (DEFRA, 2012). The Flood and Coastal Resilience Partnership Funding scheme is meant to encourage investment in flood risk management measures by communities. It provides funding for flood and coastal defence projects as well as property level protection assistance that are to be executed in conjunction with communities. It is part of government's strategy for disaster prevention and mitigation and also part of a funding strategy for building property resilience since total prevention of flood events is perhaps practically impossible. The UK Government is also investing in review and implementation of revised building regulations and surface water drainage, sewage system and back garden management among others (DEFRA, 2012).

3.4.5 Service/Production Sector

The resilience of the supporting facilities of business has a lot to do with the disaster resilience of the business and of course a nation at large. Fresh positive evidence is emerging in respect of investments in built environment resilience. UNISDR (2013a) reported that Orion, a New Zealand Company invested US$ 6 million on seismic protection; as a result, the investment saved the company up to US$ 65million. This example among others remains a good example for other businesses to copy.

3.4.6 Power

A level of risk can be managed via the proactive use of prevention, mitigation and existing disaster resilience measures (Keipi and Tyson, 2002). For example, International Development Bank financed the strengthening of Sabaneta Dam in the Dominican Republic in 1998; this eventually mitigated the risk of flood to the extent that when Hurricane George struck in the same year, there was no significant damage to the power plants. Also, no potential downstream damage was recorded (Keipi & Tyson, 2002). Resulting from previous experiences with a flood, Yorkshire Electricity Distribution Ltd (YEDL) invested in making its infrastructure more resistant to flood risks. YEDL built defences at its high-risk electricity sub-stations after the year 2000 flood events, and this is believed to have helped the company to reduce the impact of flooding on its assets (Pitt, 2008). In the year 2007, there was a massive flooding in North East England, the investment made by YEDL paid-off, as the Blackburn Meadows electricity substation

protected by flood defences was not significantly affected. The sewage treatment plant that shares the same site with the power sub-station was with no form of protection from flooding; consequently, the treatment plant was significantly damaged and cost £17 million to repair.

From the examples above, it is clear that stakeholders in the disaster resilience theme have been making frantic efforts to curtail the impact of disasters on the society. Noticeably, changes in disaster-related policies worldwide are also affecting the area of finance and investment in disaster risk reduction and disaster resilience. For instance, a major shift was observed when DEFRA (2011) recommended that property owners should take the responsibility of adapting their properties to flood since the total prevention of flooding is seemingly impossible. This brings to prominence the need to invest in enhancing coping and adaptive capacities for operations as well as resistance and resilience ability of properties to disasters. Also, the recommendation DEFRA (2011) technically emphasise the shift in the responsibility for funding of building resilience from the government to individuals, businesses and the wider private sector. It is ideal to say that this is connected with recent cuts in government spending in the United Kingdom (Committee on Climate Change Adaptation, 2015; Crawford & Phillips, 2012) and the identified capacity of the private sector worldwide in building resilience (ADPC, 2013).

The change in policy raises the question of whether property owners have the resources required to achieve this. If government interventions in developed countries (DEFRA, 2015a) can help in achieving this, it is going to be a problem in poorer or developing nations. These nations are largely dependent on foreign assistance and guidance regarding capacity building and infrastructure finance, and they have relatively weak disaster risk management systems.

3.5 Barriers and drivers for funding capability enhancement

3.5.1 Barriers

While discussing issues relating to the use of resistance and resilience measures, (Bichard & Kazmierczak, 2012) mentioned poor attitude and wrong perception of property owners as one of the barriers to investment in flood resistance and resilience measures. The study stated that many people are aware of living in risk areas but they seemingly underestimate the risk. Many property owners simply do not see the reason to spend on flood-proofing their properties. In a similar vein, Kenna (2008) decried the availability of just little

incentive for installing resilient measures. It opined that risk-based insurance system is a viable incentive for enhancing investment in property resilience.

Although the use of incentives remains a viable means of encouraging the adoption of resilience, efforts toward the realisation of the full cost of direct and indirect impacts of the disaster remain germane. This is because the underestimation of the impacts of the disaster on businesses limits the adoption of property level resilience measures, since a convincing picture of benefits to cost of investments in resilience cannot be seen (Wedawatta *et al.*, 2014). While discussing barriers to investment and actions in enhancing disaster resilience, (PwC, 2013) mentioned the difficulty in engaging businesses on issues that go beyond their operating boundary. It is believed that a strong business case with adequate awareness and interest building efforts is the potential solution to the identified barrier. Many businesses are driven mainly by profit and are unwilling to venture beyond their traditional scope of operation. Investment in resilience should, however, be seen as a way of making all investments attractive and secured (United Nations, 2013). Although some organisations have accepted the need to build resilience, limited in-house capacity and leadership to assess risks, understand risks, and after that implement necessary actions remain a challenge (PwC, 2013).

The broad list of barriers provided by PwC (2013) are risk management capability and maturity – internal buy-in, awareness, facilities; technical barriers – workforce capacity, technology, knowledge sharing, and access to early stage capital; Financial – technology risk, incentives, technology cost gaps; local enabling environment – policy, infrastructure, political and governance risks. Also, Pitt (2008) canvassed for the revision of regulations so as to make all new and or refurbished buildings in high-risk areas resistant or resilient. This simply implies that the lack of regulations that are meant to ensure the provision of resilience is a barrier. Kulatunga (2010b) made an interesting submission; the study stated that culture had been an impediment to the effective deployment of disaster risk reduction and resilience strategies in some instances. Integration of DRR activities with culture is needed to overcome this culture-related barrier (Kulatunga, 2010b)

Also, DEFRA (2015b) outlined six factors as barriers to the creation of disaster-resilient people and communities. The barriers listed are unconvincing proof of the benefits of enhancing resilience, inadequate understanding of what motivates communities towards acting on resilience, naivety of communities, insufficient understanding of the use of

information available for resilience building, incentives and covers provided by the insurance market, and influence of alternative incentives on household level flood management decisions. The factors outlined as barriers by the respective authors above are obviously relevant and seemingly accurate. It is, therefore, important to explore all possible avenues to confront the barriers. Among the several options of overcoming barriers to a concept is the act of making the drivers and benefits of such concept more prominent. Presented in the next section are drivers of investment in resilience, as found in the literature. This research study will help in providing justification for investment in resilience, thereby directly addressing the first barrier presented by DEFRA (2015b) in a defined manner.

3.5.2 Drivers

There are some drivers for investment in disaster resilience as seen in literature. PwC (2013) mentioned the opportunity to develop and distribute new products and services as one of the drivers. Expanding a company's range of products and services in the market does not only increase a company's revenue and stake in the market but also gives the company a strong competitive advantage. The products and services are basically to be used by others to enhance their own resilience. Also, the opportunity to expand markets for existing products and services is a viable driver for investing in resilience (PwC, 2013). For example, Safaricom/GE is a partnership that supports the expansion of low-carbon telecommunication infrastructure in Kenya; this is done through the use of solar-powered base station units. This project ensures continued communication since the base station units are resilient to a power cut. Cost savings is another driver for investing in resilience (UNISDR & GFDRR, 2012). Ensuring the continual availability of raw materials from resilient suppliers will lead to cost saving for a manufacturing company, non-resilience of the supply chain will result in increased raw material operational cost. Reputation and brand value is another driver for investment (PwC, 2013), For instance, Siemens Company developed a low-cost portable water purification system that does not require chemicals and does not depend on electricity. It can be used to meet the post-disaster needs of communities. This development has boosted the reputation of the company not just with in respect of other business they are into but about their capability in offering technologies that can help overcome post-disaster challenges. In the writings of Edo *et al.* (2014) companies engage or invest in resilience activities for three main reasons: (1.) Legal compliance (2.) Social responsibility (3.) Economic benefits, the three

reasons but legal compliance is not far from the submissions of PwC (2013) as regards the drivers of investment. It should be noted that social responsibility and economic benefit could be satisfied through any of the ways earlier discussed.

3.6 Benefits of investing in resilience

Economic loss from disasters will continue to increase unless drastic control measures are taken (Bouwer *et al.*, 2007; Ki-Moon, 2013; Pielke *et al.*, 2008). Beyond the tendency of reducing economic loss from disasters through improved investment in built environment disaster resilience, some other benefits abound. Market opening, expansion and stabilisation potentials of investing in resilience refer to the tendency of a new product/service being created, or existing ones expanded or existing ones made established. This will be achieved because of innovations towards enhancing the resilience of enterprises.

The opportunity to develop and distribute new resilience-enhancing products and services is a true driver of investment in resilience (PwC, 2013). This opportunity brings the benefit of a competitive market advantage alongside the creation of a new income stream for a typical organisation. It is also a chance to diversify risk portfolio. Swiss Re explored the market opening and expansion ability of investing in disaster resilience in Ethiopia. PwC (2013) reported an arrangement made by Swiss Re (and partners) in Ethiopia whereby farmers pay their insurance premium by working on community-identified projects to build resilience. In the illustration above, the farmers were indirectly contributing towards building resilience, enhancing their resilience while Swiss Re (and partners) expanded their market and were investing in disaster resilience. Being able to introduce new products and services to the market or expanding existing products and services also increases a company's revenue and market share. It also has the ability to enlarge and extend a company's relevance, success as well as competitive advantage. Cost savings can be referred to as one of the drivers for investing in resilience; the actual benefits of all cost-saving efforts are some or all of the following: reduced operational cost, security of profit, reduced cost of raw materials, and enhanced resource efficiency (PwC, 2013). The image of an organisation speaks a lot about the potential success of such organisation. Therefore, the need to build brand value and reputation cannot be overemphasised. An organisations brand value and image can be boosted through investment in resilient activities. Beyond the benefit of a pleasant social image, it is an opportunity to display market leadership and prowess (PwC, 2013; UNISDR & GFDRR,

2012). This will increase the confidence of all stakeholders especially that of consumers and investors. In addition to the aforementioned benefits, UNISDR and GFDRR (2012) stated that investing in disaster r resilience guarantees the safety of lives and properties, it helps to reduce the diversion of resources to response and recovery, increases investors' assurance, creates business opportunities, secures economic growth and makes employment safer and also help cities that have invested in resilience and even organisations to attract investment. Other benefits are reduced failure probabilities and time to recovery, and community wellness (UNISDR and GFDRR, 2012).

3.7 Incentives for investing in resilience

The decision to invest in disaster resilience depends on the size, sector, current capability level of the party involved and the jurisdiction in which investment is needed. Some of the incentives that are already in use or recommended for use by NRMCA (2013) are premium incentives or income tax credits for building to code, FORTIFIED standards or using robust materials. Others are making incentives available to organisations rendering key services during disaster events, expansion of the coverage of sustainability certification to include resiliency and running a lesser mortgage rate for building to disaster resilience standards. Even if incentives are not readily available, potential benefits should be sufficient to convince governments or organisation to invest in resilience. In fact, business organisations that decide to invest in risk management stand the chance of financially outperforming their peers (UNDP, 2013b).

3.8 Chapter Summary

This chapter focused on issues relating funding sources and samples of disaster resilience investments and capability enhancement. The barriers and drivers to organisation, individual as well as government's commitment to resilience, were also discussed in the chapter. Despite the existence of barriers, there are obvious benefits of committing to enhancing disaster resilience. It is exciting to note that examples of financial and non-financial commitments are available in different types of organisations belonging to various sectors among which are education, health, housing, service, hospitality and production sector. To enhance the level of commitment, more incentives can be introduced. Beyond what has been achieved, it is necessary to establish the specific capabilities for enhancing disaster resilience; this will help to direct the course of financial and non-financial commitments towards enhancing disaster resilience. Presented in the

next chapter is a detailed discussion of capabilities and capabilities for built environment resilience flood resilience.

CHAPTER FOUR
CAPABILITIES RELATED TO ACHIEVING DISASTER RESILIENCE OF THE BUILT ENVIRONMENT

4.1 Introduction

The previous chapter focused on sources of funds for capability enhancement and disaster risk reduction. Issues relating to financial and non-financial commitment to resilience were discussed. This chapter (Chapter 4) presents a discussion of resources, means, attributes, and facilities i.e. capabilities that can help the built environment of an organisation to withstand, respond, adapt to or recover quickly from a shock. It is presented with a focus on disaster resilience of the built environment at the company level because it is the scope of the study (see section 1.6 and refer to Figure 3.1). The specific topics covered in this chapter includes capacity and capability, assets/resources of an organisation, the concept of maturity and maturity model methodology.

4.2 Capability and capacity

Khan *et al.* (2008) defined capacity as "resources, means, strengths which exist in households and communities and which enables them to cope with, withstand, prepare for, prevent, mitigate or quickly recover from a disaster". UNISDR (2009) submitted that "capacity is the combination of all the strengths, attributes and resources available within a community, society or organisation that can be used to achieve agreed goals". UNISDR (2009) stated that capacity could also be described as capability and capacity refers to infrastructure, physical facilities, institutions, societal coping mechanisms, human knowledge, skills, social relationships, as well as leadership and management. According to Morgan (2006), capacity has many perspectives; the study pointed out some characteristics within which some principles relating to capacity can be built. No matter the point of view of interest, capacities are built or developed based on identified or assessed needs (Dynes, 2005). The inherent resilience referred to by Cutter *et al.* (2008) while explaining the Disaster Resilience of a Place Model is simply the capacity or capability mentioned by other authors (Khan *et al.*, 2008; Morgan, 2006). Capabilities define the coping response, absorptive ability, and adaptive ability; these abilities influence the resilience of a system in a disaster situation. It should be noted that capability in respect of disaster could be inbuilt to confront emergencies; it can also exist to help the system adjust to shocks brought about by mishaps. In the light of this, Yen-Tsang (2012) described the capability of a firm as a combination of competencies, skills

and abilities used to coordinate a set tasks or activities to achieve a particular goal. 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).

Some studies have identified a variety of capabilities that contribute to the recovery of businesses from disasters (Stephenson, 2010). However, little or no reference was made to their importance to the restoration of physical premises/built environment of businesses. Although these capabilities were not specifically referred to as capabilities for enhancing commercial premises flood resilience, they seem to have the potential of helping a business to reclaim its premises after a mishap. Hence, these capabilities were considered in this study, subject to further verification of suitability for enhancing premises resilience (verification reported in Chapter 6).

This study agrees with the submission of Czajkowski (2016), a study on decision making in natural disasters, the study referred to the work of Kunreuther and Useem (2010) while explaining behavioural biases and highlighted the connection and importance of different capabilities to different disaster stages. Kunreuther and Useem (2010) described the overall timeline of disaster risk and what needs to be done at each stage (Figure 4.1). At the pre-event stage, mitigation should be done in advance, the individual, business or community should also get ready to manage consequences during the disaster and be prepared for all recovery related activities. At the event stage, one should possess and deploy the strength and resources required to reduce damage. At the post-event stage, all strengths and resources required to restore the premises should be deployed.

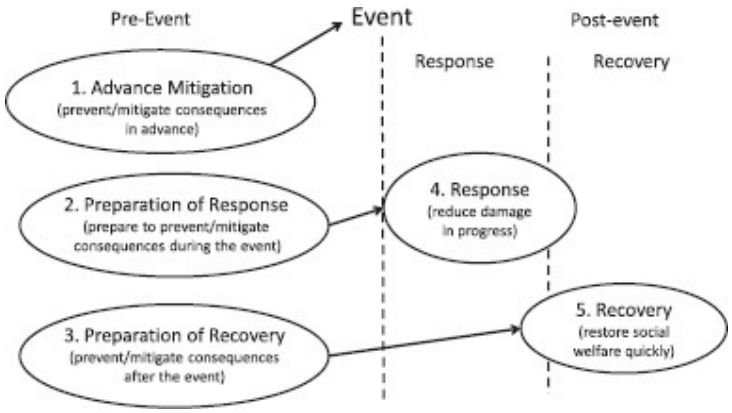

Figure 4.1 Timeline of disaster risk (Kunreuther & Useem, 2010)

Beyond the relevance of the capability areas to specific stages of disaster, there is also a relationship between the capability areas and the assets of an organisation (Grant, 1991) (see Section 4.3 and Figure 4.3). Since capabilities include physical means, resources, skills, knowledge, leadership, social relationship among others (UNISDR, 2009), it is rational to conclude that capabilities are either possessed or meant to be put in place by an asset. This is because the listed constituents of capabilities (skill, knowledge, etc.) have to be deployed to achieve the goal of disaster resilience, whereas, to achieve any goal in an organisation, organisation assets need to be deployed (Yen-Tsang, 2012). Section 4.4 presents a discussion on organisation assets and Section 4.5 discusses the link between business assets and built environment disaster resilience.

4.3 Capabilities and built environment disaster resilience

From the discussion in the last section and most especially the definition of capability, it can be deduced that capabilities for built environment disaster resilience include both physical and non-physical measures i.e. structural and non-structural measures. Structural measures are physical measures for mitigating, controlling or preventing catastrophes (e.g. flood defences and property level flood protection) while non-structural measures are non-physical efforts e.g. policies, business continuity management steps, movement of items, property survey among others (Mambretti *et al.*, 2008).

Obviously, different structural measures are required to control the impact of various types of disasters. That is, the measures that are needed to prevent damage from wildfire is different from what should be put in place in the case of flood disasters. Although, there are similarities between the non-structural measures required to reduce the impact of all disasters. In this study, while identifying the capabilities for built environment flood resilience, special attention was placed on literature relating to preparation for flood, response to and recovery from flood. This was done to ensure that factors that are strongly connected to flood resilience or have the potential of influencing built environment resilience to flood are extracted. It is worthy of note that some literature has discussed factors that affect organisation resilience, but none specifically focused on capabilities for enhancing disaster or flood resilience of the built environment.

For instance, Stephenson (2010) focused on organisation resilience but clearly identified its little or no focus on business premises and physical asset as a limitation to the study. Ponomarov and Holcomb (2009) focused on understanding supply chain resilience while

Cardoso *et al.* (2015) focused on assessing the performance of supply chains under demand uncertainty using resilience metrics and Labaka *et al.* (2015) developed a framework for improving the disaster resilience of critical infrastructure. Despite the huge impact of built environment resilience on the disaster resilience of business, it has received a relatively limited specific attention in researches that focused on business recovery and reduction of economic loss; this limited attention is a gap that needs to be filled. There has always been more focus on how a business will relocate to another site or a temporary site. Although a gap has been observed, previous studies deserve commendation as they have made valid contributions to literature and practice in their own ways. This study intends to bridge the identified gap by focusing on the maturity or progressive advancement of capabilities for enhancing the disaster resilience of the built environment of a business premise. These capabilities encompass the specific steps, resources and structural measures required for enhancing the flood resilience of business properties.

Labaka *et al.* (2015) alongside other literature (Table 4.1) contributed to the list of capability areas for enhancing flood resilience of the built environment of MSMEs extracted for this study (see 4.2 and 4.3 for a detailed discussion on capability). Figure 4.2 is a diagrammatic representation of the main classes of literature from which the capability areas presented in Table 4.1 were extracted. Major databases and repositories for disaster resilience reports and other publications were searched, the literature found highlighted what to consider while establishing capabilities for built environment disaster resilience and contributed to the list of identified capabilities.

The components of Figure 4.2 are discussed as follows. The bottommost box named **"other literature materials"** mainly contains publications on organisational and infrastructure resilience. Not all the literature that belong to each category of literature is listed in Figure 4.2, among the others, literature in this category are Stephenson (2010) and Lee *et al.* (2013). The box containing **"Flood risk management strategies**" represents literature on general flood risk management strategies for resistance and resilience of critical infrastructures (CIRIA, 2010). The main strategies are listed, and they are areas where businesses are expected to build capabilities towards achieving flood disaster resilience of the built environment. The strategies contributed to the list of capability areas extracted for use in this study. The box containing **"Organisation assets"** (third box from the bottom in Figure 4.2) represents literature on assets of an organisation,

the assets are either going to possess and deploy some capabilities on other assets or other assets deploy their capabilities on them towards ensuring the flood resilience of the built environment and the business as a whole. For instance, people/staff will have to fix flood barriers and related facilities when a flood warning is received, stakeholders of the business will have to agree to make some expenses towards ensuring disaster resilience and so on. Similar interactions exist between all other assets towards ensuring the resilience of each asset and the organisation as a whole (see Section 4.5 and Figure 4.3 for more details). This category of literature buttressed the arguments and submissions of other categories of literature mentioned earlier and highlighted some capabilities adopted in this study.

The list of capabilities identified from literature on organisation assets, flood risk management strategies at the receptor and other literature make up the capability areas presented in Table 4.1. The capability areas were subsequently verified and consolidated by experts (see Section 6) before the development of the capability maturity model that was developed by this study (see Chapter 7).

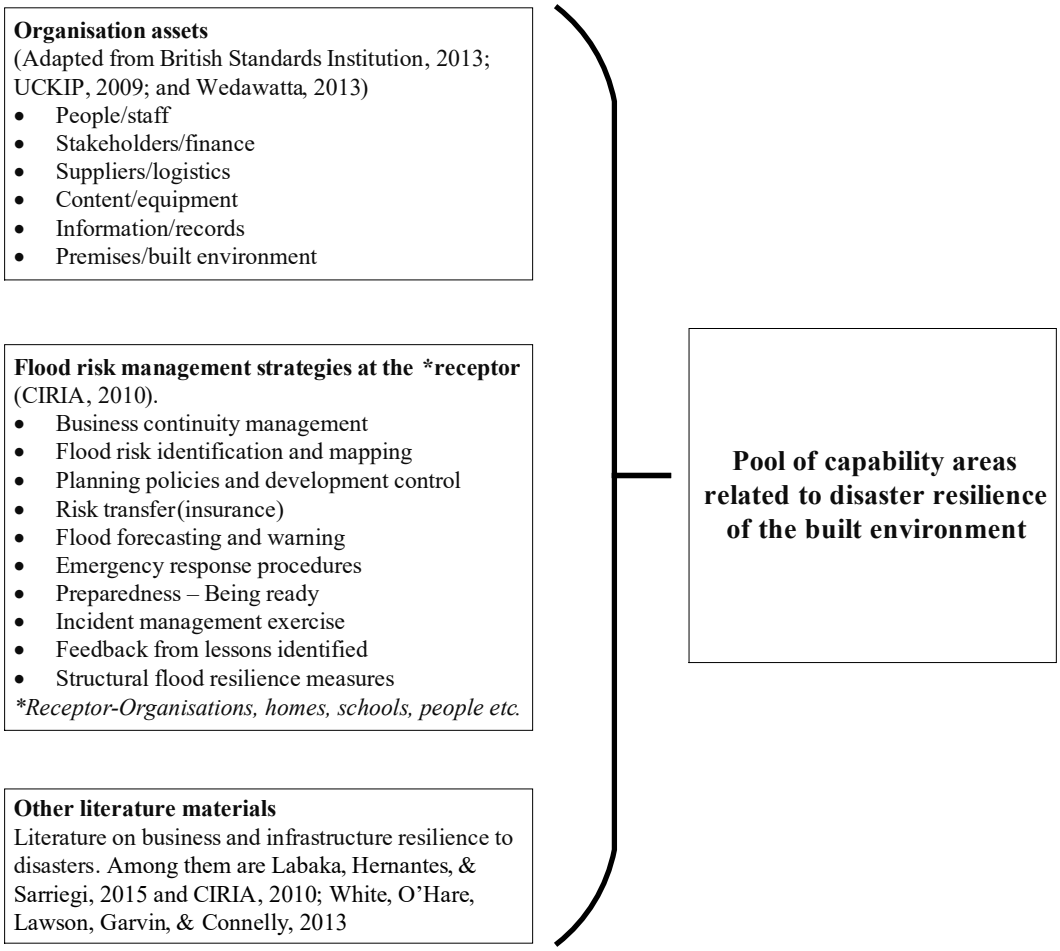

Figure 4.2 How the capability areas related to flood resilience of the built environment were identified

The capability areas identified from the literature are presented in Table 4.1, the capabilities have been mapped to business assets, and the coverage and purpose of each capability area is presented in the table.

Table 4.1 Identified capabilities for enhancing business premises flood resilience

SN	Capability areas	Organisation assets					Literature source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/Finance (SF)	Data/ Information(DI)	Content/ Equipment/Services (CE)	Supply/ Logistics (SL)		Author	Researcher		
1	Understanding flood risk to property	1	1				CIRIA (2010); White *et al.* (2013b)	1	1	This capability area refers to a business' awareness of the type and frequency of flood at the location of the business. Knowledge of climate projection and flood projection in the area. Periodic assessment is necessary - physical vulnerability evaluation and water entry channel survey. Initial consideration of remedial measures e.g. DPC, waterproofing, re-pointing. Consideration of grant options. Influence of other businesses' action on the business' flood risk – e.g. sewerage work, pollution. Understanding of hazard consequences to organisation and all assets (Stephenson, 2010)	This is expected to lead to a detailed mitigation survey. With information on mitigation and protection that is needed. This might influence other decisions. The effect or influence of surrounding businesses will also be established.
2	Planning or review for a flood resilience scheme	1	1				CIRIA (2010); White *et al.* (2013b)	1		It relates to all activities associated with the definition of products and planning criteria for selecting schemes and measures. Knowledge of a variety of measures for flood resilience, Ability to conduct or secure an analysis of cost implication of options and preparation for funding. The analysis might involve the use of relevant data and or engagement of professionals. Knowledge of flood resilience measures or systems i.e. permanent or temporary, manually deployed or automatically activated, building aperture or perimeter technologies. Involvement in flood action groups, this will have implications on the deployment of supports and facilities in an emergency situation. Engagement with community level schemes e.g. Planned maintenance and the understanding of professionals to engage in the planning.	This is expected to lead to a clear, workable plan and schedule for a flood mitigation/resilience scheme. This will influence financial sourcing or planning. It will also affect where and how to seek help. It will determine the support, technology and materials to use. This will determine the overall sophistication of method i.e. use of sand bags, manual floodgates, self-rising/automatic barriers, among others.

Table 4.1 Identified capabilities for enhancing business premises flood resilience (Continued)

SN	Capability Areas	Business assets					Literature Source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/ Finance (SF)	Data/ Information(DI)	Content/ Equipment /Services (CE)	Supply/ Logistics (SL)		Authors	Researcher		
3	Survey of property	1	1		1		(CIRIA, 2010; White *et al.*, 2013b)	1		Knowledge of how to engage qualified (accredited and certified) professionals to inspect vulnerable points around the property (i.e. walls, building services and infrastructure) measure apertures (i.e. Doors, windows and other openings) as well as other property potential failure assessments. Appraisal of needs and capability to deploy, store and maintain facilities. Consideration for visibility and aesthetics. Appraisal and continuous monitoring of organisations ability to install measures as well as the performance of installations. Understanding of what to expect during property survey activities.	This is expected to result in a detailed design or intervention specification for the property.
4	Acquisition of relevant products	1	1				(White *et al.*, 2013b)	1		This capability area covers the understanding of the purpose and function of flood resilience products. Ability to recognise the suitability of the products and facilities. Product evaluation for BSI kite mark standards or customer reviews. Communication and correspondence with product manufacturers, supplier or installers. Clear and comprehensive specification document to stakeholders. *The Kitemark is a certification mark operated by the British Standards Institute (BSI). PAS 1188 covers flood resilience products, technologies and systems.	This should lead to the communication of clear specifications to the supplier or manufacturer, achievement of a smooth acquisition process, and acquisition of quality products and facilities.

Table 4.1 Identified capabilities for enhancing business premises flood resilience (Continued)

SN	Capability Areas	Business assets					Literature Source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/ Finance (SF)	Data/ Information(DI)	Content/ Equipment /Services (CE)	Supply/ Logistics (SL)		Authors	Researcher		
5	Installation and Post-flood management scheme relationships	1	1		1		(White *et al.*, 2013b)	1		This capability covers a business' strength, readiness and efforts on product quality assessment., management of installation period and preparations for potential disruption. Post installation relationship management with supplier and installer. Maintenance contracts and the like. The organisation's access to helpful community resources e.g. flood wardens and or representatives, eemergency service or police (special equipment might be needed on special occasions). Inspection, sign-off, operation manual availability. Post installation and periodic risk assessment arrangements.	Satisfactory installation and post-installation monitoring and maintenance arrangement. Relationship with local businesses.
6	Operation and Maintenance	1					(White *et al.*, 2013b)	1		This refers to the understanding and circulation of operational instructions. Operation, storage and maintenance requirement, and the methodology for appropriate activation of products. Management of maintenance regime and storage facilities for temporary fixtures. Funding for aftercare and maintenance. Emergency plans to cater for flooding than the products cannot manage. Availability of alternatives in case product fails. Availability of support for product activation. The relationship between authorities plan and organisation's plans.	Effective response readiness.

Table 4.1 Identified capabilities for enhancing business premises flood resilience (Continued)

SN	Capability Areas	Business assets					Literature Source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/ Finance (SF)	Data/ Information(DI)	Content/ Equipment /Services (CE)	Supply/ Logistics (SL)		Authors	Researcher		
7	Organisation of disaster scenario simulations *(Full participation of members)*	1					(CIRIA, 2010; Stephenson, 2010)		1	This capability refers to the organisation of drills, flood scenario simulation and participation of staff in the simulation exercise. This capability determines end user's ability to deploy relevant technologies after warning e.g. temporary or demountable flood barriers.	It creates physical and mental alertness.
8	Safety precautions – built environment related	1					(CIRIA, 2010)		1	Observing safety precautions prevent the escalation of the impacts of catastrophe. Precautions include switching off lighting at night, fastening water tank and external furniture. An enterprise can establish a defined procedure for achieving this.	To prevent complications.
9	Retaining the interest of customers in goods and services	1			1	1	(Wedawatta, 2013)		1	Retained interest of customers/ maintenance of appealing service or products. This can also be facilitated by the organisations' ability to keep the link with customers	Sustenance of cash flow for future
10	Turn-over, income generation and cash flow management	1	1		1	1	(UKCIP, 2009; Wedawatta, 2013)		1	This refers to turn over volume and cash flow management skills. This defines the liquidity and financial management sophistication of the company.	Fund availability
11	Insurance adequacy and management	1	1		1		(CIRIA, 2010; Wedawatta, 2013)		1	This refers to an organisation's knowledge and administration of insurance as a risk transfer mechanism. Even if steps have been taken to protect property from flooding, there is still need for flood insurance, especially if the property is at risk of flooding.	Sufficient coverage for repairs, lease of temporary equipment, adequacy for cleaning-up. Safely kept insurance details, policies and contact.
12	Transport/delivery system	1				1	(UKCIP, 2009; Wedawatta, 2013)		1	Accessibility and delivery re-routing arrangements.	Access preservation.
13	Utility supply	1				1	(Stephenson, 2010; Wedawatta, 2013)	1	1	This capability refers to existing supply arrangement and availability of utility alternatives. Possession of suppliers' contacts on-site and off-site, availability of alternates and back-up.	Continuity of supply through preservation of existing system or availability of alternatives.

Table 4.1 Identified capabilities for enhancing business premises flood resilience (Continued)

SN	Capability Areas	Business assets					Literature Source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/ Finance (SF)	Data/ Information(DI)	Content/ Equipment /Services (CE)	Supply/ Logistics (SL)		Authors	Researcher		
14	Communication system	1				1	(Wedawatta, 2013)		1	Management's possession of key contacts and mechanisms for information dissemination when utility services are down.	Continuity of supply through preservation of existing system or availability of alternatives.
15	Flood proof store/flood proof protection for flood stock and contents *(Stocks and equipment)*	1			1		(UKCIP, 2009; Wedawatta, 2013)			This refers to the existence of a flood proof safe or mechanism to protect stocks and equipment	In-house protection for some contents
16	Record/Business data management	1		1			(CIRIA, 2010; Wedawatta, 2013)		1	Understanding of the criticality of business information, data policies and techniques to the running of business as well as the management system of such data. Backup facilities onsite and off-site, maintenance arrangements, usage of related policies. Alternate platforms, servers and application for operations.	Accessibility of documents relating to premises repair/renovation.
17	Management of disruption to production/service	1			1	1	(CIRIA, 2010; Wedawatta, 2013)		1	This refers to an organisation's cultural attitude or usual approach to crisis/disruptions. Harmonisation of differences in perception occasioned by the managerial hierarchy.	Preservation of right frame of mind in the interest of the organisation.
18	Crisis response budget (Income generation/cash-flow)	1	1				(Labaka *et al.*, 2015; UKCIP, 2009; Wedawatta, 2013)		1	This refers to an organisation's approach to making crisis response funds available. Availability of fund for managing damages caused by the flood on one's premises. One might also be liable for someone else's damages (You are responsible to others if your property damaged theirs). The debt level of the business can influence this.	Availability/Sufficiency of funds for repairs, leasing temporary equipment, adequate for cleaning-up.

Table 4.1 Identified capabilities for enhancing business premises flood resilience (Continued)

SN	Capability Areas	Business assets					Literature Source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/ Finance (SF)	Data/ Information(DI)	Content/ Equipment /Services (CE)	Supply/ Logistics (SL)		Authors	Researcher		
19	General awareness and commitment to resilience	1	1				(Stephenson, 2010; Wedawatta, 2013)		1	Training and awareness creation and appreciation of the need for built environment disaster resilience within the organisation. What if scenario, reporting processes, and general intelligence. The existence of standards, a network of information. Information flow.	Appreciation of the need for built environment resilience.
20	Statutory compliance	1	1				(CIRIA, 2010)	1	1	Organisation's compliance with existing property-related standards. Monitoring of developments relating to risks and resilience standards.	Compliance with relevant laws
21	Paper records management	1		1			(NCC, 2013)		1	Organisation's approach to maintaining copies and back-up of documents. Safekeeping in a flood-proof container or off-site storage.	Accessibility of documents relating to premises repair/renovation.
22	Decision making without recourse to superior in emergency situations	1	1		`		(Stephenson, 2010)		1	This capability refers to the devolvement of decision making to staff. It refers to the ability of staff to make decisions in emergencies. Devolved management and harmonisation of differences.	Quick response to people activated prevention and protection facilities.
23	Definition of roles and responsibilities and how it changes in disaster situations	1	1	1			(Stephenson, 2010)		1	A detailed outline of responsibilities in emergencies or on issues relating to crisis response. Top level reporting or otherwise, priorities, dependency occasioned by information/data flow, roles during disruptive events.	Understanding of Information flow – aids decision-making.
24	Post event review, analysis and management	1	1			1	(CIRIA, 2010)			Plans for adapting and performing better in the future, innovativeness, lessons learnt – view sharing and documentation. This capability area also includes post event vision, open communication system, and knowledge sharing activities within and outside the organisation.	Accumulation and documentation of personal and general experiences in preparation for life after the event.

Table 4.1 Identified capabilities for enhancing business premises flood resilience (Continued)

SN	Capability Areas	Business assets					Literature Source	Mapped to asset by		Coverage and description of capability area	Purpose of capability area
		People/Staff (PS)	Stakeholder/ Finance (SF)	Data/ Information(DI)	Content/ Equipment /Services (CE)	Supply/ Logistics (SL)		Authors	Researcher		
25	System and protocols for mobilising external resources when needed *(Network strength)*	1	1	1	1	1	(Stephenson, 2010)			This refers to the organisation's resource mobilisation strength. The strength depends on the connection of the business with relevant stakeholders. Resources are needed to achieve the organisation's built environment disaster resilience goals. For example, contractors/manpower might have to be mobilised to save equipment during flood events, fire brigade or facilities should be mobilised to pump out water and engage clean up the team as well as professionals needed for repairs.	Effective mobilisation of resources when needed e.g. contractors to assist in preserving equipment from flood water, firefighters, professionals needed for repairs among others.
26	Adaptability or flexibility of property. (Physical attributes of premises)	1	1			1	(IBM Global Services, 2002)	1	1	This capability area covers the flexibility and distribution of workplace; this attributes enable employees, suppliers and customer's collaboration anywhere and anytime. This can be from the same work area or another location. For example, the property design can allow full operation at upper floors if the ground floor is flooded (and under repair). The capability area also covers the physical attributes of the property and the structural flood resilience and resistance measures adopted.	Accessibility or partial usability of property.

The categories of literature from where the capabilities presented in Table 4.1were extracted is discussed in section 4.3 and represented in Figure 4.2. A more detailed review of one of the main classes of literature "organisation asset" is presented in section 4.4. A more detailed discussion is necessary not only because "organisation assets" form a class of literature from where the capabilities for built environment flood resilience were identified in this study (see Figure 4.2) but also because organisation assets will be deployed or utilised in deploying the capabilities needed for flood resilience. Organisation assets sustain the operations and existence of an organisation (Grant, 1991). Each of the business assets has roles to play in the overall well-being of an organisation (Grant, 1991) including its disaster resilience. The assets also possess the capabilities required for enhancing the disaster resilience of one another; the possession of some attributes by an asset can also enhance the disaster resilience of such asset (See section 4.4 for more details on organisation assets and section 4.5 for the interaction between business assets and built environment flood resilience).

4.4 Business assets and disaster resilience

Assets are resources that an organisation deploys towards achieving its goals (Bryson *et al.*, 2007). This includes all processes, resources, and attributes required for the conception and delivery of a set of products or services; they are also needed for sustaining the existence of such organisations (Bryson et al. 2007). Assets or resources also include all tangible and intangible assets utilised by an organisation to achieve its goal (Ray *et al.*, 2004). Fry *et al.* (2004) grouped organisation assets into four; they categories are people, physical assets, financial and formation. Rainey and Steinbauer (1999) opined that organisational assets should be classified as human, financial, and technological resources. Hansen *et al.* (2004) submitted that an organisation's asset is in two broad classes, they are, administrative and productive assets.

The administrative assets oversee the activities of the productive assets Hansen *et al.* (2004); the administrative assets include the leadership and decision-making echelon of business organisations. The productive assets include all entity and facilities that are directly involved in the production or service process. The administrative assets lead and govern the activities of the productive assets and influence the choice and deployment of other assets, the choices made largely determines the fate of the organisation when disaster strikes (Hansen *et al.,* 2004). On the contrary, Russo and Fouts (1997) grouped assets into human resources, physical assets and technologies, and organisational

capabilities as well as reputation and political capacity. Lee (2009) believed there are six types of organisational resources and listed them as human, financial, physical, administrative, political and reputation. Human, financial, and physical resources are considered traditional inputs common to all organisations. Administrative resources are described as the assets managing and controlling the activities of other traditional assets (Hansen *et al.* 2004; Lee 2009). Political resources and organisation's reputation are other key assets to business organisations as well as government agencies (Lee, 2009).

IBM Global Services (2002) also attempted a distribution of assets of an organisation to help the management understand interdependencies towards prioritising business enhancement proposals (including resilience). IBM submitted that a business and related value chain could be viewed through six classifications referred to as "solution layers". The layers are strategy, organisation, business and IT, processes data and applications, technology, and facilities and security. Although the "solution layers" appear logical based on the explanations provided, the layers or classifications was not wholly adopted as the classification of organisation assets in this study. This is because other literature made slightly different yet logical submissions also.

The business areas or layers drafted and used by UK Climate Impact Programme (UKCIP) for Business Areas Climate Assessment Tool (UKCIP, 2009) are presented in Table 4.2 below. The classification was adopted by Wedawatta (2013) while discussing threats and opportunities to businesses arising from extreme weather events. It was adapted by (Newcastle City Council, 2013) as well as other authors.

Table 4.2 Business areas (UKCIP, 2009)

SN	**Business area/assets**	**Components**
1	Markets	Availability of demand for goods and services
2	Finance	Investors, insurance, finance issues
3	Logistics	Supplies, Supplier, Transportation, Power
4	Process	Processes, service delivery, operations, activities, equipment, assets
5	People	Employees and customers
6	Premises	Building fabric and structure or grounds

Similar classification referred to as business resources (Table 4.3) were also highlighted in Business continuity management (BCM) standard, BS2599 Part 1 (Code of Practice). Strategies for business protection against disasters are recommended in the listed areas (British Standard Institutions, 2007).

Table 4.3 Business resources/areas (British Standard Institutions, 2007)

SN	Business resources	Components
1	Stakeholders	Investors, Finance
2	Information	Data, records, communication
3	Supplies	Logistics, transport
4	Technology	Equipment/other assets
5	People	Staff, customers
6	Premises	Property, work area

BS2599 Parts 1 and 2 replaced PAS 56, a Publicly Available Specification, published in 2003 but both have now been succeeded by ISO 22301 - ″ Societal Security — Business continuity management systems — Requirements″ and ISO 22313 - ″ Societal Security — Business continuity management systems — Guidance″ . The classification of business assets by previous authors was adapted as presented in Table 4.4 and used in this study (Table 4.1 and Section 4.4).

Table 4.4 Business assets/resources (Adapted from literature and adopted for this study)

Business assets	Components
People	Staff, customers
Finance/Stakeholders	Investors, finance issues, insurance
Logistics	Supplies, Supplier, Transport, Power
Content/Equipment/Service/Process	Processes, service delivery, operations, activities, equipment, assets
Information/Data	Data, records, communication
Premises/Built environment	Property, work area

4.4.1 People/staff

People are great resource and investment to any business. They lead and execute many of the tasks involved in the operations of a business (Newcastle City Council, 2013). A minimum of staff is required to carry out some critical activities and a specific amount of staff is required to provide some level of service. Similarly, a level of skills, competencies and capabilities are required to execute some tasks (Newcastle City Council, 2013). This category of an asset includes the staff of the organisation, i.e. professional, non-professional, career, non-career, full-time, part-time employees (UKCIP, 2009). This category of people has roles to play in mitigating the loss of a business from disasters.

4.4.2 Finance/Stakeholders/Investors

Finance remains the backbone of any business, the business owner usually provides this, partners or investors that decide to support the concept of the business (Rainey and Steinbauer, 1999). Stakeholders are key assets to any organisation; they provide the funds with which an organisation operates. The stakeholders can either be connected to the organisation because of their financial commitment or they are involved in the administrative activities of the organisation. Hansen *et al*. (2004) submitted that administrators govern productive assets that contribute directly to organisation purposes. The magnitude of input of the stakeholders often determines the status and the capability of the organisation. In this study, this category of organisation asset includes investors and the governing team of a business. Financial resources are basic needs for acquiring other assets like equipment, machines, products and for recruiting employees and paying wages (Fernandez & Rainey, 2006). Sufficient fund is needed to meet the financial obligations of a business (Fernandez and Rainey 2006).

4.4.3 Supplies/Suppliers/Logistics

There are priority suppliers on whom a business depends on for its operations. Some of these suppliers provide the raw materials with which a business operates, sometimes as a supports or a key anchor to its operation (UKCIP, 2009). Beyond the provision of materials to support operation, some organisations also provide support staff as part of their logistic responsibility to another organisation. The mode of service rendered to each other depends on the agreement between an organisation and its logistic support or supplier (British Standard Institutions, 2007).

4.4.4 Content/Equipment/Services/Products/Process

The services being delivered by some organisations require specific plants and machinery as well as some other facilities (Fry, Stoner, and Hattwick, 2004; Newcastle City Council, 2013). A number of facilities required is a function of the type of services being rendered by the organisation (Fry, Stoner, and Hattwick, 2004). Retail houses usually require more of contents rather than machinery, some machinery and equipment are still required for some specific activities.

4.4.5 Information/Data/Records

Information and information technology is a core asset to any business (IBM Global Services, 2002). Several businesses still make use of hard copy records and data. Both hard copies and soft copies are vulnerable to flood disaster and therefore require protection. Information technology is essential to the operation of several organisations in this age; this is usually used for voice and data communication (IBM Global Services, 2002). The extent of deployment of information and communication technology in information and data management is also dependent on an organisation's size and line of business (Russo and Fouts, 1997). Business information is used in the day-to-day running of the activities of a business while some information is not regularly needed for the day-to-day operation of the organisation. As such, some information is usually kept for reference purposes only. The reference information, as well as the data relevant to the day-to-day operations of a business, are either kept in soft copy and/or hard versions.

4.4.6 Premises/Built Environment

Buildings are among the greatest physical assets of any business (Newcastle City Council, 2013). Buildings and equipment provide mechanical means for production and service delivery (British Standard Institutions, 2007). Therefore, these assets need to be protected from being damaged by a disaster. All organisations operate from specific location or locations; this is where all activities take place. Sometimes, organisations distribute its locations of operation for specific reasons (IBM Global Services, 2002). The line of business of a typical organisation determines the design and premises of a business. Although other intangible assets like reputation are important (Roberts & Dowling, 1997), they were not treated as a substantial type of asset in this study.

4.5 Business assets and built environment disaster resilience

The disaster resilience of the built environment/premises requires input from all other assets of an organisation. For an organisation to achieve its goals, organisational assets are deployed and all relevant activities must be coordinated (Yen-Tsang, 2012). Considering the explanations and discussions presented about business assets in section 4.4, the link between the assets and the disaster resilience of the built environment can be seen in the following illustrations.

The 'staff/people' of an organisation or the owner of the business will have to set up flood barriers during flood events, therefore these set of people should have necessary capabilities to perform that function. Similarly, the 'stakeholders/financiers' will have to provide financial resources to acquire needed facilities and support disaster resilience related decisions. Also, suppliers that support a business has links and networks that can be useful for undertaking disaster resilience activities by a business. Beyond the utilisation of suppliers' network, suppliers can help strengthen the disaster resilience of the built environment of the businesses it serves. For instance, Primark became a signatory to the accord on building safety to its suppliers (Goldfingle, 2013; Khan & Wichterich, 2015). Also, the existence of equipment and contents that permit the full use of resilience methods and allows adequate flexibility and movement during flood events or business equipment that can maintain suitable stability during earth movements will limit damage and shorten the period of non-availability of the built environment after a disruptive event.

Further, the availability of necessary data and records after a disruptive event can aid recovery and future disaster preparation processes (Pitt, 2008), e.g. flood survey details, early warning monitoring systems, business records relating to finance, guides and manuals on operation and maintenance of flood facilities, records of those that aided the recovery of an organisation from previous events, financial records to examine business status and funds available for disaster or premises resilience to disasters among others. Some documents are clearly needed for insurance claims and stock management; their loss might delay premises and business recovery (Pitt, 2008). Premises/built environment itself is an asset that requires some inherent characteristics to remain resilient to disasters. The adequacy of the in-built disaster resilience capability of a property and other non-structural contributions from all other assets as well as external sources will guarantee the resilience of the built environment and a business as a whole.

Beyond the contribution of other business assets to the disaster resilience of the built environment, there is also an interaction between all other assets but it is not highlighted in this study so as to keep the focus of the study. Figure 4.3describes how the overall resilience of the premises/built environment depends on the inherent resilient properties of the built environment and the contributions of other assets to the disaster resilience of the built environment.

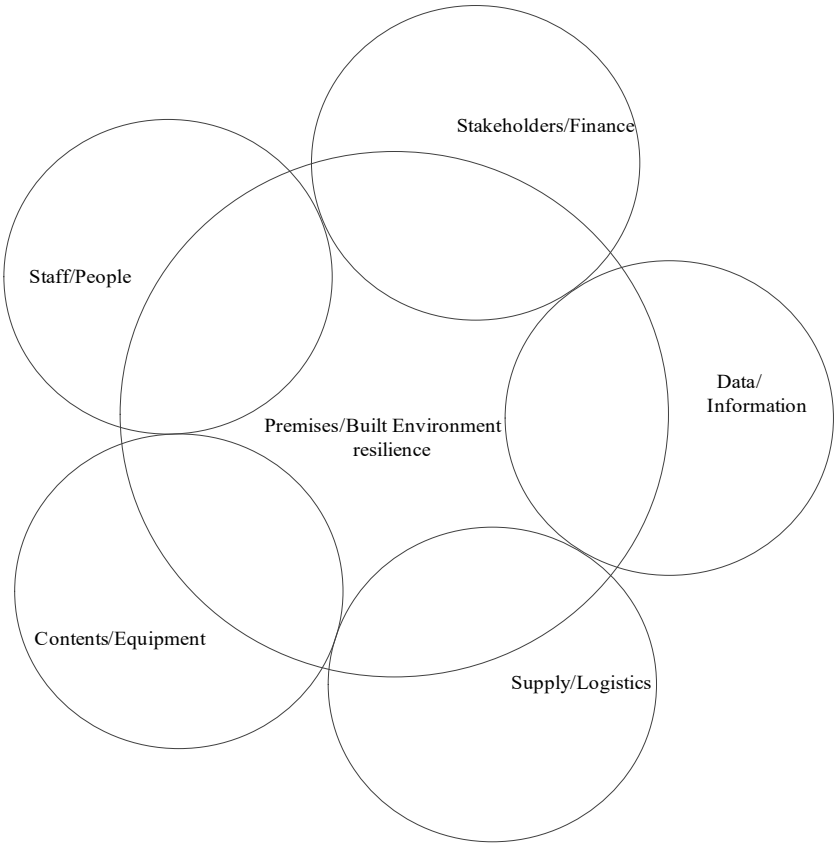

Figure 4.3 Resilience of the built environment requires input from other assets

4.5.1 Perspectives of evaluating organisation resilience

Some studies have been done in the area of organisation resilience. These studies identified dimensions, parameters and indicators of organisation resilience. McManus *et al.* (2008) outlined three dimensions and fifteen indicators for measuring and comparing organisation resilience. The three dimensions are situation awareness, management of keystone vulnerabilities, and adaptive capacity. The fifteen indicators identified by the study under the dimension "situation awareness" include connectivity awareness, recovery priorities; planning strategies and organisational connectivity were listed under the dimension "management of keystone vulnerabilities" while communication and

relationships and information and knowledge are among the indicators of the dimension named “adaptive capacity”. Stephenson (2010) added to the list of indicators derived by McManus *et al.* (2008), two indicators were added to each of the dimensions and another dimension of organisational resilience was added. This brought the total of dimensions of organisation resilience to four and indicators of resilience to twenty-three factors. The new dimension is “resilience ethos” with two indicators namely commitment to resilience and network perspective. The new indicators include informed decision-making, staff engagement and involvement, and innovation and creativity. Each indicator is measured by a set of three or more questions (Lee *et al.*, 2013; Stephenson, 2010; Stephenson *et al.*, 2010).

In a similar vein, Wedawatta (2013) studied resilience of construction MSMEs to extreme weather and assessed the resilience of organisations using three indicators namely vulnerability, coping strategies and coping capacity. Each of these parameters was evaluated based on a list of factors referred to as business areas, among these business areas are markets, financial situations, supply chain and logistics, business premises, workforce, and production processes and services offered. Each of these business areas has sub-items for measurement. It is worthy of note that the business areas adopted by Wedawatta (2013) can also be described as organisation assets (see Section0).

It is interesting to note that the studies mentioned above focused on organisation resilience and achieved their intentions. However, they all paid limited attention to the physical premises/built environment of their respective target organisations. Stephenson (2010) identified the limited attention to the physical assets of an organisation in the study as a limitation to the study. Stephenson (2010) is a progress on McManus *et al.* (2008) and it is the basis for Stephenson *et al.* (2010) and Lee *et al.* (2013). This study builds on this gap among others (see section 1.2) to focus on capabilities for disaster resilience of the built environment of a business organisation, with a specific focus on flood (see section 1.6 for details on the scope of study).

4.6 The concepts of maturity and Capability Maturity Modelling (CMM)

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). According to the definition, maturity is concerned with a set of processes that leads to a goal. It is ideal

to submit that the degree of appropriateness or effectiveness of the processes determines the suitability of the result.

Dooley *et al.* (2001) noted that the definition by Paulk *et al.* (1993) combined processes (defined, managed, measured, and controlled) with outcomes (effective). The study suggested that it is better to separate activities from outcomes. The study, therefore, defined "maturity as the extent to which a process is explicitly defined, managed, measured, and continuously improved". As much as the modified definition seems reasonable, a second look reveals that "continuous improvement" is done to achieve better efficiency and effectiveness. Therefore, "effectiveness" in the original definition of process maturity by Paulk *et al.* (1993) can be viewed as the effectiveness or efficacy of the processes leading to a goal or result. This will uphold the submission of Paulk *et al.* (1993) but contrast Dooley *et al.* (2001). The accentuation of simultaneity in the processes in each capability level (Dooley *et al.*, 2001) contrary to the sequential relationship presented by Paulk *et al.* (1993)appears valid. Dekleva and Drehmer (1997) also supported the existence of simultaneity in maturity levels. Both positions are hereby acknowledged in this study, and the submissions will be considered wherever necessary. Nevertheless, it should be noted that the attributes in a preceding level will better describe a system or process than the attributes in a succeeding level. Even if there is simultaneity in characteristics listed in both levels. Therefore, the progressive characteristic of the maturity concept remains valid, maybe with limitations.

Capability maturity modelling is a methodology used to model capability levels. It provides a framework for describing process improvement strategies. It helps to describe current capabilities and performance improvement options (Yeo & Ren, 2009). It originated from the software industry and has been applied in other areas such as project management (Kerzner, 2002), systems engineering, product development (Dooley *et al.*, 2001), construction industry among others. The original version of capability maturity model classified software organisations into five levels based on defined characteristics for each level. Capability maturity model is simply a concept that defines the key practices that describe the respective successive levels of process maturity. The original version provides a method for evaluating an organisation's quality software production capabilities. The attributes that describe each level are defined based on the key process areas of software production.

4.7 Capability Maturity Model Integration (CMMI)

The Capability Maturity Model (CMM)developed by Paulk *et al,* (1993) eventually metamorphosed to Capability Maturity Model Integration (CMMI) (SEI, 2010). The CMMI emerged as a result 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, among them are (Eadie *et al.*, 2011, 2012; Keraminiyage *et al.*, 2007b; Sarshar *et al.*, 2000; Sun *et al.*, 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 describe the implementation of key process areas, the features are a commitment, ability, the performance of activities, measurement/evaluation and analysis, and verification (SE1, 2010). The CMMI comprises of maturity levels presented in a progressive manner containing process improvement criteria across the levels (Eadie *et al.,* 2012, SEI, 2010). There are five maturity levels presented in a stepwise progressive manner and labelled 1 to 5, 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 the process areas has a purpose and each of the process areas is characterised by generic goals and generic practices as well as specific goals and specific practices (SE1, 2010). This concept is adopted in this study with adequate consideration for the original CMM. The process areas are capability areas in this study, the purpose of each capability area is defined (see Table 4.1), the generic and specific goals and practices are carefully mapped in the context of disaster resilience to the capability areas identified in this study (see Table 4.1 for capability areas and chapter 6 and 7 for details on maturity model development).

A brief description of capability maturity levels is presented below; details of maturity level characteristics/definitions are presented in Table 4.5 to 4.9. The maturity levels are named as follows in the original CMM, Level 1 – Adhoc, Level 2 – Repeatable, Level 3 – Defined, Level 4 – Managed, Level 5 – Optimising (Paulk *et al*., 1993).

- 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). A detailed list of characteristics of capability maturity levels is presented in Table 4.5 to 4.9. Some of the capability maturity level definitions were developed based on: (1.) Chess analogy i.e. progression from novice to grandmaster (Stephenson, 2010) (2.) analogy of an athlete i.e. from being able to crawl to being an Olympic runner (Virtual Corporation, 2005). Some were also developed based on the defined characteristics of respective capability levels contained in previous studies

via a mapping exercise (Macgillivray *et al.*, 2007). In this study, effort was made to extract only the characteristics of maturity levels that are relevant to the maturity definitions for built environment resilience capability. The extracted characteristics were thereafter mapped to the identified flood resilience capability area to produce the conceptual flood resilience capability maturity model (See details in 5.4.1 and appendix K).

Table 4.5 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 *et al.* (2014); Kaur (2014) ; Keraminiyage *et al.* (2007a) ; Niazi *et al.* (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 *et al.* (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.* (2007a) ; 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)

Note: The reference code reads "Maturity level 1, Adhoc, characteristic 1 to 20".

Table 4.6 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 *et al.* (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)

Note: The reference code reads "Maturity level 2, Repeatable, characteristic 1 to 20".

Table 4.7 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 *et al.* (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)

Note: The reference code reads “Maturity level 3, Defined, characteristic 1 to 21”.

Table 4.8 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)

Note: The reference code reads "Maturity level 4, Managed, characteristic 1 to 23".

Table 4.9 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)
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)

Note: The reference code reads “Maturity level 5, Optimizing, characteristic 1 to 23”.

Since improvement efforts are stirred by understanding one's current performance, capability maturity assessment can stir or reveal the need for capability enhancement towards flood disaster resilience. The link between maturity, disaster resilience and the scope of this study is discussed further in Section 4.8.

4.7.1 Maturity models in literature

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). Presented in Table 4.10 are some existing maturity models. The table reveals some existing areas of application of the maturity-modelling concept.

Table 4.10 Summary of Maturity Models in literature

SN	Area	Focus/Purpose	Developer	Source
1	Capability Maturity Model (CMM)	Software and systems engineering.	Software Engineering Institute (SEI) of the Carnegie-Mellon University	Paulk *et al.* (1993); SEI (2010)
2	Structured Process Improvement in Construction Enterprises (SPICE)	Project Management	Construct IT, University of Salford	Construct IT (2000)
3	Structured Process Improvement in Construction Enterprises-Facilities Management (SPICE-FM)	Facilities Management	Construct IT, University of Salford	Construct IT (2001)
4	Project Management Process Maturity Model	Project Management	Kwak and Ibbs	Kwak and Ibbs (2002)
5	Organisational Project Management Maturity Model (OPM3)	Project Management (Based Project Management Book of Knowledge)	Project Management Institute	PMI (2003)
6	Portfolio, Programme and Project Management Maturity Model (P3M3)	Portfolio, Programme and Project Management	Office of Government Commerce	OGC (2010a)
7	PRINCE 2 Maturity Model	Project Management	Office of Government Commerce	OGC (2010b)
8	Project Management Maturity Model	Project Management	KLR Consulting	KLR Consulting (2008)
9	Capability Maturity Model Integration (CMMI) version 1.3	Software Engineering	Software Engineering Institute (SEI)	SEI (2010)

Table 4.11 Summary of Maturity Models in literature (Continued)

SN	Area	Focus/Purpose	Developer	Source
10	Trillium (Based on capability areas)	Model for Telecom Product Development & Support Process Capability	Bell, Canada	April and Coallier (1995)
11	Federal Aviation Administration – Integrated Capability Maturity Model (FAA-iCMM)	Federal Aviation Administration	US Federal Aviation Administration	(Ibrahim *et al.*, 2009)
12	eSourcing Capability Model for Client Organisations	e-sourcing	ITSQC	ITSqC (2009)
13	People Capability Maturity Model (CMM-P)	People Capability	Software Engineering Institute	Curtis *et al.* (2009)
14	IT Services Capability Maturity Model (IT Service CMM)	IT Services	CIBIT Consultants and Department of Computer Science, Vrije Universiteit De Boelelaan	Niessinka *et al.* (2005)
15	Business Continuity Maturity Model (BCMM)	Business Continuity	Virtual Corporation	Virtual Corporation (2005)
16	ITIL Maturity Model	IT service management	AXELOS	AXELOS (2013)
17	Risk management capability maturity model for complex product systems (CoPS) projects	Risk management of complex projects	Yeo and Ren	Yeo & Ren (2009)
18	Stakeholder Organisation Capability Enhancement Framework (SOCEF) (Based on CMMI)	Public Private Partnership stakeholder organisations	Babatunde *et al*	Babatunde *et al.,* (2016)

Table 4.10 shows that the maturity modelling methodology has been applied in various fields and for various purposes. Saleh and Alshawi (2005) stated that 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) have two types. 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). The study also identified other types of models alongside normative models; examples are Goal centred, comparative, improvement, and general models. Others are user satisfaction, system use, system quality and general models. This study is interested in developing a model that leads to continuous improvement. Open Group (2006) listed the benefits of Capability

Maturity Model to include: its provision of a yardstick against which to periodically measure improvement, it clearly states the activities to be undertaken by an organisation in order to improve its processes or capabilities, it provides a foundation for the management and improvement of efforts. The abovementioned benefits justify the use of capability maturity modelling method to achieve the target of this study.

4.8 Maturity model methodology and disaster resilience

The applicability and the importance of 'maturity' in disaster resilience theme are presented hereby. Normatively, each organisation usually has a target or goals with respect to the vision(s) of the organisation. For an organisation that has the understanding of resilience, a target on resilience is likely to be set. Achievement of the goals is a function of the "current status" of the organisation. "Current status" above refers to the level of sophistication and resources available, the degree of knowledge of the organisation on or the perceived degree of importance of the goal. As the organisation grows, its performance in respect of set goals and future targets will continue to evolve. In a similar way, an organisation's target in respect of resilience develops based on some factors. Among the factors are the sophistication and volume of resources available in the organisation, the level of understanding or perceived importance of resilience to the organisation. The phenomenon of progressive increase describes maturity. Therefore, maturity relates to resilience. This study views built environment flood resilience through the lens of maturity and anchors this on "capability maturity modelling methodology (Section 4.8)". The methodology has been applied in several areas of study and varieties of context (See Table 4.10). The application of capability maturity modelling in the field of disaster resilience in the built environment by this study is novel. Maturity levels in conventional CMM are concerned with process capability and defined based on key process areas, maturity in this study is concerned with capabilities for resilience and resistance and are defined based on key capability areas. Capability maturity models are suitable for self and joint assessment as well as a continuous improvement programme/guide.

4.8.1 Disaster resilience as a process and an outcome

Bonanno *et al.* (2011) described resilience as an outcome pattern that is characterised by a steady trajectory of functioning. The study noted that resilience is a robust phenomenon that emerges in response to stress. Therefore, it can be deduced from further discussions in the study that resilience involves process, emergence and outcome. Luthar *et al.* (2000)

submitted that resilience is a construct that describes the ability of individuals to maintain positive adaptation in situations of significant adversity.

4.8.2 Requirements for moving between levels

One of the major characteristics of a maturity model is the existence of various levels through which an organisation or individual is expected to progress. As a result, some conditions would have to be satisfied before a higher level can be attained. The summary provided by Alshawi *et al.,* (2005) provides a guide to requirements for progression through the levels. Alshawi's submissions are adapted for this study and presented as follows. Progression from Level 1 (Ad hoc) to Level 2 (Repeatable) requires the achievement of some specific goals; basic practices should also be undertaken. Movement from Level 2 to Level 3 (Managed) requires the institutionalisation of some managed process and activities; this 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, this 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 for capability was related to the progression requirements presented above. The level definitions will allow an organisation to identify its current status and steps required for progression to a higher maturity. Practically, what is needed for progression to a succeeding higher level is the accomplishment of the characteristics listed in the specific maturity level (See Table 7.8).

4.9 Chapter summary

Understanding the disaster resilience capability maturity level of an organisation or a system will provide a good guidance on how to make disaster resilience investment decisions by the company. This study will assist in encouraging disaster resilience capability enhancement in organisations thereby increasing overall community and city resilience. Since the operation of a business organisation depends on the built environment (premises) and other assets, all considerations for the enhancement of

capabilities towards the resilience of the built environment (business premises) in this study were made with due attention to other resources/assets that make up an organisation. The other resources/assets are people, supplies/suppliers, stakeholders or investors, equipment or machine, and information. The research methodology of the study is presented in the next chapter.

CHAPTER FIVE
RESEARCH METHODOLOGY

5.1 Introduction

The previous chapter (Chapter 4) focused on capabilities related to achieving disaster resilience of the built environment. Among the topics discussed in the chapter are capabilities, assets of an organisation and maturity model methodology. Presented in this chapter is the methodology used in achieving the objectives of this study. The discussions in this chapter include an analysis of the processes and approaches adopted; a review of available alternatives and justification for the options adopted is presented in relevant instances. The topics discussed in the chapter include research design, research philosophy, research approach, research strategy, methodological choices, and time horizon among others. The procedure of data collection and analysis are also discussed.

5.2 Research Design

Creswell (2013) described research design as the research process; it consists of the plans and procedures, data collection methods and the method of analysis adopted in a research. Similarly, Collis and Hussey (2009) defined research methodological design as the approach used in the process of a research. The approach includes theoretical foundations, data collection and data analysis. According to Crotty (1998), the four stages of a research are epistemology, theoretical perspective, methodology, and methods and further outlined the constituents of the four stages (See Figure 5.1)

Epistemology	Theoretical perspectives	Methodology	Methods

• Objectivism
• Constructivism
• Subjectivism
	• Positivism
	• Interpretivism
	  ○ Symbolic interactionism
	  ○ Phenomenology
	• Critical inquiry
	• Feminism
	• Postmodernism and others
		• Experimental research
		• Survey research
		• Ethnography
		• Phenomenological research
		• Grounded theory
		• Heuristic inquiry
		• Action research
		• Discourse analysis among others
			• Sampling
			• Statistical analysis
			• Questionnaire
			• Observation
			• Interview
			• Focus group
			• Document analysis
			• Content analysis and others

Figure 5.1 Crotty's four stages of research (Adapted from Crotty, 1998 and Gray, 2013, pg. 19)

The acceptability of classifications in terms of appropriateness and adequacy is not universal as Rudestam and Newton (2007) submitted that there are arguments and some confusion about the selection of appropriate direction and classification of the research process. The 'Nested model' is another research design model, which was developed by Kagioglou *et al.* (1998). The model discusses research philosophy, research approach, and research techniques as research elements (Figure 5.2).

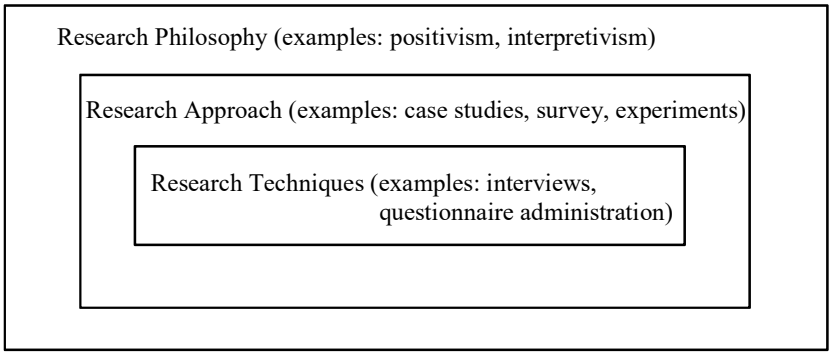

Figure 5.2 The Nested Model (Adapted from Kagioglou *et al.*, 1998)

According to Kagioglou *et al.* (1998), the outermost layer (i.e. research philosophy) directs the choices of research approach and research techniques. Similar to the Nested Model is the 'Research onion model' produced and discussed by Saunders *et al.* (2016). The Saunders *et al.* onion model contains six layers or phases; the outermost layer is research philosophies, the next layer presents research approaches, this is followed by research strategies, research choices, time horizons, and techniques and procedures (see Figure 5.3).

The 'four stages of research' presented by Crotty (1998), the 'Nested Model' by Kagioglou *et al.* (1998) and the 'research onion model' by Saunders *et al.* (2016) provide similar interpretation of the components of research design. However, the structure of presentation of the models differ. This is based on slight differences in interpretation and the need to present some phases as separate entities. For instance, Saunders *et al.* (2016) identified research strategy, research choices and time horizons as separate layers between research approach and techniques and procedures unlike Crotty (1998) and Kagioglou *et al.* (1998). This study found Saunders *et al.* (2016) 'Research onion' model as a comprehensive, widely accepted and suitable guide for designing a research; the model was adopted for explaining the overall design of this study. The research onion model appears suitable for explaining the design of a research because it presents all principles, phases and

knowledge angles relating to research in a systematic, comprehensive, logical, and easy to understand manner (Figure 5.3).

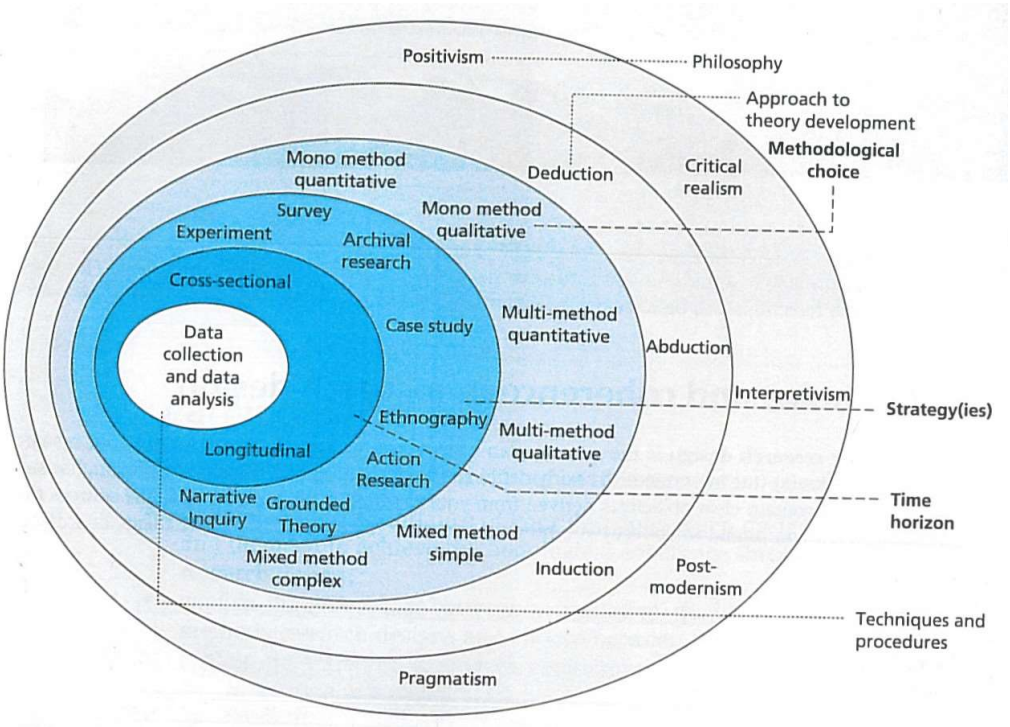

Figure 5.3 Research Onion model (Saunders *et al*., 2016, p 164)

A key point to note about the onion model is that the options provided in each layer are not mutually exclusive. The classification of the research process by Saunders *et al.* (2016) is comprehensive and provides a clear guide on important considerations towards achieving the objectives of a study. As earlier mentioned, this study adopted Saunders *et al.*'s (2016) classification of the research process. Therefore, the research layers in the onion model are discussed in more detail as follows (Section 5.2.1 – 5.2.6).

5.2.1 Research Philosophies

Before presenting the philosophical stance of this research (Section 5.2.1.1), a discussion of research philosophies is hereby presented. According to Saunders *et al.* (2016), research philosophy underpins the nature and development of knowledge. The methodology with which a research is done and the research objectives are achieved is greatly influenced by the philosophical position of the researcher (Flick, 2009; Saunders *et al.*, 2016). This study agrees with the submission of other researchers about the need for a philosophical standpoint for a research. A number of research philosophies were identified by Saunders *et al.* (2016) and presented in the outermost layer of the 'research onion model' (Figure 5.3). The

philosophies are positivism, critical realism, interpretivism, postmodernism and pragmatism.

Saunders *et al.* (2016) outlined three perspectives of philosophy in research as epistemology, ontology, and axiology, the epistemology and ontology are much more popular in literature and among researchers. Guba and Lincoln (1994) emphasised the need to understand research philosophy by stating that not just any methodology, epistemological position or any ontological position is suitable for any research. However, this does not imply the superiority of any but emphasises the need for a clear standpoint on research philosophy in any research. According to Guba and Lincoln (1994), epistemology describes the nature of the relationship between the researcher and the researched. It is the view postulated by a would-be knower about the most appropriate way to investigate a phenomenon. Epistemology is a set of assumptions that guides an individual's mode of investigating the world or a phenomenon (Easterby-Smith *et al.*, 2012; Saunders *et al.*, 2016). Gray (2013) described epistemology as a philosophical stance that guides an individual's decision on adequacy and legitimacy of knowledge. Among the various positions within epistemology are positivism, critical realism, subjectivism, postmodernism, pragmatism and interpretivism (Crotty, 1998; Easterby-Smith *et al.*, 2012; Flick, 2009; Saunders *et al.*, 2016).

Ontology as a perspective of philosophy describes a researcher or an individual's perception of the nature of reality (Guba & Lincoln, 1994). It is about the question and assumptions on 'what is reality?' and 'how does reality work?' Ontology is about the nature of reality or existence, what makes up reality. Ontology relates to 'what is' why epistemology covers 'what it means to know' (Gray, 2013). The popular ones among ontological stances are objectivism and constructivism (Sutrisna, 2009). Saunders *et al.* (2016) also presented ontological positions for positivism, realism, postmodernism, pragmatism and interpretivism. According Saunders *et al.* (2016) positivists depend on the use of observable reality to produce stable generalizations, critical realists depend on what we see, experience, and the structures that shape what we see in their researches while interpretivists create new, provide deeper understandings of the context of interest by engaging the society. Postmodernists critique positivism and objectivism and emphasized the importance of language in describing reality and what it means to know; for pragmatists research must sart with a problem and must result in a deployable practical solution (Saunders *et al.*, 2016). Axiology emphasises the significance of value to judgements and the dependence of judgements on value (Hart, 1971; McNamee, 1998). Collis and Hussey (2009) described axiology as a philosophical branch concerned with whether judgements from researchers are influenced by the

researcher's stance on value. Table 5.1 shows an extended continuum of epistemological and ontological perspectives.

Table 5.1 Continuum of most popular philosophical stances (Adapted from McNamee, 1998 and Sutrisna, 2009)

Philosophy	**Continuum**
Epistemology	Positivism ⟷ Interpretivism
Ontology	Objectivism ⟷ Constructivism
Axiology	Value free ⟷ Value-laden

The philosophical position of this research is presented in the next section.

5.2.1.1 The philosophical position of this research

This study was structured on appropriate epistemological and ontological directions as recommended by Guba and Lincoln (1994), Burrell and Morgan (1979) and Easterby-Smith *et al.* (2012) among other authors. The philosophical stance of this study in terms of the basis of knowledge as well as the assumptions on the nature of knowledge is constructivism (social constructivism) and interpretivism. It is also ideal to refer to the philosophical position of this study as pragmatism. The justification for the above statements is presented in the remaining paragraphs in this section (Section 5.2.1.1).

In this study, several stakeholders were engaged via an expert forum (Section 5.4.7.2) and case study organisations (Section 5.4.3). Their submissions helped in achieving the aim of the research. This implies that knowledge was 'constructed' by engaging participants in an interactive and participatory manner. It should be noted that social constructionists (constructivists) believe that knowledge is located, accumulated and structured via interaction with the society (Flick, 2009). Therefore, the ontological position of the study is constructivism.

From the epistemological perspective, the engagement of stakeholders via the expert forum (Section 5.4.7.2) and case studies (Section 5.4.3) implies that knowledge was sought within the scope of reference of the participants; this highlights the 'interpretivist' position of this study. The acquisition of knowledge within the scope of participants rather than the researcher introduces the likelihood of 'subjective' submissions and interpretations (Easterby-Smith *et al.*, 2012, Flick, 2009). This is also an attribute of constructivism (explained in the last paragraph). Based on these explanations, it is clear

that this study believes that knowledge is located within the society; and can be accumulated and interpreted or structured via interaction with the society. According to Burrell and Morgan (1979) interpretivism paradigm of research implies that knowledge is sought within the scope of reference of the participants in the research and not the observer/researcher; to achieve this, the subject and the researcher are engaged in an interactive, cooperative and participatory process. In this study, the subjective tendencies resulting from the expert panel review and case study strategy utilised were neutralised via triangulation (see section 5.6) and final model validation (see Chapter 8 for details). Eventually, knowledge was created via interaction with the participants, and it was, of course, established on relevant theories (Section 5.3) and literature (chapters 2, 3 and 4). This is the basis of the initial statement that the epistemological and ontological position of this study is interpretivism and constructivism.

It is also ideal to describe this study as a pragmatic research. This is because the study started with a research problem and contributed a practical solution (i.e. Table 7.8 – Built Environment Flood Resilience Capability Maturity Model). It is ideal to overlook the abstract distinctions of research philosophy and focus on the practical outcome of the research; that is, an outcome that can inform future practice (Saunders *et al.*, 2016). Pragmatists do not bother about specific methods of doing a research but rather advocate the use of any or variety of knowledge and methods that are needed to address the research problem (Saunders *et al.*, 2016). Based on this explanation, describing this research as a pragmatic study is not out of context. This is because focus can be placed on the final practical outcome (i.e. Table 7.8 – Built Environment Flood Resilience Capability Maturity Model); and the concepts, theories, knowledge and ideas engaged in the study were not considered in an abstract form but how they can influence the thought processes and procedures towards finding a solution that can inform future practice (i.e. built environment flood resilience capability maturity assessment).

5.2.2 Research Approach

Saunders *et al.* (2016) identified three research approaches i.e. deduction, induction and abduction approaches (Figure 5.3). Deduction research approach involves the production of a conceptual or theoretical structure and testing the structure (Sutrisna, 2009). The theoretical structure is referred to as a hypothesis. The hypothesis is a guess founded on the belief of a researcher or the interpretation of existing body of knowledge. Hypothesis describes the relationship between variables and entities relating to the focus of a study.

The conceptual structure or the hypothesis is after that modified based on the findings from the research (Saunders *et al.,* 2016).

In an induction research, a researcher approaches the 'researched' with an open mind; no theory is developed e.g. Grounded Theory methodology whereby theory is built strictly on the submissions of respondents (Sutrisna, 2009). Hyde (2000) presented a possible variation to keeping an open mind; it stated that on some occasions, a qualitative researcher could adopt formal deduction procedures, although most qualitative researches are induction. An example of such situations is theory testing undertaken via pattern matching (Hyde, 2000).

In the abduction research approach, the researcher collects data to explore a phenomenon, identify themes, explain patterns and propound new theories or modify existing ones, and then test the theories through additional data collection (Saunders *et al.,* 2016). In other words, in the abduction research approach, known premises (data or theory) are used to identify themes, patterns, meanings, generate testable conclusions, and produce conceptual frameworks. These frameworks are tested in subsequent round(s) of data collection (Saunders *et al.,* 2016). Suddaby (2006) submitted that in an abduction research, a researcher operates back and forth i.e. the process involves the movement from theory to data (deduction) and data to theory (induction). It is therefore appropriate to state that an abduction research straddles induction and deduction approaches (Suddaby, 2006). It can be deduced from the discussion above that abduction studies depend on data or an existing body of knowledge to formulate an initial position on what is to be researched. Summarizing its discussion on research approach, Saunders *et al.* (2016) highlighted the possibility of combining induction and deduction in the same piece of research.

This study started with an initial position formed from the literature to produce a conceptual model. The procedure for developing the conceptual model from the literature is presented as part of the discussions on the research methodology flowchart of this study (see Figure 5.5 and section 5.4.1). The conceptual model was subjected to rounds of iteration with some carefully selected members of the society. The outcomes of each interaction were constructed and interpreted with reference to what is known before being subjected to further review by an expert team. This back-and-forth movement confirms the abduction approach of this research. The multiple rounds of interaction, with the

people experiencing the event related to the phenomenon of interest (via expert forum and case study), enhanced the richness and validity of the findings.

The submission of Hyde (2000) about the existence of exceptions to the act of keeping an open mind in induction research through the use of deduction research procedures and Saunders *et al.*'s (2016) submission about the possibility of engaging both deduction and induction procedures in the same research were utilised in this study. A deduction procedure was applied when capabilities for built environment flood resilience was extracted from what was known (existing body of knowledge) and used to develop a conceptual model before engaging relevant respondents in the society. An induction procedure was involved each time responses informed the next action during the rounds of iteration, but the back and forth movement implies abduction approach (Saunders *et al.*, 2016). Figure 5.4 is a representation of research approaches.

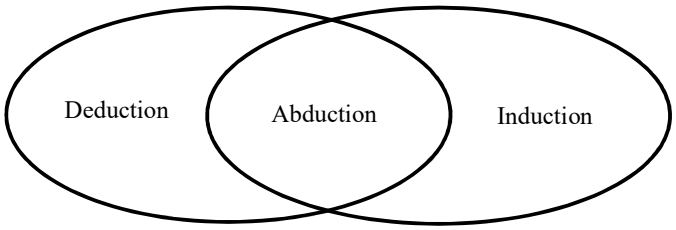

Figure 5.4 Research approaches

5.2.3 Research Strategy

Saunders *et al.* (2016) identified varieties of research strategies available to researchers. Choosing an appropriate strategy is central to the achievement of the objectives of a research. The choice of strategy depends on the objectives of a study as dictated by the research question; it is also influenced by the philosophical position of a researcher (Saunders *et al.*, 2016). Saunders *et al.* (2016) presented seven research strategies; they are an experiment, survey, case study, action research, grounded theory, ethnography and archival research. Similarly, Yin (2003) identified survey, experiment, case study, among others as strategies for research. A variation, combination and modified versions of the strategies mentioned above have been employed in researches. It was pointed out that each research strategy has its pros and cons (Yin, 2003). Case study and expert forum strategy were engaged in this study, the case study and expert forum strategies permit deep inquiry into the phenomenon being researched. Multiple case study of MSMEs were undertaken, and case study interviews were adopted as data collection method. Multiple

case studies enhance the generalisability of a research unlike single case study (Flick, 2014; Yin, 2014).

Based on the mode of execution and the purpose of this study, the study is exploratory, descriptive, and explanatory. It is exploratory because the researcher observed the need for capability enhancement and attempted to understand more about it. Beyond understanding more about it as an initial work for further research (an attribute of exploratory research), the study went ahead to provide descriptions of capabilities for built environment flood resilience. After that, the study provided explanations on capability areas required for enhancing flood resilience of the built environment as well as capability level definitions and also developed a capability maturity model. Thus, this study answered the questions 'what' (What are the capabilities needed?), 'why' (Why is each needed?) and 'how' (How can their maturity be assessed?). Yin (2014) discussed the possibility of using case study research strategy for exploratory, descriptive and explanatory purposes. Exploratory research usually answers the question 'what', descriptive research answers 'what' and 'how' while explanatory research explains how variables relate or influence each other (causal relationships) thereby answering the question 'why'. Further discussions on expert forum review and case study as the research strategy of this study is presented in sections 5.4.2 and 5.4.3 respectively. The sections are part of the discussions on the methodology flowchart of this research (Figure 5.5).

5.2.4 Methodological choices

The layer following the research strategy layer is methodological choices. This research adopted the mono-method qualitative option. The strategies involved included case studies and expert forum review. Several researchers acknowledged the appropriateness of a mono-method qualitative or quantitative research (Denzin, 1989; Saunders *et al.,* 2016; Yin, 2014). They submitted that if the quality checks of ensuring the quality of a research are applied, the limited robustness or bias that are usually mentioned by the proponents of mixed and multi-method will no longer be relevant. The quality tests are validity, reliability and triangulation (Discussed in section 5.6). The advocates of mixed-method choice stated that the use of mixed-method enhances research credibility (Creswell & Clark, 2011). However, the use of triangulation and adequate consideration for research credibility measures i.e. construct validity, internal validity, and reliability will preserve the credibility of a research irrespective of methodological choice (Flick,

2014; Yin, 2014). The qualitative method which is the "mono-method" adopted in this research was chosen in the study to allow a limitless exploration of possibilities towards the achievement of the aim of this study (Aim - Section 1.4; the model Table 7.8). Quantitative researches are characterised by scaling of items and generation of closed answers unlike qualitative researches which permit limitless exploration of possibilities (Creswell & Clarke, 2011). Further discussions on qualitative research as the methodological choice of this study is presented as part of the discussions on the research methodology flowchart (See Figure 5.5 and section 5.4).

5.2.5 Time Horizon

Time horizon describes the magnitude of time available for research (Saunders *et al*., 2016). It refers to the period available for a research and how research activities will be undertaken within a period. The importance of having a defined time frame in a research cannot be overemphasised. Since a doctoral research has a definite time limit, the achievement of the aim of this study has to be based on a capture on the phenomenon i.e. the capabilities for enhancing flood resilience in the built environment within the available time frame. Therefore, this study is a cross-sectional research, it is based on the findings of a phenomenon within a definite time frame (Saunders *et al*., 2016).

5.2.6 Research Techniques and Procedure

Techniques and procedure is the innermost layer of Saunders et *al.* (2016) research onion model. According to Crotty (1998) and Saunders *et al.* (2016), research techniques and procedure refers to the methods adopted for the collection and analysis of data. Researchers depend on two main sources of data i.e. primary and secondary data and both were engaged in this study. The primary sources of data employed in this study are case study interviews, expert forum and direct observation. The secondary sources are documentations (notes, written reports of events, news excerpts, as well as articles in mass media and newspapers), journal articles, textbooks and conference proceedings. Research techniques and procedure refers to the modes of data collection and analysis, a detailed discussion of the data collection, presentation and analysis methods employed in this study is presented in sections 5.4.7 and 5.4.8.

Based on the mode of execution of this research study, the study is qualitative i.e. the attributes, processes and variables in the study are not experimentally measured and data processing were largely based on the objective interpretation of participant submissions

(Denzin and Lincoln, 1998). A flowchart of the overall methodology of this study is presented in Figure 5.5. The discussions in sections 5.4 to 5.6 are detailed explanations of the stages highlighted in the research methodology flowchart (Figure 5.5). Other relevant details are also presented alongside the discussions. Section 5.4 presents discussions on conceptual framework development, expert panel review, case studies, and data collection as well as data analysis methods among others. Sections 5.5 and 5.6 presents the shortcomings of case study research and measures for overcoming research design shortcomings respectively. The outcome of all the processes is presented in chapters 6, 7 and 8.

To aid the interpretation of the flowchart presented in Figure 5.5, a brief commentary is presented hereby. The research process began with literature review and synthesis; this was meant to expand the researchers understanding of MSMEs, built environment, and disaster resilience. Most importantly, the review led to the identification of capabilities for enhancing flood resilience of the built environment of businesses (refer to Table 4.1 for details) and the extraction of maturity level characteristics from existing capability maturity levels. The capabilities were used to develop a conceptual capability maturity model (Appendix K). The processes involved in the development of the conceptual model are presented in the second rectangular box (Figure 5.5), the process includes expert review and scoring of agreement and importance of the capability areas followed by a mapping exercise (see section 5.4.1.1). After completing, the conceptual model (as indicated in the flowchart - Figure 5.5). The conceptual model was sent to a panel of experts (see section 5.4.2, 5.4.7.2 and Chapter 7 for details) this resulted in the production of an intermediate model. The intermediate model was taken to four case studies for further refinement, and this led to the production of a refined model which was later validated via case study (See Chapter 9 for details) and expert evaluation (See Chapter 9 for details). Figure 5.5 is the methodology flowchart of this study.

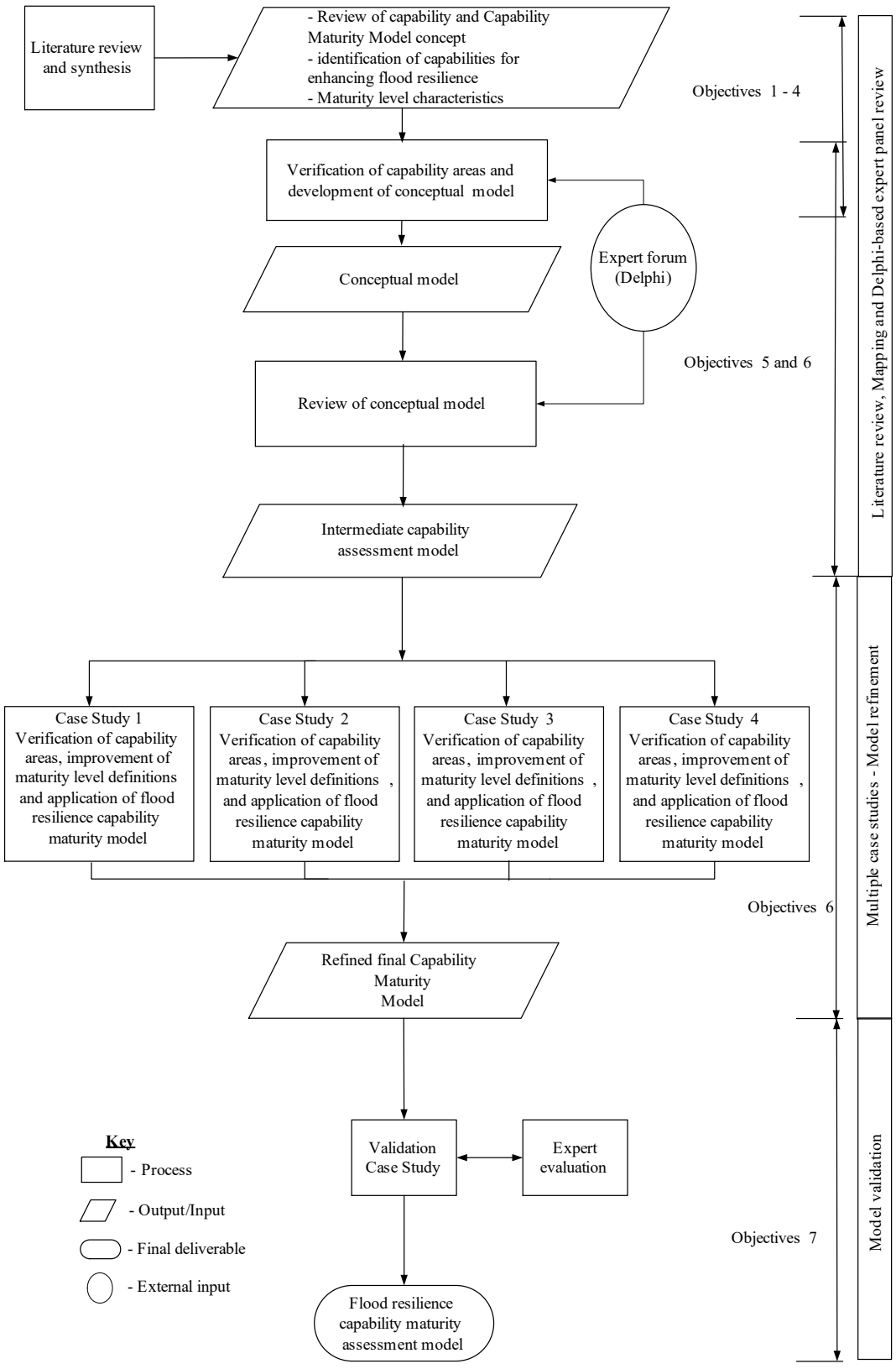

Figure 5.5 Research methodology flowchart

Discussed in the next section (Section 5.3) are the theories that explain the main constructs of this study. One of the theories explained the principle of maturity and the other theory explains the relationship between capabilities and influencers of capabilities. Section 5.3 is succeeded in this chapter by sections 5.4, 5.5, and 5.6. The sections (i.e., 5.4, 5.5, and 5.6), as previously mentioned, contain detailed explanations on the tasks and activities outlined in the research methodology flowchart.

5.3 Theories relevant to this research

Research is expected to be well situated amidst literature and underpinned by established theories (Willing, 2001). Some theories are related to this study, among these theories are Argyris Immaturity-Maturity theory, the theory of reasoned action, and expectancy theory among others. Argyris maturity theory and the theory of reasoned action were selected and discussed as theoretical foundations for this study. Argyris maturity theory was chosen because it clearly supports and emphasises the existence of development on traits, characteristics or attributes along a continuum (Khelashvili, 2014). The theory relates directly to the construct of this study i.e. stepwise growth in flood resilience capability of an organisation as well as the evaluation of the growth towards improvement (refer to section 1.4 – aim of the study). Similarly, the theory of reasoned action, which explains that an individuals' decision to exhibit a particular attitude (positive, negative or neutral) dependent on the outcome expected from displaying a behaviour by the person (Fishbein, 2000). This theory explains the psychology behind improvement plans and the decision of an organisation to embrace the plans.

Capability maturity areas in this study are directions for enhancing flood resilience of the built environment of an organisation. An organisation needs to monitor and improve in these areas, using the maturity level definitions as guides for the improvement (see Table 4.5 to 4.9 and Table 7.8). The decision of an organisation to consider these improvement practices described as maturity level definitions in the capability maturity model is a function of the organisation's attitude, social norm, and perceived own-ability (Fishbein, 2000; Yen-Tsang *et al.,* 2012). Although a factor like financial limitations can determine an individual or organisation's behaviour, the theoretical explanation for such circumstance is discussed further in section 5.3.2.

5.3.1 Argyris immaturity-maturity theory

Argyris Immaturity-Maturity Theory explains the nature of humans and their behaviours; the theory posits that a person's development follows a continuum of immaturity to maturity (Accel-Team, 2013; Khelashvili, 2014; Morden, 2004). On this continuum are traits that can be associated with a matured person, among these traits are independence, self-control, and self-confidence. Similarly, an immature person is dependent, lacks self-control and self-confidence (Accel-Team, 2013). This principle aligns with the concept of maturity modelling developed by Paulk *et al.* (1993).

Argyris theory accentuated the tendency of progression across a continuum of attributes, characteristics, qualities, or traits. Although the theory originally explains peoples' development on personality traits, its relevance in describing the progression in the maturity of an organisation on a list of traits or attributes is evident. This is because personality traits and attributes influence interpersonal and group behaviour as well as organisational norms (Bock *et al.*, 2005; Lewis *et al.*, 2003). For example, the traits of a leader determine the leader's style of leadership, and the leader's style dictates the norm, attributes and attitudes of the organisation (Argyris, 1957; Argyris, 1973). A leader that appreciates disaster resilience is likely to grow his organisation with consideration for disaster resilience capabilities. From the definition of capabilities by UNISDR (2009), capabilities are set of skills, social relationships, facilities, leadership, human knowledge and coping mechanisms among others (see section 4.20 for details), it is clear none of the attributes that define capability can be fully attained at once. Therefore, Argyris theory on the existence of a continuum of maturity to immaturity and the concept of capability maturity modelling by Paulk *et al.,*1993 (see Section 4.6) provides a good theoretical foundation for this study. The theory supports the existence of a continuum of maturity and progressiveness of development, continual growth and monitoring of individuals and organisations on a set of criteria. The Argyris theory has been applied in different areas such as motivation, organisational behaviour, human resource, and organisation learning (Banner & Blasingame, 1988; Bhatia, 1985; Hersey & Blanchard, 1993).

5.3.2 The theory of reasoned action (TRA)

Theory of reasoned action explains the philosophy behind what propels the action of an organisation or an individual (Yen-Tsang, 2012). The theory submitted that human actions are propelled by planned behaviour and outcome-related intentions (Fishbein & Ajzen, 1975; Fishbein & Ajzen, 1977). TRA explains the possibility of predicting a

behaviour via attitude towards the behaviour through an individual's intention (Fishbein & Ajzen 1975; Fishbein & Ajzen 1977). Theory of reasoned action developed in 1967 by Martin Fishbein and Icek Ajzen is described as a model of persuasion as well as a behavioural theory (Fishbein & Ajzen, 1975; Hale *et al.*, 2002). The theory focuses on attitudes and norm (Figure 5.6) as they influence behaviours, this theory simply explains an individual's plan to behave in a certain way under certain situations (Fishbein, 2000). For an organisation to achieve its goals, related activities and associated tasks must be purposefully executed by all relevant stakeholders (Yen-Tsang, 2012).

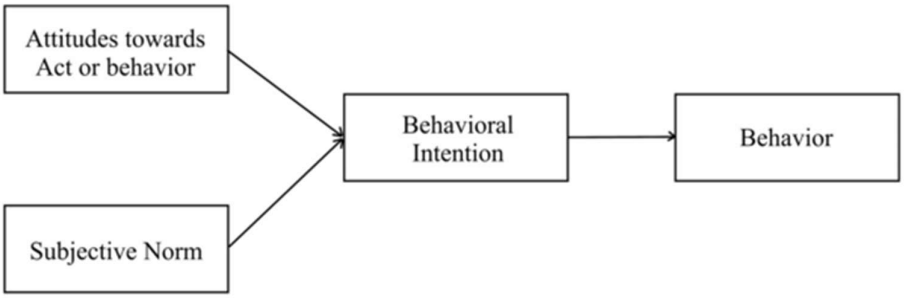

Figure 5.6 Theory of Reasoned Action (Fishbein & Ajzen, 1975)

Fishbein (2000) presented an integrative model that included "self-efficacy" alongside attitude and subjective norm as influences on behaviour. Both the original and integrative models simply posited that the decision to behave in a way (behaviour) is affected by the desired outcome of the decision (this determines either positive, negative, or neutral attitude), submissions of the people around (norm) and perceived self-ability or efficiency (Fishbein, 2000; Fishbein and Ajzen, 1975).

This theory is relevant to this study in some ways, firstly, the maturity status of an organisation is a result of the influence of attitude, norm and perceived ability or efficacy of the organisation and probably, resource availability. Secondly, the decision of an organisation to/not to (attitude) enhance its maturity is largely dependent on the outcome perceived, or the result desired from doing so and the norm (subjective norm or normative belief) that define policies within the organisation. Thirdly, the capabilities of an organisation are influenced by attitude, norms and self-efficacy – Figure 5.7 (Yen-Tsang *et al.,* 2012).

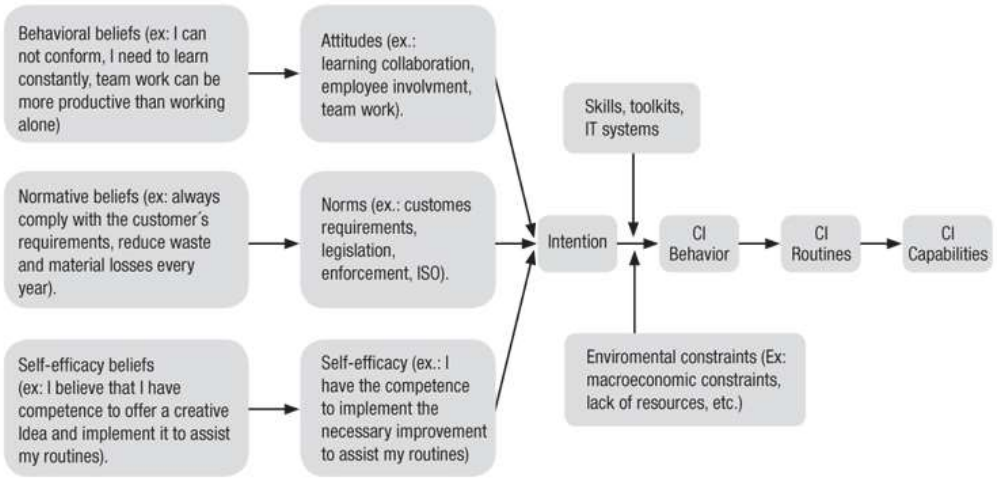

Figure 5.7 Influences on continuous improvement capabilities (Yen-Tsang *et al.,* 2012)

Interestingly, the proper understanding of the influences on an individual's or an organisation's behaviour could help in shaping their behaviours in the proper way (Lewis *et al.,* 2003). Truly, since attitude, norm, perceived self-efficacy affects behaviour and behaviours are simply our actions, the maturity level of an organisation will be affected by attitude, norm and self-efficacy. It is possible to state that lack of understanding naturally is another influence on behaviour and capability maturity, yes, it is, but it should be noted that understanding is a product of behavioural belief (Figure 5.7) and behavioural belief influences attitude, attitude is part of the constructs of the theory of reasoned action.

Further, beyond attitude, norm, and perceived self-efficacy, the volume of available resources for enhancing capabilities can affect an organisation's flood resilience capability maturity. As indicated by Yen-Tsang *et al.,* (2012), lack of resources is an environmental factor that affects behaviour and capability (Figure 5.7). In that regard, Argyris Immaturity-Maturity theory which explains the existence of a continuum on attributes explains the relationship between capability improvement and lack of resources in business organisations. Organisations with limited resources are simply at the immature state regarding resource availability; such organisations need the support of stakeholders and personal improvement to attain a higher maturity on the continuum. On the other hand, the maturity of business organisations that are not limited by their level of resources can be suitably explained using the theory of reasoned action. For instance, Dlugolecki (2004); Yoshida and Deyle (2005) and Woodman (2008) reported that majority of MSMEs are not equally prepared for disasters. Obviously, some businesses

are unprepared because of their attitude, norm and perceived ability while some are unequally prepared because of financial limitations. Summarily, the two theories discussed in Section 5.3.1 and 5.3.2 provide an adequate theoretical foundation for this study.

5.4 Qualitative research

This study is a qualitative research. The word qualitative refers to the attributes of entities, processes, and meanings that are not experimentally measured (Denzin & Lincoln, 2008). The word 'measured' in their description of qualitative refers to the examination of the intensity, amount, quantity, and frequency. Qualitative researches are usually associated with social constructivism perspective of reality. Qualitative research is interpretive and naturalistic; qualitative researchers interpret a phenomenon of interest based on the account of the persons experiencing it (Denzin and Lincoln, 1998). As a result, objective interpretation of participant submissions by the researcher as well as other means of encouraging the validity of findings and contribution of the study (e.g. triangulation) are important. This research is a qualitative study. As described earlier and presented in Figure 5.3 (Saunders *et al.* research design model) and Figure 5.5 (Research methodology flowchart), this study employed case study (see Section 5.4.3) and expert forum review (see section 5.4.2) as the strategy for achieving the objectives of this qualitative research. A discussion regarding other relevant methodological choices in Saunders *et al* (2016) research onion model is presented in section 5.2.4.

5.4.1 Conceptual model of the study

A conceptual model graphically describes the construct and variables as well as the relationship between them in a proposed research (Miles & Huberman, 1994). It was stated that a conceptual framework or a model could be rudimentary, elaborative or common-sensical, theory-driven, literature-driven, descriptive or even casual. An initial conceptual framework has been developed for this study; this will be updated as the research progresses. Yin (2003) stated that conceptual frameworks are essentially for researchers to represent or portray the primary ideas identifying with their study the interrelationship between the ideas and the circumstances inside which the interrelationships can be said to be valid inside of the phenomenon being studied. This is also true about models. Miles and Huberman (1994) further argued that the development of a conceptual structure is iterative; it is sure to be re-examined and updated. Conceptual structures control the reasoning of a researcher and researchers can conceptualise the

same phenomenon for examination differently. It was said in an earlier section of this thesis (Section 1.4) that the aim of this study is to develop a disaster resilience capability assessment model that identifies built environment flood resilience capabilities of MSMEs. To achieve the aim of this study, a conceptual model was developed by mapping (Section 5.4.1.1) the maturity level characteristics of the capability maturity model (Table 4.5 to 4.9) with the capability areas identified from the literature and verified by selected experts (Table 4.1and Table 6.4). The resulting conceptual flood resilience capability maturity model is presented in Appendix K. Several other methodical steps were taken to develop further the model towards achieving the aim of this study.

5.4.1.1 Mapping exercise

Capability maturity model levels are characterised by a progressive measure of sophistication or the extent to which practice, process or capability is defined, controlled or institutionalised (Macgillivray *et al.,* 2007). 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 previous researchers (Babatunde, Perera, & Zhou, 2016; Macgillivray *et al.*, 2007). The mapping process involves the alignment of capability maturity level characteristics of an existing maturity model to form capability maturity level characteristics in a new area is referred to as a mapping exercise. The mapping exercise is a tedious activity (Macgillivray *et al.,* 2007; Sarshar *et al.* (2000) but it has been successfully adopted in previous studies (Babatunde *et al.,* 2016; Macgillivray *et al.,* 2007). The mapping exercise was used to produce the conceptual capability maturity model in this study (See Appendix K).

Upon the completion of the development of the conceptual model (Appendix K) via the mapping exercise, the conceptual model was reviewed and improved by an expert review panel that verified the flood resilience capability areas identified from the literature. A description of the panel of experts is presented in the next section (Section 5.4.2), and the report of the outcome of the expert review of the conceptual model is presented in section 7.4. The production of a conceptual model aligns with the principles of abduction research identified by Saunders *et al.* (2016) and discussed in Section 5.2.2 (i.e. Research approach).

5.4.2 Expert panel review (modified Delphi-based approach)

The acquisition of knowledge from experts take different forms, among these forms are Delphi technique, focus group, expert and elite interviews, expert panel review and interview, nominal group technique (Eadie, 2009; Flick, 2014; Gallagher *et al.*, 1993; Potter *et al.*, 2004). Babatunde *et al.* (2016) and Eadie (2009) among other researchers have previously applied the expert panel review technique successfully. The expert panel review technique allows the acquisition of deep knowledge from a team of experts when well managed. The expert panel review technique followed a modified Delphi approach in this study followed. Traditionally, in Delphi studies questions are put forward to a panel of experts, and their responses are analysed (Powell, 2003) but in this study, questionnaire was only used in an aspect of the expert review process.

The modifications to the conventional Delphi process deployed in the expert review exercise includes (i.) the provision of more details on each capability area in the conceptual model in succeeding expert reviews after the first round, this aided the interpretation and verification of the capability areas and (ii.) the use of a well-controlled qualitative feedback for the expert panel review. Other authors also modify the traditional Delphi procedure and other consensus methods (Boulkedid *et al.*, 2011; Van de Ven & Delbecq, 1972).

Adnan and Morledge (2003) and Dalkey (1967) identified anonymity of response, iterated controlled feedback and statistical response and analysis as usual features of Delphi method. In this study, the first two features were completely maintained but statistical response and analysis was used for only one of the rounds in the iteration. The other round in the iteration was based on a well-controlled qualitative feedback from the expert panel and consensus was ascertained when comments were adjudged to be adequately addressed and no further comments were received. The experts engaged in this study were selected based on specific criteria (see Section 5.4.7.2.2) as expected of a Delphi approach. Further review and refinement of the conceptual model was done in multiple case studies.

The expert panel review exercise in this study consists of two main rounds. The first round was a review and evaluation of the appropriateness of capability areas identified from the literature. The panel members were asked to review and indicate their level of agreement with the capability areas as well as the importance of each capability area. A questionnaire

was used to acquire knowledge from the panel during the first round and the analysis of their responses was statistically carried out. The first round of the expert panel review involved the scoring of identified capabilities on a Likert scale by a team of carefully selected experts. The round was meant to assess the general understanding and acceptability of the capability areas. The second iteration in the Delphi process was a qualitative review, which was more rigorous and can therefore be regarded as the main round of review for capability verification.

The second round, as mentioned earlier, was a qualitative review supported by verbal and email interactions and clarifications; the round involved a review of the capability areas alongside the conceptual maturity model. Figure 5.11 presents the graphical illustration of the expert review process while the analysis and results of the first and second round are presented in Chapter 6 and Chapter 7 respectively.

The details of the composition and size of the expert panel are presented in section 5.4.7.2 (i.e. under data collection methods). As earlier mentioned, the Delphi process was modified for use in the expert panel review exercise in this study. The expert panel review was followed by multiple case study activities (See sections 5.4.3 and 7.6); this helped in further refining the intermediate capability maturity model (See Figure 5.5 for the flowchart of the methodology).

5.4.3 Case study research

Case study research design involves a relatively detailed focused evaluation, analysis and reporting of a phenomenon (Flick, 2014; Yin, 2014). There are various methods of data collection in cases study researches but case study researches largely rely on subjective data, usually collated from the account and judgement of participants that experienced the activities (Yin, 2014). These accounts and judgements are usually subjective since they are products of description and interpretation, opinion and feelings. In order to enhance the objectivity of the results of case studies, replicative, falsification and triangulating methods are utilised (Denzin & Lincoln, 2008). It is recommended that researchers should tease out experiential knowledge from respondents' opinion and preferences (Stake, 2004). Relevant discussions of case study as a research strategy among other research strategies identified in Saunders *et al* (2016) research onion model is presented in section 5.2.3.

5.4.4 Rationale for selecting case study design

As Gummesson (1991) stated one of the main reasons for adopting case study design is the opportunity it gives for understanding complex phenomena. It allows the discovery of several factors and the complex relationship between them; other research designs do not permit this. Each of the case study types has rationales for selection. The available types of case studies and the factors required for selecting an option are discussed in the next section (Section 5.4.5).

5.4.5 Types of case study research design

Yin (2014) stated that case studies could be either single or multiple cases. The choice of case study form depends on the nature of a research work. Four basic types of case study design stem out of two main types i.e. Single and multiple case study (Figure 5.8). The four types are single case design with a holistic(single) unit of analysis, single case design with multiple units of analysis, multiple-case designs with a holistic unit of analysis, and multiple case designs with multiple units of analysis (Yin, 2014). For instance, the single case study design is appropriate when the case is considered critical (e.g. for testing a well-formulated theory), revelatory, common, unusual, or revelatory. Multiple case study refers to the use of more than one case study in the same research (Saunders *et al.*, 2016; Yin, 2014).

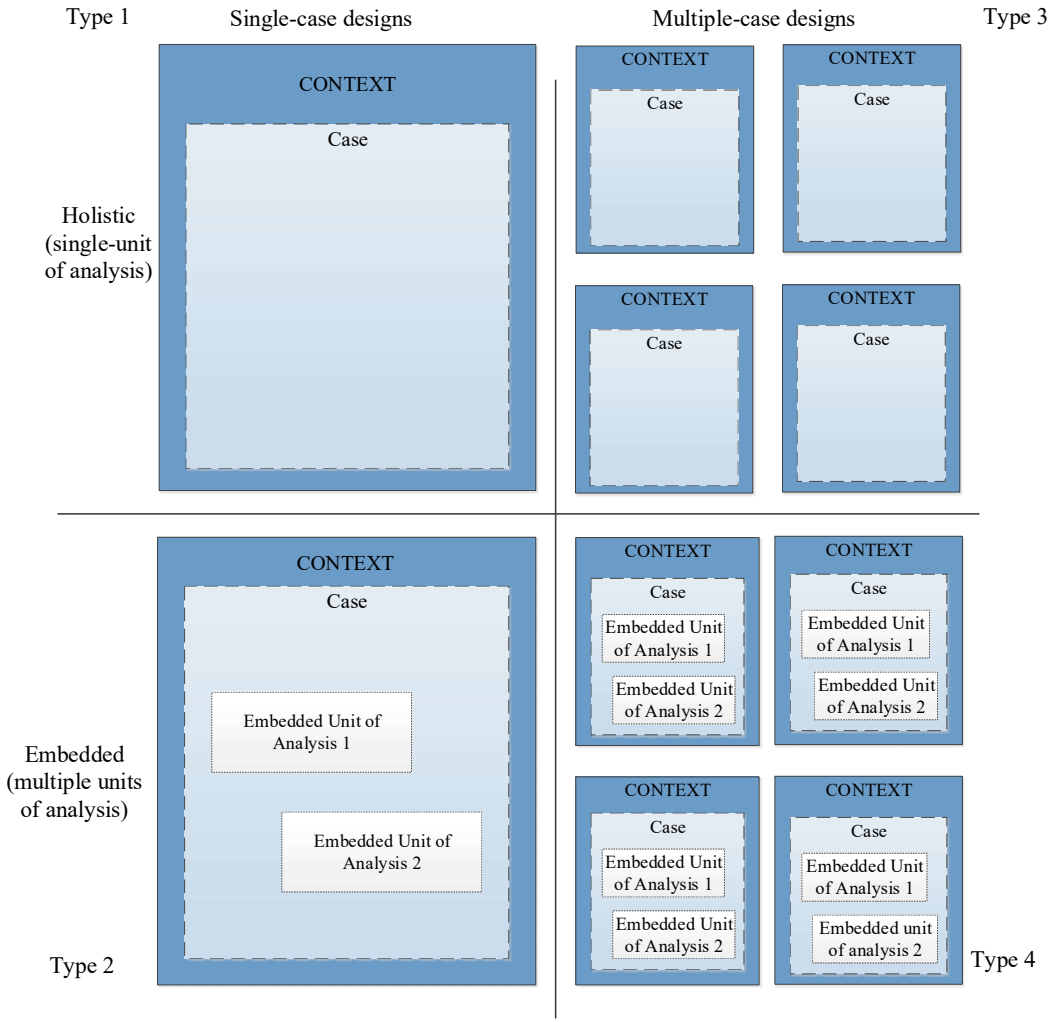

Figure 5.8Basic types of designs for case studies (Yin, 2014, page 50)

The cases to be engaged in a multiple-case design is expected to fulfil the criteria set for case selection in the study; the cases can also satisfy some of the rationales for doing a single case study. Multiple case studies were used in this study, this type of case study requires more time and resources to conduct. The rationale for the choice of multiple case study is a decision to replicate the findings from a previous case with another case. Replication is to confirm whether the same or contrasting findings will be found from different case studies i.e. literal or theoretical replication respectively (Yin, 2014). The choice of multiple case study is not the same as the use of multiple respondents as obtainable in survey research (Yin, 2014).

The selection of a single business as a case in this research cannot be considered sufficient. This is because the operation structure and business line of organisations differ

and these attributes dictate the structure of their business premises, the level of consistency or disparity in approach and view, all these attributes influence disaster resilience decisions and actions. Because of this, multiple case studies were employed to achieve a case verification of capability areas, review premises recovery experiences, test the developed capability evaluation tool and improve the tool using findings from the case studies. Multiple case studies obviously guarantee inferences that are more reliable and as well reduce misinterpretation (Barkley, 2006; Yin, 2014).

Yin (2014) recommended the use of two or more case studies in multiple-case designs; it 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. Four business organisations selected based on the selection criteria set for the study (see section 5.4.6) were engaged in this study. Since multiple case study findings are more robust and compelling, the results was adequate for the development of a final capability maturity model. Case studies rely on analytical generalisation unlike survey and experiments that depend on statistical generalisation; as a result, the replication logic was followed. The replication approach/logic for multiple case studies as applied in this study is presented in Figure 5.9.

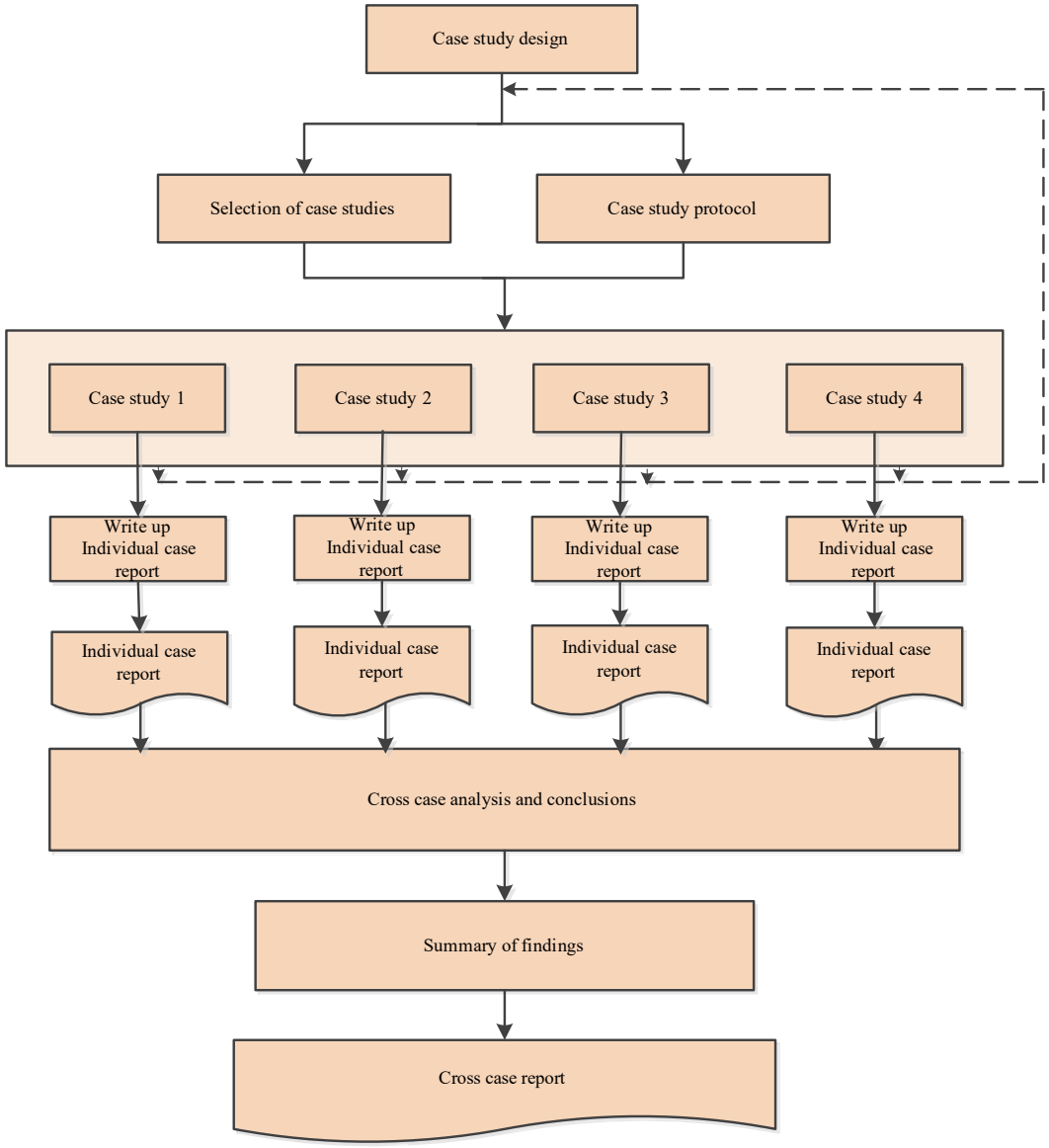

Figure 5.9 Procedure for multiple case studies (Adapted from Yin, 2014, p. 60)

The purpose of the case study aspect of this research was achieved via the approach presented in Figure 5.9. The findings from respective cases were reported vis-à-vis the specific activities scheduled to be undertaken in each case study. The activities are verification of capability areas, review of premises recovery experiences, application of the developed capability evaluation tool and submissions concerning steps to improve the tool. Inferences were drawn from each, and a cross case report was produced. Findings and inferences from the case study aspect of this research were used in developing the refined capability maturity model, and this model was thereafter validated.

5.4.6 Criteria for case selection

Amaratunga and Baldry (2001) stated that discretion and judgement could not be totally excluded from the selection of case samples. Creswell (2013) underpinned the submission when it argued that researchers select cases purposively. The author opines that a large number of cases are not necessary for the selection of case samples for a study. Cases are selected based on some criteria; these criteria are then viewed and applied to the context of a specific study (Creswell, 2013). 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. Therefore, this study selected four MSMEs based on some rationale. The rationale for choosing these businesses is that; they belong to specific classes of England's property use class order, and they have experienced flooding before. In addition, the organisations must have experienced flooding that led to the stoppage of business for a moment. However, it is acknowledged that the magnitude of the impact of flood on organisations differ; some businesses will experience significant stoppage while some will experience minor stoppage in operation because of flooding. Another consideration for selecting the cases is the readiness of the organisations to participate in the study. The main criteria for selecting the case studies are presented in items 1 to 3 as follows:

1) The organisation must belong to any of the England property use class orders listed from 'a' to 'e' below. The use class order is a framework that specifies the categories of use of properties and lands (National Archives, 2016). Some classes that can be managed are selected for use in this study; the selected classes also satisfy the remaining criteria (criteria two and three below) for case selection in this study.
    a. Class A1 - '*Shops, retail warehouses, hairdressers, undertakers, travel and ticket agencies, post offices, pet shops, sandwich bars, showrooms, domestic hire shops, dry cleaners, funeral directors and internet cafes'* (Planning Portal, 2016).
    b. Class A3 – Restaurants and cafés i.e. restaurants, snack bars and cafes (food and drink consumption on the premises) (Planning Portal, 2016).

c. Class A4 – Drinking establishments i.e. wine bars and others, except nightclubs (Planning Portal, 2016).
d. Class A5 – Hot food takeaways (consumption off premises).
e. Class C1 – Hotels, boarding and guest houses *"(where no significant element of care is provided (excludes hostels)"* (Planning Portal, 2016).

This criterion is important because it is necessary to have a guide on the type of property, the possible structure of the business occupying the property, as well as other considerations like the probable mode of interaction of the business with the community, government agencies and other stakeholders while developing the maturity model. The type of establishments in the categories above is often Micro, Small and or medium-sized enterprise.

2) The organisation must be a Micro, Small and or Medium sized enterprise (MSME)

It is important to define the size of the organisation in order to have an idea of the structure of the organisation, what to consider during expert review and case studies as well as what to include in the model. Selecting micro, small and medium-sized organisation as a target for a capability enhancement study like this research is also appropriate because of the significant contribution of this category of businesses to the economy.

3) Preferably, it must have suffered flood attack before.

This criterion is important because an organisation that has suffered and recovered flood attack was expected to have a more appreciable understanding of flooding and capabilities for resisting, absorbing and recovering from flooding.

Based on the criteria mentioned above, four case study organisations were selected and engaged 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. Presented in Figure 5.10 is an illustration of available units of analysis. The figure is divided into four main compartments (coloured boxes) with each serving as a summary point in the matrix. The figure describes the design options available (i.e. about an individual or an organisation), the possible study conclusions (if the case is an individual or an organisation). Figure 5.10 also stated the probable source of data (i.e. from individuals or an organisation). The description in the boxes refers to the type of

questions that might be included in a case study protocol; the guides were decided based on design, expected study conclusions, and data collection source. The box shaded brown was used as a guide for drafting the questions included in the case study protocol for this study i.e. questions were drafted for interviews to be conducted with individuals about their organisations, the cases are the organisations.

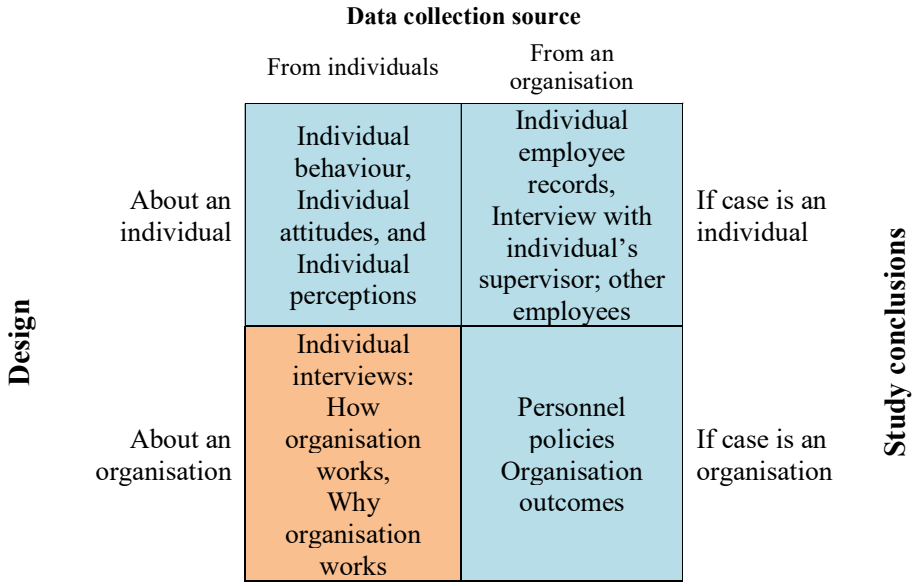

Figure 5.10 Units of analysis in case studies (Yin 2014, pg. 92)

5.4.7 Data collection method

As earlier described in section 5.4, this study is a qualitative study and qualitative methods of data collection was used, although questionnaire was used to elicit knowledge from a team of experts in an aspect of the study. Among the data collection methods available to qualitative researches are documentation review, the use of archival records, interviews (e.g. open, semi-structured, structured, expert or elite interviews), direct observations, participant observation and physical artefacts (Flick, 2014; Yin, 2014). This study collected evidence and data from documentation, expert forum review, and case study interviews (see section 5.4.7.1 to 5.4.7.3). Data collection and presentation methods occupy the innermost layer of the Saunders et *al.* (2016) research onion model. It is referred to as techniques and procedures in the model (Figure 5.3 and section 5.2.6).

5.4.7.1 Documentations

Yin (2014) submitted that documentary information is often used in case study researches. Documentations are usually in various forms such as letters, memoranda, diaries, notes, agendas, written reports of events, administrative documents, progress reports, internal records, related research reports, news clippings, articles in mass media, newspaper articles among others (Yin, 2014). 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 were 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. Another data collection approach is discussed in the next section (Section 5.4.7.2).

5.4.7.2 Expert forum review (modified Delphi-based)

The literature review conducted led to the identification of capabilities and process areas for achieving built environment resilience. Since the capability areas were from a variety of studies on property and organisation resilience, a verification exercise was carried out to confirm their validity for achieving flood resilience of the built environment of businesses. This ensured that the capability areas identified are applicable to flood resilience in the built environment. Towards achieving a successful verification, a forum of experts was constituted. The forum consisted of built environment and disaster resilience practitioners, business owner, academics, and researchers (Table 6.1). The expert review process was based on modified Delphi approach.

The expert review process can be used to achieve a variety of objectives. It allows the collation of ideas towards decision-making. It was adopted in this study to confirm the applicability and suitability of the capability areas for achieving flood resilience and to refine and improve the conceptual model. As discovered in the literature review, capabilities for built environment resilience have not been expressly outlined. This necessitated the verification of capability areas.

The specific goals of the expert review process were to:

i. verify the identified capability areas,
ii. identify any further capability area and
iii. refine the conceptual capability maturity level definitions (See Appendix K).

A detailed discussion on the expert review process is presented below (See Figure 5.11 for the flowchart of the expert review process).

5.4.7.2.1 Formation of the expert review process monitoring team

The author as part of this research undertook the monitoring of the expert review process. The capability areas to be verified have already been extracted from literature, and this was later followed by the refinement of the capability level definitions. The experts were asked to rate their agreement with each of the identified capability areas on a scale of one to five, with five being the highest, based on their suitability for enhancing built environment flood resilience.

5.4.7.2.2 Selection of panel members

The panel members are experts in disaster resilience; they also have direct knowledge of flood resilience and the built environment. This was expected to enable the panel members to furnish high-confidence information and as well add their extensive day-to-day experience. The choice was made of experts who have knowledge of the built environment, have experienced flooding, worked on the recovery of communities that have experienced flooding, disaster and flood-related policymaking or has flood protection or flood damage response experience and expertise in the built environment. Consideration was also given to the possession of an idea of general flood risk management strategies. CIRIA (2010) divided flood risk management into three phases; the phases are source control, pathway modification and receptor resilience (properties and people). The panel was also briefed on the significance of structural and non-structural areas of investment in flood risk management and how this relates to built environment resilience. The briefing was to ensure that panel members have an adequate information about what is expected from them.

The constituted panel represented property owners, businesses, and everyone concerned with the well-being of a property and business. To enhance the depth of representation, public and private sector experts were intentionally included. As earlier mentioned, expert forum review was undertaking after extracting detailed information from literature and

structuring the information into a questionnaire made up of a list of capability areas. After that a conceptual model developed from the capability areas was given to the experts to review. Some existing building programmes, resource codes and standards were consulted alongside other literature.

A 10-member expert forum team were involved in capability area verification, and six experts were engaged in the conceptual capability maturity model review. The sizes of the expert review panels align with the proof provided by Boje and Murnighan (1982), the study observed no effect of group sizes on decision-making techniques when it engaged groups made up of 3, 7, and 11 members. Also, Adler and Ziglio (1996) submitted that the composition and quality of a panel matter more than the size especially when the heterogeneity of the panel is not prominent. Similarly, Powell (2002) acknowledged the variation in the number of participants in panel based research techniques, but submitted based on the comment of Murphy *et al.* (1998) that there is scant evidence of panel size on the credibility of outcomes and that an expert panel is not expected to be statistically representative but rather be made up of experts with appropriate qualities. Panel sizes ranging from 5 – 10 has also been engaged by previous researchers (Babatunde *et al.,* 2016; Eadie, 2009)

The panel involved in this study was selected by making sure that all conceptual and specific areas relevant to the context of the study were identified and the ability and expertise of each respondent were determined. Table 5.2 shows the criteria used to ensure that the panel consists of all necessary areas of expertise. Alongside the listed attributes, it was ensured that:

- All members of the panel are conversant with flooding and flood damage to premises/built environment either as a professional, flood victims, or researchers
- All are actively contributing to issues relating to flood and the built environment through their areas of expertise to date,
- All academics/researchers engaged have carried out extensive research in the area of flooding, communities, household and business recovery.

Although eighteen experts were initially spotted to have satisfied the selection criteria, 10 of them were available and engaged in the first round of review and six were available

for the second iteration (discussion on the adequacy of panel members have been presented in section 5.4.2). Table 5.2 is the summary of the criteria for panel section.

Table 5.2 Selection Criteria – Participants must belong to any of the identified categories (Adapted from Eadie, 2009)

SN	Attributes necessary	Remark	Code names of the specific people	Achieved with panel that was chosen
1	Business owner/Potential user of research output	Represented	LJ	1 of 10 adequate (more businesses will be engaged in case studies)
2	Business Recovery/Continuity Managers	Represented	LT, JR, KC	2 of 10 adequate
3	Built environment professionals	Represented	JR, EM, TS, RC	4 of 10 adequate
4	Academic/Researcher	Represented	EM, TS, PS	3 of 10 adequate
5	Insurance Professional/Risk Managers/Loss Adjuster	Represented	KH, TR	2 of 10 adequate
6	Engineers/Civil Engineers	Represented	LT, JR	2 of 10 adequate
7	Public and private sector representatives	Represented	All	10 of 10 adequate
8	Willing to take part in the Delphi process	100% of panel	All	10 of 10 adequate

5.4.7.2.3 **The expert review process**

The selected panellists were contacted, and they indicated their readiness to participate in the study. It is important to state that the responsibilities of the experts were two, firstly, they were expected to do a verification by reviewing and rating the capability areas extracted from the literature and possibly add more. Secondly, they were expected to verify the capability areas during another round further and at the same time refine the capability maturity model that was developed using the capability areas.

The first task was achieved using a 5-point Likert scale questionnaire administered to the selected and consented experts alone. The questionnaire was used as a method of knowledge extraction from the team of experts due to its suitability for numerically evaluating adequacy and consensus (Hsu & Sandford, 2007). A tightly aligned, structured instrument was recommended when confirmatory evaluations are desired (Harris & Brown, 2010). The questionnaire can be combined with an interview or other qualitative methods for confirming adequacy and accuracy of results (Harris & Brown, 2010). Questionnaires have the advantage of showing patterns while the qualitative interviews and reviews provide the opportunity of receiving in-depth insights on a phenomenon of interest (Kendall, 2008).

The appropriateness of the capability areas was to be established before they were used to develop the capability maturity model. Although it is possible to use a scale of 7 or 10, the use of a 5-point Likert scale is very popular in literature and affirmed as suitable. Revilla *et al.* (2014) argued that 7 – 11 answer categories on Likert scale yield data of lower quality compared to a 5-answer category scale. Midpoint marks are usually regarded as an acceptable mark, therefore in this research, 2.5 was set as the cut-off point. That is, only capability areas whose mean score is 2.5 or above was considered for conceptual model development and reviewed in subsequent expert panel review rounds (no capability scored below 2.5 eventually – See chapter 6).

The decision on the applicability of the capability areas during the scoring verification exercises was based on the level of agreement and importance attached to the capability areas by the expert team. Upon the completion of the scoring exercise, the capability areas were used to develop the capability maturity model. The expert panel then refined the capability areas and the model. Presented in Figure 5.11 is the flowchart of the Modified-Delphi based expert review process undertaken for the refinement of the capability areas and the conceptual capability maturity model. The first process of verifying the capability areas extracted from literature was based on a scoring system. Questionnaire containing the identified capability areas was used as a method of acquiring knowledge from the expert forum (this is discussed earlier – Chapter 6).

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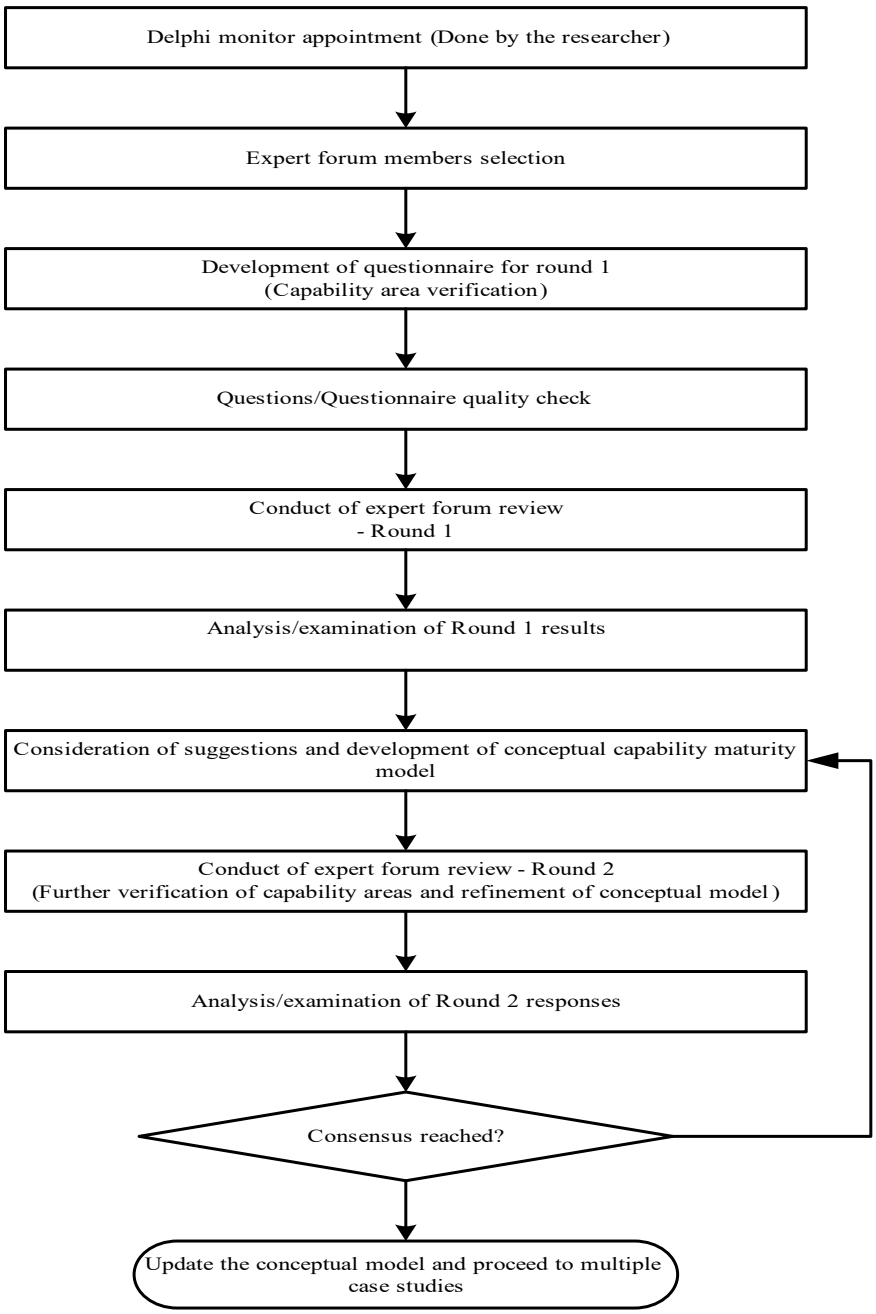

Figure 5.11 Graphical illustration of the expert review process (Delphi)

As indicated in Figure 5.11, upon the completion of the expert review process, the research process continued with case studies. The data collection method used in the case studies is discussed in the next section – case study interviews.

5.4.7.3 Case Study Interviews

Case study research strategy was adopted in this study (See 5.4.3 to 5.4.6 for details). Four case study business organisations were engaged (Section 7.6.2). The case study organisations satisfied all the case study selection criteria discussed in section 5.4.6; semi

structured interviews were conducted with stakeholders in the case organisations. A semi-structured interview does not limit the depth of probe of an interviewer but rather prevents the interviewee from roving or digressing excessively (Flick, 2014). The case study interviews conducted in this study is more of a review exercise because the case studies were meant to help in verifying the flood resilience capabilities earlier processed by experts in this study and refine the intermediate model developed. Although, further details were collected. An interview protocol was prepared for the case study interviews conducted. Adequate care was taken to prevent the interview protocol from limiting the depth of discussion, and repetition of already answered questions.

A continual review of the relevance of the questions being asked and the interviewees' responses in relation to the purpose of the interview was undertaken during the interview. This was to ensure a relevant course for the interview. Despite the use of a case study interview protocol for the interview (refer to Appendix L), the guide was not followed bureaucratically; this was done to allow the acquisition of adequate, relevant new information. A total of 12 interviews were conducted in the four case study organisations engaged (see section 7.6 to 7.10 for details). Respondents were asked to describe the flood attack and the recovery experience of their organisation and its premises. They were also asked to bear their minds on the appropriateness of the already identified capability areas for enhancing the flood resilience of the built environment of their premises. They were also engaged in refining the developed capability maturity model (Table 7.3, see the full version in Appendix L). The case study organisations were after that assessed using the capability maturity model developed with their inputs (Table 7.9).

5.4.8 Data presentation and analysis methods

The questions that a study intends to answer determines the research design that will be adopted by the study. The research design influences the type of data that will be collected in a study (Yin, 2014). The data presentation and analysis methods used in this study are discussed in section 5.4.8.1 to 5.4.8.5.

5.4.8.1 Mean score

Mean score was used to evaluate the level of agreement of the expert panel members and the importance attached to the capability areas identified to be required for enhancing the flood resilience of the built environment (Table 6.2 and Table 6.4). The capability areas were rated on an ordinal scale which allows for rank order. However, rank ordering of

capabilities was not the intention of this aspect of the study but the determination of acceptability and importance of capabilities based on the scores assigned by the experts. The rating of capabilities done by the experts was used to calculate mean scores from which a cut-off point was set and capabilities below the cut-off point were meant to be eliminated. This stage was an initial iteration that provided an understanding and acceptability of the capabilities prior to subsequent rounds of iteration. Hsu and Stanford (2007) submitted that data analysis in a Delphi or an expert opinion study can be qualitative or quantitative. The main statistics used in such studies are mean, median and mode; while standard deviation and range are used when a measure of dispersion from a central value is required (Hasson *et al.*, 2000; Saunders *et al.*, 2016). Dalkey (2002) and Brown and Helmer (1964) opined that the true result lies within a sample; therefore, the median value can be taken as a representative of the opinion of a group. This submission was corroborated by the observation of Hsu and Stanford (2007) when it stated that median and mode are often used.

Jacobs (1996) also opined that the use of median is beneficial as it tends to give a convergent opinion while dealing with a skewed response set, such as the type sometimes obtained in ordinal scale measurements. Saunders *et al.* (2016) also mentioned the tendency of the mean being influenced by extreme data set, but suggested the elimination of such values from the data set when necessary. Ludwig (1994) argued that both mean and median could be misleading when responses are divergent (i.e. clustered) towards specific points rather than a point. The submissions of Jacob (1996), Ludwig (1994) and Saunders *et al.* (2016) are logical, but Dalkey (1969) and Oh (1974) emphasized the importance of iteration towards achieving convergence in an opinion-based research. That way, irrespective of the method of analysis adopted, convergence of group opinion can be achieved by effectively conducting rounds of iteration. It is evident that both mean and median have their respective limitations. Interestingly, Eadie (2009) decided to use both mean and median values to assess the rating of a list of factors by experts in rounds of iteration. The study found no notable difference in the results obtained via the two measures and thus concluded that the use of mean is reasonable. In another study, Murray and Jarman (1987) utilised a 5-point Likert scale questionnaire for an expert opinion study and adopted mean as the method of analysis.

In this study, mean was adopted and used to measure the acceptability of the capability areas and the agreement of the experts with the capability areas (Table 4.1, Table 6.2 and

Table 6.4) in round one of the Delphi-based expert review process, while the second round was a qualitative review. The use of qualitative review in the second round of iteration provided an opportunity for a thorough analysis of capabilities rather than a conclusion totally based on mean or median.

The data collected from the expert ratings were also used to calculate Kendall's coefficient of concordance and correlation. The Likert scale has been used by previous researchers for establishing an agreement or otherwise and computing mean score (Field, 2005). Mean score (MS) is often computed by using the following formula:

$$MS = \frac{\sum (f \times s)}{N}, \quad (1 \leq MS \leq 5) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where s = score given to each factor or attribute by the respondents, the score ranges from 1 to 5 (1 = least rating and 5 = highest of rating);

f = frequency of each rating (1-5) for each attribute; and

N = total number of responses.

The mean was also used to compute the group score for each of the evaluation criteria rated by the model validation expert forum (Section 8.4.4), the median was also applied for the same purpose just to confirm the outcome generated from the mean. The median is the middle data in a data set after ordering in an ascending or descending order (Saunders *et al.*, 2016).

5.4.8.2 Kendal coefficient of concordance

Kendall's coefficient of concordance (W) is a statistical tool that is used for measuring the degree of agreement between respondents on an ordered list of factors or entities by mean scores (Field, 2005). It measures the variability of the ranks of entities to the maximum possible variability (Field, 2005). Xia *et al.* (2009) employed Kendall's coefficient of concordance to measure the degree of agreement between the members of a panel constituted to rate a list of competencies. Interpretation and decisions in Kendall's analysis is based on concordance coefficient value and level of statistical significance at a chosen confidence level (Field, 2005; Xia *et al.*, 2009). Kendall coefficient of concordance is a suitable tool for evaluating intragroup homogeneity (Baumgartner *et al.*, 1999). Kendall coefficient of concordance was used in this study to assess the degree of

agreement between the expert panel members on two ratings i.e. Agreement with the relevance of the capability areas and the importance of the capability areas to the enhancement of built environment flood resilience. The details of other expert forum activities are presented in section 5.4.2 and 5.4.7.2. It was necessary to evaluate the concordance of the experts in respect of the adequacy of the capabilities for built environment resilience to avoid the use of irrelevant entities in the development of a built environment flood resilience capability maturity model (see the maturity model in Table 7.8).

5.4.8.3 Correlation

Spearman's rank correlation is a nonparametric statistical tool that measures the strength of association between variables (Kossowski & Kauke, 2011). Correlation coefficient value ranges from −1.00 to 1.00 (Kossowski & Kauke, 2011). A correlation matrix shows the magnitude of the correlation between a list of factors. Xia *et al.* (2009) employed correlation as a data analysis tool to measure the strength association between competencies rated by a team of experts. The study made decisions on the competencies based on the significance of the correlation between them. A significant correlation between factors in a correlation matrix implies the existence of a multiplier effect (Xia *et al.*, 2009) i.e. lack of independence or even duplication. Similarly, Yoon (2012) utilised Spearman rank correlation to compare social vulnerability to natural disasters. Spearman's rank correlation coefficient describes a relationship or association between variables when Pearson's correlation coefficient is deemed unsuitable because of the mode of data distribution (Kossowski & Kauke, 2011). Pearson's product-moment correlation coefficient is used when there is a linear relationship between data or variables are measured on an interval or ratio scales (Kossowski & Kauke, 2011; Yoon, 2012). Spearman correlation was used in this study because capability areas were rank-ordered by experts. As a result, a non-parametric statistical tool that can measure the strength of association between the capability areas is appropriate.

5.4.8.4 Content analysis

The case study interview conducted were analysed using content analysis. Content analysis involves the making of a reference to the frequency at which an issue is mentioned by a respondent (Fellows & Liu, 2015). Significant reference or affirmation of an issue in an interview or a set of interviews implies that the issue is significant. In some analysis, the number of time a reference is made to an issue or a topic is numbered

and counted to confirm their importance (Fellows and Liu, 2008). In content analysis, key points are noted from interviews and discussed, the points can also be grouped based on similarities and identified themes are discussed or taken forward for further use in a research (Xia *et al*, 2009). The same principle of identifying key points and topics by interpreting submissions in the context of the research are also utilised in the analysis of textual data e.g. documentations (Yin, 2014). The interviews were done in this study were conducted in case studies. The purpose of the case studies was to verify the capability areas and further develop an intermediate model (i.e. the model that emerged after expert panel review - Table 7.3, see the full version in Appendix L). Data from the case studies was analysed using content analysis i.e. identifying key points and topics in the interview and documentations. Selective coding which involves matching points or ideas in a discussion to an existing or a formed theme (Yin, 2014) was mainly employed. This was appropriate because needed themes (i.e. capability areas and maturity level characteristics) have already been identified and documented. As earlier mentioned, verification of capability areas and the refinement of the intermediate model took place case studies. Beyond selective coding, the possibility of adding to the existing theme was considered via open and axial coding. The results of the multiple case study exercise are reported in section 7.6.

5.4.8.5 Percentages

Percentage was employed to present an analysis and comparison between the capability scores of the case study organisations. Capability maturity scores were computed using the capability maturity model developed, but a cross-case comparison of assessed capability maturity was done for each capability area. The comparison was done within each case study organisation and across the different case organisations. The comparison was supported with figures (See Section 7.10).

5.5 Shortcoming of case study research

Case study research strategy has shortcomings despite its advantages; this has attracted criticisms from different researchers (Yin, 2014). Case study has been criticised for the tendency of the sloppiness of a researcher, the failure to follow a systematic process and the possible biased influence of the researcher on findings and conclusion (Amaratunga & Baldry, 2001; Maxwell, 2012; Yin, 2014). Other concerns about case studies are the difficulty in generalising the findings (Berger, 1983), it takes time because of the volume

of relevant materials that are often accumulated and the existence of avoidable narratives during case study data collection (Yin, 2014).

Although researchers have identified some limitations of case study research, the limitations can be largely managed or overcome (Amaratunga and Baldry, 2001; Flick, 2014; Maxwell, 2012; Yin, 2014). A good case study is not easily done, but when properly done, it has the advantage of permitting the conduct of an in-depth study into a phenomenon (Flick, 2014). The identified shortcomings of case study research were managed towards ensuring the quality of this study by engaging the strategies discussed in section 5.6.

5.6 Measures for overcoming research design shortcomings

In this study, the measures suggested by Flick (2014) and Yin (2009) were engaged to overcome the shortcomings of case study research towards preserving the quality of this study. The measures are reliability, validity and triangulation. Validity is divided into the construct, internal and external validity and triangulation has types, they are data, investigator, theory and methodological triangulation (see section 5.6.4 for more details) in a study. There are specific measures recommended for judging the quality of case study researches. The criteria are also useful for achieving quality and ensuring the reliability of research designs, case study inclusive (Yin, 2014). See section 5.6.1 to 5.6.4 for discussions on the criteria and how they were employed in this research.

Alongside the established measures of overcoming the shortcomings of a research design, some ingredients are essential to the delivery of a quality research. Kulatunga *et al.* (2009) and Kulatunga *et al.* (2010) revealed the importance of some critical ingredients, among these are clearly establishing the research problem, commitment of the lead researcher, dedication and cooperation of research team members, setting clear and realistic goals, and effective communication between everyone connected to the research. Although the scope of Kulatunga *et al.* (2009) and Kulatunga *et al.* (2010) is on collaborative construction research among universities and industry partners, some of the submissions are clearly essential to the delivery of any quality research at any level.

5.6.1 Construct validity

Validity relates to the accuracy of a researcher's perception of the reality of what is being studied i.e. the interaction between the variables of a research and the interaction between

the variables as perceived by the researcher and used in the research (Flick, 2014). Yin (2014) defined construct validity as the ability to identify appropriate operational measures for the phenomenon being studied. This is achieved by clearly defining the phenomenon of interest and outlining the most appropriate indicators of measurement. It is recommended that the use of multiple sources of evidence and the establishment of a related set of evidence are viable tactics for ensuring or assessing the quality of a research (Yin, 2014). These tactics were employed in this study, data was collected via multiple sources and a chain of evidence was observed. The data sources are (i) interviews (ii) direct observation (iii) documentation (iv) expert forum review was also conducted. An expert review panel was engaged in Modified-Delphi rounds; semi-structured interview was conducted with informants in selected four case study business organisations, and documentation relating to the interest of this study and the case study organisations were utilised. The use of multiple sources and the establishment of a connected chain of evidence guarantees the validity of this study.

5.6.2 Internal and External Validity

Internal validity relates to the actual connectivity of variables used in a study (Yin, 2014). This connectivity is referred to as causal relationship between variables by Yin (2014). To ensure internal validity in this research, the tactics recommended by Yin (2014) were adopted. These tactics are the use of explanation building with adequate consideration for similarity between patterns of intra-case and inter-case studies findings as well as rival explanations. Similarly, external validity, which intends to establish the level of generalizability of research, was also conducted in this study. The need to adopt case study strategy is hinged on the fact that the questions 'how' and 'why' needs to be answered. To achieve external validity, the replication logic recommended for multiple case studies by Yin (2014) was adopted (See Figure 5.9 for explanations). Validation exercises were also conducted on the model developed, this is discussed in chapter 8.

5.6.3 Reliability

Reliability describes the existence of consistency, minimum error and bias in a study (Yin, 2014). It describes the situation of achieving the same result if a researcher conducts the same research under the same set of conditions and terrain. To achieve reliability in this study, case study protocol was developed for all case studies as recommended by Yin (2014). Bryman (2015) described reliability as the extent to which research result or its measures will be achieved at different times. Roberts *et al.* (2006) suggested the visitation

of data several times; this was done in this study. In addition, detailed notes were kept during the process of the research and research group members were independently engaged to verify field notes, analysis and the findings of this study. This approach is described as inter-rater reliability, and it enhances the reliability and overall credibility of research (Roberts *et al.*, 2006; Weber, 1990). The interactions were also recorded and revisited to confirm the accuracy of informants' submissions after extracting needed information from the bulk of responses. The keeping of detailed notes on the decisions made during the research process also ensured ease of auditing and maintenance of chain of evidence as recommended by Roberts *et al.* (2006). The importance of noting subtle nuances of communication during qualitative data collection has been emphasised in literature (Atkinson and Heritage, 1984 cited in Roberts,2006). The nuances usually indicate emphasis among other occurrences, and adequate attention was placed on this in this study. A thorough engagement with the data collected was undertaking in this study, adequate re-visitation of data was undertaking to establish a truthful connection between the data and the results being reported. Quotes of key responses were also introduced in order to present the exact findings and interpretation of findings in a clear and auditable manner; these actions are supported by previous researches (Bryman, 2001; Roberts *et al.*, 2006; Weber, 1990).

In summary, the steps recommended by previous researchers for enhancing the reliability of research were adopted in this study. Written comments of expert forum members during the expert review process (See Section 5.4.7.2 for details on the process and Chapter 6 as well as Chapter 7 section 7.4 for results) were adequately documented, detailed notes on decisions on each were recorded and well kept. Also, in the case studies (See section 5.4.3 for details of process and Chapter section 7.5 for the results), case study protocol was used, adequate notes on the process were taken, research group members were engaged as independent researchers help examine for consistency, the notes, analysis and findings of the research. The interactions in the case studies took place face to face, and follow-up conversations were done via phone calls. All these tactics among other measures were undertaken to ensure the reliability and overall credibility of this study.

5.6.4 Triangulation

Triangulation is a concept that helps in eliminating bias and enhance the reliability of research. Flick (2014) defined triangulation as the 'combination of different methods,

study groups, local and temporal settings, and different theoretical perspectives in dealing with a phenomenon'. Denzin (1970) cited in Flick (2014) identified data, investigator, theory and methodological triangulation as types of triangulation. Denzin defined the different types of triangulation as follows: Data triangulation is the collection of data from different sources. Investigator triangulation is the act of using different individuals or researchers to check for researcher's bias on the phenomenon being. Theory triangulation is the act of assessing or viewing data from different theoretical standpoints while methodological triangulation which could be inter or intra-method. The use of different scales to measure the same set of criteria in a questionnaire is an example of intra-method triangulation while the utilisation of both questionnaire and interview for researching the same phenomenon is an example of inter-method triangulation (Flick, 2014). Triangulation ensures quality in case studies; it was used to ensure the neutralisation of bias in the data collected via case studies in this study.

5.7 Summary of research design

The overall continuum of a research design is presented in Table 5.3. The table was created based on the submissions of earlier researchers. Table 5.3 summarises the two extremes to research methodology while Figure 5.12 graphically presents the research design of this study.

Table 5.3 Continuum of research design (Adapted from Sutrisna, 2009 and Saunders *et al.*, 2016*)*

Philosophy	**Continuum**
Epistemology	Positivism ⟷ Interpretivism
Ontology	Objectivism ⟷ Constructivism
Axiology	Value free ⟷ Value-laden
Research approach	Deduction ⟷ Induction
Research Method	Quantitative ⟷ Qualitative

As earlier mentioned, the summary of the methodology of this research is presented in Figure 5.12, the summary was drafted using the concepts and presentations of Crotty (1998) and Saunders *et al.* (2016) research design models (see Figure 5.1 and Figure 5.3).

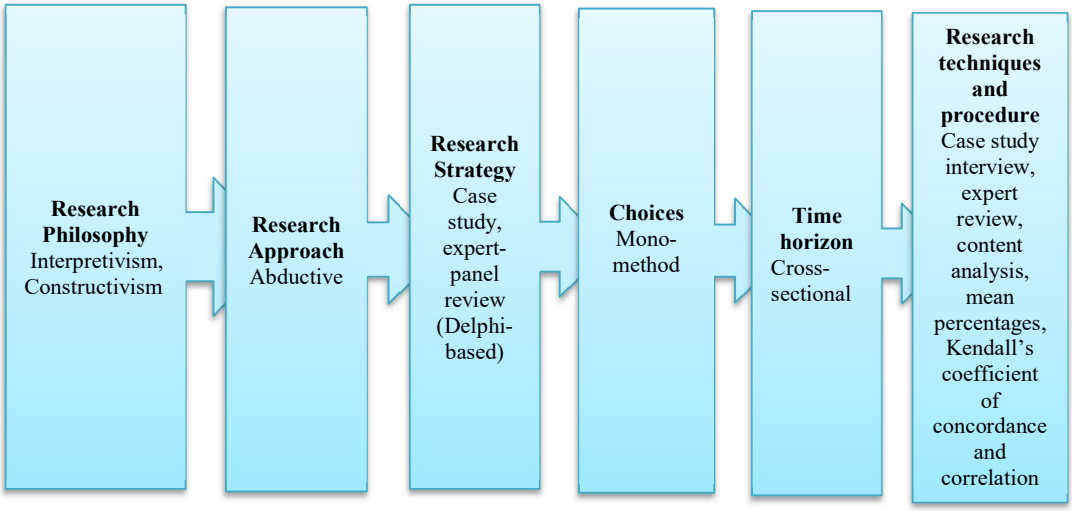

Figure 5.12 Summary of the research design of this study

5.8 Chapter Summary

The tools, methods, processes, and circumstances surrounding the decisions taken towards achieving the aim and objectives of this study was discussed in this chapter (Chapter 5). The chapter started with an introduction section that presents a brief in the previous chapter (i.e. Chapter 4) and the new chapter. The introduction section also presents a brief overview of this (Chapter 5). This research design section of this chapter is structured using Saunders *et al.* research onion model (Saunders *et al.*, 2016). Among the topics discussed in relation to the aim of this study is research design, this entails research philosophy, approach, strategy, as well as methodological choices, time horizon and research techniques adopted in the study. Also discussed are the relevant theories, a discussion on the application of expert forum review and case studies in this research. Discussions in the chapter ended with the presentation of data collection and analysis methods, as well as measures for overcoming some research challenges. The results of the research processes and the methodological considerations discussed in this chapter are presented in the next chapter (i.e. Chapter 6).

CHAPTER SIX
IDENTIFICATION AND VERIFICATION OF KEY CAPABILITY AREAS

6.1 Introduction

The methodology employed in achieving the objectives of this study was presented in the last chapter (chapter 5). This chapter presents the analyses of data, results and findings relating to the identification and verification of capability areas. The chapter covers the initial review of capability areas identified from literature by three academics, the rating of identified capability areas, the rating was done by administering copies of questionnaire to experts selected based on set criteria (see section 5.4.7.2.2). The follow-up interviews conducted were also reported. This chapter simply reports all activities undertaken towards the verification of key capability areas for achieving flood resilience of the built environment. Data collected on the rating of importance of capability areas were analysed using descriptive statistics, mean score, Kendal coefficient of concordance, and correlation on Statistical Package for Social Science (SPSS). The purpose of this chapter is to present the process and the outcome of efforts undertaken to identify and verify key capability areas required for enhancing or achieving the flood resilience of the built environment of businesses (business premises). The result of the rating of capability areas by experts is presented in this chapter while chapter 7 (next chapter) discusses the process and the outcome of the development of flood resilience capability maturity model.

6.2 Steps involved in the identification and verification of capability areas

The summary of the process of capability identification and verification is presented in Figure 6.1to aid the understanding of the contents of this chapter. See Figure 5.5 for the methodology flowchart of this study. The process started with the identification of capabilities or factors that can influence the flood resilience of a business property via an extensive literature review. A total of 26 capability areas were identified from the literature (see Table 4.1), this was preliminary reviewed by a team of academics (supervisory team of this research). The preliminary review was aimed at restructuring the name and shortening the descriptions of the identified capability areas before expert panel verification. The formulation of the expert review panel is discussed in section 6.5, upon the completion of the expert review exercise, the verified capability areas were used to develop a conceptual maturity model via a mapping exercise (See Section 5.4.1.1) based on the concept of capability maturity modelling.

The processes involved in the identification and verification of capability areas were discussed in more details in the remaining sections of this chapter while other activities leading to the development of the capability maturity model are presented in the succeeding chapters. It should be noted that the scoring of capability areas on a Likert-scale, reported in this chapter, was succeeded by a detailed qualitative review of capabilities by an expert panel (Sections 7.3 and 7.4). The Likert-scale scoring was used to assess the understanding and acceptability of the capability areas while the second iteration (i.e. the qualitative review) can be described as the major approach for capability verification. The verification exercises were undertaken in a Delphi manner (See Section 5.4.2 for the details of the expert panel review process). Figure 6.1shows the discussions presented in this chapter, the discussions include the stages in the first part of the Delphi process through which the identified capabilities were verified. The second part of the process is presented in chapter 7, it includes the verification of capability areas and the refinement of the conceptual maturity model (discussed in section 7.4). Please refer to Figure 5.11 for an overview of the whole expert review Delphi process and Figure 5.5 for the overall methodology flowchart.

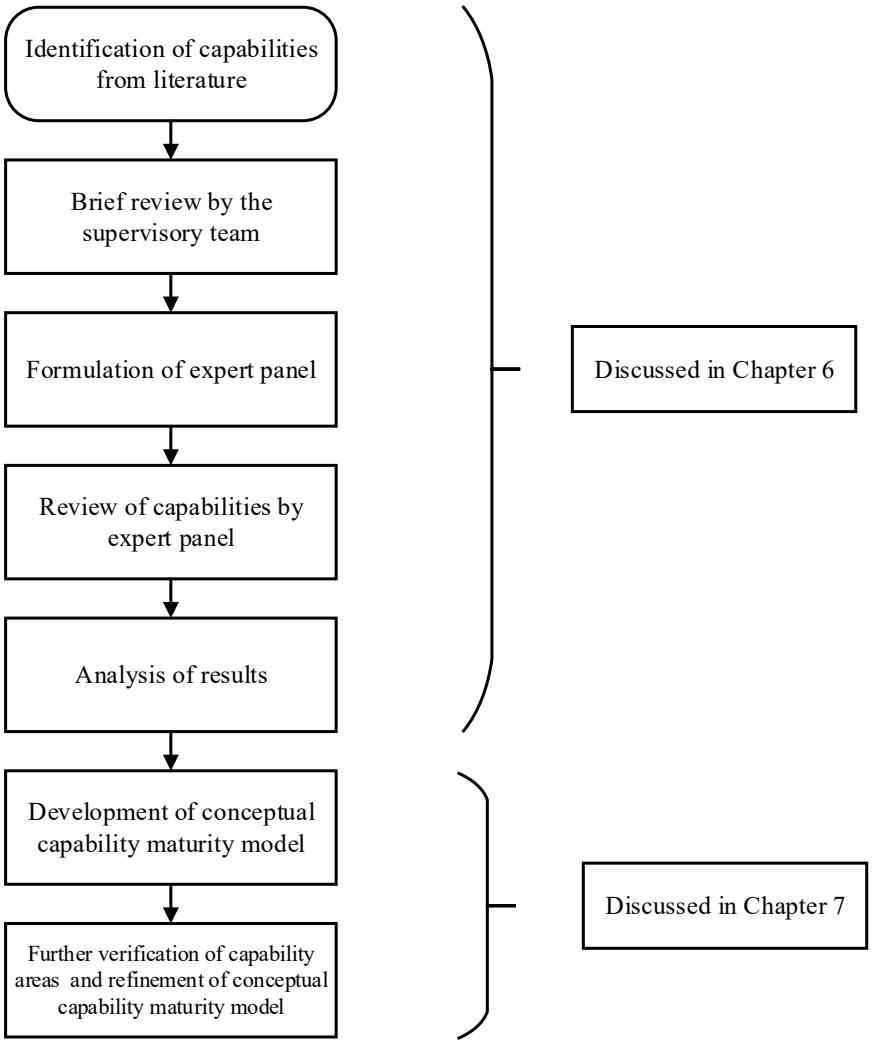

Figure 6.1Overview of capability area identification, verification and model development process

6.3 Identification of capability areas from literature

The identification of capability areas started with literature review, this resulted to the identification of 26 capability areas (see Table 4.1 for details).

6.4 Review by the supervisory team

The 26 capability areas were presented to a team of four academics for review; the preliminary review resulted in no additions to the list of capability areas, none was also eliminated. Upon the completion of the preliminary review, all the 26 capability areas were used to design the questionnaire (Appendix B) administered to an expert panel (See Table 6.1) for verification. The experts were asked to indicate their level of agreement and importance of the identified capability areas on a Likert scale (see chapter 5, section

5.4.7.2 for details of the process and Section 6.5 to 6.7 for the outcome). The formulation and composition of the expert forum is presented in the next section.

6.5 Formulation and composition of expert forum

The criteria for the selection of expert forum members was discussed in details in Chapter 5 section 5.4.7.2.2. Presented in this section is the actual composition of the panel and their areas of expertise. The experts are expected to verify the capability areas identified from the literature and after that refine the conceptual flood resilience capability maturity model. The first verification of capability areas was carried out by administering copies of questionnaire to the selected experts. The experts were engaged again to verify the capability areas further and improve the conceptual capability maturity model. The experts include flooding and property level resilience professionals, a business owner with flood experience, Civil engineer and flood recovery coordinator, resilience planning officers, insurance professionals, policy officer, and researchers in the field of business and property resilience. Table 6.1 presents the background information of the expert forum members. The table describes the width and depth of knowledge and experience of the experts engaged.

Table 6.1 Designation and brief on expert forum members

SN	Code ref.	Designation	Area/Profession
1	JR	Working with communities exposed to flooding. Property level resilience practitioner. Principal officer - Flood Risk Management, Technical Consultancy.	Flooding and property level resilience professional with many years of experience.
2	LJ	The owner of a flood affected business. Chair of a Flood Action Group	A business owner with flood experience, Chair of flood action group. Flooded on a number occasions. Experienced in managing self and community businesses.

Table 6.1 Designation and brief on expert forum members (continued)

SN	Code ref.	Designation	Area/Profession
3	LT	Flood Recovery Coordinator for a flood disaster	Flood Recovery Coordinator. Civil Engineer – Will contribute from Civil Engineering perspective and individual/community business and business premises recovery perspective
4	EM	Academic	Community, household, and business resilience. Done several researches on extreme weather events and impact on businesses and households
5	RC	Policy Officer, Government agency	Participated in funded flood disaster projects). Worked as the national contact point for Property level protection scheme in the Floods team. Implementing a review to embed the approach in delivery of flood management
6	KH	Insurance professional	Insurance professional with over 20 years' experience
7	TR	Insurance professional	Operations Vice President and the Engineering Manager of a Leading insurance firm
8	KC	Resilience Planning and Continuity Officer	Business Resilience, Resilience Officer
9	TS	Researcher	Property and Flood Risk Management expert
10	PS	Researcher	Flood risk assessment and management, territory, risk, and public policy.

6.6 Review of capability areas by the expert team (i.e. verification of capability areas)

One of the objectives of this study is to identify and assess the key capability areas for enhancing the flood resilience of the built environment of businesses (i.e. objective 4).

An expert panel was constituted to evaluate the applicability of the identified capability areas (Table 4.1) to the flood resilience of the built environment of business organisations. It should be noted that the capability areas cover both structural and non-structural measures. Structural measures in the context of flooding are physical facilities used to ensure that properties withstand, absorb or quickly recover from flood attack (CIRIA, 2010). Examples of structural measures are flood barriers, self-closing bricks, impermeable wall and floor construction materials among other resistance and resilience construction materials and technologies (CIRIA, 2010). Similarly, non-structural measures are steps, actions and activities that can aid the flood resistance or resilience of an organisation or property; they are non-physical items, examples are flood risk identification, disaster-related organisation policies, emergency response plans, incidence management exercises among others (CIRIA, 2010). Some of the capabilities referred to in this study are about the intellect of the people involved in the management of the business or property e.g. understanding of flood risk to property.

The expert panel members indicated their level of agreement with the suitability of the identified key capability areas for enhancing built environment flood resilience (referred to as first rating). The panel members also assessed the degree of importance (referred to as second rating) of each of the capability areas (Section 6.3). A 5-point Likert scale was used for the exercise. The result of the analysis done with the ratings of the 10-member expert panel is presented in Section 6.7.

6.7 Analysis and results

Expert ratings on their agreement with the list of capabilities was used to compute mean scores. The result of the rating on the level of agreement is presented in Table 6.2. The result showed that the top five capability areas for enhancing flood resilience are understanding of flood risk to property, review for a flood resilience scheme, acquisition of relevant products for flood risk management (materials and technologies), survey of the property, and the availability of flood proof protection for stocks and contents. The top five key capability areas recorded mean scores above 4.00 on a scale of 5.00 (Table 6.2), it can be said that the experts largely agreed on the need for a business to possess the listed capabilities for resistance and resilience. Out of 26 capability areas, only one scored below 3.00 on a scale of 5.00. Therefore, it can be summarised that the 26 factors are important for enhancing the flood resilience of the built environment of businesses.

Experts were given a chance to suggest as many as possible areas to the list, but there were no additions. “Ref code” i.e. KCA1 – KCA26 are code references representing the position of the Key Capability Areas 1 to 26 in the first rating. Based on the results, it is rational to recommend the consideration of the full list of factors for adoption by businesses, and of course, for further verification and use in this research.

Table 6.2 Result of first rating – Level of agreement with the identified capability areas for enhancing built environment flood resilience

Ref. code	Capability areas	Mean
KCA1	Understanding of flood risk to property	4.80
KCA2	Planning or review for a flood resilience scheme	4.60
KCA3	Acquisition of relevant products for flood risk management (building materials and technologies)	4.60
KCA4	Survey of property	4.30
KCA5	Flood proof store/flood proof protection for stock and contents (Stocks and equipment)	4.20
KCA6	Operation and maintenance ability	4.10
KCA7	Safety precautions - built environment related	4.00
KCA8	Turn-over and cash flow management	3.90
KCA9	Record/Business data management (e.g. back up of documents at distant locations)	3.90
KCA10	General awareness and commitment to resilience	3.90
KCA11	Decision making without recourse to superior in emergency situations	3.90
KCA12	Definition of roles and responsibilities and how it changes in disaster situations	3.90
KCA13	Post-event review, analysis and management	3.90
KCA14	System and protocols for mobilising external resources when needed (Network strength)	3.90
KCA15	Adaptability/Flexibility of property (Property design & construction)	3.90
KCA16	Installation and Post-flood management scheme relationships	3.80
KCA17	Organisation of disaster scenario simulations	3.80
KCA18	Management of disruption to operation/production/service	3.80
KCA19	Insurance adequacy and management	3.70
KCA20	Crises response budget	3.70
KCA21	Paper records management (e.g. duplication of documents at distant locations)	3.70
KCA22	Communication system	3.60
KCA23	Transport/delivery system	3.50
KCA24	Utility supply	3.50
KCA25	Statutory compliance	3.30
KCA26	Retaining the interest of customers in goods and services	2.90

Note: Number (n) = 10. Kendall’s coefficient of concordance (W) = 0.221. Level of significance = 0.000
KCA – Key Capability Areas

Further statistical tests were done to confirm the suitability and acceptability of the 26 factors. Kendall’s coefficient of concordance (W) was computed to measure the degree of agreement between the members of the expert panel in respect of their rating of the

identified capability areas. SPSS software version 22 was used for the statistical analysis. According to Doke and Swanson (1995), Kendall's coefficient of concordance indicates the degree of agreement by mean ranks; it takes into account the variations between the rankings. Table 6.2 reveals that Kendall's coefficient for the 26 capability areas was 0.221, which was statistically significant at 0.01 (1% significant level). It can be concluded that there is a statistically significant agreement among the expert panel members.

Furthermore, the correlation matrix for the dataset was produced, and the result is presented Table 6.3 below. The correlation matrix for the dataset reveals that the majority of the 26 capability areas identified are not highly correlated with each other at 0.05 significance level (A lot of them are not even significantly correlated with each other). This implies that there is no multiplier effect (Xia *et al.*, 2009) i.e. none or insignificant dependence, lack of dependence, duplication, overlap among the variables and therefore confirms the validity of the listed capabilities. These outputs provide a viable justification for proceeding to another stage in the research.

Table 6.3 Correlation matrix for the first rating

Code ref.	KCA1	KCA2	KCA3	KCA4	KCA5	KCA6	KCA7	KCA8	KCA9	KCA10	KCA11	KCA12	KCA13	KCA14	KCA15	KCA16	KCA17	KCA18	KCA19	KCA20	KCA21	KCA22	KCA23	KCA24	KCA25	KCA26
KCA1	1.000																									
KCA2	.645*	1.000																								
KCA3	0.102	-0.132	1.000																							
KCA4	0.327	0.423	0.089	1.000																						
KCA5	-0.249	-0.090	0.244	0.522	1.000																					
KCA6	0.094	0.464	0.154	-0.082	-0.312	1.000																				
KCA7	0.395	0.306	0.000	.690*	0.000	-0.209	1.000																			
KCA8	0.140	-0.133	-0.076	0.082	-0.171	0.074	-0.118	1.000																		
KCA9	0.553	0.381	-0.075	0.322	0.345	0.373	0.175	-0.269	1.000																	
KCA10	-0.108	0.361	-0.132	0.516	0.394	0.297	-0.000	-0.201	-0.401	1.000																
KCA11	-0.538	0.028	-0.176	-0.141	0.394	0.004	-0.272	-0.016	-0.262	0.329	1.000															
KCA12	0.000	-0.407	-0.362	-0.301	-0.247	0.212	-0.218	0.158	-0.407	0.038	-0.610	1.000														
KCA13	0.377	-0.208	-0.176	-0.282	-0.609	0.069	0.000	0.270	0.460	-0.380	-.713*	0.538	1.000													
KCA14	-0.108	-0.583	-0.176	-0.282	-0.261	-0.224	-0.000	-0.595	-0.210	-0.380	-0.380	0.538	-0.625	1.000												
KCA15	-.639*	-.825**	-0.075	-0.000	-0.229	-0.500	-0.029	-0.003	-0.118	0.071	0.185	0.320	-0.027	0.432	1.000											
KCA16	-0.466	-0.072	-0.000	-0.081	-0.082	-0.408	-0.589	-0.007	-0.172	-0.497	.690*	0.000	-0.265	-0.265	-0.238	1.000										
KCA17	0.375	0.161	-0.612	-0.218	-0.249	-0.094	-0.000	-0.140	-0.046	-0.538	-0.108	-0.000	-0.108	-0.108	-0.320	-0.186	1.000									
KCA18	0.000	0.000	-0.000	-0.488	-0.401	-0.000	-0.000	-0.000	-0.536	.818**	-0.000	-0.396	-0.000	-0.000	-0.367	-0.333	-0.559	1.000								
KCA19	0.181	0.560	-0.148	-0.039	-0.184	-.711*	-0.372	-0.003	-0.590	-.642*	-0.105	-0.217	-0.035	-0.245	-0.419	-0.499	-0.090	-0.404	1.000							
KCA20	-0.456	0.071	-0.261	-0.199	-0.309	-0.311	-0.375	-0.113	-0.242	-.746*	-.746*	-0.115	-0.389	-0.177	-0.233	-.857**	-0.456	-0.531	-0.561	1.000						
KCA21	0.577	0.298	-0.354	-0.000	-0.552	-0.076	-0.000	-0.302	-.692*	-0.124	-0.087	-0.034	-0.547	-0.211	-0.253	-0.108	-0.144	-0.000	-0.282	-0.042	1.000					
KCA22	0.094	0.511	-0.154	-0.370	-0.165	-0.577	-0.060	-0.465	-0.118	-0.608	-0.057	-0.089	-0.219	-.729*	-0.358	-0.309	-0.282	-0.337	-0.436	-0.275	-0.239	1.000				
KCA23	0.000	-0.258	-0.000	-0.218	-0.040	-0.151	-0.316	-0.224	-0.369	-0.172	-0.559	-0.630	-0.559	-0.559	-0.292	-0.224	-0.500	-0.447	-0.036	-0.073	-0.115	-0.113	1.000			
KCA24	-0.398	0.154	-0.081	-0.130	-0.246	-.730*	-0.283	-0.007	-0.118	-.677*	-0.330	-0.157	-0.270	-0.270	-0.036	-0.624	-0.398	-0.401	-0.583	-.687*	-0.357	-.675*	-0.279	1.000		
KCA25	-0.090	0.257	-0.406	-0.158	-0.072	-0.215	-0.171	-0.412	-0.490	-.809**	-0.253	-0.082	-0.078	-0.288	-0.112	-0.579	-0.542	-.687*	-.670*	-.673*	-0.230	-0.449	-0.036	-0.425	1.000	
KCA26	-0.313	-0.012	-0.621	-0.195	-0.168	-0.088	-0.594	-0.388	-0.007	-0.243	-0.532	-0.250	-0.050	-0.123	-0.052	-0.487	-0.448	-0.120	-0.375	-.657*	-0.238	-0.128	-0.179	-0.296	-0.307	1.000

Notes: See Table 6.3 for code references. *Correlation is significant at the 5% level (2-tailed). **Correlation is significant at the 1% level (2-tailed).

Apart from indicating their level of agreement with the key capability areas, experts indicated the level of importance of each of the capability areas (referred to as second rating in this study). Some experts rated the capability areas differently on their level of agreement with each capability and the importance of each capability. However, Table 6.4 shows that the experts rated the importance of all the identified capabilities high. This implies that the experts agree with the ability of the identified capability areas to contribute to the flood resilience of the built environment of business organisations.

Table 6.4 reveals that understanding of flood risk to property, planning or review for a flood resilience scheme, insurance adequacy and management, general awareness and commitment to resilience, and the acquisition of relevant products for flood risk management (building materials and technologies) are the top five areas of capability for built environment flood resilience. The top five in terms of experts' agreement with and importance of the capabilities are similar. The new inclusions in the first five capabilities in the second rating are insurance and general awareness and commitment to resilience, they eliminated Acquisition of relevant products for flood risk management and flood survey of property. It should be noted that insurance and general awareness and commitment to resilience scored 3.70 and 3.90 respectively in the first rating (agreement) and both scored 4.30 in the second rating (importance). It is important to emphasise that the importance of all the capability areas is evident in their mean scores, they all scored above 2.50 out of 5.00 in the rating. Therefore, their suitability as capability areas has been confirmed through their scores in both expert ratings.

Obviously, some of the experts' rating of agreement differs (i.e. first rating) from their assessment of the importance (i.e. second rating) of the capability areas. The result presented in Table 6.4 reveals the new positions of the experts. The changes in the position of capability areas on the list can be noticed by comparing the second rating with the first rating. However, the mean score of each factor remains high. The least score in the first rating is 2.90, followed by 3.30 while the least score in the second rating is 3.40. Despite some changes in the mean score of the listed factors in the rating exercises, Kendall coefficient of concordance (see Table 6.4) revealed a statistically significant concordance at 1% significant level, with a score of 0.225. This represents a statistically significant agreement among the expert panel members. "Ref code 1" shows the position of the capability areas in the first rating. "Ref code 2" i.e. R2KCA1 – R2KCA26 is the

code reference for capability areas 1 – 26 in the second rating, it also serves as the key for the correlation matrix generated for second rating (Table 6.5).

Table 6.4 Result of second rating – Importance of capability areas for enhancing built environment flood resilience

Ref. Code 2	Ref. Code 1	Capability areas	Mean
R2KCA1	KCA1	Understanding of flood risk to property	4.90
R2KCA2	KCA2	Planning or review for a flood resilience scheme	4.80
R2KCA3	KCA19	Insurance adequacy and management	4.30
R2KCA4	KCA10	General awareness and commitment to resilience	4.30
R2KCA5	KCA3	Acquisition of relevant products for flood risk management (building materials and technologies)	4.20
R2KCA6	KCA6	Operation and maintenance ability	4.20
R2KCA7	KCA5	Flood proof store/flood proof protection for stock and contents (Stocks and equipment)	4.20
R2KCA8	KCA7	Safety precautions - built environment related	4.10
R2KCA9	KCA4	Survey of property	4.00
R2KCA10	KCA22	Communication system	4.00
R2KCA11	KCA11	Decision making without recourse to superior in emergency situations	4.00
R2KCA12	KCA15	Adaptability/Flexibility of property (Property design & construction)	4.00
R2KCA13	KCA17	Organisation of disaster scenario simulations (Full participation of members)	3.90
R2KCA14	KCA24	Utility supply	3.90
R2KCA15	KCA13	Post event review, analysis and management	3.90
R2KCA16	KCA14	System and protocols for mobilising external resources when needed (Network strength)	3.90
R2KCA17	KCA8	Turn-over and cash flow management	3.80
R2KCA18	KCA18	Management of disruption to operation/production/service	3.80
R2KCA19	KCA12	Definition of roles and responsibilities and how it changes in disaster situations	3.80
R2KCA20	KCA16	Installation and Post-flood management scheme relationships	3.70
R2KCA21	KCA9	Record/Business data management (e.g. back up of documents at distant locations)	3.70
R2KCA22	KCA20	Crises response budget	3.70
R2KCA23	KCA21	Paper records management (e.g. duplication of documents at distant locations)	3.70
R2KCA24	KCA25	Statutory compliance	3.50
R2KCA25	KCA26	Retaining the interest of customers in goods and services	3.40
R2KCA26	KCA23	Transport/delivery system	3.40

Note: Number (n) = 10. Kendall's coefficient of concordance (W) = 0.225. Level of significance = 0.000
KCA means Key capability areas

Also, a correlation matrix for the dataset was produced for the second rating and the result is presented in Table 6.5 below. The result obtained for the dataset reveals that the majority of the 26 capability areas identified are not highly correlated with each other at 0.05 significance level (A lot of them are not even significantly correlated with each other). This implies that there is no multiplier effect (Xia *et al*, 2009) i.e. lack of dependence, duplication, overlap among the variables and therefore confirms the validity of the listed capabilities once more. The correlation matrix produced from the second rating is presented in Table 6.5. The code references should be read with Table 6.4.

Table 6.5 Correlation matrix for the second rating

Code ref.	R2KCA1	R2KCA2	R2KCA3	R2KCA4	R2KCA5	R2KCA6	R2KCA7	R2KCA8	R2KCA9	R2KCA10	R2KCA11	R2KCA12	R2KCA13	R2KCA14	R2KCA15	R2KCA16	R2KCA17	R2KCA18	R2KCA19	R2KCA20	R2KCA21	R2KCA22	R2KCA23	R2KCA24	R2KCA25	R2KCA26
R2KCA1	1.000																									
R2KCA2	.667*	1.000																								
R2KCA3	-0.262	0.148	1.000																							
R2KCA4	0.218	-0.218	0.043	1.000																						
R2KCA5	0.497	.745*	-0.081	-0.488	1.000																					
R2KCA6	0.497	0.093	0.257	0.407	0.097	1.000																				
R2KCA7	0.598	0.548	-0.145	-0.130	0.542	-0.074	1.000																			
R2KCA8	0.111	0.167	-0.591	-0.218	0.373	-0.497	0.465	1.000																		
R2KCA9	0.063	0.471	-0.148	-0.123	0.323	-0.463	0.465	0.439	1.000																	
R2KCA10	.745*	0.000	-0.484	0.488	0.000	0.583	0.312	0.000	-0.337	1.000																
R2KCA11	0.000	0.000	0.000	0.000	0.000	0.000	0.401	0.000	0.000	0.000	1.000															
R2KCA12	0.063	-0.282	-0.415	0.205	-0.182	0.211	0.195	-0.063	0.135	0.337	0.590	1.000														
R2KCA13	1.000**	.667*	-0.262	-0.218	0.497	0.497	0.598	-0.111	-0.063	.745*	0.000	-0.063	1.000													
R2KCA14	0.441	.661*	0.566	-0.206	0.380	0.380	0.252	-0.441	-0.114	0.000	0.296	-0.192	-0.441	1.000												
R2KCA15	-0.072	-0.377	.746*	-0.282	0.265	0.265	-0.047	-0.574	-0.041	-0.433	0.385	-0.008	-0.072	.773**	1.000											
R2KCA16	-0.072	-0.538	0.258	-0.516	-.690*	0.553	-0.261	-0.574	-0.511	0.385	0.000	-0.300	-0.072	-0.008	-0.005	1.000										
R2KCA17	-0.062	-0.234	.821**	-0.163	0.132	0.279	-0.026	-0.561	-0.394	-0.293	0.293	-0.359	-0.062	.792**	.801**	0.097	-1.000									
R2KCA18	0.000	-0.000	0.000	-0.488	0.000	0.000	-0.401	-0.000	-0.590	0.000	-0.000	-0.337	-0.000	-0.296	0.000	0.000	-0.293	1.000								
R2KCA19	-0.071	-0.107	0.270	-0.140	0.080	-0.527	-0.222	-0.500	-0.024	0.000	-0.383	-0.169	-0.071	-0.065	0.286	-0.286	-0.000	-0.479	1.000							
R2KCA20	0.315	-0.472	0.119	-0.041	0.380	-0.239	-0.335	-0.315	-0.278	0.000	-0.549	-0.420	-0.315	-0.504	-0.626	-0.272	-0.300	-0.338	-0.202	1.000						
R2KCA21	-0.487	-0.046	-.676*	-0.040	-0.048	-0.143	-0.040	-0.304	-0.296	-.694*	-0.000	-0.234	-0.487	-0.093	-0.558	-0.177	-0.434	-0.531	-0.414	-0.317	1.000					
R2KCA22	-0.122	-0.137	-0.316	-0.199	-0.061	-0.061	-0.309	-0.304	-0.461	-0.286	-0.531	-0.488	-0.122	-0.197	-0.605	-0.051	-0.218	-0.694*	-0.352	-0.780**	-0.663*	1.000				
R2KCA23	-0.504	-0.142	-0.506	-0.041	-0.401	-0.401	-0.448	-0.315	-0.228	-0.549	-0.000	-0.548	-0.504	-0.132	-0.203	-0.089	-0.498	-0.211	-0.324	-0.064	-0.466	-0.017	1.000			
R2KCA24	-0.418	-0.000	-0.296	-0.117	-0.080	-0.240	-0.178	-0.179	-0.533	-0.560	-0.400	-0.357	-0.418	-0.034	-0.562	-0.181	-0.171	-0.641*	-0.345	-0.558	-.755*	-.896**	-0.074	1.000		
R2KCA25	-0.418	-0.045	-0.620	-0.156	-0.113	-0.220	-0.018	-0.477	-0.196	-0.600	-0.480	-0.074	-0.418	-0.433	-.770**	-0.004	-0.619	-0.240	-0.054	-0.487	-.699*	-.719*	-0.487	-.788**	1.000	
R2KCA26	-0.272	-0.408	-0.321	-0.089	-0.304	-0.304	-0.407	-0.272	-0.461	-0.000	-0.000	-0.231	-0.272	-0.424	-0.527	-0.176	-0.153	-0.456	-0.525	-0.347	-0.261	-0.484	-0.463	-0.475	-0.365	1.000

Towards deciding on the capability areas to adopt for use in the other stages of this study, a decision rule was made. The rule stipulated a cut-off point of 2.50 for capability areas. This implies that a capability area is expected to achieve a mean score of 2.5 for it to be accepted on the list of capability areas to be used to develop the capability maturity model in this study. Interestingly, none of the capability areas scored below 2.50. Recall that the experts rated their agreement with the ability of the capabilities to contribute to the enhancement of built environment flood resilience of organisations and the importance of the capabilities to achieving the stated purpose.

The outputs discussed above provided a viable justification for proceeding to the next stage of this study i.e. development of conceptual capability maturity model from the verified capability areas. The 26 capability areas were adopted as capabilities for enhancing built environment flood resilience at the organisation level (see Figure 3.1 for levels of building resilience) in the interim (i.e. subject to expert forum review during maturity model development – Chapter 7).

Although some studies have discussed capacity and capability in the theme of disaster resilience, they all focused on directions different from the interest of this study. For instance, Ginige *et al.* (2010) aimed at strengthening the capacities of individuals and institutions towards disaster risk reduction in the built environment with a focus on Sri Lanka. The study identified capacity gaps and discussed issues relating to regulatory structure, implementation of laws and regulations, resources and skills among others. This study focused on capacity gaps in a defined location with a specific interest in its analysis on a community scale. Chen *et al.* (2008) presented an assessment method for evaluating environmental planning and hazard mitigation in hillslope communities. Debris and landslide susceptibility of such community can be determined by the outcome of the study. It was referred to as a disaster resilience capacity evaluation method for hillslope communities. The study focused on the community as a whole with a very limited attention to the built environment.

Also, Tadele and Manyena (2009) focused on building institutional capacities towards preventing, preparing for and responding to disasters. The study highlighted areas of good practice and complexities surrounding capacity building for resilience. The studies described above addressed different aspects of capacity building and enhancement in the theme of disaster resilience but none focused on flood resilience of the built environment

of businesses at the organisation scale. The 26 capability areas identified and verified in this research has expanded knowledge in the area of capacity and capability in the theme of disaster resilience in the built environment. Specific capabilities required for built environment resilience at the organisation scale has been identified and verified.

6.8 Discussion of findings on capability areas

The outcome of this stage of the research is the identification of 26 capability areas for enhancing the resilience of the built environment of business. The ability of a built environment or a business premise to absorb, withstand or recover quickly from the impact of flood disasters is dependent on the existence of the afore-listed capabilities. Presented below is a discussion on the top-ranking capability areas in the two ratings. It is worthy of note that the resilience of a business property and the built environment at large is not a function of the physical characteristics of the property alone but also the use, users, management of the property and the attributes of external stakeholders (Bosher, 2008; Gibberd, 2015; Labaka *et al.*, 2015; UN ESCAP and AIT, 2012). This claim was further emphasised by the high scores assigned by experts to the non-physical capability areas identified in this study. Therefore, this should be borne in mind while considering the discussion presented below as well as other discussions on capabilities for enhancing built environment flood resilience in this study.

Experts have rated the suitability of the identified capability areas; understanding of flood risk came top on both ratings. This capability refers to a business' awareness of the type and frequency of flood, knowledge of property vulnerability and water entry channels, understanding of its consequences to organisation assets (See Table 4.1 for details of each capability). Knowledge of the above by an organisation will affect several other decisions that will be taken, among these is its disposition to the need for a mitigation survey (White *et al.*, 2013a). Also, the understanding of flood risk will influence an organisation's decision on plans for a flood resilience scheme. Since there are a variety of schemes and measures, the company's decision will be influenced by how much it's aware of the available measures. Other decisions that can be influenced by understanding of risk is how to analyse the cost implication of options with the help of relevant data and professionals. Planning for a scheme is expected to lead to the workable layout of resilience scheme. Achieving this is a function of the abilities of the organisation in effectively using in-house or external resources. The review of plan will influence where and how to finance a scheme of choice and the sophistication of the method to adopt

among others (CIRIA, 2010; White et al., 2013). Another high scoring capability is the ability of the organisation to acquire suitable products for flood risk management. This is dependent on the scheme the organisation decides to adopt and ability to interact with manufacturers, suppliers and installers (White et al., 2013). Whether the organisation settles for dry-proofing or wet-proofing option, appropriate technology and facilities need to be acquired. Clear specifications are necessary, proper kite marks and other quality assurance criteria need to be considered.

Furthermore, a strong agreement with the need for effective conduct of flood survey was indicated. Ensuring the use of a professionally accredited surveyor to inspect vulnerable points and measuring apertures are important (White et al., 2013). This will guarantee a detailed and adequate specification for the property. The availability of flood protection measures for stocks and contents will surely limit the extent of damage to stocks and contents. This will limit the disruption to the appearance of the premises of the business, and the duration of clean-up is likely to be reduced if there will be any. Presented above is a discussion on the top five capability areas in the first rating, below is a discussion of the top five capability areas in the second rating.

The top scoring capabilities include understanding of flood risk to property; it also scored very high in the first rating (Table 6.2). Others are review for a flood scheme, it also scored very high in the first rating, and insurance adequacy and management which refers to the importance of having business premises insured. A favourable policy and a quickly paid compensation will surely aid the recovery of the premises of a typical business. Although, currently there are outstanding issues on the availability of affordable insurance to businesses (in the UK). There are arguments on the non- inclusion of businesses in the scheme that is aimed at ensuring the availability of affordable insurance to property owners. FloodRe is a temporary measure that is expected to precede the opening of a free market for the insurance of flood risk (RICS, 2015). The scheme is financed by premiums to reinsure flood risk and a statutory levy on UK property owners, FloodRe is not available to businesses because the government and the Association of British Insurers (ABI) believe that businesses source insurance at normal prices (RICS, 2015).

Also, general awareness and commitment to resilience scored high, this relates to the organisation's appreciation of the need for built environment resilience. It relates to

devolved management and harmonisation of differences in perception occasioned by the managerial hierarchy. If differences are not technically or appropriately harmonised, the specific need for the organisation to act will not be identified. Acquisition of relevant products for flood risk management was among the five top scoring capabilities in both rating. This confirms its high level of importance.

As earlier mentioned, the high scores allocated to the identified capability areas confirms their ability to contribute to the resilience of the built environment. It is clear that there are seeming links between the capability areas, this simply implies that the possession of one cannot single-handedly ensure the resilience of the built environment. It is, therefore, important to ensure the existence of all each organisation. The next chapter (Chapter 7) is a development on this chapter (Chapter 6). It presents the process leading to the development of a capability maturity model capable of describing the maturity of organisations on the verified capabilities (i.e. capabilities discussed in this chapter).

6.9 Summary of chapter

Presented in this chapter is the rating of capability areas by experts. This was done to establish the appropriateness and acceptability of the capability areas for achieving built environment flood resilience. Ten experts were carefully selected (refer to section 5.4.7.2 and section 6.5) to review and indicate their level of agreement with and the importance of each of the identified 26 capability areas for enhancing built environment flood resilience. All the capability areas scored above 2.50 (out of a maximum of 5.00). A discussion of the findings from the exercise was presented in Section 6.8; details of the meaning of all the capability areas is presented in an earlier table (Table 4.1). Presented in the next chapter is a discussion on the process of developing a built environment flood resilience capability maturity model.

(Bititci *et al.*, 2015)

CHAPTER SEVEN
DEVELOPMENT OF FLOOD RESILIENCE CAPABILITY MATURITY MODEL

7.1 Introduction

The capabilities that can assist a business organisation to withstand, absorb, or quickly recover its premises after a flood event has been identified, verified and discussed in the previous chapter (i.e. chapter 6). An outline of the discussion in the chapter is presented in Figure 6.1. This chapter (i.e. chapter 7) discusses the development of a flood resilience capability maturity model for Micro, Small and Medium Sized Enterprises. The model development process included the development of a conceptual model, which entails the mapping of the key capability areas to maturity levels, further verification of the capability areas and the refinement of capability level definitions. The resulting intermediate model was improved further and this resulted in the final built environment flood resilience capability maturity model. The coverage of this chapter is indicated in Figure 7.1.

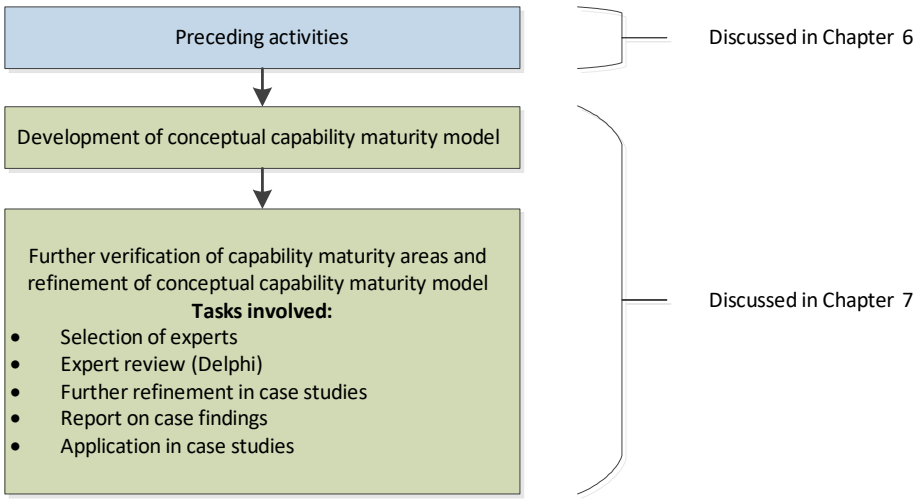

Figure 7.1 Coverage of chapter 7

7.2 Development of conceptual built environment flood resilience capability maturity model

The development of the conceptual model started as discussed in chapter 6, the coverage of chapter 6 is diagrammatically represented in Figure 6.1. The processes reserved for discussion in Chapter 7 (this chapter) are presented hereby. A capability maturity model is a representation constructed according to levels ranging from novice to expert (levels

1 – Adhoc to level 5 – Optimising); the model presents practices or capabilities in a defined format. It is an evaluation tool that allows organisations to understand their current status and define how to enhance their capabilities in the context of practice, process or phenomenon of interest. The maturity layers are characterised by a progressive measure of sophistication or the extent to which practice, process or capability is defined, controlled or institutionalised (Macgillivray *et al.*, 2007). Capability maturity model (CMM) has been adopted for use across several sectors (Babatunde *et al.*, 2016; Macgillivray *et al.*, 2007). Macgillivray *et al.* (2007) agree with Sarshar *et al.* (2000) on the complexity of mapping existing capability maturity model to a new area. The process involves the extraction and recreation of maturity modelling principles in the new area.

The capability model allows organisations to establish their maturity level with respect to a stated phenomenon or practices. Progression across the maturity levels depends on the satisfaction of the attributes named with the level and the possession of the characteristics designated in the higher level. Capability maturity model (CMM) appears suitable for benchmarking purposes. Evaluation of current capabilities can be done in preparation for future decisions in an organisation.

In this study, the characteristics of maturity levels 1 (Adhoc) to 5 (Optimizing) were abstracted from CMM literature and presented in Table 4.5 to 4.9. The identified characteristics were recreated by mapping with the identified key capability areas for enhancing built environment resilience (see Chapter 6, Table 6.4). The result of the mapping exercise is a conceptual model (See Appendix K); the model shows the characteristics of maturity levels 1 – 5 (i.e. Adhoc to Optimizing) for each of the capability areas. The flood resilience capability maturity model is meant for assessing and profiling built environment resilience capabilities of businesses. Through the establishment of the prevailing maturity of a typical organisation, the organisation can be spurred to invest more. As presented in the methodology flowchart (Figure 6.2), the conceptual model developed by mapping the maturity characteristics and the key capability areas identified and verified (as explained in Chapter 6, Table 6.4) was thereafter made available to experts for refinement.

7.3 Selection of expert forum members for the refinement of conceptual model

In order to review and refine the conceptual model (See Appendix K) that was developed, a six-member expert panel was engaged (Table 7.1). The size of the panel aligns with the

proof provided by Boje and Murnighan (1982), the study observed no effect of group sizes on decision-making techniques when it engaged groups made up of 3, 7, and 11 members. The six-man panel for this study was selected by identifying the areas and categories of people relevant (see Table 5.2) to the capability maturity model that is being developed in this study. This was done with a special focus on significant and specific involvement as well as the experience of a potential member in issues relating to built environment resilience.

The eventual panel members were from among the ten experts that participated in the review and rating of the identified capability areas. Their designation and a brief on each member are presented in Table 7.1 below. The criteria for selecting experts have been discussed elaborately in section 5.4.7.2.2; Table 7.1 is only meant to provide a brief on the six members engaged in reviewing the conceptual model.

Table 7.1 Designation and area of practice of expert review panel members

SN	Code ref.	Designation/Area of Practice
1	JR	Property level resilience practitioner. A current member of a city council resilience team
2	TR	Property/General risk and damage assessment professional. Operations Vice President and Engineering Manager of an insurance firm
3	LJ	The owner of a flood affected business. Chair of a Flood Action Group
4	LT	Flood Recovery Coordinator for businesses, household and communities. Project Manager and Construction professional.
5	RC	Policy Officer, Government agency. Worked as the national contact point for property level protection scheme.
6	KH	Insurance professional (Business and property risk management).

Note: See Table 6.1 for more details on expert panel members

7.4 Expert review of conceptual Capability Maturity Model

After the selected experts agreed to participate in the review process, the conceptual model that was prepared via a mapping exercise (Appendix K) was forwarded to them with some accompanying documents. The mapping exercise is discussed in section

5.4.1.1, and the capability maturity modelling which is the underlying concept of the resultant capability maturity model is discussed in Section 4.6. Among the documents forwarded to the experts are a cover letter, instruction sheet, conceptual model, and general characteristics of maturity levels. The circulation of the documents was followed by follow-up interactions with most of the experts; they sought some clarifications and provided some verbal comments. Clarifications were also made from the experts after receiving comments from them; this was done via follow-up interactions. Table 7.3 (see the full version in Appendix L) is the outcome of the expert forum review of the conceptual model i.e. the intermediate model. This model was made after carefully considering the comments and suggestions of the experts (refer to section 7.4.1 and 7.4.2).

7.4.1 Experts' comments on maturity level definitions

(Please read the code references in this section with the conceptual model – Appendix K)

Members of the expert forum team did a comprehensive review on the conceptual model. Their specific contributions are presented hereby. The code references in this section should be read with the conceptual model presented in Appendix K and Table 7.1 (Designation and area of practice of expert panel members).

JR suggested the addition of "No survey work considered or undertaken" to KCA3/ML1 (i.e. Survey of property, maturity level 1 – Adhoc), "multiple departments or individuals are aware, and it's discussed" to KCA3/ML3 and whole organisation aware of the importance to KCA3/ML4. Both suggestions were adopted and included in the model. JR also requested the consideration and probable inclusion of a theme that describes the capability of individual staff and probably business units and the hierarchy of organisations. This recommendation was not adopted because the interest of this study is to evaluate the built environment flood resilience of the organisation (MSMEs) and not individual's flood resilience. Also, there is the possibility of difference in the assessment of an organisation in respect of each capability by different staff cadre, but much difference is not anticipated. Much difference is not expected if the assessment model is applied to each category of individuals with all sincerity. Whenever much difference is recorded, the organisation is required to do a joint assessment.

Also, KH's requested for a forward-thinking component in level 5 (optimising) for the acquisition of relevant products/ facilities for flood risk management (KCA4), but this

has already been addressed by the existence of ML5Op/C11 – related processes are kept to date. Forward thinking characteristic was also requested for insurance adequacy and management (KCA11) but ML5Op/C7 have already addressed this – there is focus on continual improvement of process performance through innovation and technological advancement. KH and LJ commended the comprehensiveness of the model and requested that the final version of the model should be made less wordy.

Further, LT stated that the maturity level characteristics are comprehensive enough and suitable for MSMEs, but some MSMEs might not have a structure in place to fully appreciate the implication of flood risks and the capability maturity model. LT stated that such establishments need support from trade unions. Also, KH commented that there is no sufficient differentiation between level 4 and level 5 of acquisition of relevant products (KCA4). Also, LT requested for more differentiation between level 4 and level 5 for the acquisition of relevant products/ facilities for flood risk management (KCA3). As a result, additional level definitions were added to level 5. The level definitions are: operating environment is well-understood ML5Op/C2, and quantitative approaches are used to understand internal and external variations ML5Op/C6. More details were also added to the maturity level definitions of adaptability/flexibility of property and the name was revised to physical resilience of the fabric and structure of the property (KCA26) based on LT's suggestions.

Also, RC requested that there should be a criterion that shows they recognise there's flood but they feel there are structural or financial barriers to planning for such, ML2Re/C4 have already addressed this request – organisation recognises importance but resources are not allocated. RC also suggested for a statement referring to the quality of survey conducted as this will have an influence on the level of resilience that should be expected from the measures. In response to this, ML3De/C10 was strengthened with more details.

7.4.2 Consolidation of capability areas

TR suggested the merger of operation and maintenance (KCA6) with installation and post-flood management scheme (KCA5). However, based on the submissions of other expert panel members, installation and post-flood management scheme was revised to include manitenance i.e. maintenance and post-flood management scheme relationships. Also, operation and maintenance (KCA6) was renamed as operation of acquired facilities, the maintenance aspect is now part of post flood management scheme relationships

(KCA5). With the development, the comments of TR, JR, and RC were satisfied. Also, TR suggested the exclusion of safety precautions (KCA8) as a substantial capability area, this is because the required safety precautions are about the plan in place for flood by the organisation. A similar submission was made by RC but LT and LJ were silent on it, the suggestion was therefore adopted, safety precaution was merged with definition of roles and how it changes in disaster situations (KCA 23). Also, retaining the interest of customers is perceived not to be good enough to stand alone as a capability area, it was merged with turnover and cash flow management (KCA10).

Further, TR stated that businesses take advice from insurance brokers and that insurance (KCA11) will no longer be available to businesses through Flood Re in the UK therefore insurance can be taken off the list of capabilities. LT also felt it can be eliminated because of the FloodRe issue. RC also raised concerns about some businesses' decision not to claim, the capability was retained because three other experts did not object to its relevance as a capability area, also insurance adequacy and management will still be relevant to businesses in other countries.

Furthermore, TR submitted that communication system (KCA14) as a capability is important but it might not be so relevant to small businesses. Based on the recommendation of LT, TR, and RC, communication, transport and delivery were merged with utility arrangement during disasters and name utility and communication. Concerning flood proof store for stocks and contents (KCA15), TR recommended that it should be merged with adaptability and flexibility of the property (KCA26). TR's recommendation was not immediately accepted because JR, KH, LJ and RC supported its inclusion as a separate capability area but this will be considered further in case studies. KCA8 was merged with KCA26 and the name was revised as suggested by JR, KH, RC. Also, TR questioned the relevance of management of disruption to operations (KCA17) as a separate capability area, JR, KH, LJ, LT and RC supported its inclusion as a separate capability area although their interpretation relates to definition of roles and responsibilities (KCA23). Management of disruption was left as a separate capability area but will be considered further in case studies.

General awareness and commitment to resilience (KCA19) was merged with awareness and understanding of flood risk to property (KCA1) based on experts' interpretation and recommendation. Statutory compliance (KCA20) was removed as an independent

capability area; it was viewed as a general guiding principle for all other capabilities, everything is expected to be done within the ambit of the law. As a result, statutory compliance was removed from the list of capabilities. JR, KH, LJ, LT, TR and RC acknowledged the importance of adaptability, flexibility of property (property design and mode of construction) but the name was revised to 'the physical resilience of the fabric and structure of the property' (KCA26). KCA25 had its label shortened to 'Network strength'. LT commended the comprehensiveness and the appropriateness of the capability areas and emphasised that some organisations, especially small organisations, will need help to interpret the full implication of the capabilities and the level definitions.

Based on RC and TR recommendation, "acquisition of relevant products" (KCA4) has been changed to acquisition and installation of relevant products and "installation and post-flood management scheme relationships" have been changed to "maintenance and post-flood management scheme relationship". LT and JR identified the difference in perception of individuals about the state of an organisation as a potential limitation of the tool. However, whenever much difference is anticipated or recorded, the organisation is required to jointly use the tool for evaluation (i.e. do a joint evaluation).

The expert review was aimed at verifying the capability areas for enhancing an MSME built environment flood resilience and refining the maturity level definitions contained in the maturity assessment model. From the discussion above, it is clear that some of the panel suggestions were adopted while some were not taken up. Some were not taken up because they are already addressed in the model, or they are beyond the scope of this study. Their comments range from the small bits of the model to the overall model and from commendations to suggestions for improvement.

All the panel members appreciated the importance of the inclusion of forward thinking components (expressions that signify the existence of a chance for continual improvement) and suggested its inclusion in all capability areas. As a response to the suggestion, forward thinking components in all capability areas and appropriate levels were pointed out or made more prominent.

The comprehensiveness of the conceptual model was recognised and commended by all panel members, but a concern was raised about its ease of application by business organisations. As a result, a less comprehensive and a less wordy assessment tool was

recommended to be produced from the model. In addition to the comprehensiveness of the model, the existence of a visible stepwise progression between the maturity levels, based on sophistication/measures of ability was recognised and commended. Among other general comments by the experts are the need to help MSMEs to appreciate the implication of flood risks as many may not have a supportive structure on the ground. Such supports are expected to come from trade organisations or the government. This is obviously a very relevant suggestion, but this study can only support the MSMEs by revealing what such organisations have done with respect to what needs to be done and their maturity with respect to what has been done. This will guide potential helpers on how much is still left to be done.

After a careful consideration of the submissions of the panel. The initial 26 capability areas eventually were consolidated into 20 capability areas with associated capability level definitions (See Table 7.3, see the full version in Appendix L). After the round of review whose outcome was presented above (section 7.4.1 and 7.4.2), feedbacks received from panel members were acknowledged, after that there were follow-up interactions for clarifications and further review concerning the submissions of other panel members where necessary. Eventually, the follow-up review did not result in any change in the model. Thus, the intermediate model was produced (See Table 7.3, see the full version in Appendix L). Presented in Table 7.2 is the summary of consolidation of capability areas.

Table 7.2 Summary of consolidation of capability areas

Code	**Key Capability Areas**	**Outcome of review**	**Revised code**	**Revised definition of capability areas**
KCA1	Understanding of flood risk to property	KCA19 merged with KCA 1 and definition revised KCA19 => KCA1	KCA1	Awareness and understanding of flood risk to property
KCA2	Planning or review for a flood resilience scheme	No change	KCA2	Planning or review for a flood resilience scheme
KCA3	Survey of property	No change	KCA3	Survey of property
KCA4	Acquisition of relevant products for flood risk management	No change	KCA4	Acquisition and installation of relevant products
KCA5	Installation and Post-flood management scheme relationships	Renamed	KCA5	Maintenance and Post flood management scheme relationships
KCA6	Operation and maintenance ability	Renamed	KCA6	Operation of acquired facilities

Note: Respective colour fills do not have specific meanings, the filled cells indicate capabilities that changed after expert review; capabilities with the same colour fill were merged.

Table 7.2 Summary of consolidation of capability areas

KCA7	Organisation of disaster scenario simulations (Full participation of members)	No change	KCA7	Organisation of disaster scenario simulations
KCA8	Safety precautions – built environment related	Merged with KCA23 (KCA8 => KCA23)		
KCA9	Retaining the interest of customers in goods and services	Merged with KCA10 (KCA9 => KCA10) and definition revised		
KCA10	Turn-over and cash flow management	KCA9 Merged with KCA10 (KCA9 => KCA10) and definition revised	KCA8	Turn-over, cash flow and customer management
KCA11	Insurance adequacy and management	No change	KCA9	Insurance adequacy and management
KCA12	Transport/delivery system	Merged with KCA13 and KCA14 and renamed KCA12 => KCA13+KCA14	KCA10	Utility and communication system
KCA13	Utility supply	Merged with KCA12 and KCA14 and renamed KCA13 => KCA12+KCA14		
KCA14	Communication system	Merged with KCA12 and KCA13 and renamed KCA14 => KCA12+KCA13		
KCA15	Flood proof store/flood proof protection for stock and contents *(Stocks and equipment)*	No change	KCA11	Flood proof store/flood proof protection for stock and contents
KCA16	Record/Business data management *(e.g. backup of documents at distant locations)*	No change	KCA12	Record/business data management
KCA17	Management of disruption to production/service/operation/process	No change	KCA13	Management of disruption to production/service/operation
KCA18	Crises Response budget	No change	KCA14	Crises Response budget
KCA19	General awareness and commitment to resilience	Merged with KCA1		
KCA20	Statutory compliance	Eliminated		
KCA21	Paper records management *(e.g. duplication of documents at distant locations)*	No change	KCA15	Paper records management
KCA22	Decision making without recourse to superior in emergency situations	No change	KCA16	Decision making without recourse to superior in emergency situations
KCA23	Definition of roles and responsibilities and how it changes in disaster situations	KCA8 merged with KCA23 KCA8 => KCA23	KCA17	Definition of roles and responsibilities and how it changes in disaster situations

Note: Respective colour fills do not have specific meanings, the filled cells indicate capabilities that changed after expert review; capabilities with the same colour fill were merged.

Table 7.2 Summary of consolidation of capability areas

KCA24	Post-event review, analysis and management	No change	KCA18	Post event operation, analysis and management
KCA25	System and protocols for mobilising external resources when needed *(Network strength)*	Name shortened	KCA19	Network strength
KCA26	Adaptability/Flexibility of property *(Property design and construction)*	Name was revised	KCA20	Physical resilience of the fabric and structure of property

Note: Respective colour fills do not have specific meanings, the filled cell indicates capabilities that changed after expert review; capabilities with the same colour fill were merged.

Table 7.3 (see the full version in Appendix L) is the capability maturity model produced after the expert forum review. It is composed of 20 capability areas for enhancing built environment flood resilience and maturity level definitions across five levels (Level 1 – Adhoc to Level 5 – Optimising).

Table 7.3 Built Environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	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** **Coverage** - Awareness of the type, frequency of flood. Knowledge of climate projection and flood projection in the area. Periodic assessment is necessary - physical vulnerability evaluation and water entry channel survey. Initial consideration of remedial measures Understanding of hazard consequences to the organisation and all assets. Training and awareness creation and appreciation of the need for built environment resilience within the organisation. What if scenario, reporting processes, general intelligence. The existence of standards, a network of information. Information flow. Devolved management and harmonisation of difference in perception occasioned by managerial hierarchy. **Goal** - Appreciation of the need for built environment resilience. This is expected to lead to a detailed mitigation survey with information on mitigation and protection that is required. This might influence other decisions. The effect or influence of surrounding businesses will also be established.	Yet to recognise the strategic importance of climate and flood 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 tools or database ML1Ad/C14. Unaware of the need to understand ML1Ad/C16.	Individuals, departments, or function makes an effort but they are not shared ML2Re/C3. Senior Manager/Owner may recognise the importance, but resources are not allocated ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Importance is recognised. They are communicated verbally (within the team(s)) ML2Re/C13. Heavy reliance on knowledge of individuals ML2Re/C16	Importance is recognised ML3De/C2. Tools, templates and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18.	High recognition of importance ML4Ma/C2. The need for processes/tasks are highly recognised and supported with stated means of improvement ML4Ma/C9. Tools, database and records are available for statistical and managerial analysis ML4Ma/C14. The risk is identified ML4Ma/C17.	Operating environment is well-understood ML5Op/C2. They anticipate and respond to uncertainty ML5Op/C4. Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, lessons learnt are captured and fed back into the system ML5Op/C10. High level of awareness ML5Op/C20. Active use of information ML5Op/C21.

Note: Please see the full version of Table 7.3 (the intermediate model) in Appendix L

7.5 Systematic evaluation of disaster resilience capability maturity

The review and rating of capability areas and expert forum review of the developed conceptual model resulted in the development of a refined capability maturity model. This implies that research objective four i.e. to identify and assess key capability areas for enhancing built environment resilience has been achieved (See Table 6.2 to Table 6.5) while research objective five i.e. to develop a built environment resilience capability maturity model for businesses has been partially achieved (Table 7.3, see the full version in Appendix L). Objective five was fully achieved when the interim capability model was updated with inputs from case studies (see Figure 5.5 for details). To achieve objective five in full, the intermediate capability maturity model (Table 7.3, see the full version in Appendix L) was taken to case studies. The case organisations were interviewed on the adequacy of the capability areas and the capability level definitions in the model. After that, the capability assessment model was applied in the case organisations.

Capability maturity modelling is a strategic approach to status evaluation and stepwise improvement. Its successful application in the software industry, construction as well as other sectors (Babatunde *et al.*, 2016; Macgillivray *et al.*, 2007; Paulk *et al.*, 1993; Sarshar *et al.*, 2000) provides a suitable justification for its adoption as a methodical approach for capability enhancement in the disaster resilience theme. This research adopted a list of capability areas identified from the literature and verified by experts as factors having the ability to enhance the flood resilience of a business property or business premises and in turn the business. The resulting capability maturity model provides a strategic guide for enhancing resilience. This is because it describes what is required to attain a higher maturity status on each capability area for built environment resilience. It is worth emphasising that the capability areas cover both structural and non-structural requirements and cuts across important processes and attributes for ensuring the flood resilience of the built environment, all through the stages of a disaster. Some of the capabilities are needed at the preparation stage; some are needed during response stage, while some are needed during recovery. In short, the capabilities are related to pre-event, event and post-event needs.

It is also worthy of note that some of the capability areas are measures of an organisation's intellectual strength about factors that influence decisions on the flood resilience of the

built environment. For example, “awareness and understanding of flood risk to property” (Table 7.3, see the full version in Appendix L) is a capability that influences other decisions. Similarly, some of the capabilities are actions to be taken by an organisation towards ensuring the resilience of their built environment, while some are measures of the ability of the organisation to engage relevant stakeholders. Also, some of the capabilities are descriptions of the abilities of some of the assets of an organisation. For example, “acquisition and installation of relevant products” as a capability area relates to the acquisition of facilities by the company and the ability of staff to deploy them when needed.

7.6 Model refinement, internal validation and testing of Capability Maturity Model in case studies

Upon the successful completion of the expert review of the capability maturity model, the model was taken forward to selected case organisations for further improvement and testing of its applicability to real life situations. Before presenting and applying the capability model in selected case organisations, respondents in the organisation were interviewed on their flood and premises recovery experiences. They were briefed on the purpose of the capability maturity model and its expected significance. In each case study, three stakeholders were engaged i.e. the manager or owner and staff. These stakeholders are the prospective users of the capability model. The purpose of presenting the model to the stakeholders in the case study organisations is to:

i. Further verify the capability areas
ii. Ensure that all pre-event, event and post-event, as well as process related issues, have been addressed in the model
iii. Assess the adequacy, applicability and suitability of the model in evaluating the built environment resilience capabilities of business organisations

To achieve purpose (i) accounts of the recovery experience of case organisations will be compared with the list of capabilities left after expert forum review (see Table 7.2), the applicability of the capability areas will then be established by noting their relevance in the recovery process. Also, interviewees in the case organisations will be questioned directly on the suitability of capability areas. The second purpose of the case study (ii) will be achieved by requesting respondents to comment on the adequacy of the content

of the model. To achieve the purpose (iii) respondents will be asked to comment on the adequacy and suitability of the model.

7.6.1 The criteria used for selecting the case studies used in this research

Some specific criteria were used in deciding the case organisations to engage in this study. A detailed discussion of the criteria for selection is presented in Chapter 5 section 5.4.6. For the ease of flow and understanding of this chapter, a summary of the criteria is presented as follows:

1. They belong to either Class A1, Class A3, Class A4, Class A5, or Class C1 of England's property use class orders (see Section 5.4.6 for details on property use class order).
2. The organisation must be a Micro, Small and or Medium sized enterprise (MSME)
3. The organisation must have experienced flood attack before.

Apart from the above criteria, the organisation must be ready to participate in the study. 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.

7.6.2 Background information on the selected case studies

The background information of the four case organisations selected and engaged in this study are presented in section 7.6.2.1 to 7.6.2.4

7.6.2.1 Case study 1: Guest House/Bed and Breakfast

Case study 1 (CS1) is a bed and breakfast. Bed and breakfast (B&B) is a small establishment that offers overnight accommodation and breakfast (Lee, Reynolds, & Kennon, 2003). Bed and breakfast lodging establishments are becoming more popular due to the desire of travellers who do not want to stay in conventional hotels. Most of the customers of bed and breakfasts are relatively wealthy, frequent travellers, well-educated and on short-term vacations (Lee *et al.*, 2003). Bed and breakfast operations have been predicted to serve bigger roles in the construction industry in the future.

Currently, bed and breakfasts attract tourists, business travellers, business groups, travellers on short vacation and those travelling to attend various social events and conferences. Bed and breakfast operations are peculiar as a result of home away from home atmosphere which is capable of creating a feeling of security and intimacy. These

small lodgings also provide conveniences such as phones/faxes and internet facilities. Lanier and Berman (1993) classified travellers as first generation guests, 2nd generation guests and 3rd generation guests. The first generation guests can stay anywhere but they hardly return to the same place. The second generation guests are less adventurous and prefer to follow recommendations from others, while the third generation guests always come back to a place they have patronised before. Bed and breakfasts are private family homes on most occasions. Bed and breakfast business is becoming popular in many locations across Europe and America and beyond. Due to its short-term service nature and the short-term accommodation needs of tourists, bed and breakfast services are available in many tourist locations.

Case study 1 in this research is a bed and breakfast situated in a busy tourist town located at Lake District national park in England; it is adjacent to Derwent water and close to River Greta. The business runs in a property owned by the business owners. The two business partners that manage the business also manage the property. The property was built around 1908, but it has witnessed some remodelling. The property consists of bedrooms, reception rooms, dining room, living room, kitchen, utility, patio, garden, garage and it is close to town centre. It is fitted with mains water, gas and electricity supply.

The property is a semi-detached three-storey edifice built in a Lakeland. The property is a guesthouse that has been in existence for about 24 years. The guesthouse has an entrance lobby and hall that leads to the dining room, living room, kitchen, utility room, and outside utility store and water closet. The first floor has a landing, a private bedroom, family bedroom with double and single beds, double bedroom with double bay windows. All bedrooms have en-suite shower rooms, and the kitchen and utility rooms have steel sink units. Every guest room is fitted with coffee and tea making facilities among other facilities. The business also has other equipment and furnishings. The business currently has an average turnover of 72,000 pounds per annum (£ 72,000/annum). The property was flooded in 2009, 2012 and December 2015. The flood risk map of the area where Case Study 1 is situated is presented in Figure 7.2; the case organisation is located at the centre of the map (the black ring).

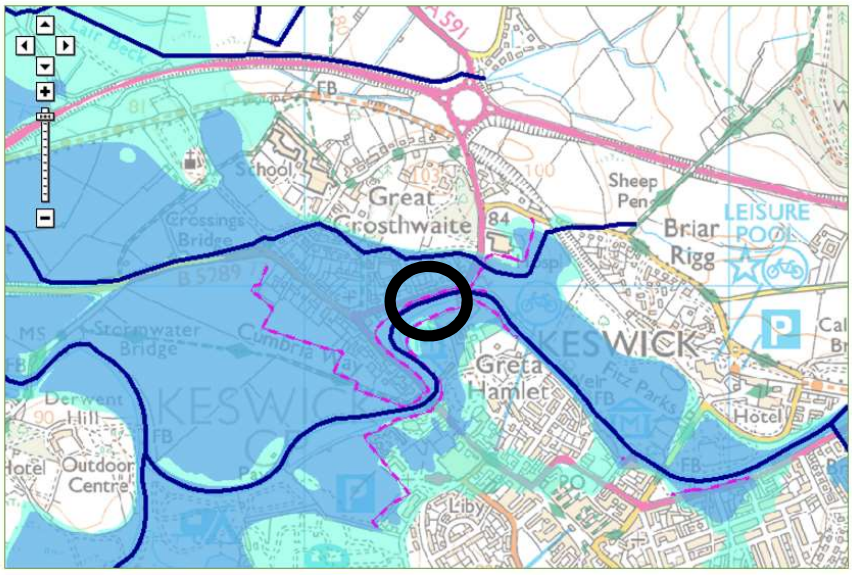

Figure 7.2 Flood risk map of the area where CS1 is located in Keswick, UK (Environment Agency, 2016)

Legend and interpretation of the flood risk map for river and sea flooding

1. **Flood Zone 3** ▢ can be flooded by the river. It has an annual river flooding probability of 1 percent (i.e. 1 in 100) or greater.
2. **Flood Zone 2** ▢ has a likelihood of flooding of 0.1 percent (1 in 1000) per year.
3. Flood zones 2 and 3 are natural floodplains that stand the risk of being flooded. The existence of flood defences and suitable water channels can prevent flooding.
4. **Flood Zone 1** 'Areas without blue shading'. There is an annual likelihood of flooding of 0.1 percent (1 in 1000) in these areas.
5. The blue line ╱ represents the main river.
6. This symbol ▢ represents flood defences.
7. The symbol ▢ represents the areas that are meant to be protected by flood defences.
8. The exact case study location is at the centre of the flood maps.

7.6.2.2 Case study 2: Restaurant

Case 2 in this study is a restaurant situated on a waterfront, River Ouse, York, United Kingdom. The restaurant boasts of serving a selection of chicken dinner, burgers and chargrilled steak and produces menu and flavour that suits the world. The restaurant

specialises in chicken dishes. The property housing the restaurant houses another business at the upper floors. The Landlord that owns the hotel being operated at the upper floors owns the property, but the restaurant owners were given the liberty to manage the ground floor of the building. The property is an early 19th-century asset. Currently, the restaurant operating in the property records a turnover of about two hundred and fifty thousand pounds annually (£250,000 per annum).

It should be noted that although the focus of this study is built environment flood resilience, it is the people using the property, the management of the property and the physical characteristics of the property that leads to its flood resilience (Labaka *et al.,* 2015). This is why each property is being discussed alongside the business operating in the property. The ground floor where the business operates is finished with a stone-cement floor with concrete and rubber membranes; the walls are made of stone (stonewalls). Other parts of the building are finished with other types of tiles; the business also has several other facilities used for operations. The business was flooded about five times in 2015 due to its closeness to a river that overflows its banks because of torrential rain. The premise that consists of an eating area with furniture, bar, kitchen and the store was submerged up to six feet in floodwater in December 2015. The flood risk map of the area where Case Study 2 is situated is presented in Figure 7.3. The actual case study area is situated at the centre of the map (the black ring).

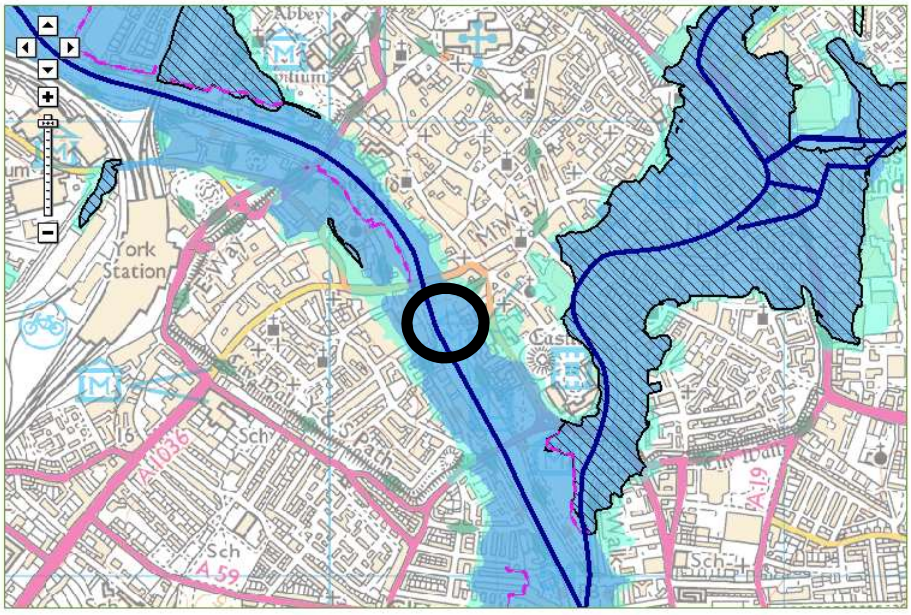

Figure 7.3 Flood risk map of the area where CS2 is located in York, UK (Environment Agency, 2016)

Legend – Flood Zone 3 ▢; **Flood Zone 2** ▢; **Flood Zone 1** 'Areas without blue shading'; Main river – blue line ▢; the symbol ▢ represents flood defences; the symbol ▢ represents the areas that are meant to be protected by flood defences. See details under legends in Figure 7.2

7.6.2.3 Case study 3: Retail outlet *(Toys, games and fun books)*

Case Study 3 is a retail store that specialises in the sale of toys and games. The business is a private limited company founded in January 2012 with its office located at Cockermouth, United Kingdom. Currently, the business has two directors; they are also the owner of the property within which the business operates. The property is a two-storey terraced Georgian house built around 1750. The business currently records a turnover of about two hundred and fifty thousand pounds annually (£250,000 per annum). The shop location suffered significant flood damage during the 2009 flood alongside other businesses. The business serves both young and old, but it is mostly known for pre-school, early school up to the secondary level games, toys and fun books. The business was submerged up to about 5-feet during the 2009 flooding, but this provoked a community-wide intervention that led to the construction of flood defences worth some millions of pounds along major rivers in the town. Unfortunately, the town got flooded again, and the business selected as case study 3 in this study was affected. Because of the community-wide intervention on the construction of flood barriers and remodelling of

streets, the business did not adopt property level flood resistance and resilience measures. The 2009 damage to the business premises was repaired and the floor was finished with ceramic tiles while walls were repaired and painted. The organisation got flooded again in December 2015 when the community-wide measures were breached by the flood. This led the business to adopt some property level measures like a floodgate, sump pump and others. Respondents in this case study presented a recap of their flood and recovery experiences, resultant investment and investment decisions, the applicability of maturity model and suggestions towards improving built environment resilience capability. Their current capabilities were also assessed using the intermediate model. This is reported in section 7.7. The flood risk map of the area where Case Study 3 is situated is presented in Figure 7.4. The actual case study area is situated at the centre of the map (the black ring).

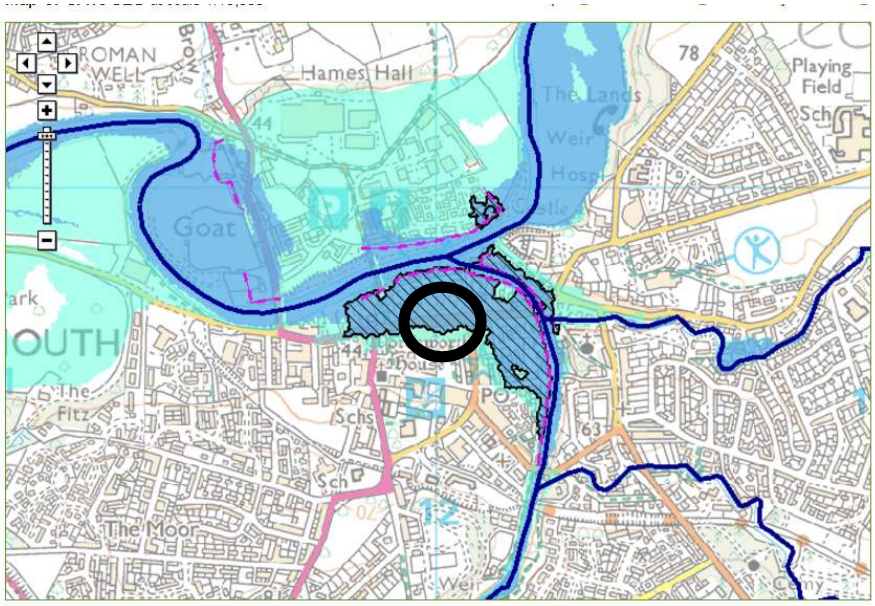

Figure 7.4 Flood risk map of the area where CS3 is located in Cockermouth, UK (Environment Agency, 2016)

Legend – Flood Zone 3 ▢; **Flood Zone 2** ▢; **Flood Zone 1** 'Areas without blue shading'; Main river – blue line ╱; the symbol ▢ represents flood defences; the symbol ▨ represents the areas that are meant to be protected by flood defences. See details under legends in Figure 7.2

7.6.2.4 Case study 4: Coffee shop

Case study 4 (CS4) is a coffee shop situated at Quayside, Newcastle, England. River Tyne, a river at the quayside reached a high level after a storm and a tidal surge along the North East coastline (Chronicle, 2013). The coffee shop operates in a multi-storey

terraced building situated close to River Tyne. It has the privilege of having a window directly overlooking the river. The location is perceived suitable because of the view it provides for River Tyne that attracts to the quayside, its closeness to offices is also an advantage. The area was flooded in 2013, and this led to the closure of some roads and stoppage of business activities in the area. Some businesses were flooded but only the basement and the stock room of the coffee shop was affected. After the flood, the affected areas were cleaned and backflow valves were inserted in drains pipes. The property has a Landlord, but the director of the business is responsible for the management of the business premises. Currently, the business has 13 members of staff and records a turnover of about one hundred thousand pounds annually (£100,000 per annum).

The shop serves a range of drinks, including chocolate and cold beverages. Muffins and pastries, porridge, lunchtime sandwiches, rolls and yoghurt are also available. Take away orders are also available. The business is furnished with wooden tables and chairs with bright and light décor and large windows. The floor is finished with tiles, with the mat at the entrance. The coffee shop, the restaurant, and the guest house belongs to the hospitality and tourism industry. The hospitality industry's contributions to the 2015 UK Gross Domestic Product (GDP) and other direct and indirect contributions to the economy was adjudged significant (Oxford Economics, 2015). The flood risk map of the area where Case Study 3 is situated is presented in Figure 7.5; the actual case study area is situated at the centre of the map (the black ring).

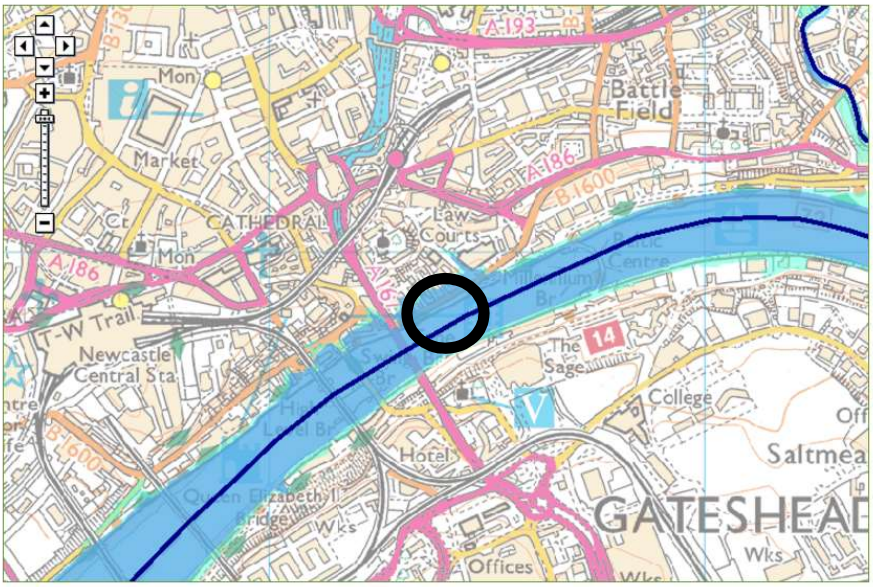

Figure 7.5 Flood risk map of the area where CS4 is located in Newcastle upon Tyne, UK (Environment Agency, 2016)

Legend – Flood Zone 3 ■; **Flood Zone 2** □; **Flood Zone 1** 'Areas without blue shading'; Main river – blue line ╱; the symbol ▣ represents flood defences; the symbol ▨ represents the areas that are meant to be protected by flood defences. See details under legends in Figure 7.2

7.7 Findings from case study organisations

The background information of the case studies has been discussed in section 7.6.2. The details of the stakeholders engaged in the organisations are presented in this section (Section 7.7), and findings from the respective case study organisations are presented in section 7.7.1 to section 7.7.4 with a summary presented in section 7.9. As previously stated, respondents from the case study organisations were interviewed on their recovery experiences, after that; they were requested to contribute to the refinement of the capability maturity model. The details of the stakeholders in the case study organisations are presented in Table 7.4 below.

Table 7.4 Background information on case study organisations and interviewees

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

Table 7.4 Background information on case and interviewees (Continued)

Respondent reference	Business type	Stakeholder engaged
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

As presented in Table 7.4, the stakeholders engaged are key persons in the respective organisations. They are all involved in the day-to-day administration of the businesses; they witnessed all the flooding their businesses have ever experienced, and four of the stakeholders engaged in the case studies are Landlords as well as business owners. Obviously, the respondents are suitable to contribute to the achievement of the aim of this study. The involvement of multiple stakeholders in each case study enhanced the robustness of the case study exercise. The participation of multiple stakeholders in each organisation provided the opportunity to compare submissions, and identify the differences and similarities in the understanding of flood resilience and flood resilience activities in the organisations.

Before presenting the specific contributions of the case studies to the refinement of the capability maturity model, the recovery experiences of the organisations from flood disasters are presented hereby. An account of their preparatory, response and flood recovery experience was used to identify and verify the applicability of the intermediate model to real life situations. The intermediate model contains the expert verified capability areas and the maturity level definitions (See Figure 5.5).

7.7.1 Findings from case study 1

7.7.1.1 Flood recovery experience

CS1 is a guesthouse that has experienced significant flooding in the past seven years. After the property got flooded in 2009, C1R1 and C1R2 (the property owners) who are also the business owners attempted to achieve a complete seal around the house. C1R1 said

"The staircase was taken out, all electrical wiring was made to drop down and everywhere was sealed up with waterproof adhesives as much as possible, existing suspended floors were replaced with impermeable concrete slab". – C1R1

CIR2 described the challenges faced while attempting to build a water-proof wall and still comply with building a regulation standard that requires the insertion of insulation in walls. The ability of the insulation to absorb water thereby dampening the wall made it unappealing. The intention was to install completely waterproof walls for flood resistance, but the insulation was also meant to aid indoor heat control by reducing heat loss in the property. A damp-proof membrane was inserted in floors, but wall insulation started from a height so as to prevent the insulation from wicking up water.

C1R1 and C1R3 stated that wooden skirting boards in the property were replaced with tiles and waterproof grouting, swimming pool adhesives was used for tiles and concrete waterproof floor. Some furniture in the guest house kitchen were raised and some parts were made detachable for easy conveyance to the upper floor during flood. All the activities were undertaking were done with due consultation with loss assessor, the insurance company and a construction firm. Also, C1R1 and C1R2 reported that during the repairs and retrofitting of the property, the construction firm workers were not turning up for work regularly. There were also some challenges with proper installation of doors, cracks on floor, installation of insulating material; all this affected the duration of recovery. C1R1 stated that the property got flooded in 2009 and this caused the business to remain shut for 51 weeks and 17 months in 2012. The property owner (C1R1 and C1R2) then made a significant investment of about £30,000 in waterproofing the property as described above. Beyond the earlier described resilience and resistance techniques adopted, non-return valves were used for pipes, and sewage pipes and sump pump fitted with generator was also installed.

The C1R1 and C1R2 also discussed their arrangement with neighbours; the arrangement was to ensure the installation and activation of flood gates and pumps acquired for resistance and resilience whenever the need arise (if more hands are needed). A perimeter wall of about 1.2m high was also built around the property to keep away water during flood. C1R1 stated that the repair and retrofitting activities were funded with personal savings and earnings from business and sale of other assets.

According to C1R1, a community foundation paid for the flood survey of some properties, but the surveys were done after people have returned to their properties. As a result, some suggested improvements could no longer be effected. Parts of their survey reports were also showing wrong figures, for example, the number of doors and openings in a property. All through the flood event and the recovery process, CIR1 and CIR2 (also the business owners) stated that they had several interactions with neighbours, builders, project manager, building surveyor, community groups, community flood group, government representatives, National Flood Forum, the planning board, insurance firm among others. This was necessary because they all have contributions to make to the process, for instance, the environment agency was providing updates on the environmental, river, and flood water condition, C1R1 said

> *"…the environment agency people kept updating us so we might protect some assets by pumping the water back to the river using individual and community pumps when the water rises to a level…The affected county council operates the community pump…" – CIR1*

After the flood, the insurance firm was contacted, loss assessment was done and other procedures followed before a project manager, the builders and other workmen were deployed for repair activities. CIR1 and C1R3 stated government and planning board representatives also came around to assess the effect of some planning decisions such as the perimeter walls, river system, drainage and culvert system. According to C1R1, several repairs and retrofitting activities were involved and the property was fit for reoccupation 17 months after the 2012 flood. C1R1 and C1R2 (the business owners) desired to sell the property but lamented the inability of the financial investment made on the property to increase its market value or make it attractive to potential buyers.

It is interesting to note that the December 2015 floods occurred after repair and retrofitting activities have been completed on the property. The property was dried out and ready for occupation within four weeks, though with outstanding limited repair works as against the 51-week closure period experienced after the 2009 flood and 17-month closure after 2012 flooding.

The preparation, response and flood recovery experience of CS1 revealed the prominent deployment of some capabilities contained in the intermediate capability maturity model (Table 7.3, see the full version in Appendix L). For example, the retrofitting activities

carried out on the property are attempts to enhance the flood resistance and resistance capabilities of the fabric of the property, undertaking the retrofitting activities implies that the business has an understanding of flood risk, has reviewed for a flood resilience scheme, and it has sourced fund for crisis response. Other visible capabilities are network strength – evident in the strength of interaction with several external individuals, bodies, groups and agencies, insurance coverage among others. These findings underline the importance and relevance of the capability areas. Presented in the next section (Section 7.7.1.2) are specific contributions of respondents in the case study to the review and refinement of capability areas and capability maturity level definitions.

7.7.1.2 Review of capability areas and maturity level definitions

C1R1, C1R2 and C1R3 were asked to comment and help refine the flood resilience capability maturity model that was being developed. During the discussions, the stakeholders were requested to comment on the remaining 20 capability areas that were left in the intermediate maturity model (model after expert forum review) and review the adequacy of the maturity level definitions. C1R1, C1R2, and C1R3 agreed with the ability of the capability factors to contribute to the resilience of the built environment. Further, they commented on some specific capabilities in the model, C1R1 emphasised the importance of getting competent personnel for flood survey, as well as hiring qualified professionals for retrofitting. C1R1 believed that it is about one's level of understanding (maturity), reference was made to the contact made to councils and professional bodies by her organisation while seeking professionals to engage. According to C1R1, getting qualified professionals to do a thorough survey and give property owners independent advice is also a challenge to many. CIR1 and C1R2 submitted that flood surveys should be done before or immediately after a flood; when done after, it will help property owners to know how best to protect their property while putting the property back in order.

While reviewing the other capability areas for flood resilience, C1R1 submitted that the presence of flood proof store is equivalent to having an upper floor in the property. A flood proof store will limit the extent of content damage and mess within the property thereby aiding the speed of recovery of the premises. C1R1, C1R2, and C1R3 submitted that a business that has access to upper floors would not require a flood-proof store since upper floors can serve the same purpose. Also, reference was made to the importance of acquiring suitable facilities as well as being able to set up the acquired facility and having it maintained as appropriate. C1R1 said

'I attended a flood fair with National Flood Forum this has enhanced our ability to set up the floodgates, pumps and the like and I also teach employees as well as neighbours. Some of these facilities are also tested at intervals'

The National Flood Forum, community flood foundations, non-governmental aid organisations (they provide funds to property and business owners), government building regulation representatives, building surveyors, builders and building materials supplier attended the flood fair. C1R1 said

'We had many people from different categories, people that give money, people that give advice, people that are needed for various kinds of support before, during and after flooding.'

CIR1 and C1R2 emphasised the need for maintenance and post-flood relationships, the need for regular meetings and communication with agencies, professionals and manufacturers for update and post-flood assistance. C1R1 stated that there is need to keep in touch with flood-related developments in one's community, this is because community decisions affect one's property flood resilience. C1R1 and C1R3 highlighted the importance of disaster scenario simulation to training and perfection of skills required for setting up flood protection facilities and ensuring that facilities are functioning. The importance of an organisation's financial status to property and business resilience was also mentioned. Further, insurance was identified as a relevant capability, but its non-availability to businesses through FloodRe in the United Kingdom made C1R1 and C1R2 request for its removal from the model. However, since it is applicable in other countries, insurance was left in the model.

Also, they supported the need for a flood-proof store and the movement of items to upper floors during flood.C1R1 submitted that upper floors can serve as a flood proof store, this will limit the extent of litter and speed up premises recovery, although going up and down the stairs is not easy. The other capabilities in the model were also adjudged appropriate for the model as they were perceived to have significant contributions to the flood resilience and recovery of the premises of a business and the business as a whole. C1R1 referenced her organisation's arrangement with neighbours and staff to protect the premises of the business whenever the need arise. They are permitted to make informed decisions in emergencies without a request for permission from superiors. All members

of staff and even neighbours know where necessary keys are, how flood barriers are fixed, how pumps are operated, the agency to communicate. C1R1, C1R2 and C1R3 identified the need to review happenings after flooding i.e. post-event review, analysis and management, they also submitted that crisis response budget as a capability is realistic but it might be difficult for small businesses to set funds aside for that purpose but larger businesses can. The inclusion of the ability to mobilise support and resources as a capability area was adjudged appropriate. It was stated that there might be a need for professional advice at some point, and there might be a need for other different forms of assistance. Further, there might be need for help with the installation of flood facilities, there might need to engage a community flood pump in saving a property. Also, items might have to be moved to a higher level so as not to litter the floor if flood water flows in, the aforementioned makes it important for a business to have good network strength.

Alongside the aforementioned, the need to adopt physical resistance and resilience measures was emphasised and this is evident in the magnitude of effort that the organisation has made on their business premises in this regards. C1R1, C1R2, and C1R3 requested that the capability maturity model should be made less wordy, simplified and easier to understand. All the respondents engaged in CS1 agreed with the maturity level definitions; no significant amendments were made. They stated that a standard and clear concept was involved in developing the model. Therefore, the progression of maturity from level 1 (Adhoc) to level 5 (Optimizing) is clearly visible.

7.7.2 Findings from case study 2

7.7.2.1 Flood recovery experience

CS2 is a restaurant; stakeholders in the organisation, C2R1, C2R2, and C2R3 were interrogated on the flood recovery experience of the business. The property housing the business is owned by another individual, but the business has the responsibility of managing the entire ground floor. The organisation gets flooded often, it got flooded about five times in 2015, but it was able to re-open within two days at a time. Clean up was completed on time on that occasion and these was made possible by the type of construction materials used on the premises and the ability of the organisation to network and mobilise equipment for drying, the use of flood gates and waterproof membrane under the floor.

Water seeped in through walls, but it was not as severe as it could have been without the existence of those measures and capabilities. Another flood survey was about to be done during the time this case study was conducted. C2R1 stated that though the business is insured (occupant insured content, landlord insured the property), the insurance firm has not paid for the last flooding event (5 months after the flooding). As a result, the business owners were left with no option than to use savings to repair the part that needed repairs on both the content and the property so as to return to business. On utility during flood events, emergency lighting comes on while all other services are turned off. C2R1 shared the idea of C2R2 by stating that there is no need for continuous availability of power aside from the emergency light since people will not patronise a flooded restaurant.

As part of the organisation's effort towards resilience, flood updates are continually monitored and advice is sort from national flood forum, community groups and relevant agencies. The frequency of flooding of the business and all other flood-related experiences caused the company to build the business premises with resilient materials, such that in the event of some magnitude of flooding, only cleaning will be needed. The premises are finished with a stone-cement floor with concrete and rubber membranes, part of the floor is finished with light brown tiles, the walls are made of stones (stonewalls), the furniture is low water absorbing wood, plastic and metal chairs are with cushion while the tables have low water absorbing legs.

According to C2R3 and C2R1, all employees are updated and have been trained on what to do when warnings that require actions are received. This has really helped the business to minimize damage during previous floods, C2R1 stated

> *'my employees are always in touch with me whenever I am away, they know how to respond to flood-related emergencies, flood resilient materials have been used to finish the premises, but we still make sure entry points are blocked to minimize inflow of debris and reduce clean up tasks'*

Cleaning and restoration activities were executed by the owner and the staff of the organisation after the last flood (December 2015), the company only had to source some facilities including dryers and dehumidifier from outside. C2R1 and C2R2 emphasised the advantage of knowing where to source for facilities and necessary assistance, their inability to connect with appropriate persons and more damage to the property during the

previous flooding delayed business recovery. According to the respondents, relatively, the recovery process was faster after the last flood event (December 2015), this was attributed to the lessons learnt from previous experiences as well as the knowledge acquired from previous recovery exercises. The general response was swift, mobilisation of drying equipment was fast, decision making and other activities were quick. The cleaning was done in-house because the magnitude of flood impact was not much, the floor is finished with stone on a layer of concrete placed on a layer of rubber membrane. The organisation only had to hire big heaters and dehumidifiers. The restoration of the property took about four months.

Respondents in the case study were satisfied with the last recovery experience, although the speed can be better especially if funds for cleaning, repair operations and reopening publicity can be readily available. The respondents stated that successful return to business would guarantee continuous cash flow and readiness of the organisation for recovery from future flood attack. Presented in the next section (section 7.7.2.2) are the specific contributions of the respondents in the case study to the verification of capabilities and the overall refinement of the capability maturity model being developed in this study.

7.7.2.2 Review of capability areas and maturity level definitions

After reviewing the recovery process of the organisation, the business owners were asked to contribute to the refinement of the capability maturity model that is being developed. It was not difficult to relate the activities narrated in the recovery process with the content of the capability model. Case study respondents – C2R1, C2R2, and C2R3 – agreed with all the capability areas and the level definitions but emphasised the importance of the physical characteristics of the property to the flood resilience of the property as well as the business in general.

Commenting on each of the capability areas, C2R1 submitted that understanding of flood risk is not as important as the actions inspired by the understanding, though understanding remains the starting point. Concerning flood survey of properties, C2R3, C2R2 and C2R1 agreed to its importance, and that is why the organisation is planning to conduct another flood survey. Since water goes through the floor, wall, doors and other openings, it is important to carry out a flood survey and decide how to stop water entry. The organisation also has flood protection facilities, C2R1 stated that the last time he was away, members

of staff set up the flood barriers, initiated premises protection steps like lifting items off the ground, blocked all openings and ensured that physical damage is limited to the barest minimum. The importance of the physical characteristics of the property to flood resilience cannot be over emphasised. C2R1 and C2R3 stated that, that was why the floor, wall, ceiling, furniture was built in a flood resilient manner (see Section 7.7.2.1 for description).

On maintenance and post-flood management scheme, the organisation agreed to the need for an arrangement, but since only floodgates are the flood-related facilities owned by the business, the organisation believed that it could maintain the gates itself. About simulation of flood scenario, C2R1 stated that it is not done as a routine, rather they monitor the river level. C2R1 said

> *'the river level is 3.80m, once the river level rises to about 3.60m – 3.70m we make our flood arrangements, with that we have enough time to fix everything, and the more we do it, the faster we became'- C2R1*

The cash flow of an organisation was identified as a crucial capability; this is because the majority of flood resilience activities depend on the availability of fund and the cash flow pattern of the business will determine if the business will be able to fund the flood resilience efforts or not. The importance of the cash flow management capability of an organisation was also identified to be important. Also, insurance is perceived to be a significant capability, although the insurance company is yet to settle the claims made on the last flooding event.

C2R1 stated that the business currently does not have a flood-proof store and only has access to ground floor alone, C2R2 and other respondents agreed with the importance of having a flood safe or a raised store space to keep some essential items. In previous flood situations, items ae usually saved from floods by placing them on tables and other raised surfaces. According to the respondents, documents are currently kept off the property to avoid flood damage. Crisis response budget was highly appreciated as a capability area by C2R1 and C2R3; the company has decided to start putting money aside for flood recovery purposes in the future. Decision making is still significantly centralised as a result of the size of the organisation; employees often report almost all activities to the manager C2R1, C2R1 will then assign duties. This approach could be effective if there's

enough time to make flood arrangements otherwise it will be counterproductive. Other capabilities in the model were verified and approved as capabilities for enhancing flood resilience.

Concluding the verification exercise, C2R1 and C2R3 submitted that quick recovery can only be achieved if physical damage to the property is limited and there is the timely hire of necessary recovery facilities and services. Reference was made to the speedy arrival of the insurance company and the quick deployment of dehumidifier and dryers for drying the business premises after the December 2015 flood.

On capability level definitions, respondents demanded the simplification of the model, preferably as listed points. This is expected to enhance the ease of use of the model. The specific maturity characteristics were not changed; explanations were only provided on their meanings. It should be noted that respondents in CS1 also requested for the simplification of the model. As a result, the capability level characteristics from level 1 (Ad hoc) to level 5 (Optimizing) were restructured after the four case studies as presented in Table 7.7, scoring checkboxes were after that introduced as presented in Table 7.8.

From the discussions in the case study, respondents in the organisation acknowledged the suitability of the model; they believe it will help MSMEs to identify what has been done and what needs to be done to achieve a flood disaster resilient built environment. The model was requested to be simplified for ease of application. The availability of structure and the readiness of micro and small businesses to make use of formal evaluation methodology like a capability maturity model is a point to consider further. This is because it was discovered that the business bothers less about formal assessment and does not have the structure to appreciate the importance of such document fully. It should, however, be noted that business might not appreciate a concept until its rewards and benefits become clearer. A well-thought mode of use, therefore, has been developed; this involves the engagement of someone who understands the model to support the business owners and property owners while filling the appropriate boxes in the model (This was done and reported in section 7.10). Also, an abridged version might also be considered for micro businesses as an option in future.

7.7.3 Findings from case study 3

7.7.3.1 Flood recovery experience

Case study 3 (CS3) is a retail outlet that has experienced flooding several times. Stakeholders in the organisation (see Table 7.4) before contributing to the model that is being developed reviewed the recovery experience of the organisation. The organisation was flooded in 2009 and got flooded again in December 2015. C3R1, C3R2 and C3R3 (the stakeholders – see Table 7.4) emphasised the importance of the knowledge acquired from previous flood experiences and understanding of flood risk to the quick recovery of the business premises and the business the last time it flooded. C3R1 stated

> *'we knew what to do, we knew how to engage the insurance company, we knew how to arrange for premises clean up, so the flood did not have a lasting impact on us.'*

All necessary arrangements including cleaning up and repairs were swiftly done. The business started trading within 36 hours after the flood; all necessary cleaning was quickly completed. C3R1 stated that their insurance firm offered to send a clean-up team, but they were afraid of the team disposing of many of their items in the name of being spoilt or contaminated. Some houses and businesses already have some of their items disposed of by their insurers. The respondents, C3R1 and C3R3, also identified the suitability of their business relationship with their insurance company. The business owner (also the Landlord) identified his understanding of the insurance process and expectations from his insurance company as an advantage.

C3R1 stated that he was able to lay out plans and present such to his insurers, the insurers' subsequent approvals of such made smooth their relationship. He is also familiar with the insurance process and knew whom to contact for repairs and other supports because of previous flooding experiences.

> *'We knew what to expect; they came with loss assessor, I engaged a loss adjuster, I knew what not to accept, I knew what I wouldn't let them do for me (the business)'- C3R1*

Also, his construction experience assisted him in selecting the right personnel to engage in restoring his property. Everything on the ground floor was reportedly damaged i.e. the floor finish, wall finishes, skirting, doors, and others. Humidity also affected the

wallpaper and fittings on the first floor. After the last flooding event in December 2015, the business installed sump pumps to help in managing the volume of water that is retained in the property. The goal is to ensure that the rate at which water flows into the property is lower than the speed at which it is evacuated. Alongside the sump pump, flood barriers were installed so as to limit future damage from disasters. All new facilities acquired by C3 were installed to British Standard and tested. There were no contradictions in the account of C3R1 by C3R2 and C3R3.

It should be noted that the ability of the built environment to withstand, absorb or resist flood can significantly reduce the overall impact of disasters on businesses. This is because a property is expected to protect what it shelters, whenever it fails, there are consequences on both the property, the content (businesses facilities) and of course the business. Since businesses cannot operate in damaged properties, it is believed that if damage to properties and business facilities can be limited, the speed of return to business will be faster for all businesses.

7.7.3.2 Review of capability areas and maturity level definitions

The stakeholders in CS3 were interrogated on capability areas and were asked to contribute to the refinement of the intermediate capability maturity model. The stakeholders (C3R1, C3R2 and C3R3) confirmed the validity of the capability areas in enhancing the speed of recovery of properties from flood. They emphasised the importance of awareness and understanding of flood risk and how the understanding of C3R1 strengthened by previous flood experiences, assisted the organisation in dealing with insurance firms and knowing what to do and whom to contact (Reference was made to the account of recovery experience given earlier). C3R1 emphasised the importance of having a flood proof store; their first floor served as a flood proof area for their stocks and computers, this reduced damage to stocks prevented the loss of business data and limited the amount of litter that could have delayed premises cleaning. Mobilisation of support and facilities was also described as a key factor.

C3R1 described the initial challenge of the organisation with sourcing dehumidifiers as well as electricians needed to certify that everything about electricity was okay after the previous flood. Before the last flooding occurred, all the plugs have already been moved above flood level (to a higher level), so fuses were not taken out by electricity company since it was not affected by floodwater. Other businesses had problems finding an

electrician to officially approve (issue certificate) the wellness of electrical services before power mains is reconnected. The business also utilised the contacts gotten from previous flooding experiences to resolve other challenges. Also, the business acquired generator to serve as an alternative power source in case of future floods and also a power source for the pump acquired. Since sockets and cables have been raised high up above the ground, there won't be any fear of shock. The importance of funds availability was also mentioned; it was stated that if the insurance firm has delayed payments, getting funds for recovery activities might be difficult. This underlines the importance of savings and crisis response budget.

All respondents confirmed the appropriateness of other capabilities in the maturity model. Flood survey has been done by the organisation, a flood scheme was planned and executed, relevant facilities which include floodgates and sump pumps were acquired, training were attended so as to learn more about flood protection and operation of flood facilities. Decision making, post-event review and all other capabilities were adjudged suitable capabilities for enhancing built environment flood resilience. C3R1 and C3R2 firmly supported the simulation of flood scenario; they stated that since the facilities are not going to be used in probably up to once many years, it has to be regularly tested alongside other flood plans and procedures. CS3 interviewees agreed with the structure of the model and its contents, the progression of maturity was noticed, the comprehensiveness of the model was appreciated. No significant amendments were made on the model except that the flood proof store needs to be merged with the physical characteristics of the property as a capability model. This is because the organisation used a higher floor as a flood proof compartment but stated that a separate flood proof store could be used by businesses operating on a ground floor alone. A C3R1 recalled how he moved the computer holding the business records to a higher floor before the flood. The maturity grading concept was adjudged clear and scientific.

7.7.4 Findings from case study 4

7.7.4.1 Flood recovery experience

CS4 is a coffee shop, a review of recovery from previous flood experience was also undertaking. The business' flood experience was not as huge as the experience of the three other case organisations. The main premises of the business were not seriously flooded but the stock room at the basement. According to C4R1, flood water entered the

section of the business via a rise through the drain and got the area flooded. The stock room was formed with a concrete wall. As a result, no serious damage was recorded on the premises except for some contents. The flood water was pumped out and backflow valves were fitted in pipes so as to prevent reoccurrence backflow of flood water through the drain. The business resumed operation just after a day. The interviewees in the organisation were also interrogated on the capability areas and were also requested to contribute to the refinement of the capability model, contributions from the case study is presented below.

7.7.4.2 Review of capability areas and maturity level definitions

The understanding of flood risk to property and the business influenced the extent of contributions and comments of the respondents (i.e. C4R1, C4R2, C4R3) on the capability areas and the model. More explanations had to be done before they could comment on the contents of the model. There are limited efforts towards attaining capabilities aimed at minimising damage from flood disasters. There are very limited plans for flood resilience. The respondents agreed with the validity of the contents of the model (i.e. the capability areas and maturity progression methodology), but there are only limited efforts aimed at strengthening the organisation in these regards.

It was evident from the case study interactions that only the businesses that have experienced flooding more than once or have lost funds to property damage, flood repair, and significant business stoppage have better plans and understanding of resilience and the need for resilience. It was also clear that the top-ranking stakeholders like the property owners, business partners and managers have a firm grip on the understanding of the resilience concept, the need for it, and capability enhancement efforts towards resilience. They were also able to explain the recovery process and activities much more than any other person engaged in the organisation. More can still be done towards entrenching the concept in all stakeholders in organisations, especially, the organisations that are yet to experience flooding.

It is interesting to note that case study 4 (CS4) introduced a different perspective compared to what was obtained in CS1, CS2, and CS3. Since there has not been any huge impact of flood on the organisation, despite the exposure of the business to flood risk, stakeholders in the organisation have limited understanding of the need for premises resilience to flooding. Obviously, CS4 represents a different category of MSMEs; this

underlines the importance of having to take some organisations through the meanings of capability areas for built environment flood resilience for them to understand and appreciate the capability maturity model.

7.8 Cross-case analysis

Table 7.5 presents an excerpt from the interactions in the case studies, the excerpts are statements by case study interviewees showing agreement and suggested amendments to the contents of the capability maturity model. Table 7.5 provides an opportunity to compare the submissions in the individual case studies for the purpose of verification, affirmation, suggestions for improving the capability maturity model.

Table 7.5 Summary of contributions to model refinement in case studies (Statements showing agreement and suggested amendments to the model)

Code ref	**Key capability areas**	Case study 1	Case study 2	Case study 3	Case study 4
KCA1	Awareness and understanding of flood risk to property	We have regular interactions with neighbours, builders, project manager, building surveyor, community groups, community flood group, government representatives, National Flood Forum, the planning board, insurance firm among others.	Flood updates are continually monitored and advice is sort of national flood forum, community groups and relevant agencies. Understanding of flood risk is not as important as the actions inspired by the understanding, though understanding remains the starting point.	We have the knowledge of flood risk. It was acquired from previous flood experiences; this has expanded our understanding.	We are aware, but we have no special plans for flood resilience.
		The need for capability was confirmed.	The need for capability was confirmed.	The capability is needed.	The capability is needed.
KCA2	Planning or review for a flood resilience scheme	Business owners attempted to achieve a complete seal around the house – Flood scheme adopted.	The frequency of flooding of the business and all other flood-related experiences caused the company to build the business premises with resilient materials.	A flood scheme was planned and executed. The business acquired generator to serve as an alternative power source in case of future floods and also a power source for the pump acquired.	No special plans, they only did what they were told to do when the business got flooded. .
		The capability is needed.	The capability is necessary. Remove planning from name.	The capability is required. Change to Review for a flood scheme.	The capability is required.
KCA3	Survey of property	A community foundation paid for the flood survey of some properties. The capability is needed.	Another flood survey was about to be done during the time this case study was conducted. The capability is needed.	The organisation has done flood survey. The capability is needed.	Done
		The capability was confirmed.	The need for capability was confirmed.	The capability is required.	The need for capability was confirmed.

(Note: See the source of the code references in this table in Table 7.2)

Table 7.5 Continued (Statements showing agreement and suggested amendments to the model)

Code ref	**Key capability areas**	Case study 1	Case study 2	Case study 3	Case study 4
KCA4	Acquisition and installation of relevant products	Non-return valves were used for pipes. Sewage pipes and sump pump with generator was installed.	We sought help from a community group and flood forum. We now have floodgates and clear flood arrangements.	Alongside the sump pump, flood barriers were installed to limit future damage from disasters. All new facilities acquired were installed and tested to British Standard. The capability is needed.	The floodwater was pumped out, and backflow valves were fitted in pipes to prevent reoccurrence of backflow.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA5	Maintenance and Post-flood management scheme relationships	There is need to keep in touch with flood-related developments in the community.	Since only floodgates are the flood-related facilities owned by the business, the organisation is in charge of maintenance.	We can manage what we have ourselves.	No standard plans, though it is necessary.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA6	Operation of acquired facilities	The arrangement was made with neighbours to ensure that the installation and activation of flood gates and pumps. Approved.	My employees know how to respond to flood-related emergencies. The capability is needed.	Training was attended so as to learn more about flood protection and operation of flood facilities. The business acquired generator to serve as an alternative power source in case of future floods and also a source of energy for the pump acquired.	Agreed
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.

(Note: See the source of the code references in this table in Table 7.2)

Table 7.5 continued (Statements showing agreement and suggested amendments to the model)

Code ref.	**Key capability areas**	Case study 1	Case study 2	Case study 3	Case study 4
KCA7	Organisation of disaster scenario simulations	I also teach employees as well as neighbours. Some of these facilities are also tested at intervals for the perfection of skills and to ensure the functioning of facilities	Frequent set-up due to water level rise has improved our abilities and confirm the state of the facilities and our strategy. This serves as our simulation. We set up once water level rises	Since the facilities are not going to be used in probably up to 5 years, it has to be regularly tested alongside other flood plans and procedures	Agreed
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA8	Turn-over, cash flow and customer management	Repair and retrofitting activities were funded with personal savings and earnings from business and sale of other assets. Approved.	Flood resilience activities depend on the availability of fund, and the cash flow pattern of the business will determine fund availability.	Important. Volume depends on the size of business.	Agreed. We spent on cleaning and backflow prevention.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA9	Insurance adequacy and management	Insurance is not available to businesses through FloodRe in the United Kingdom. Though important, remove from list.	Business is insured (occupant insured content, landlord insured the property)	Understanding of the insurance process and expectations from insurance company is an advantage	Insured.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA10	Utility and communication system	We have alternatives.	Emergency lighting comes on while all other services are turned off. That is all that is needed. No one will patronise a flooded restaurant.	All sockets have been raised; we have a generator.	Agreed, though the business did not close for long.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.

(Note: See the source of the code references in this table in Table 7.2)

Table 7.5 continued (Statements showing agreement and suggested amendments to the model)

Old code ref	**Key capability areas (New ref. code)**	Case study 1	Case study 2	Case study 3	Case study 4
KCA11	Flood proof store for stock and contents	The presence of flood proof store is equivalent to having an upper floor in the property. Merge with physical characteristics of property (KCA20).	No flood-proof store, we should have, however.	The first floor served as a flood proof area for their stocks and computers, this reduced damage to stocks, prevented the loss of business data and limited the amount of litter that could have delayed premises clean. Merge with physical property characteristics.	It is necessary, though the business does not have.
		Merge with physical characteristics of property (KCA20).	Merge with physical characteristics of property (KCA20).	Merge with physical characteristics of property (KCA20).	The need for capability was confirmed.
KCA12	Record/Business data management	We moved the computer, files and similar items upstairs.	Documents are currently kept off the property to avoid flood damage	We moved our items including PC and files	A good management system can help quick recovery.
		The need for capability was confirmed. Change name to electronic record management.	The need for capability was confirmed. Name should suggest its electronic record. Level definitions are okay.	The need for capability was confirmed.	The need for capability was confirmed.
KCA13	Management of disruption to operation	Swift to act. It is important.	The river level is 3.80m, once the river level rises to about 3.60m – 3.70m we make our flood arrangements	The business monitors continually and responds immediately.	Needed
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.

(Note: See the source of the code references in this table in Table 7.2)

Table 7.5 continued (Statements showing agreement and suggested amendments to the model)

Old code ref	**Key capability areas (New ref. code)**	Case study 1	Case study 2	Case study 3	Case study 4
KCA14	Crises Response budget	Repair and retrofitting activities were funded with personal savings and earnings from business and sale of other assets. Approved.	Business owners were left with no option than to use savings for repair of damaged parts. We will start putting money aside for flood recovery purposes in the future	Insurance benefit helped us, if not for that recovery would be difficult. Saving for the rainy day is ideal.	Important
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA15	Paper records management	Ours is kept in easily detachable drawers. Records are key to recovery paper works.	Documents are currently kept off the property to avoid flood damage	We moved our items including PC and files	Needed
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA16	Decision making without recourse to superior in emergency situations	They are permitted to make informed decisions in situations of emergency without request for permission from superiors.	'My employees are always in touch with me whenever I am away; they know how to respond to flood-related emergencies.	Decision making is a critical capability for enhancing built environment flood resilience	Needed
		The need for capability was confirmed. Use less words to describe the capability.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA17	Definition of roles and responsibilities and how it changes in disaster situations	We know our roles, we also alerted neighbours in case we need help with some things during emergencies.	Employees often report almost all activities to the manager before duties are assigned.	Ít is clearly stated. We understand our flood arrangements.	Needed, though no formal review was done.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.

(Note: See the source of the code references in this table in Table 7.2)

Table 7.5 continued (Statements showing agreement and suggested amendments to the model)

Code ref	Key capability areas	Case study 1	Case study 2	Case study 3	Case study 4
KCA18	Post event operation, analysis and management	There's need for a review of happenings after flooding.	There were post flood discussions.	Post-event review is an important capability for enhancing built environment flood resilience	Needed.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	Need for capability was confirmed.
KCA 19	Network strength	Activities were undertaken with due consultation with loss assessor, the insurance company and a construction firm.	The ability of the organisation to network and mobilise equipment for drying and dehumidification sped up the last recovery. Flood updates are continually monitored, and advice is sort from national flood forum, community groups and relevant agencies.	After the flood before the last, there was an initial challenge with sourcing dehumidifiers as well as electricians needed to certify that everything about electricity was okay	Needed.
		The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.	The need for capability was confirmed.
KCA20	Physical resilience of the fabric and structure of property	The staircase was taken out, all electrical wiring was made to drop down and everywhere was sealed up with waterproof adhesives, existing suspended floors were replaced with impermeable concrete slab.	Clean up was completed on time on that occasion, and these were made possible by the type of construction materials used on the premises. Floodgates and waterproof membrane under concrete floor, tiles and stone wall.	We now have flood gates; floors have been tiled, we have a sump pump with a generator. We are not planning a complete seal but to make sure that flood water inflow is less than outflow.	The stock room was formed with a concrete wall. As a result, no serious damage was recorded on the premises except for some contents
		The need for capability was confirmed. Name should reflect not just resilience but adaptation and resistance options. Merge KCA11 with this.	The need for capability was confirmed. This can be called physical characteristics of the property. Merge KCA11 with this.	The need for capability was confirmed. Modify name to cover the state of the property. Merge KCA11 with this.	The need for capability was confirmed.

(Note: See the source of the code references in this table in Table 7.2)

Table 7.5 continued (Statements showing agreement and suggested amendments to the model)

Target	**Purpose**	Case study 1	Case study 2	Case study 3	Case study 4
Model	Maturity level characteristics refinement and general comment on model	A standard and clear concept (capability maturity methodology) were engaged in developing the model. Therefore, the progression of maturity from level 1 (Adhoc) to level 5 (Optimizing) is clearly visible. The model should be made less wordy/simplified.	Capability level definitions should be simplified, preferably as listed points. This is expected to enhance the ease of use of the model. The model was simplified as requested (see Table 7.7).	The progression of maturity is noticeable; the comprehensiveness of the model was appreciated. No significant amendments were made on the model except that the flood proof store needs to be merged with the physical characteristics of the property as a capability area.	Adequate.
		Adequate	Adequate	Adequate	Adequate

7.9 Summary of findings from case studies

The comments of respondents from case organisations confirmed the comprehensiveness and appropriateness of the model. Respondents' specific comments have been presented and discussed in section 7.7. Some captivating comments across the case studies towards improving the model are presented in quotes below. Responses to each comment are presented directly in front of each:

Table 7.6 Common comments across case studies

Code ref	Capability area	Comment	Response
KCA9	Insurance adequacy and management	*Insurance can contribute to the resilience of the built environment, but the variation in insurance administration from country to country should be noted, especially the non-inclusion of businesses in the FloodRe Scheme in the United Kingdom" – CS1 and CS2*	This was noted. It will be communicated to potential users of the model for individuals' consideration.
KCA11	Flood proof store	*'The inclusion of a flood-proof store as a capability area is more relevant to businesses situated on the ground floor' – CS1, CS2, and CS3* *'Flood Proof store might not be made to stand alone; it can be made a part of physical characteristic of property' – CS1, CS2, and CS3*	This was noted and based on another comment; the capability area was eventually merged with another capability area. This was accepted, and as a result, the 20 capability areas brought from expert forum review became 19 after case study.

Table 7.6 Common comments across case studies (Continued)

Code ref	Capability area	Comment	Response
KCA20	Physical resilience of the fabric and structure of property	*'The place of the physical characteristics of the building (i.e. resistance and resilience measures) and understanding of flood risk to property should be made more prominent among the capability areas in the model.'* *– CS1, CS2, and CS3* *CS1, CS2, and CS3*	Noted. More details were added to the definition in each maturity level.
General Comment	General Comment	*'Although all the capability areas are important to property resilience, some might not be available in some business organisations' – CS1, CS2, and CS3*	This simply implies that such organisations will have a poor rating in respect of such capabilities.
General Comment	General Comment	*'The model should be made to an easily manageable size as much as possible' – CS1, CS2, and CS3*	The text in the final model was reduced, codes were removed, and level definitions are presented as numbered items.

There was agreement among the stakeholders engaged about the comprehensiveness, practicality and potential use of the model for evaluating capability maturity for built environment resilience. In addition to the comments aimed at improving the model, respondents from case study organisations commended the comprehensiveness of the model and the inclusion of important capabilities. The model is said to contain adequate criteria and reasonable descriptions for evaluation. It can be concluded from the responses obtained from the case studies and other previous responses that the model is suitable. It is very useful in evaluating the maturity of capabilities for built environment resilience in business organisations.

The development of the capability maturity model began with 26 capability areas extracted from literature; the capability areas were reduced to 20 after expert forum review, this was then consolidated to 19 at the end of case studies. The resulting capability

evaluation model which contains 19 capability areas and capability level definitions ranging from level 1 (Ad hoc) to level 5 (Optimising).

Table 7.7 shows a sample of the capability maturity model before the evaluation checkboxes were introduced while Table 7.8 shows the final resilience capability maturity evaluation model (evaluation checkboxes have been introduced) The checkboxes will aid the use of the model during evaluation. Check boxes 1 to 5 represents sub-level definitions for each capability area in each maturity level, they are meant to be ticked if an assessor believes that a particular level definition suits the organisation that is being assessed. An assessor is expected to insert the overall score on a capability area. The overall score will be the maturity level selected for that organisation on a capability area, this is decided by using the main description of each maturity level for each capability area, the score is then added to the number of the sub-criteria selected. Each sub-criterion is scored 0.2 (See Appendix R for a sample evaluation).

The final capability maturity model (Table 7.8) contains 19 capability areas with capability level characteristics of each one across five maturity levels (1- Adhoc to 5-Optimising). Each maturity level has main and sub-level characteristics; the characteristics/definitions are utilised as explained in the preceding paragraph.

Table 7.7Sample of Capability Maturity Model before the evaluation check boxes were introduced (After case studies)

SN	Key Capability Areas(KCA)	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.	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.	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.	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.	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. 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	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	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	1. High recognition of importance 2. The need for processes/tasks are highly recognised 3. Related processes are supported with stated means of improvement stated 4. Tools, database and records are available for statistical analysis and managerial decisions 5. Capable of identifying risks	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

Table 7.8 Final Built Environment Flood Resilience Capability Maturity Model (After case studies)

SN	Key Capability Areas (KCA)	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 7.8 continued

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
2	Review for a flood resilience scheme	Engage in very little planning with no centrally coordinated support function. No standardised procedure and poor knowledge of flood schemes. 1 2 3 4 5 1. Engage in very little planning 2. Feeble centrally coordinated support function 3. Very weak standardised procedures 4. Organisation pays lip service to related activity or processes 5. Little understanding of flood resilience schemes and related activities Overall score	Staffs recognise importance, but they are only discussed verbally (within the team(s)). Senior staff or owner understands the importance of review for flood scheme, but resources are not allocated. 1 2 3 4 5 1. Individual make an effort but they are not shared 2. Importance is recognised, but resources are not allocated 3. Simple tools and templates accessible 4. Importance is also recognised by others but simply for discussions 5. Heavy reliance on knowledge of individuals Overall score	The importance of flood scheme is recognised. Standard processes are followed to achieve the goals relating to review of schemes and actions are coordinated with stakeholders. 1 2 3 4 5 1. Importance is recognised 2. Tools, templates and relevant databases are available 3. Standard processes are established and improved overtime 4. Actions are coordinated with stakeholders 5. Related trainings are attended Overall score	Importance and need for a review scheme are highly recognised. Largely supported even with statistical or managerial analysis. 1 2 3 4 5 1. High recognition of importance 2. Supported with stated means of successful execution 3. Focus is also on improvement of process 4. Tools, database and records are available 5. Statistical and managerial analysis is done Overall score	High level of awareness. High recognition of importance and processes are kept up to date. Quantitative approaches are used for analysis of variations. 1 2 3 4 5 1. Very High recognition of importance 2. Understand internal and external variations 3. Quantitative approaches are used 4. The organisation is up to date 5. Active use of tools and databases Overall score

Table 7.8 cont'd

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
3	Survey of property	The need for the pre-crisis survey is unclear. Processes are chaotic, and plans are abandoned. 1 2 3 4 5 1. Highly reactive, need for pre-crisis survey is unclear 2. Activities and processes are chaotic including selection of professionals 3. Individuals act with no central coordination 4. Budgets are exceeded, or no clear budget is prepared 5. Documented schedules are abandoned Overall score	Individuals or departments only make attempts. Senior staff or owner understands, but funds are not allocated. 1 2 3 4 5 1. Individuals or departments or units makes effort 2. Senior Manager/Owner recognises the importance 3. Resources are not allocated 4. Importance is recognised 5. Heavy reliance on knowledge and effort of individuals Overall score	Importance is recognised, and relevant actions are coordinated with stakeholders (professionals and government) 1 2 3 4 5 1. Importance is recognised 2. Relevant actions are coordinated with stakeholders 3. Capable of deploying needed resources – professionals 4. Databases and relevant records are accessible to the organisation 5. Standard procedures are followed Overall score	High recognition of the need for a survey. Supported with an outline of means for successful execution. 1 2 3 4 5 1. Importance is highly recognised 2. Survey related activities are highly supported 3. Means of successful execution are stated 4. Improvement plans on related processes exist 5. The process is consistent and systematic Overall score	High level of awareness. High recognition of importance. Related processes are kept up to date. 1 2 3 4 5 1. High level of awareness 2. Importance is highly recognised 3. Processes are kept up to date and reflect recent needs 4. Active use of information and knowledge of what to expect during survey 5. Adequate access and active use of tools and databases Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
4	Acquisition and installation of relevant products	Limited knowledge on the need for the acquisition and deployment of resilience/resistance products. Moreover, no attempt to identify a benefit. 1 2 3 4 5 1. Basic understanding of the need for relevant products 2. No clear attempt to identify more benefits yet 3. No record or database of related products acquisition 4. No clear communication with professionals/suppliers yet 5. The process is chaotic when attempted Overall score	Individual divisions make an effort. Senior staff or owner recognises the need, but no funds are allocated. 1 2 3 4 5 1. Senior Manager/Owner/staff recognise the importance 2. Individuals or departments have plans 3. Resources are not allocated 4. Heavy dependence on the effort of individuals 5. Pockets of good practices Overall score	Importance is recognised, and related actions are coordinated with suppliers, professionals. 1 2 3 4 5 1. Importance is recognised 2. Acquisition activities are coordinated with stakeholders 3. Purpose and function of products/technologies are known 4. Product evaluation is centrally coordinated 5. Mid-term focused plans. Overall score	High recognition of importance. The need for this task is highly recognised and supported with clear plans for successful execution. 1 2 3 4 5 1. Need is highly recognised 2. Acquisition is treated with high importance 3. High management support 4. Clearer plans for successful execution (coordination with stakeholders) 5. Clear plans for improvement in technology acquired Overall score	Very high level of awareness and recognition of importance with active use of information tools and database. 1 2 3 4 5 1. Very high importance is attached 2. There is standard procedure for keeping process and records up to date 3. High level of product awareness 4. Active use of information and tools 5. There is an informed use of relevant databases Overall score

Table 7.8 continued

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
5	Maintenance and Post-flood management scheme relationships	No centrally coordinated support, no stable environment. Related processes are chaotic. 1 2 3 4 5 1. No centrally coordinated support but might be done 2. Related efforts are chaotic 3. No formal process but can emerge 4. Slightly aware of the need for such relationship 5. No supportive, stable environment Overall score	Stakeholders are involved, pockets of related good practices with high dependence on the efforts of individuals 1 2 3 4 5 1. Appropriate stakeholders are engaged 2. There are pockets of good practices 3. Importance of post scheme relationship is known 4. High reliance on individual efforts 5. Need for such relationship is only verbally discussed across departments. Overall score	Strong support exists, there is coordination with stakeholders. 1 2 3 4 5 1. Importance is recognised 2. Strong support by management 3. Better coordination with internal and external stakeholders 4. Relationships are consciously renewed and improved 5. Reasonably better relationship Overall score	Pre and post-flood relationships are highly recognised and supported. 1 2 3 4 5 1. High recognition of importance 2. Highly supported by the management 3. Clear guideline on post-flood relationships with suppliers, installers and professionals 4. Relationships are improved overtime. 5. Strong in-house link community resource Overall score	High recognition of importance with adequate support functions. Fully integrated best practices. Top managers are exemplars 1 2 3 4 5 1. High recognition of importance 2. Process, products and people records are kept to date with active use of information 3. Sound and continually lubricated relationship with stakeholders 4. Fully integrated best practices 5. Leverage strategic alliances and network with community and institutions Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
6	Operation of acquired flood facilities	No formal processes or arrangement for operation and maintenance of installed facilities. The organisation pays lip service to the activity or process. 1 2 3 4 5 1. No formal processes but can act when needed 2. No supportive, stable environment but can emerge 3. Organisation pay lip service to task 4. Related successes cannot be sustained 5. Related arrangements are short focused Overall score	There is an individual arrangement for maintenance. Organisations experiment on processes planned. 1 2 3 4 5 1. Individuals have knowledge and plans, but they are not shared 2. Organisation experiments on processes planned 3. Roles are clear and achievable, with measurement strategies 4. Key individuals demonstrate track record with hopes of repeating earlier success 5. Basic processes and basic generic training exist. Overall score	Processes are described in standards. Related actions are coordinated with stakeholders. 1 2 3 4 5 1. Standards are documented and understood 2. Proactively managed 3. Mid-term focused plans 4. Actions are coordinated with stakeholders 5. There is training programme for capacity development Overall score	Activities are supported by stated means of improvement. Strong team orientation. 1 2 3 4 5 1. Processes are highly supported and improved 2. Strong teamwork with relevant parties 3. Human capacity building is high 4. Consistent and systematic approach 5. High recognition of need Overall score	There is focus on continual improvement with close links with stakeholders. 1 2 3 4 5 1. Fully integrated best practices 2. Sound relationship with stakeholders 3. Strategic alliance and institutional arrangements 4. Continual improvement through innovation and technological advancement 5. Records are kept up to date and lessons are fed back into the system. Overall score

Table 7.8continued

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
7	Organisation of disaster scenario simulations	Highly reactive, very little preparation or none is done. 1 2 3 4 5 1. Engage in very little planning 2. No centrally coordinated task but it can emerge 3. Individuals act, no institutional coordination 4. Attempted scenario simulation is chaotic 5. Organisation pays lip service to the activity or process Overall score	Organisations are reactive. Limited planning. 1 2 3 4 5 1. There are personal plans in place 2. The personal plans are not shared 3. Large dependence on historical practice 4. Organisation experiments on processes planned 5. Weak ability as a team Overall score	There is formal planning. 1 2 3 4 5 1. Formal simulation and planning 2. Proactively managed rigorous process 3. Mainly inward looking 4. Coordinated training is done during simulations 5. Relevant actions are coordinated with stakeholders (e.g. neighbours). Overall score	Formal planning is supported with stated means of improvement. 1 2 3 4 5 1. Formal simulation and planning 2. Focus is on improvement 3. Performance is measured and analysed 4. Best practices are incorporated 5. Focus on human capacity building is high Overall score	Formal planning and simulation with innovation and documentation of lessons learnt. 1 2 3 4 5 1. Formal simulation and planning 2. Established culture through simulation and innovation 3. Focus is on continual improvement with fully integrated best practices 4. Lessons are captured and fed into system 5. Records are kept to date Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
8	Turn-over, cash flow and customer management	Successes cannot be sustained. No tools or database in use. 1 2 3 4 5 1. Engage in little planning 2. Established/stated financial processes are abandoned in crisis 3. If policy exists, it is not enforced 4. No tools or database exists, but there are plans 5. Budgets and schedules are usually exceeded Overall score	Simple tools and templates are used for some activities 1 2 3 4 5 1. Key individuals demonstrate track record 2. Financial tasks are monitored, controlled and reviewed for compliance with policy 3. Large dependence on historical practice 4. Tools and templates are available for use 5. Pockets of good practices Overall score	Formal planning exists with tools and templates 1 2 3 4 5 1. Standard financial planning and control 2. Tools, templates are used 3. Database and records are available 4. Mainly inward looking 5. Mid-term focused plans Overall score	Tools, database and records are available for statistics analysis and management 1 2 3 4 5 1. Process is continually enhanced 2. Measures of performance are statistically/technically analysed 3. Projections are made for statistical analysis 4. Financially prepared for eventualities 5. They anticipate eventualities Overall score	Sophisticated tools and methodologies are used for financial planning and cash management. 1 2 3 4 5 1. Anticipate and respond to eventualities 2. Qualitative and quantitative analysis are done with sophisticated tools 3. Sharp focus on continual improvement 4. Quantitative techniques for measuring improvements 5. Lesson learnt are clearly reflected in procedures Overall score

Table 7.8 continued

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
9	Insurance adequacy and management	Little or no recognition of importance. 1 2 3 4 5 1. Little recognition of importance 2. Organisation pays lip service 3. Unaware of the need but ready to know 4. If policy exists, it is not enforced 5. Little understanding Overall score	Importance is recognised by senior member/staff, but resources are not allocated. 1 2 3 4 5 1. Senior members or manager recognise importance 2. Large dependence on historical practice 3. Some appropriate stakeholders are engaged 4. Heavy reliance on knowledge and advice of ordinary individuals 5. Company has access to skilled people who can give controlled advice Overall score	Importance is recognised 1 2 3 4 5 1. Average recognition of importance 2. Insurance scheme is available 3. Processes are described in standards 4. Understood by the team 5. Implementation is due to the support of few stakeholders Overall score	Higher recognition of importance. 1 2 3 4 5 1. Higher recognition of importance 2. Insurance scheme exist 3. The need for processes/tasks are highly recognised 4. Formally reviewed 5. The team highly understands purpose Overall score	There is focus on continual improvement. 1 2 3 4 5 1. Insurance scheme exist 2. Sufficient attention to adequacy and improvement of policy 3. Lessons learnt are documented for future use 4. There is attention on securing better deals 5. Records are kept up to date Overall score

Table 7.8 Continued

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
10	Utility/communication system	Highly reactive. Little or no plans to counter utility supply failure. 1 2 3 4 5 1. Highly reactive 2. Supply is abandoned in times of crisis 3. Short term focused strategies 4. Efforts are made on case-by-case basis 5. Basic and narrow range methods are engaged Overall score	The organisation is reactive. Partial plan to counter utility supply failure. 1 2 3 4 5 1. Partial plan to counter utility supply failure. 2. Experiment on processes planned or introduced 3. Appropriate stakeholders are engaged 4. Pockets of good practice 5. Mid-level proven approach Overall score	Countermeasures are more proactively managed. 1 2 3 4 5 1. More proactively managed 2. Standard processes are established and improved overtime 3. Mid-term focused plans 4. Mainly inward looking 5. More advanced but proven approach/technology Overall score	Relevant stakeholders formally review utility failure countermeasures. 1 2 3 4 5 1. Formal measures and plans for improvement exists 2. Projections and Plans are partially made on statistical/numerical analysis 3. Performance can be reasonably predicted 4. Advanced but proven approach 5. It requires complex integration Overall score	They anticipate and respond to utility-related uncertainties. 1 2 3 4 5 1. Proactively managed 2. High focus on continual improvement through innovation and technology 3. Sophisticated tools or methodologies are available for qualitative and quantitative analysis 4. Sophisticated tools or methodologies are available for qualitative and quantitative analysis interpretation 5. Advanced, innovative, multiple complex installations Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
11	Electronic data/record management	No centrally coordinated support function. 1 2 3 4 5 1. The process is chaotic e.g. data policy, off-site back up, alternate servers, etc. 2. If policy exists, it's not enforced 3. Basic relevant tools or database 4. Partial centrally coordinated system 5. Little understanding of surrounding principles Overall score	Individuals or departments have personal plans 1 2 3 4 5 1. Record management plans are not shared 2. Weak/fragile team ability influences data flow 3. Roles relating to data management seems clear 4. Mid-range tools and templates are used for some activities 5. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions Overall score	Data management procedures are described/documented in standards 1 2 3 4 5 1. Procedures are described in standards 2. Processes are formally reviewed 3. Data/record purposes, inputs, verification steps, and outputs are defined 4. More advanced tools, templates and relevant database are available 5. Processes are understood Overall score	Procedures and performances are reviewed and reported. 1 2 3 4 5 1. Process and procedures are reviewed 2. Performance on task is reported 3. Advanced tools and databases are used for statistical analysis 4. Consistent and systematic approach 5. Complex but proven system Overall score	Quality and performance in respect of record management are stated and recurrently revised 1 2 3 4 5 1. Quality and performance requirements are stated 2. Advanced and some innovative tools. Standards are recurrently revised 3. Lessons learnt are documented and fed back into the system 4. Active use of information 5. Consistent, systematic and continually improved approach Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
12	Management of disruption (to production/service/operations/processes)	Highly reactive, little or no plans for service coordination. 1 2 3 4 5 1. No standardised procedures 2. Engage in little planning. Little plan for operations coordination. 3. Little institutional coordination. Procedures are abandoned in times of crises 4. Strategies are applied on case by case basis 5. If any plan exists, they are short term focused Overall score	Senior Manager/Owner may recognise importance, but resources are not allocated. 1 2 3 4 5 1. Strategies are applied on case by case basis 2. Organisation experiments on processes planned 3. Stakeholder responsibilities are revised over time through training and updates 4. Roles are clear and achievable, but success cannot be repeated 5. Heavy reliance on knowledge of individuals Overall score	Standard processes exist and are perceived to be well understood. 1 2 3 4 5 1. Standard procedures are described and understood 2. Procedures are understood 3. Reasonably high team orientation 4. Processes are improved over time 5. Organisation is perceived to have the ability to sustain operation Overall score	Relevant stakeholders formally review processes 1 2 3 4 5 1. Established processes are regularly reviewed with stakeholders 2. Post event reviews are done 3. Strong teamwork 4. Highly anticipate predictable and non-predictable eventualities 5. Systematic in approach Overall score	Quality and process performances are stated and recurrently revised using qualitative and quantitative methods. 1 2 3 4 5 1. Continual review of process and performance standards 2. Qualitative and quantitative methods are used. 3. Lesson learnt are documented and reflected in operations 4. Resilience concepts are embedded in all legal and operational frameworks 5. Dynamic and defined focused on resilience Overall score

Table 7.8 Continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
13	Crisis response budget	Engage in little or no financial planning for response disasters. 1 2 3 4 5 1. If policy on crisis budget exist, it is not enforced 2. Financial arrangements are abandoned in times of crises 3. Basic tools or templates for disaster finance planning 4. Budgets and schedules documented in plans are usually exceeded 5. Little financial planning for response to disasters. Overall score	Senior Manager/Owner understands importance but resources are not allocated. 1 2 3 4 5 1. Leader recognises need 2. No resources are allocated 3. Large dependence on historical practice 4. Reactive in approach 5. Simple tools and templates are used for planning Overall score	Need is understood and supported by management or owner. 1 2 3 4 5 1. Need is understood 2. Well supported by management or owner 3. Resources are provided 4. Provision and implementation of crises budget is in line with policy 5. Partial compliance with what the policy dictates Overall score	Need for crisis budget is highly recognised. 1 2 3 4 5 1. Need is highly recognised 2. Related issues are highly supported and revised 3. Eagerly anticipate the financing of predictable and unpredictable eventualities 4. Reviews are done 5. Performance is reported Overall score	Anticipate and respond financially to the crisis. Quantitative and qualitative tools are used. 1 2 3 4 5 1. Crisis budget is considered on day to day decision making 2. Adequacy is stated and recurrently revised 3. Records are kept up to date 4. They anticipate using qualitative and quantitative tools for analysis 5. Standard tools and methodologies are used for crisis budget decisions Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
14	Paper records management	No centrally coordinated support function. 1 2 3 4 5 1. Unreliable centrally coordinated support function 2. Process is chaotic or clearly unmanaged 3. If policy on data management exists, it is not enforced 4. Basic or no tools or plans for paper record management 5. No arrangement for offsite duplication but ready to change Overall score	Individuals or departments have personal plans in place, but they are not shared 1 2 3 4 5 1. Individuals or departments make separate plans 2. Weak coordination between teams 3. Clear and achievable roles are set 4. Mid-level tools and methods are used 5. Monitored, controlled, reviewed and evaluated for compliance Overall score	Standards are documented for the organisation. 1 2 3 4 5 1. Standards are documented 2. Processes and achievements are examined 3. Record purposes, inputs, verification steps, and outputs are defined 4. More advanced tools and templates are used 5. Relevant database is available Overall score	Review of standards and performance is done. 1 2 3 4 5 1. Frequent review of performance on record management 2. Review outcomes are reported 3. Advanced/sophisticated tools are used 4. Relevant database is available 5. Improvement process is stated Overall score	Quality and performance in respect of record management are stated and recurrently 1 2 3 4 5 1. Quality and performance is stated 2. Lessons learnt are documented and implemented 3. Standards are recurrently reviewed 4. Easy access and management using advanced and innovative technology (storage and transfer system) 5. Active use of information Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
15	Decision making in emergency situations	No standard procedures, little or no recognition of need. 1 2 3 4 5 1. No standard procedure or specific instructions but can emerge 2. Individuals use their discretion 3. Unaware of the need for change in communication line on such occasions 4. No attempt to identify the benefit 5. No understanding of the implication of decision making freedom in disaster situations Overall score	Only a few or Senior personnel or owner recognise the need for decision making without recourse to superior in an emergency. 1 2 3 4 5 1. Senior personnel or owner or only a few recognise importance 2. Few people can produce results 3. Each department has plans, but they are not shared 4. Pockets of good practices 5. Success can be seen, and repetition of success is expected Overall score	The importance is recognised by many. 1 2 3 4 5 1. Importance is recognised 2. Standard decision-making processes are established 3. Decision-making processes are revised 4. Supported by the management 5. Some level of independent decision making can be observed Overall score	There is higher recognition of importance 1 2 3 4 5 1. Higher recognition of need and importance 2. Flexible and open to change 3. Adaptive leadership and followership style 4. Need for independent decision making is highly recognised 5. Means of improvement is stated. It is encouraged. Overall score	Tolerant and open-minded leadership exists in the organisation. 1 2 3 4 5 1. They include resilience in their day to day activities 2. Tolerant and open-minded leadership exists 3. Rational decisions are appreciated/rewarded 4. They lead in establishing visionary culture 5. Dynamic, flexible and goal oriented Overall score

Table 7.8 continued

SN	Key Capability Areas(KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
16	Definition of responsibilities and how it changes in disaster situations	No standardised procedure. Unaware of need. 1 2 3 4 5 1. No standard procedures but can emerge during crises 2. Actions depend on individuals 3. Unaware or slightly aware of need for role change in disaster situations 4. No institutional coordination to support 5. Little or no monitoring and reporting of delivery of duties Overall score	Organisation experiments on processes planned. 1 2 3 4 5 1. Organisation experiments on processes planned 2. Plans are executed in line with policy 3. Roles in crises are clearly laid out 4. Key individuals demonstrate track record with hopes of repeating success 5. Performance is measured or there is capacity for performance measurement Overall score	Expected changes in the role are documented. 1 2 3 4 5 1. Standard processes and duties are established 2. Procedures are well understood 3. Processes are improved over time 4. They engage in formal planning, roles are stated 5. Processes have defined purpose, inputs, verification steps, and outputs Overall score	Flexible and adaptive. Expected changes are stated and open to creativity. 1 2 3 4 5 1. Flexible and open to change 2. Adaptive leadership and followership style with space for creativity 3. Adapt to situations based on creativity and innovation 4. Staff have autonomy and liberty to respond to emergencies 5. Execution of roles and responsibilities can be described as consistent and systematic Overall score	There is focus on continual improvement of roles in different situations. 1 2 3 4 5 1. Roles are specified, and operating environment is well understood 2. There is focus on continual improvement 3. Innovation and technological advancements are used for determining roles in emergencies 4. Tolerant and open-minded operation style 5. Dynamic, flexible and strong project driven attribute Overall score

Table 7.8 continued

SN	Key Capability Areas	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
17	Post event review, analysis and management	Importance not really recognised. No formal processes. 1 2 3 4 5 1. Importance is slightly recognised 2. Plans for formal processes are underway 3. Little or no tools and documents are available 4. Slightly aware of the need for review 5. Partial and very weak centrally coordinated support function Overall score	Senior personnel or owner may recognise importance, but very little is done 1 2 3 4 5 1. Senior Manager/Owner recognises importance 2. Resources are not allocated 3. Simple tools and templates are used during review 4. Weak coordination 5. Individuals act with limited coordination Overall score	Importance is recognised. The task is supported by management. 1 2 3 4 5 1. Importance is recognised 2. The management gives strong support 3. Standard processes are established 4. Processes are improved with time 5. They engage in planning and review Overall score	Higher recognition of importance. More rigorous review by stakeholders. 1 2 3 4 5 1. Formal, rigorous review by stakeholders 2. Higher recognition of importance 3. Highly supported by management 4. Means of improvement are stated 5. Staff are involved and engaged in planning, Post-event analysis and reviews are done, and performances are reported. Overall score	There is a highly significant focus on continual improvement of Post event operation, analysis and management. 1 2 3 4 5 1. Lessons learnt are captured and fed back into operations 2. Sophisticated tools and methodologies are available 3. Tools are used for qualitative and quantitative analysis with suitable interpretations 4. There is focus on continual improvement through innovation and technological advancement# 5. Suitable interpretations are given to all analysis Overall score

Table 7.8 continued

SN	Key Capability Areas	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
18	Network strength	No centrally coordinated support function. 1 2 3 4 5 1. Processes and related activities are disorderly 2. Little standard arrangements 3. Partial institutional coordination 4. Barely or unaware of the need to build network strength for premises resilience 5. No centrally coordinated support function but can emerge Overall score	Senior management understands importance but resources are not allocated. 1 2 3 4 5 1. Senior personnel or owner recognise importance. 2. No resources are allocated to build the network 3. Feeble team orientation 4. Weak ability as a team, though appropriate stakeholders are engaged 5. Better at repetitive works Overall score	The importance of network strength is recognised and supported by management. 1 2 3 4 5 1. Importance of network strength is recognised 2. The management supports efforts at achieving this 3. Reasonably high team orientation 4. Reasonably high teamwork ability 5. Standard processes are established Overall score	Higher recognition of importance and need. It is supported with stated means of improvement. 1 2 3 4 5 1. Higher recognition of importance 2. Higher recognition of need 3. Supported with stated means of improvement 4. Strong teamwork with internal partners/parties 5. Strong teamwork with external partners and community Overall score	There is sound relationship with internal and external stakeholders. There is focus on continual improvement. 1 2 3 4 5 1. There is focus on continual improvement through review and innovation 2. Sound relationship with internal and external partners 3. Sound relationship with social network and community 4. Strategic alliance and arrangement with institutions 5. Strong negotiation ability and influence on others Overall score

Table 7.8 continued

SN	Key Capability Areas	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
19	Physical characteristic of property – fabric, design, construction and waterproof compartment	Basic design, construction and protection system. Little or no understanding of the benefit of a flood-proof compartment/ flood proofing. 1 2 3 4 5 1. Basic construction system. Little or no resilience measures. 2. Not flexible, not adaptable. The workplace cannot be distributed, but management knows. 3. Little understanding of need for flood-proof compartment 4. Basic, narrow flood proof store is available 5. Basic design or Fundamental resistance measures or nothing done. Overall score	Mid-level design, technology, construction and protection system. Mid-level effort towards flood proofing. 1 2 3 4 5 1. Mid-level construction system. Slight resilience measures. 2. Partial flexibility, workplace cannot be distributed 3. Senior Manager/Owners understand importance of flood proof compartment, but limited resources are allocated 4. Mid-level but proven approach, technology of flood proofing is adopted 5. Mid-level design or Mid-range products are used or use of sandbags as protection against flood water entry. Overall score	Advanced design, technology, construction and protection system. The importance of flood proof compartment/flood proofing is recognised. 1 2 3 4 5 1. Advanced and proven construction system. 2. Fair and reasonable flexibility. 3. Importance of flood proof compartment is recognised. Management supports acquisition/construction. 4. Use of major assembles that enhances adaptability or workplace distribution 5. Advanced design or proven products or technology e.g. property level protection - use of products that prevent the inflow of water. Overall score	More advanced and proven design, technology and construction and complex protection system. Importance and need for flood-proof compartment/flood proofing property are highly recognised. 1 2 3 4 5 1. More advanced and proven construction system. 2. Organisation uses facilities that require complex assembly and integration or flexible workplace. 3. Partially complex but adaptable system. Performance can be reasonably predicted. 4. Need for flood-proof compartment is highly recognised and acquisition is highly supported. 5. More advanced design or proven products and technology. Temporary flood barrier schemes and property level protection. Overall score	Sophisticated and proven design, technology and construction and complex protection system with innovative technology that requires large-scale assembly. Importance and need for flood-proof compartment/flood proofing property are highly recognised. There is focus on improvement – capacity and efficiency. 1 2 3 4 5 1. Sophisticated and proven construction system 2. Advanced and complex flood resistant products, involves large-scale multiple complex assemblies 3. Large scale multiple complex assemblies and installations. Largely adaptable or resistant system. 4. Flood proofing system is automated, sophisticated methodology/system. 5. Sophisticated design or some innovative products, technology with a focus on improvement. Automated flood defence schemes and property level protection. Overall score

7.10 Application of the built environment flood resilience capability maturity model in case studies

After the refinement and improvement of the capability maturity model in case studies, Respondents from the case organisations were asked to assess the current capability maturity levels of their organisations. This was achieved by using the scoring points provided in the model for capability maturity levels 1 to 5. Within each capability maturity level, a set of characteristics are also provided, this provides additional sub-criteria for rating organisations based on each capability area. The sub-rating in each capability level on each capability area ensures that the extent to which an organisation has achieved a capability maturity level can be evaluated.

Bay and Skitmore (2006) and Rwelamila and Phungula (2009) utilised quantitative approach to assessing project management maturity in organisations. Similarly, the model developed in this study was used to reveal the built environment flood resilience capability maturity levels of selected case study organisations. Further explanations on each capability area are provided in Table 4.1. Please note, the assessment model is presented in Table 7.8 and a sample calculation (worked example) is presented in the appendix (Appendix R). Presented in Table 7.9 is the calculated capability maturity scores for the case study business organisations.

Table 7.9 Maturity score of case organisations

Ref. code	Capability areas	Case 1	Case 2	Case 3	Case 4
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

Table 7.9 Maturity score of case organisations (Continued)

Ref code	Capability areas	Case 1	Case 2	Case 3	Case 4
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 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 some businesses in UK but others and other countries

Table 7.9 shows the current capability maturity levels of four case study organisations with respect to capability areas for enhancing disaster resilience of the built environment to flood.

CS1 has a relatively high score on each of the capability areas, the score ranges from 3.20 to 4.80, that is level 3 (defined) and level 4 (managed). CS2 has capability maturity level scores that range from 2.40 to 4.60, that is, level 2 (repeatable) to level 4 (managed). The findings also revealed that CS3 has scores ranging from 3.20 to 4.80, that is level 3 (defined) and level 4 (managed). CS4 currently has capability maturity that ranges from 1.20 to 3.80, that is level 1 (Ad hoc) to level 3 (defined). CS1, CS2, and CS4 believed it was not necessary to be assessed on insurance management, because, insurance will no longer be available to businesses in the nearest future. The unavailability is based on the terms of a recently adopted insurance policy (FloodRe) in the UK. The organisation that was assessed had a pleasant relationship with the insurer after the last flood event, the respondents therefore believed that insurance will be privately made available to the organisation in the future. It was stated that even if premium increases, the organisation's capability with respect to insurance is high and therefore will be able to negotiate through. The adjudged capability and the pleasant relationship seems evident in the high maturity rating recorded under insurance management.

The calculated capability maturity score for each case study organisation on the capability areas are illustrated in Figure 7.6.

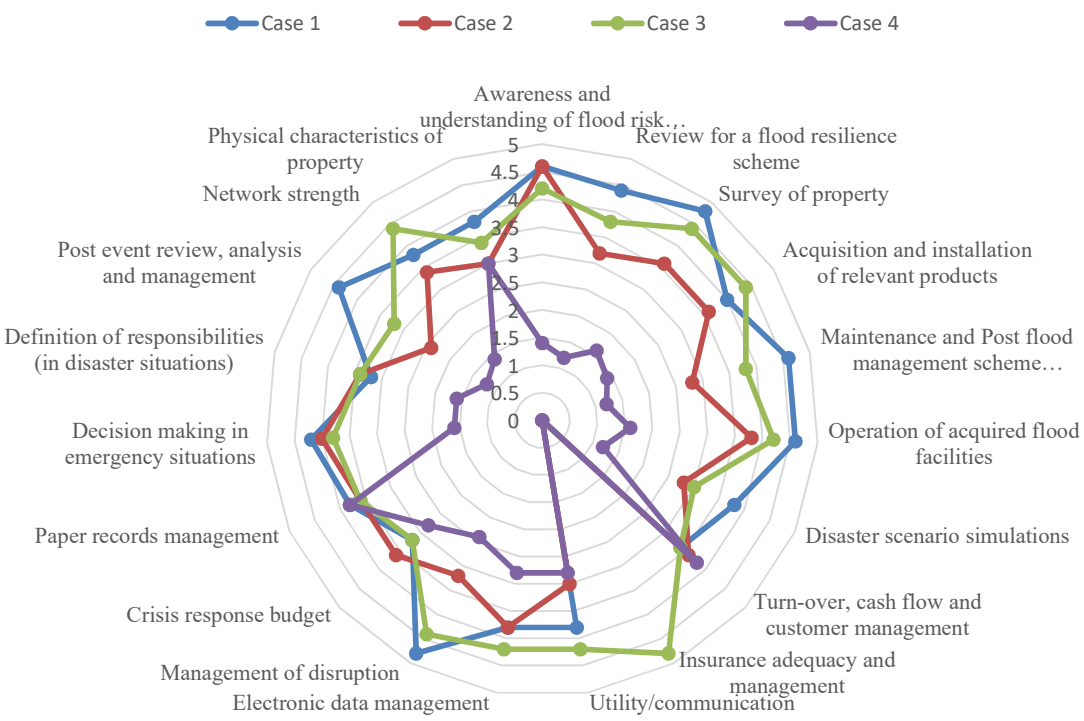

Figure 7.6 Current capability maturity level of case study business organisations

The assessment of capability maturity of respective case study organisations (Table 7.9 and Figure 7.6) revealed that:

- Case study 1 (CS1) which is a guesthouse has a relatively high capability maturity. The organisation's maturity ranges between level three (defined) and level four (managed). 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. Among the capability areas where CS1 is below 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. The capability areas where CS1 belongs to capability maturity 3 (defined) are disaster scenario simulation, utility/communication, electronic data management, crisis

response budget, network strength, and physical characteristic of property among others. 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" (insurance will not be available to businesses through FloodRe). 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 capability area 4 (Managed) in two of the 19 capability areas, the capability areas are awareness and understanding of flood risk and 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. Among the capability areas are review for flood resilience scheme, survey of property, acquisition and installation of relevant products, electronic data management, utility and communication and physical characteristics of the property. 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. The capability areas are maintenance and post-flood management scheme relationship, disaster scenario simulation, and post-event review analysis and management. One capability area i.e. Insurance adequacy and management was also described as 'not applicable' based on the same reason presented by CS1 i.e. insurance will not be available to businesses through FloodRe. It should be noted that the FloodRe policy is not applicable to all countries. It can be deduced from the result that CS2 has a lower maturity rating than CS1; as a result, it is reasonable to expect CS1 to experience a lesser damage to business premises or recover faster than CS2 after a flood event.
- Case study 3 (CS3) belongs to maturity level 4 in nine of the nineteen capability areas, this 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.

The capability areas where the organisation is on maturity level four are awareness and understanding of flood risk, survey of property, acquisition and installation of relevant products, the operation of acquired flood facilities, insurance adequacy, electronic data management and network strength among others. CS3 is on maturity level 3 in the following capability areas: disaster scenario simulation, paper records management, crisis response budget, the definition of responsibilities, post-event review, analysis and management and physical characteristic of property. The capability status of CS3 depicts an encouraging level of readiness to confront and manage flood situations. However, it is important to state that the physical characteristics of the property largely dictate the magnitude and type of flood that the property can withstand. Interestingly, the capabilities in Table 7.9 will also influence the decisions that will be made with respect to the physical characteristics of the property.

- 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; this represents 21.05% of 19 capability areas. The case study ranks in maturity level 1(Ad hoc) in eleven out of 19 capability areas; this represents 57.89% of the capability areas related to achieving disaster resilience of the built environment of a business. CS4 has a relatively low maturity rating; it belongs to maturity level 3 in physical characteristics of property, paper records management, and turnover and cash flow management. It belongs to maturity level 2 (Repeatable) under utility and communication, electronic data management and management of disruption (attitude to stressors). Insurance adequacy and management were also identified as “not applicable” while the organisation ranks in maturity level 1 (Ad hoc) in all other capability areas.

Figure 7.7 presents the summary of capability maturity of the case study organisations. Each of the organisations shows varying degree of maturity on the capability areas.

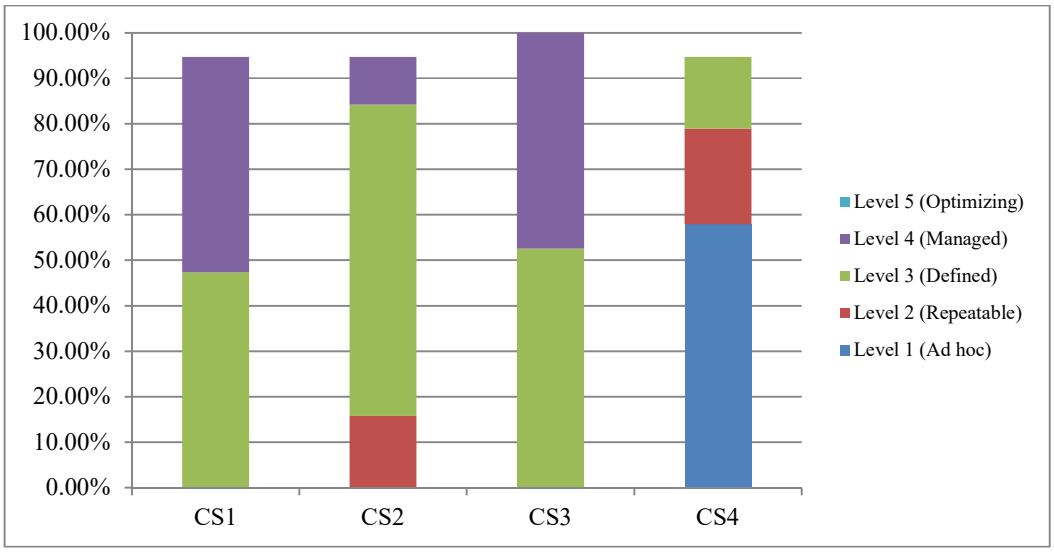

Figure 7.7 Summary of capability maturity status of case study organisations

As shown in Figure 7.7, CS1 belongs to Level 3 (Defined) on about half (47.36%) of the capability areas. It also belongs to Level 4 (Managed) on 47.36% of the capability areas. The remaining 5.26% (needed to make 100%) accounts for the capability area that was regarded as not being relevant to the organisation but relevant to others. Similar to CS1 is CS3, CS3 also ranks in Level 3 (Defined) and Level 4 (Managed) in all the capability areas. CS3 ranks in Level 3 (Defined) in 52.63% of the capability areas and Level 4 (Managed) in 47.36%. The capability maturity of CS2 is distributed among three levels. CS2 belongs to Level 2 (Repeatable) in 15.79% of the capability areas unlike CS1 and CS3 that rank in Level 3 and 4 alone. CS2 ranks in Level 3 (Defined) on 68.42% of the capability areas compared to 47.36% and 52.63% of CS1 and CS3 in Level 3 (Defined). The remaining 10.53% represents the capability maturity of CS2 in Level 4 (Managed) compared to 47.36% recorded by CS1 and CS3. None among CS1, CS2 and CS3 belongs to Level 1(Ad hoc) and Level 5 (Optimizing) in any of the capability areas. With respect to case study organisation 4 (CS4), the organisation's maturity on the capability areas belongs to three maturity levels, Level 1(Ad hoc), Level 2 (Repeatable) and Level 3 (Defined). CS4 is on Level 1(Ad hoc) in 57.89% of the capability areas, 21.05% on Level 2 (Repeatable) and 15.79 on Level 3 (Defined). CS4 is largely a novice (Ad hoc) with respect to flood resilience capability maturity as it is 57.89% Ad hoc (Level 1), 21.05% repeatable (Level 2) and 15.79% (Defined).

CS1, CS2, CS3 are organisations that have experienced flooding before unlike CS4. 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 (See section 7.6.2.4).

7.11 Chapter summary

The considerations, processes and procedures leading to the development of capability maturity model have been presented in this chapter. The model is the main deliverable of this study. The discussions in the chapter include a brief introduction on the purpose of the chapter, the procedure of selecting the experts and case studies engaged during the process of model development. The model development began with the verification of capability areas identified from the literature (See chapter 6); the verification was followed by the development of a conceptual model (See procedure of development in Section 5.4.1 and appendix K for the conceptual model). The activities leading to the production of the final built environment flood resilience capability maturity model after the preparation of the conceptual model include verification and refinement by a team of carefully selected experts, case study refinement as and testing of the model in four case studies. The model development started with a total of 26 capability areas, these were pruned down to 20 by the expert review team, and it was consolidated to 19 after the case studies. This implies that the final capability maturity model contains 19 built environment flood resilience capability maturity areas, with capability level characteristics across five maturity levels (Adhoc – level 1 to Optimising – level 5). The result of the application of the model in selected case study organisations was also presented (section 7.10). The application of the model in case organisations represents internal validation, the external validation exercise is presented in the next chapter (chapter 8).

CHAPTER EIGHT
CAPABILITY MATURITY MODEL VALIDATION

8.1 Introduction

The development of the flood resilience capability maturity model was discussed in the last chapter (i.e. Chapter 7). As recommended by Macal (2005) and Cheung (2009) among other studies, the development of a framework or a model should be followed by a validation exercise to establish its applicability, acceptability and validity. Presented in this chapter (i.e. Chapter 8) is the validation exercise conducted to establish the comprehensiveness, objectivity, practicality, replicability, reliability and overall suitability of the Built Environment Flood Resilience Capability Maturity Model for assessing, profiling and benchmarking capabilities for flood resilience. The discussion in this chapter is structured around rationale for validation, the validation process and the result of validation exercise.

8.2 Rationale for validation

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. It was also done to ensure the adequacy and appropriateness of the Built Environment Flood Resilience Capability Maturity Model developed. The validation of a model guarantees that the model addresses and contains all requirements in terms of method and results (Macal, 2005). Validation of a model is important if the model is to be used (Macal, 2005). The model developed in this study was verified and validated via expert evaluation and case study approach. Discussions on the validation process and the results of the validation exercises are presented in sections 8.3, 8.4 and 8.5.

8.3 The validation process

Upon the completion of the modification of the capability maturity model using the contributions from the case studies, arrangements were made for the validation of the model. Two methods were employed for the validation exercise; this was done to adequately establish the validity of the model developed. Both methods adopted (i.e. case study and expert evaluation) are supported in literature as methods for model or framework validation (Cheung, 2009; Macal, 2005; Yeung, 2007). The case study

validation is a direct use of the model in a real case, it validates mainly the freedom of the model from significant operational issues while the expert evaluation mainly validates the adequacy and usability of the model in overall terms. Figures 8.1 and 8.2 describe the process of the expert validation exercise and the case study validation process respectively; please refer to Figure 5.5 for the overall flowchart of research methodology.

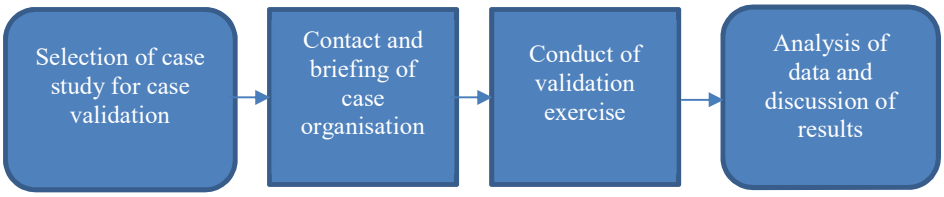

Figure 8.1 Expert validation process

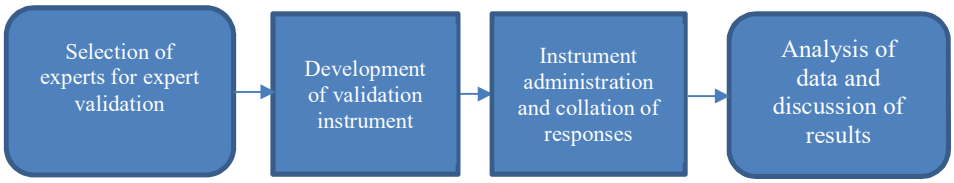

Figure 8.2 Case study validation process

Upon the completion of the validation exercises, a summary of findings from the exercises was prepared (see Section 8.6).

8.4 Expert validation (Scoring approach)

The expert evaluation process and the outcome of the exercise is presented in section 8.4.1to section 8.4.4

8.4.1 Selection of experts

For the expert evaluation approach, 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 and Babatunde *et al.* (2016), Cheung (2009) and Yeung (2007). The studies engaged stakeholders from academia, public sector and practice. A discussion on the design of the validation questionnaire used in this study is presented in the next section.

Based on Bryman (1996) support for purposively selecting experts for knowledge acquisition and validation in researches as well as the successful deployment of the questionnaire approach of validation by the earlier mentioned studies, this study selected a set of respondents using a set of criteria. The criteria for the selection of respondents for the validation survey are as follows:

1. Participant must be conversant with flooding and flood damage to premises/built environment either as a professional, flood victim (business organisation),
2. Must be actively contributing to issues relating to flood and the built environment through their areas of expertise to date,
3. Academics/researchers engaged must have carried out extensive research in the area of flooding, communities, and business recovery.

8.4.2 Design of evaluation instrument

A questionnaire was used as the instrument for the expert evaluation aspect of the model validation in this study. This approach was also used by Babatunde *et al.* (2016); Cheung (2009); Yeung (2007). The respondents 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 used by Awodele (2012); Babatunde *et al.* (2016); Cheung (2009) and Yeung (2007), they are also similar to the criteria described by Martis (2006). The model was scored based on the criteria using a scale of 1 – 5, 1 represents Poor, 2 – Fair, 3 – Average, 4 – Good, and 5 – Excellent (Appendix O). The validation questionnaire also contains a section for information on respondents' background details as well as a brief on the purpose of the validation exercise and the background of the research.

8.4.3 Expert evaluation process

Based on the set criteria, five stakeholders were identified and invited to participate. The prospective respondents were from academia, public service and the private sector (business sector). The identified prospective respondents were invited to participate in the validation process. After confirming their readiness to participate, the validation instrument (See appendix O for the validation instrument – questionnaire) and the model developed (see Table 7.8) were sent to them via email. Responses were thereafter collated and analysed.

Presented in Table 8.1 is the background details of the respondents engaged in the validation exercise. Five stakeholders made up the validation team. The members came from academia, public service, and the private/business sector. The respondents' academic qualification details show that two out of 5 respondents obtained PhD Degree and the remaining three have Master's Degree. All the respondents also have an appreciable number of years of experience in their respective areas of practice; it ranges from eight to 26. From the details of the respondents, it is clear that the respondents are professionally and practically suitable for the validation exercise. Therefore, the outcome of the validation and evaluation exercise is reliable.

Table 8.1 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

The respondents were asked to rate the capability maturity model based on six criteria using a Likert scale of 1 – 5 (1 represents Poor and 5 stands for excellent). The outcome of the evaluation exercise is presented in the next section.

8.4.4 Analysis of data and presentation of results

The expert evaluation result (Table 8.2) shows that the experts were pleased with the "comprehensiveness" of the model; the validation criteria had a mean score of 4.80. The score of the model with respect to its comprehensiveness confirm the width, depth and the overall elaborateness of the model. Similarly, with respect to "Practicality", the model had a mean score of 3.60; this confirms the applicability of the model in real life. With respect to overall suitability for assessing, profiling and benchmarking capabilities for flood resilience, respondents rated the model with a mean score of 4.00; this 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 concluded that the developed capability maturity model is suitable for assessing the built environment flood resilience capability maturity of MSMEs. Based on some arguments in the literature about the adequacy of mean for ordinal data in ordinal or skewed datasets (See section 5.4.8.1), the median, which is an alternative, was also used to evaluate the model validation rating of experts. The result also showed that the experts were satisfied with the model developed, the model had a median score of 5 on 'comprehensiveness' and scored 4 on all other assessment criteria. This is obviously an excellent rating for the model.

Table 8.2 Result of expert evaluation of model

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

Presented in section 8.5 is the case study validation process and results.

8.5 Case study validation

Case study approach is also a valid method of model validation. In order to complete the process of this research, a case validation exercise was conducted (see Figure 8.2 for the summary of the process).

8.5.1 Case selection

As earlier discussed (Section 8.2) a case study validation exercise was conducted alongside the expert evaluation exercise. A case study business organisation different from the ones earlier engaged in the refinement of the model (Section 7.6) was purposively selected. The organisation satisfied all the criteria set for the multiple case studies engaged earlier in this study (See section 7.6, items 1 – 3). The conditions are that

the case study belongs to one of Class A1, A3, A4, A5, or C1; the organisation must be a Micro, Small and or Medium sized enterprise (MSME) and preferably, the organisation must have previously suffered flood attack.

Based on the aforementioned criteria, an electronic mail was sent to an identified organisation as a formal invitation to participate in the validation exercise. The organisation consented, and the case validation exercise was conducted. Presented in the next paragraph is the background information of the organisation.

8.5.2 Contact and briefing of case organisation

An email invite was sent to the case study organisation that agreed to participate in this study. A briefing on the scope and the aim of this study was given in the email sent; this was followed by a phone call. The organisation was also informed of the purpose of the case study exercise as an exercise that is meant to confirm the validity and the suitability for use of the flood resilience capability maturity model. Also provided as part of the briefing is the request for background information on the case organisation and the need for an account of the flooding experiences of the organisation. Expectations from the organisation in respect of this research were presented. Thereafter a date was fixed for the validation exercise.

8.5.3 Conduct of validation exercise

The informants in the case study organisation were the Managing Director and a staff. The interaction with the respondents in the case study organisation started with questions about the background details of the organisation. Also, questions were asked about the flooding experiences of the organisation, the two informants (manager and staff) provided similar accounts. Thereafter, there was an interaction about capabilities for flood resilience (the interaction was guided by a case protocol), pictures of the impact of the last flooding event and the renovated premises were viewed. Thereafter, the capability maturity model developed in this study was used to assess the organisation's flood resilience capability maturity. The findings from the case validation exercise is presented in the next section (Section 8.5.4).

8.5.4 Analysis of data and presentation of results

The case organisation is situated around Lake District in the United Kingdom. It is a hotel with over 70 stylish rooms, en-suite bathroom, restaurant, beautiful terrace and a steam

room among other facilities. The hotel has twelve 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. Prior to its current operation, the property underwent a major redevelopment and reopened in 2012. A director manages the solely owned hotel as well as the property and the business currently records an annual turnover of 6 million pounds.

In December 2015, the business was flooded; this resulted in damage to premises and caused a 7-month long closure. The contact persons in the hotel commended the efforts of fire service men, it was recorded that the continual pumping of water away from the property prevented damage to some facilities including the generator. Because of the magnitude of the flood and the non-resilient construction materials used for the ground floor, a significant damage was experienced. The managing director and the staff that were the contact persons in the organisation during this research described the magnitude of renovation after the flood as significant. The activity called for the engagement of a loss adjuster, Construction Company, the insurer of the property, property surveyor, and government agencies among others.

In order to minimise the impact of future events, during recovery, floodwalls protecting the area as well the property and drainage system were re-examined. Automatic self-closing airbricks were installed, damp proof membrane and the concrete floor were introduced, and the ground floor was finished with ceramic tiles. Beyond the structural improvements, other efforts towards future resilience is evident in the high rating of capabilities for resilience (See Table 8.3). The respondent in the organisation commended the capabilities listed in the model, the maturity level definitions and the suitability of the model for assessing the built environment capability maturity of an organisation towards improvement. The respondents commended the comprehensiveness and appropriateness of the capabilities and definitions contained in the model.

The capability maturity model for the evaluation of flood resilience capabilities was used in the validation case study. This was to confirm the real-life applicability of the maturity model. Presented in Table 8.3 is 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 8.3 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

The result of the validation case study is further graphically presented in Figure 8.3, the inward depressions in the blue line indicate lower maturity level of the organisation with respect to the corresponding capability.

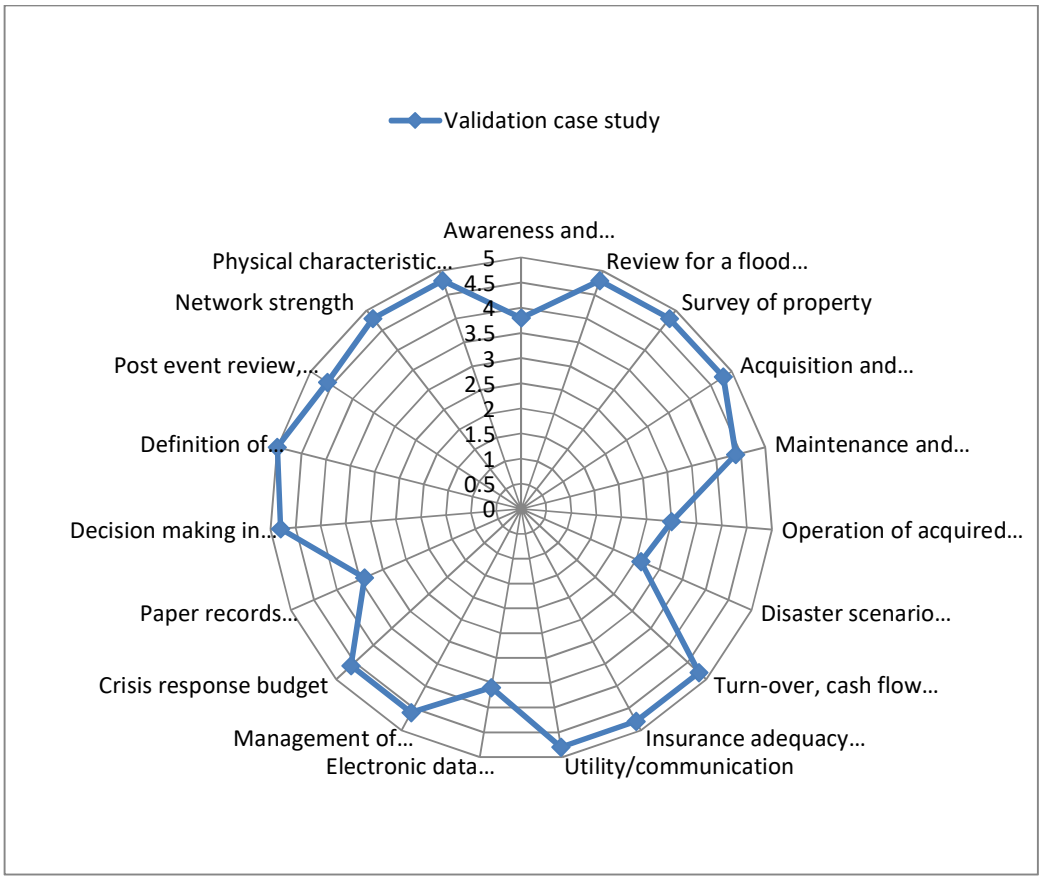

Figure 8.3 Graphical representation of validation case study result

8.6 Summary of expert evaluation and case validation exercises

The results of the validation exercises are presented in two sections, section 8.4.4 contains the result of the case study evaluation exercise and section 8.5.4 contains the result of the expert evaluation exercise. The rating of the model by experts indicate a convincing level of approval, the comprehensiveness of the model in terms of its overall elaborateness was confirmed with a high score. The model was adjudged suitable for profiling, benchmarking and improvement focused assessment of capabilities for built environment flood resilience. Similarly, the case study validation confirmed the adequacy and suitability of the model. Respondents in the case organisation commended the suitability of capability areas and the ability of the model in revealing the maturity of business organisations. Likewise, the maturity scores recorded by the organisation is also impressive. This was attributed to the organisation's previous experience with flood. A lot has been done to recover from the last experience and the consciousness of the need to enhance capabilities is high. The property is situated close to a lake and therefore has a high risk of future flooding, based on the progress made in enhancing capabilities; the

impact of future flooding is expected to be lower. It is believed that if more commitment is mobilised into enhancing built environment disaster resilience, economic loss caused by property damage, repair cost, and business interruption resulting from physical damage to premises will be significantly reduced.

8.7 Chapter summary

The validation exercise conducted on the built environment flood resilience capability maturity model developed for business organisations was presented in this chapter. The procedure of the validation exercise conducted by a team of carefully selected experts and a case study organisation was explained. Based on the outcome of the model validation exercise, the model is suitable for use. The next chapter (i.e. chapter 9) presents the conclusions from this study.

CHAPTER NINE
CONCLUSIONS

9.1 Introduction

Presented in the previous chapter (Chapter 8) is the details of activities involved in the evaluation and validation exercise of the built environment flood resilience capability maturity model that was developed in this study. The process of developing the model involved literature review, expert panel review, four case studies. The methods of data collection in the case studies included a review of documentation, semi-structured case study interviews. Detailed information on the methodological decisions in this research are discussed in Chapter 5 while data collection, analysis of results and model validation are presented in chapters 6, 7 and 8. Presented in this chapter is a review of research objectives and the summary of findings in respect of each objective. Also presented in this chapter are the theoretical and practical contributions of the study, specific recommendations emanating from the study, limitations of the study and suggested areas for further research.

9.2 Review of research objectives

The research questions and the specific objectives of this study were presented earlier in sections 1.3 and 1.4 respectively. It should be noted that a number of thoughts arose from the research questions but those thoughts have been addressed by successfully achieving the objectives of this study within the scope of the study. The aim of the study as stated earlier (refer to section 1.4) is to develop a flood-related disaster resilience capability maturity model that identifies built environment flood resilience capabilities of micro, small and medium-sized business organisations. The objectives of the study were achieved by conducting an extensive literature review, a mapping exercise and expert forum review (see sections 5.4.2 and 7.4). Other processes include the conduct of four case studies (Section 7.6) and model validation was done via case study and expert validation exercises (see chapter 8).

Table 9.1Methods for achieving objectives

SN	Objectives	Methods of achievement			
		Literature review	Mapping exercise	Expert forum	Case study (Documentations, case study interviews)
1	To review capability in the context of disaster resilience	✓			
2	To identify and assess key capability areas for enhancing built environment flood resilience of MSMEs	✓		✓	✓
3	Explore capability maturity model concept and its applicability in built environment flood resilience	✓			
4	Determine maturity level definitions for capabilities related to built environment flood resilience	✓	✓		
5	To develop a conceptual and intermediate capability maturity model for enhancing capabilities for built environment flood resilience	✓	✓	✓	
6	To refine the built environment flood resilience capability maturity model for businesses	✓	✓	✓	✓
7	Validate the capability maturity model developed			✓	✓

9.3 Summary of findings

Presented in this section is the summary of the main findings in respect of each of the objectives of this study. As presented in Table 9.1, the objectives were achieved via different methods and each of the objectives clearly contributed to the achievement of the aim of this study (Section 1.4).

9.3.1 To review capability in the context of disaster resilience

In this study, a review of capacity and capability was undertaken, the main purpose of the review was to explore the meaning of capacity and capability and thereafter establish the meaning of capability in the context of the focus of this study i.e. flood resilience of the built environment. From the definitions and discussions on capabilities and capacities (see section 4.2), it was concluded that in the context of built environment flood resilience, capabilities define the coping response, absorptive ability, and adaptive ability; these abilities influence the disaster resilience of the built environment. UNISDR (2009) submitted that capabilities include strength, resources, physical means, resources, leadership and management, etc., other literature stated that it includes skills and competencies (Yen-Tsang *et al.*, 2012). Based on the meaning and the coverage of capability (UNISDR, 2009 and Yen-Tsang *et al.*, 2012 among others) it is rational to conclude that capabilities are either possessed or meant to be put in place by an asset. Also, the existence of disaster resilience capabilities will aid the disaster resilience of the built environment and a business in general. It was also discovered that some capabilities are more important than another to specific stages in the disaster management cycle (Czajkowski, 2016; Kunreuther and Useem, 2010). Finally, some capability areas that can influence built environment flood resilience were identified from the literature, this is a separate objective and a summary of the objective is discussed in section 9.3.2.

9.3.2 To identify and assess key capability areas for enhancing built environment flood resilience of MSMEs

After reviewing capabilities and relating it to the flood resilience of the built environment, the specific capabilities that can enhance the flood resilience of the built environment of a Micro, Small and medium sized enterprise were extracted from the literature. The capabilities were sourced from the literature using the definitions and description of 'capability' by UNISDR (2009) and Yen-Tsang (2012) among others as guide. According to the aforementioned studies, capabilities are strengths, physical means, knowledge, resources, leadership, skills among other attributes that can be deployed to achieve a

specific goal(s). Based on the definition and description of capabilities, it was clear that capabilities can only be made available in an organisation by the assets of the organisation (see section 4.4.). Previous authors grouped business assets into categories for the purpose of discussing business continuity management and the achievement of organisational goals among others (British Standard Institution, 2007; Fry *et al,* 2004; Ray *et al,* 2004; Hansen *et al,* 2004; Rainey and Steinbauer, 1999). Based on their discussions, it was clear that the achievement of any organisational goal is dependent on the contributions of the assets of an organisation as assets facilitate the conception and delivery of all company objectives.

Bearing the summary in the last paragraph in mind, 26 capabilities were identified from the literature, the capabilities are strongly linked to three main classes of literature and the classes are organisation assets, flood risk management strategies, and general organisational resilience (see section 4.3 and Figure 4.2). The 26 capability areas (Table 4.1) were subjected to expert review and evaluation, after two rounds of expert review the capability areas were consolidated to 20.

The first round of the expert review involved scoring of the identified capabilities. Experts rated their agreement with the capabilities as well as the importance of the capability areas to the enhancement of the flood resilience of the built environment of businesses. The top scoring capabilities (and their scores) in terms of experts' agreement with the relevance of the identified capabilities to the enhancement of flood resilience are understanding of flood risk to property (4.80), review for a flood resilience scheme (4.60), acquisition of relevant facilities for flood risk management i.e. building materials and technologies (4.60), survey of property (4.30), and flood proof store/flood proof protection for flood stock and contents (4.20). Similarly, the experts' evaluation of the relevance of identified capabilities to the enhancement of flood resilience revealed the top scoring capabilities to be understanding of flood risk to property (4.90), review for a flood resilience scheme (4.80), insurance adequacy and management (4.30), general awareness and commitment to resilience (4.30), acquisition of relevant facilities for flood risk management (4.20). The discussion of findings from the first review of capability areas is presented section 6.8 and Table 4.1presents the meaning and coverage of each capability area. It is worthy of note that none of the capabilities scored below 2.5 (out of the maximum of 5) and therefore, all were taken to another round of expert review which was a qualitative review.

The second review resulted in the consolidation of capabilities from 26 to 20, the second expert review involved further verification of capabilities and refinement of capability maturity level definitions (discussed in chapter 7). The availability of more details on each capability area appeared to have led to a noticeable consolidation in the list of capability areas. The capabilities were further consolidated to 19 after verification and review in four case studies. The verification in case studies was done alongside the verification and refinement of capability maturity level definitions (discussed in chapter 7). The final list of capabilities is presented in the final capability maturity model (see Table 7.8). This objective was to ensure that appropriate capabilities were used in developing the built environment flood resilience capability maturity model.

9.3.3 To explore capability maturity model concept towards its application in built environment flood resilience capability assessment

Towards the development of the capability maturity model, the concept of capability maturity model which is a major theoretical base for this study was explored. The origin, meaning and developments on the concept as well issues relating to the concept were reviewed and discussed (refer to section 4.6 to 4.8 in chapter 4 for details). Basically, capability maturity modelling is a concept that describes current capabilities and as well outlines performance improvement options (Yeo & Ren, 2009). It originated from the software industry and has been applied in other areas such as project management (Kerzner, 2002), systems engineering, product development (Dooley et al., 2001), construction industry among others (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). See Table 4.10 for a summary of selected maturity models.

The adoption of the capability maturity model concept in developing a model for assessing the built environment flood resilience capabilities for business organisation is novel, its application in this area in this study is specific and more detailed than others. Some similar works have only attempted the use of the maturity concept in general organisation resilience and general business continuity management (McManus and Seville, 2007; Virtual Corporation, 2005). Using the knowledge gained from studying the existing maturity models found in literature, the approach for the use of the concept in this study was then clearly established. The needed connection between literature on capability maturity modelling and the use of the concept in this study was also established and ultimately, capability level definitions as contained in other studies were extracted

for use (see Table 4.5 to Table 4.9 for details) in developing the assessment model in this study.

9.3.4 To determine maturity level definitions for capabilities related to built environment flood resilience

As previously discussed and presented in Table 4.5 to 4.9 in Chapter 4, capability maturity level definitions were extracted from the literature. In previous studies, capability maturity level definitions were developed based on some analogies, among the analogies are chess analogy i.e. progression from novice to grandmaster (McManus and Seville, 2007); the analogy of an athlete i.e. from being able to crawl to becoming an Olympic runner (Virtual Corporation, 2005). Some of the maturity models were based on the maturity level characteristics of existing capability levels, the new definition is usually established via a mapping exercise (Macgillivray, Sharp, Strutt, Hamilton, & Pollard, 2007). Irrespective of the approach with which maturity level characteristics were established, the principle of progressive advancement between maturity levels remained intact.

In this study, many capability maturity level definitions/characteristics were extracted, adequate attention was placed on maturity level characteristics that are relevant to built environment flood resilience capability maturity. The extracted characteristics were thereafter mapped to the identified flood resilience capability areas. The mapping exercise involved the alignment of each identified maturity level characteristics with each of the verified capability areas (see chapter 6). This was done in a way that the respective definitions in respective maturity level depict progression as the maturity level increases from 1 to 5 (i.e. Adhoc to Optimisation).

9.3.5 To develop a conceptual and intermediate capability maturity model for enhancing capabilities for built environment flood resilience

After defining capability maturity level definitions in the context of capabilities for built environment flood resilience, using maturity levels characteristics from the literature as well as the goals and coverage of each capability, a conceptual maturity model was produced (See the discussion in section 5.4.1, 5.4.1.1 and Appendix K). The conceptual model contains the list of 26 capability areas initially identified from the literature and verified in one round by experts, and the capability level definitions arranged with respect to capability maturity levels 1 – 5 (i.e. Adhoc to Optimizing, see Appendix K). Each

maturity level characteristic has a reference code; the code links the maturity level characteristic to where it was mapped from literature. The code was needed for audit trail during verification and future reference. The conceptual model was then presented to an expert panel for review, suggestions for improvement were made and this resulted in the production of an intermediate maturity model (see Table 7.3 in Chapter 7). The intermediate maturity model contains twenty capability areas left after consolidation and refined version of maturity level characteristics. The eventual consolidation of capability areas by the panel can be associated with the availability of more information and the better understanding of their meanings in the second round of review. The additional information and better understanding was brought about by the availability of maturity level definitions and detailed description of coverage and goals in the conceptual model (Appendix K). As a result, some of the capabilities that sailed the first verification (Chapter 6) were recommended to either be merged or have their names modified (

Table 7.2). The intermediate capability maturity model contains capabilities and capability maturity level characteristic that were presented in appropriate maturity levels in a tabular form, similar to the conceptual model. The achievement of this objective sets the foundation for the pursuance of the next objective.

9.3.6 To refine the built environment flood resilience capability maturity model for businesses

Based on the successful production of the intermediate model from the conceptual model, the next objective was to develop the final capability maturity model by refining the intermediate model. In order to achieve this, four case study organisations were selected (See Section 7.6 for details). The account of past flooding experiences of the case organisations, and the specific comments of the respondents in the case organisations on the model were used to further refine the intermediate model. The case study activities resulted in further consolidation of capability areas, the 20 capabilities left after the expert review that led to the intermediate model (See Table 7.3) was consolidated to 19 capability areas (See Table 7.8). The capability level definitions were requested to be less wordy and this was duly considered. Beyond the consolidation of some capabilities, the suitability of other capabilities was affirmed and maturity level characteristics were modified and ratified in the case studies (see section 7.7). It should be recalled that this study adopted the concept of Capability Maturity Modelling (CMM) (discussed in section 4.6 and 4.7) towards developing a built environment flood resilience capability maturity

model (See Table 7.8). It is clear that the theoretical foundation of this study, as well as the findings from the previous objectives, contributed to the development of the final model in this study (Table 7.8).

The refined capability maturity model was used to assess the built environment flood resilience capability maturity of selected case organisations (See section 7.10 in chapter 7, Table 7.9, Figure 7.6 and Figure 7.7 for details). The result of the assessment showed that the three case studies (CS1, CS2, and CS3) that have experienced significant flooding attained higher maturity (i.e. scored higher) on the capability areas compared to the 4th case study organisation (CS4) that has only experienced slight flooding. CS1 has a relatively high score that ranged from 3.20 to 4.80, that is, level 3 (defined) and level 4 (managed). Similarly, CS2 has capability maturity level scores that ranged from 2.40 to 4.60, that is, level 2 (repeatable) to level 4 (managed) and CS3 has scores ranging from 3.20 to 4.80, that is level 3 (defined) and level 4 (managed). CS4 currently has a relatively low capability maturity level scores, it ranges from 1.20 to 3.80, that is level 1 (Ad hoc) to level 3 (defined) (see section 7.10 for details).

The relatively high maturity scores recorded by CS1, CS2 and CS3 compared to CS4 (See section 7.10 in chapter 7, Table 7.9, Figure 7.6 and Figure 7.7 for details) has been attributed to the fact that the first three case studies have experienced significant flooding. As a result, they have strengthened their capabilities in preparation and readiness for subsequent flooding. This finding outlines the importance of profiling organisations and intensifying efforts aimed at enhancing the understanding of disaster risks and the need to enhance disaster resilience capabilities before disasters. Obviously, organisations with lesser capability maturity will require more attention. Beyond revealing the maturity status of the organisations, the capability maturity model outlines required improvements for achieving higher capabilities and improved flood resilience.

9.3.7 To validate the capability maturity model developed.

The last objective of this study is to validate the built environment flood resilience capability maturity level developed in the study. The validation was done to confirm the quality, acceptability and authenticity of the research outcome (Cheung, 2009). Case study validation and expert evaluation approaches were employed for the evaluation and validation exercise. Findings from the expert evaluation exercise (Table 8.2) revealed that the experts were satisfied with the comprehensiveness, practicality, suitability for purpose

and all other criteria on which the model was assessed (see section 8.4.4 in Chapter 8 for details). The model recorded a mean score of 4.80 for comprehensiveness, 3.60 for practicality and 4.00 for suitability for purpose (see section 8.4.4 in Chapter 8 for more details). Similarly, the case study validation confirmed the adequacy and suitability of the model. The case organisation commended the suitability of capability areas and the ability of the model in revealing the maturity of business organisations as well as encouraging improvement via the adoption of the characteristics laid out in higher maturity levels. The maturity scores recorded by the organisation is impressive. This was attributed to the organisations previous flooding experience, a lot has been done on capability enhancement and the consciousness of the need to be prepared is high. The validation case study organisation ranks in maturity level 4 (i.e. Managed) by scoring above 4.00 in 13 out of 19 capability areas (see Table 8.3 for details).

The result of the evaluation exercise and the successful utilisation of the model in a case organisation as well as the pleasant feedbacks received confirms the overall suitability of the model for assessing, profiling and benchmarking capabilities for flood resilience. Thus, the aim and the objectives of this study (section 1.4) has been successfully achieved.

9.4 Contributions of the study

The result of this study provides both theoretical and practical contributions to knowledge. The contributions are presented in sections 9.4.1 and 9.4.2.

9.4.1 Theoretical contributions

The theoretical contributions of this study are as follows:

1. To the flood resilience theme, this study has provided valuable information with respect to capability enhancement. The identified flood resilience capability areas for MSMEs can be adopted for planning and use by business organisations and can be adopted by researchers for use in subsequent studies.
2. The approach adopted i.e. the application of capability maturity model (CMM) methodology in disaster resilience with a focus on the built environment is novel. This has expanded the boundary of CMM application and has contributed to the body of knowledge on capability enhancement in disaster resilience.
3. This research has enhanced the understanding of capability enhancement and capacity building with respect to flood disaster resilience. This is because the

study provides a comprehensive detail on capabilities and provided a progressive pattern of capability development i.e. capability levels definition. This study has enhanced understanding and will help relevant individuals and the research community in further interpreting the concept of capacity building and capability enhancement for disaster resilience and most especially flood resilience.

4. The identification and verification of capabilities for flood resilience in the built environment is a contribution. This was achieved through literature review, expert forum review and multiple case studies. Although, studies have discussed capacity and capability enhancement in disaster management, only very few discussed capability or capacity enhancement in the context of flood disaster resilience in the built environment. Therefore, this study has helped the research community, business organisations and other stakeholders to focus on specific capabilities for flood resilience in the built environment.
5. The evaluation ability of the maturity model developed in this study is enhanced by the provision of sub-level definitions alongside main level definitions across all maturity levels for each capability area. This allows a sub level/score to be allocated within each maturity level. This is a development on the traditional way of applying capability maturity model methodology. This approach can be adopted for use in other studies.
6. Another contribution of this study to the body of knowledge is the successful use of capabilities in developing a maturity model rather than process areas on which capability maturity model (CMM) and capability maturity model integration (CMMI) from the software industry is based. The study has successfully expanded the use of capabilities in literature, revealed and justified another perspective to the use capability maturity-modelling concept.

9.4.2 Practical contributions

The following are the practical contributions of this study:

1. A flood resilience capability maturity model was developed. There is currently no other model developed to achieve the purpose and functions of the model developed in this study. This model is expected to serve as a self-assessment, self-improvement and external evaluation tool for establishing the flood resilience capability of business organisations.

2. The model developed in this study will be of use to the management of business organisations as a reference for drafting, structuring and implementing flood resilience capability enhancement efforts. It has provided a systematic approach to capability evaluation and enhancement. The systematic approach can be used to benchmark capability enhancement processes as well as future studies.
3. The model will enable business organisations to evaluate their current capability maturity with respect to flood resilience. The result of evaluations can be used to assess an organisations progress in different years as well as an inter-organisation comparison of flood resilience capabilities.
4. The model clearly provides an improvement blueprint that business organisations can follow towards improving their capability for readiness, response, and recovery from a flood event thereby reducing loss from flood events. The model contains what needs to be done to attain a higher maturity level. The model is better viewed as an improvement tool rather than a measurement only.
5. Independent authorities can profile business organisations with respect to flood resilience capabilities using the model developed in this study. Profiling can be for defining the type, and magnitude of assistance to render. The profiling can also be used to gain a deeper understanding of the perspective and status of businesses towards rendering status-based assistance and drafting society inclined policies.

9.5 Conclusions

The need to ensure a reduction in loss from disasters cannot be overemphasised. Although a significant progress is being made in terms of human casualty, economic loss is still increasing. Several events contribute to economic loss from flood disasters but the contribution resulting from damage to the built environment is significant. Therefore, understanding and evaluating the capabilities of organisations with the intention of establishing their current ability to make their built environment withstand, absorb, resist or recover from flood attack becomes imperative. This study employed the concept of Capability Maturity Models (CMM) using capabilities for flood resilience to develop a flood resilience capability maturity model for MSMEs. This study identified 19 capability areas that can enhance the flood resilience of the built environment of a business organisation. The capabilities include some structural, non-structural measures, processes, actions and intellectual abilities that can be utilised by an organisation towards enhancing its flood resilience. All the capability areas are relevant to one or more of pre-

event, event and post-event stages of a disaster. The capability areas are awareness and understanding of flood risk to property, review for a flood resilience scheme, survey of property, acquisition and installation of relevant products. Others are maintenance and post-flood management scheme relationships, electronic data management, decision making in emergency situations, operation of acquired flood facilities, organisation of disaster scenario simulations, crisis response budget, management of disruption – (Attitude towards stressors), post-event review, analysis and management, network strength and physical characteristics of property among others. These capability areas were verified and used to develop capability maturity level definitions that range from level 1 (Adhoc) to level 5 (Optimising) based on CMM principle. Several methodical steps aimed at refining and further developing the model were taken (Figure 5.5) and this resulted in the development of the final model named 'Built Environment Flood Resilience Capability Maturity Model'.

The model was used to assess the flood resilience capability maturity of selected business organisations with respect to the eventual 19 capability areas identified in this study. The result showed that the most of the organisations engaged in this research belong to maturity level 2 (repeatable), maturity level 3 (defined) and maturity level 4 (managed) on the majority of 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 of the organisation that is less matured on many of the capability areas was attributed to the fact that the organisation has only experienced insignificant flooding once; as a result, no significant effort is being made to enhance its capability for resilience.

The developed model (Table 7.8) 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 that business organisations can 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 enhancement processes. This would be beneficial to business

organisations and regulatory bodies. The comprehensiveness and the involvement of experts as well as case organisations with flooding experience enhanced the reliability and the suitability of the model for its purpose.

9.6 Recommendations

Presented below are the recommendations from this study:

- Relevant government agencies and other stakeholders in disaster resilience should continually undertake a broad disaster resilience capability enhancement awareness programme for business organisations. Special attention should 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.
- It is important to encourage urgently business organisations to undertake flood resilience capability evaluation and improvement. The orientation of several businesses about flood is often poor until they experience disaster.
- 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 disaster resilience capability maturity can significantly reduce risk and the magnitude of damage at the organisation level.
- Built Environment Flood Resilience Capability Maturity enhancement should be a key point of discussion in disaster resilience training, workshops, seminars, conferences for business organisations, relevant government agencies, building industry professionals and other relevant stakeholders. The capability areas and other information contained in the model can serve as guides or outline for such discussions.
- The capability areas identified and used to develop the flood resilience capability maturity model in this study are key points that can help mitigate the impact of disaster and speed up the recovery of premises affected by flood. The capability areas should be adopted for use by business organisations. Business organisations should note the capability areas and effectively follow them for enhancing disaster resilience.

- The model developed in this study (Table 7.8) should be applied with sincerity by business organisations, disaster resilience teams and governments' flood disaster monitoring agencies as well as agencies responsible for the health and well-being of businesses.
- Some of the capability areas identified in this study might require funds for their achievement e.g. flood survey, acquisition of flood-related facilities; the finance options provided in Appendix R and discussed in section 3.2 should be utilised as a pointer to available options. .Details on each option can be sought in the country or locality relevant to each potential user.
- Disaster resilience monitoring agencies should profile business organisations using the model developed in this study; awareness and support initiatives should be drafted and implemented based on the results.

It is believed that if relevant stakeholders utilise the findings and recommendations of this study, built environment flood resilience capability can be methodically monitored, managed and enhanced. This is expected to have a significant effect on businesses' ability to prepare, respond and recover from disasters thereby lowering the cost of damage from flood disaster.

9.7 Limitations of the research

The limitations of this study are presented below.

- The focus of this study is flood disasters whereas flooding often occurs with high-speed wind and sometimes storm. This implies that a special consideration should be made for high-speed wind each time the model is used for evaluating capabilities for flood resilience.
- The use of the model developed is limited to flood disasters alone. Although the model is very relevant and applicable to organisations situated in flood-prone areas, its application in places with the likelihood of disasters to the magnitude of a tsunami might be limited.
- 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.
- The case study organisations engaged in this study are mainly from the hospitality sector, although adequate consideration was made for all business irrespective of

the sector in this study, the model can be applied in organisations from other sectors. This will enable further comparison of disaster resilience capability maturity across sectors and this might open more perspectives and issues for discourse.

- Successfully scoring an organisation using the model requires patience due to its comprehensiveness, many MSMEs might need further encouragement and help to complete the assessment.

9.8 Areas for further research

Based on the findings of this research, the following areas are recommended for further study.

- A web interface should be developed for the model in a future study. This will aid the ease of application of the model as well as result processing and presentation.
- The capability areas identified and used in this study should be weighted and scientifically grouped into pre-event, event and post-event stages of a disaster. This will enhance the understanding of the contributions of the capabilities to flood resilience and as well give a clearer pointer to the importance of each of the capability areas towards flood resilience.
- A mapping study can be conducted to outline the stakeholders responsible for the attainment or achievement of the respective capabilities. This will present clearer information on the parties responsible for each associated task.
- This study focused on flood disasters, a subsequent study can incorporate considerations for high-speed wind and storm disasters. This is because flood and high-speed wind sometimes occur together. This will enhance the comprehensiveness and the applicability of the model beyond flood disaster.

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APPENDICES

A. Invitation to participate in an expert panel

Capability maturity model for assessing disaster resilience capabilities of the built environment

Dear Participant,

You have been identified as a professional that is very suitable to be engaged as an expert on an ongoing Ph.D. research project. **Kindly assist on this project by accepting to participate as a member of the expert forum that is being constituted for the study.**

It will be highly appreciated if you could communicate your consent to participate or otherwise to the research team on or before Friday, 6 November 2015. Once you agree to participate, a consent form, which is part of Northumbria University's requirements, will be sent to you and other arrangements will follow. Interaction with each member of the expert forum will be **via email, phone or other means preferred by each member.**

The abstract of the research project can be found via this link http://goo.gl/eb7RD1
If you have any further queries, please contact the research team directly.

Thanks in anticipation.

Kind regards,

Onaopepo Adeniyi
Email: o.adeniyi@northumbria.ac.uk
Mobile: +44(0)7448388401

B. Expert knowledge acquisition questionnaire

Capability maturity model for assessing disaster resilience capabilities of the built environment

Dear participant,

Thank you for choosing to participate in this research.

The aim of this research is to develop a flood-related disaster resilience capability maturity model that identifies built environment flood resilience capabilities of micro, small and medium-sized business organisations.

The research findings will be useful for business owners and financiers, property owners and managers, construction practitioners and academics regarding the resilience of the built environment/premises. It should be noted that damage to the built environment from disasters and its consequential impact on economic loss from disasters is significant. As a result, it is important to strive to enhance the flood management capabilities of organisations.

This questionnaire focuses on factors (i.e. key capability areas) affecting the **flood resilience of the built environment/premises** of Micro, Small and Medium-sized Enterprises (MSMEs). This is an ongoing PhD research being undertaken at Northumbria University, United Kingdom.

The questionnaire will take approximately 7-10 minutes to complete. Participants' response will remain anonymous, treated with strict confidence and used solely for academic purposes. No feedback will be associated to participants or their organisations.

Please return this questionnaire within one week.

Thank you for your time and co-operation.

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Supervisors: Professor Srinath Perera & Professor Andrew Collins

Definition of terms

Built environment is an abstract concept used to describe the products of human building activity and includes any physical alteration to the natural environment (Lawrence and Low, 1990).

Disaster resilience of the built environment is the *"the ability of the built environment exposed to hazards to resist, absorb, accommodate and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions" – Contextualized from UNISDR (2009).*

Section A: Factors (capability areas) influencing the flood resilience of the built environment/premises of Small and Medium Sized Enterprises

(A). Please indicate your **level of agreement** with the factors based on the following scale:
1 = strongly disagree; 2 = disagree; 3 = neither agree nor disagree; 4 = agree; 5 = strongly agree

(B). Please indicate the **level of importance** of the factors based on the following scale:
1 = very low; 2 = low; 3 = neutral; 4 = high; 5 = very high

(C). For more information on each capability area, please see Section B

No.	Factors (capability areas) influencing flood resilience of the built environment of SMEs	A: Level of agreement	B: Level of importance
1	Understanding of flood risk to property	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
2	Planning or review for a flood resilience scheme	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
3	Survey of property	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
4	Acquisition of relevant products for flood risk management *(building materials and technologies)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
5	Installation and Post flood management scheme relationships	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
6	Operation and maintenance ability	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
7	Organisation of disaster scenario simulations *(Full participation of members)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
8	Safety precautions – built environment related	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
9	Retaining the interest of customers in goods and services	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5

10	Turn-over, income generation and cash flow	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
11	Insurance adequacy and management	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
12	Transport/delivery system	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
13	Utility supply	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
14	Communication system	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
15	Flood proof store/flood proof protection for flood stock and contents *(Stocks and equipment)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
16	Record/Business data management *(e.g. back up of documents at distant locations)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
17	Management of disruption to production/service	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
18	Crises response budget	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
19	General awareness and commitment to resilience	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
20	Statutory compliance	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
21	Paper records management *(e.g. duplication of documents at distant locations)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
22	Decision making without recourse to superior in emergency situations	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
23	Definition of roles and responsibilities and how it changes in disaster situations	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
24	Post event review, analysis and management	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
25	System and protocols for mobilizing external resources when needed *(Network strength)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
26	Adaptability/Flexibility of property *(Property design and construction)*	☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
	Kindly indicate and rate other factors (*if any*)		
1		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
2		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
3		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
4		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
5		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5
6		☐1; ☐2; ☐3; ☐4; ☐5	☐1; ☐2; ☐3; ☐4; ☐5

	General comments		

Thank you for your time!

C. Mean scores for experts' agreement with capability areas

Descriptive Statistics[a]

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
[Understanding of flood risk to property]	10	4.00	5.00	4.8000	.42164	-1.779	.687
[Acquisition of relevant products for flood risk management (building materials and technologies)]	10	4.00	5.00	4.6000	.51640	-.484	.687
[Planning or review for a flood resilience scheme]	10	3.00	5.00	4.6000	.69921	-1.658	.687
[Flood survey of property]	10	4.00	5.00	4.3000	.48305	1.035	.687
[Flood proof store/flood proof protection for flood stock and contents (Stocks and equipment)]	10	3.00	5.00	4.2000	.63246	-.132	.687
[Product operation and maintenance ability]	10	3.00	5.00	4.1000	.73786	-.166	.687
[Safety precautions - built environment related]	10	3.00	5.00	4.0000	.66667	.000	.687
[Definition of roles and responsibilities and how it changes in disaster situations]	10	2.00	5.00	3.9000	.87560	-1.018	.687
[Adaptability/Flexibility of property (Property design)]	10	2.00	5.00	3.9000	.99443	-.610	.687
[System and protocols for mobilizing external resources when needed (Network strength)]	10	3.00	5.00	3.9000	.56765	-.091	.687
[Post event review, analysis and management]	10	3.00	5.00	3.9000	.56765	-.091	.687
[Decision making without recourse to superior in emergency situations]	10	3.00	5.00	3.9000	.56765	-.091	.687
[General awareness and commitment to resilience]	10	3.00	5.00	3.9000	.56765	-.091	.687
[Record/Business data management (e.g. back up of documents at distant locations)]	10	3.00	5.00	3.9000	.87560	.223	.687
[Turn-over, income generation and cash flow]	10	2.00	5.00	3.9000	1.28668	-.556	.687

[Management of disruption to production/service]	10	1.00	5.00	3.8000	1.03280	-2.542	.687
[Organisation of disaster scenario simulations (Full participation of members)]	10	3.00	4.00	3.8000	.42164	-1.779	.687
[Product installation and Post flood management scheme relationships]	10	3.00	5.00	3.8000	.78881	.407	.687
[Insurance adequacy and management]	10	1.00	5.00	3.7000	1.41814	-.801	.687
[Paper records management (e.g. duplication of documents at distant locations)]	10	3.00	5.00	3.7000	.67495	.434	.687
[Crises response budget]	10	2.00	5.00	3.7000	.94868	-.234	.687
[Communication system]	10	2.00	5.00	3.6000	.84327	-.389	.687
[Utility supply]	10	2.00	4.00	3.5000	.70711	-1.179	.687
[Transport/delivery system]	10	3.00	4.00	3.5000	.52705	.000	.687
[Statutory compliance]	10	1.00	5.00	3.3000	1.25167	-.280	.687
[Retaining the interest of customers in goods and services]	10	1.00	5.00	2.9000	1.19722	.233	.687
Valid N (listwise)	10						

a. First response

D. Kendall's coefficient for experts' agreement with capability areas

Test Statistics

N	10
Kendall's W[a]	.221
Chi-Square	55.310
df	25
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

E. Correlation matrix for experts' agreement with capability areas

Code ref.	KCA1	KCA2	KCA3	KCA4	KCA5	KCA6	KCA7	KCA8	KCA9	KCA10	KCA11	KCA12	KCA13	KCA14	KCA15	KCA16	KCA17	KCA18	KCA19	KCA20	KCA21	KCA22	KCA23	KCA24	KCA25	KCA26
KCA1	1.000																									
KCA2	.645*	1.000																								
KCA3	0.102	-0.132	1.000																							
KCA4	0.327	0.423	0.089	1.000																						
KCA5	-0.249	-0.090	0.244	0.522	1.000																					
KCA6	0.094	0.464	0.154	-0.082	-0.312	1.000																				
KCA7	0.395	0.306	0.000	.690*	0.000	-0.209	1.000																			
KCA8	0.140	-0.133	0.076	0.082	0.171	0.074	-0.118	1.000																		
KCA9	0.553	0.381	-0.075	0.322	-0.345	0.373	0.175	-0.269	1.000																	
KCA10	-0.108	0.361	-0.132	0.516	0.394	0.297	0.000	-0.201	-0.401	1.000																
KCA11	-0.538	0.028	-0.176	-0.141	0.394	0.004	-0.272	0.016	-0.262	0.329	1.000															
KCA12	0.000	-0.407	0.362	-0.301	-0.247	0.212	-0.218	0.158	0.407	0.038	-0.610	1.000														
KCA13	0.377	-0.208	-0.176	-0.282	-0.609	0.069	0.000	0.270	0.460	-0.380	-.713*	0.538	1.000													
KCA14	-0.108	-0.583	-0.176	-0.282	-0.261	-0.224	0.000	-0.595	-0.210	-0.380	-0.380	0.538	-0.625	1.000												
KCA15	-.639*	-.825**	0.075	0.000	0.229	-0.500	-0.029	-0.003	-0.118	0.071	0.185	0.320	-0.027	0.432	1.000											
KCA16	-0.466	-0.072	0.000	-0.081	-0.082	0.408	-0.589	-0.007	0.172	0.497	.690*	0.000	-0.265	-0.265	-0.238	1.000										
KCA17	0.375	0.161	0.612	-0.218	-0.249	0.094	0.000	0.140	-0.046	-0.538	-0.108	0.000	-0.108	-0.108	-0.320	-0.186	1.000									
KCA18	0.000	0.000	0.000	-0.488	-0.401	0.000	0.000	0.000	0.536	.818**	0.000	0.396	0.000	0.000	-0.367	0.333	-0.559	1.000								
KCA19	0.181	0.560	-0.148	-0.039	-0.184	.711*	-0.372	-0.003	0.590	.642*	0.105	0.217	-0.035	-0.245	-0.419	0.499	-0.090	-0.404	1.000							
KCA20	-0.456	0.071	-0.261	-0.199	-0.309	0.311	-0.375	-0.113	0.242	.746*	.746*	-0.115	-0.389	-0.177	-0.233	.857**	-0.456	-0.531	-0.561	1.000						
KCA21	0.577	0.298	-0.354	0.000	-0.552	0.076	0.000	-0.302	.692*	-0.124	-0.087	-0.034	-0.547	-0.211	-0.253	-0.108	-0.144	-0.000	-0.282	-0.042	1.000					
KCA22	0.094	0.511	0.154	0.370	-0.165	0.577	0.060	-0.465	0.118	0.608	0.057	-0.089	-0.219	-.729*	-0.358	-0.309	-0.282	-0.337	-0.436	-0.275	-0.239	1.000				
KCA23	0.000	-0.258	0.000	0.218	-0.040	0.151	-0.316	-0.224	0.369	0.172	-0.559	0.630	-0.559	-0.559	-0.292	-0.224	-0.500	-0.447	-0.036	-0.073	-0.115	-0.113	1.000			
KCA24	-0.398	0.154	-0.081	-0.130	-0.246	.730*	-0.283	-0.007	-0.118	.677*	0.330	-0.157	-0.270	-0.270	-0.036	-0.624	-0.398	-0.401	-0.583	-0.687*	-0.357	-0.675*	-0.279	1.000		
KCA25	-0.090	0.257	-0.406	-0.158	-0.072	0.215	-0.171	-0.412	-0.490	.809**	0.253	-0.082	-0.078	-0.288	-0.112	-0.579	-0.542	-0.687*	-0.670*	-0.673*	-0.230	-0.449	-0.036	-0.425	1.000	
KCA26	-0.313	-0.012	-0.621	-0.195	-0.168	-0.088	-0.594	-0.388	-0.007	-0.243	-0.532	-0.250	-0.050	-0.123	-0.052	-0.487	-0.448	-0.120	-0.375	-0.657*	-0.238	-0.128	-0.179	-0.296	-0.307	1.000

Notes: See Table 6.3 for code references. *Correlation is significant at the 5% level (2-tailed). **Correlation is significant at the 1% level (2-tailed).

F. Mean scores of experts' assessment of the importance of capability areas

Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error
[Understanding of flood risk to property]	10	4.00	5.00	4.9000	.31623	-3.162	.687
[Planning or review for a flood resilience scheme]	10	4.00	5.00	4.8000	.42164	-1.779	.687
[General awareness and commitment to resilience]	10	4.00	5.00	4.3000	.48305	1.035	.687
[Insurance adequacy and management]	10	2.00	5.00	4.3000	1.05935	-1.444	.687
[Product operation and maintenance ability]	10	3.00	5.00	4.2000	.78881	-.407	.687
[Flood proof store/flood proof protection for flood stock and contents (Stocks and equipment)]	10	3.00	5.00	4.2000	.63246	-.132	.687
[Acquisition of relevant products for flood risk management (building materials and technologies)]	10	3.00	5.00	4.2000	.78881	-.407	.687
[Safety precautions - built environment related]	10	4.00	5.00	4.1000	.31623	3.162	.687
[Adaptability/Flexibility of property (Property design)]	10	2.00	5.00	4.0000	.94281	-.994	.687
[Communication system]	10	3.00	5.00	4.0000	.47140	.000	.687
[Flood survey of property]	10	2.00	5.00	4.0000	.94281	-.994	.687

[Decision making without recourse to superior in emergency situations]	10	3.00	5.00	4.0000	.47140	.000	.687
[System and protocols for mobilizing external resources when needed (Network strength)]	10	3.00	5.00	3.9000	.56765	-.091	.687
[Utility supply]	10	3.00	5.00	3.9000	.73786	.166	.687
[Post event review, analysis and management]	10	3.00	5.00	3.9000	.56765	-.091	.687
[Organisation of disaster scenario simulations (Full participation of members)]	10	3.00	4.00	3.9000	.31623	-3.162	.687
[Definition of roles and responsibilities and how it changes in disaster situations]	10	2.00	5.00	3.8000	.78881	-1.290	.687
[Management of disruption to production/service]	10	1.00	5.00	3.8000	1.03280	-2.542	.687
[Turn-over, income generation and cash flow]	10	2.00	5.00	3.8000	.91894	-.601	.687
[Crises response budget]	10	2.00	5.00	3.7000	.94868	-.234	.687
[Record/Business data management (e.g. back up of documents at distant locations)]	10	2.00	5.00	3.7000	.94868	-.234	.687
[Product installation and Post flood management scheme relationships]	10	3.00	5.00	3.7000	.82327	.687	.687

[Paper records management (e.g. duplication of documents at distant locations)]	10	3.00	5.00	3.7000	.82327	.687	.687
[Statutory compliance]	10	1.00	5.00	3.5000	1.35401	-.504	.687
[Transport/delivery system]	10	3.00	4.00	3.4000	.51640	.484	.687
[Retaining the interest of customers in goods and services]	10	1.00	5.00	3.4000	1.57762	-.620	.687
Valid N (listwise)	10						

G. Kendall's coefficient for importance of capability areas

Test Statistics

N	10
Kendall's W[a]	.225
Chi-Square	56.231
df	25
Asymp. Sig.	.000

a. Kendall's Coefficient of Concordance

H. Correlation matrix for importance of capability areas

Code ref.	R2KCA1	R2KCA2	R2KCA3	R2KCA4	R2KCA5	R2KCA6	R2KCA7	R2KCA8	R2KCA9	R2KCA10	R2KCA11	R2KCA12	R2KCA13	R2KCA14	R2KCA15	R2KCA16	R2KCA17	R2KCA18	R2KCA19	R2KCA20	R2KCA21	R2KCA22	R2KCA23	R2KCA24	R2KCA25	R2KCA26
R2KCA1	1.000																									
R2KCA2	.667*	1.000																								
R2KCA3	-0.262	0.148	1.000																							
R2KCA4	0.218	-0.218	0.043	1.000																						
R2KCA5	0.497	.745*	-0.081	-0.488	1.000																					
R2KCA6	0.497	0.093	0.257	0.407	0.097	1.000																				
R2KCA7	0.598	0.548	-0.145	-0.130	0.542	-0.074	1.000																			
R2KCA8	0.111	0.167	-0.591	-0.218	0.373	-0.497	0.465	1.000																		
R2KCA9	0.063	0.471	-0.148	-0.123	0.323	-0.463	0.465	0.439	1.000																	
R2KCA10	.745*	0.000	-0.484	0.488	0.000	0.583	0.312	0.000	-0.337	1.000																
R2KCA11	0.000	0.000	0.000	0.000	0.000	0.000	0.401	0.000	0.000	0.000	1.000															
R2KCA12	0.063	-0.282	-0.415	0.205	-0.182	0.211	0.195	-0.063	0.135	0.337	0.590	1.000														
R2KCA13	1.000**	.667*	-0.262	-0.218	0.497	0.497	0.598	-0.111	-0.063	.745*	0.000	-0.063	1.000													
R2KCA14	0.441	.661*	0.566	-0.206	0.380	0.380	0.252	-0.441	-0.114	0.000	0.296	-0.192	-0.441	1.000												
R2KCA15	-0.072	0.377	.746*	-0.282	0.265	0.265	0.047	-0.574	-0.041	-0.433	0.385	0.008	-0.072	.773**	1.000											
R2KCA16	-0.072	-0.538	0.258	-0.516	-.690*	0.553	-0.261	-0.574	-0.511	0.385	0.000	-0.300	-0.072	-0.008	-0.005	1.000										
R2KCA17	-0.062	0.234	.821**	-0.163	0.132	0.279	-0.026	-0.561	-0.394	-0.293	0.293	-0.359	-0.062	.792**	.801**	0.097	1.000									
R2KCA18	0.000	0.000	0.000	-0.488	0.000	0.000	-0.401	-0.000	-0.590	0.000	-0.000	-0.337	-0.000	-0.296	0.000	0.000	-0.293	1.000								
R2KCA19	-0.071	-0.107	0.270	-0.140	0.080	0.527	-0.222	-0.500	-0.024	0.000	-0.383	-0.169	-0.071	-0.065	0.286	-0.286	-0.000	-0.479	1.000							
R2KCA20	0.315	0.472	0.119	0.041	0.380	-0.239	-0.335	-0.315	-0.278	0.000	0.549	-0.420	-0.315	-0.504	-0.626	-0.272	-0.300	-0.338	-0.202	1.000						
R2KCA21	-0.487	0.046	.676*	0.040	0.048	-0.143	-0.040	-0.304	-0.296	-.694*	0.000	-0.234	-0.487	-0.093	-0.558	-0.177	-0.434	-0.531	-0.414	-0.317	1.000					
R2KCA22	-0.122	-0.137	0.316	-0.199	0.061	-0.061	-0.309	-0.304	-0.461	-0.286	0.531	-0.488	-0.122	-0.197	-0.605	-0.051	-0.218	-0.694*	-0.352	-0.780**	-0.663*	1.000				
R2KCA23	-0.504	-0.142	0.506	-0.041	-0.401	-0.401	-0.448	-0.315	-0.228	-0.549	0.000	-0.548	-0.504	-0.132	-0.203	-0.089	-0.498	-0.211	-0.324	-0.064	-0.466	-0.017	1.000			
R2KCA24	-0.418	0.000	0.296	-0.117	0.080	-0.240	-0.178	-0.179	-0.533	-0.560	0.400	-0.357	-0.418	-0.034	-0.562	-0.181	-0.171	-0.641*	-0.345	-0.558	-0.755*	-0.896**	-0.074	1.000		
R2KCA25	-0.418	0.045	0.620	-0.156	-0.113	-0.220	-0.018	-0.477	-0.196	-0.600	-0.480	-0.074	-0.418	-0.433	-.770**	-0.004	-0.619	-0.240	-0.054	-0.487	-0.699*	-0.719*	-0.487	-0.788**	1.000	
R2KCA26	0.272	0.408	0.321	-0.089	0.304	-0.304	-0.407	-0.272	-0.461	0.000	-0.000	-0.231	-0.272	-0.424	-0.527	-0.176	-0.153	-0.456	-0.525	-0.347	-0.261	-0.484	-0.463	-0.475	-0.365	1.000

Notes: See Table 6.3 for code references. *Correlation is significant at the 5% level (2-tailed). **Correlation is significant at the 1% level (2-tailed)

I. Cover letter for conceptual model verification and refinement by the expert panel

Capability maturity model for assessing disaster resilience capabilities of the built environment

Dear Participant,

Thank you very for agreeing to participate in the expert forum for this research.

Analysis of the questionnaire completed not long ago has been completed. Responses from experts have been considered and some have been kept for adoption after this stage.

The purpose of this stage is to have the resilience capability maturity model refined before being tested in case studies.

Kindly refer to the attached instruction sheet for the details of expectations.

The following documents are attached:

1. Instructions to experts
2. General Capability maturity levels characteristics
3. Conceptual capability maturity model

It will be highly appreciated if you could return document 'B' via email on or before Friday 7th April 2016. If you require any additional information, please contact the research team by emailing me.

Please be assured that all information gathered will be treated with utmost confidentiality.

Your decision to participate in the expert forum is highly appreciated.

Kind regards,

Onaopepo Adeniyi

Email: o.adeniyi@northumbria.ac.uk

Mobile: +44(0)7448388401

J. Instruction to experts

(Please read all instructions carefully)

The objective of this stage in the expert review process is to have the resilience capability maturity framework refined before it is tested on case studies.

1. Carefully read the general capability level characteristics **(i.e. Document A – See Table 4.5 to 4.9 in the body of this thesis)**. This will provide a clearer understanding of the peculiarity of each resilience capability maturity level characteristics (Maturity level 1 - Adhoc to Maturity level 5 - Optimizing).
2. The resilience capability maturity framework i.e. **Document B** was developed using the capability areas for enhancing built environment resilience and the general capability level characteristics **i.e. Document A**.
3. Carefully read the resilience capability maturity framework i.e. **Document B.** While reading the document, take note of the column to the right of maturity level 5.
4. **On document B, kindly indicate your satisfaction with the quality and adequacy of each capability area, the characteristics describing each capability level for each capability area.** Do this by writing in the column to the right of maturity level 5 (Comments column). **Please provide robust comments.**
5. The capability areas presented in this model relates to resources, means, strengths, competencies which enables a business to prepare its built environment to cope with, withstand, prepare for, prevent, mitigate or quickly recover from flood disaster. The capabilities have been found to have influence on the flood resilience of a property.
6. Please provide other comments that can improve the model
7. Kindly return **Documents B via email by Thursday, 7 April 2016**
8. Thank you for your time.

K. Conceptual built environment flood resilience capability maturity model - Document B

The listed key capability areas consist of issues relating to resources, means, strengths, competencies which enables a business to prepare its built environment to cope with, withstand, prepare for, prevent, mitigate or quickly recover from flood disaster. Each of the capability areas contribute to the flood resilience of the built environment of a business organisation.

SN	Key Capability Areas	Capability levels					Kindly review and comment on your satisfaction with the key capability areas and level definitions here (see instruction to experts)
		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
1	Understanding of flood risk to property Coverage - Awareness of the type, frequency of flood. Knowledge of climate projection and flood projection in the area. Periodic assessment is necessary - physical vulnerability evaluation and water entry channel survey. Initial consideration of remedial measures Understanding of hazard consequences to organisation and all assets. Goal - This is expected to lead to a detailed mitigation survey. With information on mitigation and protection that is needed. This might influence other decisions. The effect or influence of surrounding businesses will also be established.	Yet to recognise the strategic importance of climate and flood 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 tools or database ML1Ad/C14. Unaware of the need ML1Ad/C16.	Individual department or function makes effort but they are not shared ML2Re/C3. Senior manager may recognise the importance but resources are not allocated ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Importance is recognised. They are communicated verbally (within department) ML2Re/C13. Heavy reliance on knowledge of individuals ML2Re/C16	Importance is recognised ML3De/C2. Tools, templates and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exist ML3De/C18.	High recognition of importance ML4Ma/C2. The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Tools, database and records are available for statistical and managerial analysis ML4Ma/C14. Risk is identified ML4Ma/C17.	Operating environment is well understood ML5Op/C2. They anticipate and respond to uncertainty ML5Op/C4. Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, lessons learnt are captured and fed back into the system ML5Op/C10. High level of awareness ML5Op/C20. Active use of information ML5Op/C21.	
2	Planning or review for a flood resilience scheme Coverage - Products and planning criteria for a specific scheme have to be defined; there are variety of schemes and measures. Understanding of neighbour's disaster resilience decisions on one's property. Knowledge of variety of	Engage in very little planning ML1Ad/C3. No centrally coordinated support function ML1Ad/C5. No standardised procedures ML1Ad/C8. Organisation pays lip service to related activity	Individual department or function makes effort but they are not shared ML2Re/C3. Senior manager recognise the importance but resources are not allocated ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Importance is	Importance is recognised ML3De/C2. Tools, templates and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated	High recognition of importance ML4Ma/C2. The need for review for a scheme is highly recognized and supported, with stated means of successful execution and improvement	Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, processes are kept up to date ML5Op/C11. High level of awareness ML5Op/C20. Active use of information	

SN	Key Capability Areas	Capability levels					Kindly review and comment on your satisfaction with the key capability areas and level definitions here (see instruction to experts)
		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	measures for flood resilience. Analysis of cost implication of options and preparation for funding. Use of relevant data and or engagement of professionals. Goal - This is expected to lead to a clear, workable plan and schedule for a flood mitigation/resilience scheme. This will influence financial sourcing or planning. It will also affect where and how to seek help. It will determine the help, technology and materials to use. This will determine the general sophistication of method i.e. use of sand bags, manual flood gates, self-rising/automatic barriers etc.	or processes ML1Ad/C9. No understanding of flood resilience schemes and related activities ML1Ad/C13. Short-term focused strategies ML1Ad/C17. No monitoring or reporting ML1Ad/C19.	recognised. They are communicated verbally (within department) ML2Re/C13. Heavy reliance on knowledge of individuals ML2Re/C16	with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18.	ML4Ma/C9. Tools, database and records are available for statistical and managerial analysis ML4Ma/C14.	tools and databases ML5Op/C21.	
3	Survey of property Coverage - Knowledge of the importance of professional accreditation/certification of the persons that will inspect or inspected potentially vulnerable points around the property (i.e. walls, building services and infrastructure) measure apertures (i.e. Doors, windows and other openings) as well as other property potential failure assessments. Appraisal and continuous monitoring of organisations ability to install measures as well as the performance of installations. Organisation understands what to expect during property survey	Organisations are highly reactive, need for pre-crisis survey is unclear ML1Ad/C2. Property survey related processes or activities are generally chaotic ML1Ad/C7. Individuals act, no institutional coordination ML1Ad/C11. Budgets and schedules documented in plans are usually exceeded ML1Ad/C15.	Individual department or function makes effort but they are not shared ML2Re/C3. Senior manager recognise the importance but resources are not allocated ML2Re/C4. Importance is recognised. They are communicated verbally (within department) ML2Re/C13. Heavy reliance on knowledge and effort of individuals ML2Re/C16	Importance is recognised ML3De/C2. Tools, templates and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated with stakeholders (professionals, government and others) ML3De/C17.	High recognition of importance ML4Ma/C2. The need for property survey is highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9. Consistent and systematic approach to process/task ML4Ma/C22	High recognition of importance, processes are kept up to date ML5Op/C11. High level of awareness ML5Op/C20. Active use of information tools and databases ML5Op/C21.	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	activities. Goal - This is expected to result to a detailed design specification for the property. All component parts can then be outlined.						
4	Acquisition of relevant products for flood risk management Coverage - Understanding of the purpose and function of flood resilience products. Ability to deploy product whenever the need arise. Ability to recognize the suitability of products. Product evaluation for BSI kite mark standards or customer reviews. Communication and correspondence with product manufacturers, supplier or installers. Goal - Organized fixing of dates and communication of clear specifications to the supplier or manufacturer. *The Kite mark is a certification mark operated by the British Standards Institute (BSI). PAS 1188 covers flood resilience products, technologies and systems.	Yet to recognise importance of acquiring and deploying relevant quality products ML1Ad/C4. Property survey related processes or activities are generally chaotic ML1Ad/C7. No attempt to identify the benefit of products, quality, specification and communication with professionals/suppliers ML1Ad/C12. No record or database related to acquisition is available ML1Ad/C14.	Individual department have plans of acquiring and deploying relevant quality products but they are not shared ML2Re/C3. Senior manager recognise the importance but resources are not allocated ML2Re/C4. Deliverables or successes can be seen/Pockets of good practices ML2Re/C11 Heavy reliance on knowledge and effort of individuals ML2Re/C16.	Importance is recognised ML3De/C2. Mid-term focused plans ML3De/C14. Relevant actions are coordinated with stakeholders (professionals, government and others) ML3De/C17.	High recognition of importance ML4Ma/C2. The need for relevant products highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9.	High recognition of importance, processes are kept up to date ML5Op/C11. High level of awareness ML5Op/C20. Active use of information tools and databases ML5Op/C21.	
5	Installation and Post flood management scheme relationships	No centrally coordinated support function ML1Ad/C5. Processes or related activities are	Appropriate stakeholders are engaged ML2Re/C8	Importance is recognised ML3De/C2. Strong support to the process/task being	High recognition of importance ML4Ma/C2. Pre and post-flood management	High recognition of importance, processes are kept up to date ML5Op/C11. Sound relationship with	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Coverage - Product quality assessment. Management of installation period and preparations for potential disruption. Post installation relationship management with supplier and installer. Maintenance contracts and the like. Availability of helpful community resources e.g. flood wardens and or representatives. Emergency service or even police (special equipment might be needed on special occasions. Goal - Availability of visual data of installations and post-installation property survey. Relationship with local businesses.	generally chaotic ML1Ad/C7. There are no formal processes as there is no stable environment to support them. Unaware of the need for tasks to be undertaken ML1Ad/C16.	Deliverables or successes can be seen/Pockets of good practices ML2Re/C11 Importance of tasks/procedures is recognised. They are communicated verbally (within department). ML2Re/C13. Heavy reliance on knowledge and effort of individuals ML2Re/C16.	undertaken by management ML3De/C6. Relevant actions are coordinated with stakeholders (professionals, government and others) ML3De/C17.	relationship are highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9.	stakeholders, societal network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements ML5Op/C14. Fully integrated best practices. Top managers are exemplars ML5Op/C17. Active use of information ML5Op/C21.	
6	Operation and Maintenance Coverage - Understanding and circulation of operational instructions. Operation, storage and maintenance requirement. Methodology for appropriate activation of products. Management of maintenance regime and storage facilities for temporary fixtures. Funding for aftercare and maintenance. Emergency plans to cater for flooding than the products cannot cope with. Availability of support for product	Processes or related activities are generally chaotic ML1Ad/C7. There are no formal processes as there is no stable environment to support them. No standardized procedures ML1Ad/C8. Organisation pays lip service to the activity or process ML1Ad/C9. Existing processes are abandoned in times of	Individual department or function do have personal plans and abilities but they are not shared ML2Re/C3. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Roles are clear and achievable, with measurement strategies ML2Re/C9. There are skilled people who can produce controlled outputs. Key individuals demonstrate track	Processes are described/documented in standards, procedures and are well understood ML3De/C5. More proactively managed rigorous process exists. Proactive behaviour ML3De/C7. Mid-term focused plans ML3De/C14. Relevant actions are coordinated with stakeholders (government and others)	The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Strong teamwork with internal and external parties/partners. Network/Coalition building ML4Ma/C15. Human capacity building is high ML4Ma/C19.	They anticipate and respond to uncertainty ML5Op/C4. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Processes/tasks/records are kept up-to-date ML5Op/C11. Sound relationship with stakeholders, societal	

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	activation. Relationship between authorities plan and organisation's plans. Goal - Effective response readiness.	crises. Successes cannot be sustained. ML1Ad/C10. Arrangements/strategies and abilities are short-term focused ML1Ad/C17.	record with hopes of repeating earlier success ML2Re/C12. Basic processes exist, basic generic training ML2Re/C18	ML3De/C17. Training programme for capacity development exists ML3De/C18.	Consistent and systematic approach to process/task ML4Ma/C22	network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements ML5Op/C14. Fully integrated best practices. Top managers are exemplars ML5Op/C17.	
7	Organisation of disaster scenario simulations (Full participation of members) Coverage - Participation in drills and flood scenario simulations. This affects end-user's ability to deploy relevant technologies after warning e.g. temporary or demountable barriers. Goal - It creates physical and mental alertness.	Organisation is highly reactive, very little preparation or simulation is done ML1Ad/C2. Engage in very little planning and simulation of scenario ML1Ad/C3. No centrally coordinated support function ML1Ad/C5. Generally chaotic scenarios and rehearsal ML1Ad/C7. Organisation pays lip service to the activity or process ML1Ad/C9. Individuals act, no institutional coordination ML1Ad/C11	Organisations are reactive ML2Re/C2. Individual department or function do have personal plans in place but they are not shared ML2Re/C3. Organisations experiment on processes planned, introduced ML2Re/C5. Weak ability as a team ML2Re/C6. Large dependence on historical practice ML2Re/C17.	They engage in formal planning and simulation ML3De/C3. More proactively managed rigorous process exists. Proactive behaviour ML3De/C7. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18. Mainly inward looking ML3De/C20.	Staff are involved and engaged in planning ML4Ma/C4. Process is supported with stated means of improvement ML4Ma/C9. Measures of performance are technically analysed ML4Ma/C11. Best practice is incorporated ML4Ma/C18. Human capacity building is high ML4Ma/C19.	Organisation takes the lead in establishing visionary cultures, processes, and practices through simulation and similar approaches ML5Op/C3. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Processes/tasks and relevant records are kept up-to-date ML5Op/C11. Fully integrated best practices. Top managers are exemplars ML5Op/C17.	
8	Safety precautions – built environment related Coverage - Switch-off power or power banks, fastening water tank and external furniture etc. Goal - To prevent complications.	Success depends on individuals efforts. Individuals act, no institutional coordination ML1Ad/C11. Unaware of the link of the tasks to be undertaken with built environment resilience ML1Ad/C16.	Individual department or function do have personal plans in place but they are not shared ML2Re/C3. Importance of tasks/procedures is recognised. They are communicated verbally	Importance of the task/process being undertaken towards resilience is recognized ML3De/C2. Processes are described/documented in standards, procedures and are well understood	Recognise importance of resilience (Higher recognition) ML4Ma/C2. Highly recognized and supported with stated means of improvement ML4Ma/C9. Measures of performance are	Lessons learnt are captured and fed back into the system ML5Op/C10. Fully integrated best practices. Top managers are exemplars ML5Op/C17. A real time system exists (as required). Automation of process/task or techniques ML5Op/C19.	

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			(within department) ML2Re/C13.	ML3De/C5. More proactively managed rigorous process exists. Proactive behaviour ML3De/C7. Mid-term focused plans ML3De/C14.	statistically/technically analysed ML4Ma/C11. Consistent and systematic approach to process/task exists in the organisation ML4Ma/C22.		
9	Retaining the interest of customers in goods and services Coverage: Retained interest of customers/ maintenance of appealing service or products.	Yet to recognize the strategic importance of maintaining appealing service on premises resilience ML1Ad/C4. No centrally coordinated support function ML1Ad/C5. Existing processes are abandoned in times of crises. Successes cannot be sustained ML1Ad/C10. Individuals act, no institutional coordination ML1Ad/C11	Individual department or function do have personal plans in place but they are not shared ML2Re/C3. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Importance of tasks/procedures is recognised. They are communicated verbally (within department) ML2Re/C13. Large dependence on historical practice ML2Re/C17.	A visible level of service continuity can be maintained ML3De/C4. More proactively managed rigorous process exists. Proactive behaviour ML3De/C7. Standard processes are established and improved overtime ML3De/C11. Mid-term focused plans ML3De/C14.	Organisations ability to sustain service can be linked with the creativity, innovation and autonomy of its staff ML4Ma/C5. Related processes/tasks are highly supported by owner/management, with stated means of improvement ML4Ma/C9. Measures of performance are statistically/technically analysed ML4Ma/C11. Projections are forecast are partially made on statistical/numerical analysis ML4Ma/C12. Strong teamwork with internal and external parties/partners. Network/Coalition building ML4Ma/C15. Consistent and systematic approach to process/task ML4Ma/C22	They are ahead in establishing visionary cultures, processes, and practices ML5Op/C3. Quantitative approaches are used to understand the variation in processes (internal and external) ML5Op/C6. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Sound relationship with stakeholders, societal network and the community ML5Op/C14. Strong negotiation ability and influence on others ML5Op/C22.	
10	Turn-over and cash flow management	Engage in very little financial planning	Simple tools and templates are used for some activities	They engage in formal planning ML3De/C3.	Measures of performance are	They anticipate and respond to uncertainty ML5Op/C4.	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Coverage - Cash flow management Goal - It influences fund availability	ML1Ad/C3. If policy exists it is not enforced ML1Ad/C6. Existing financial processes are abandoned in times of crises. Successes cannot be sustained ML1Ad/C10. No tools or database relevant to the process are in use ML1Ad/C14. Budgets and schedules documented in plans are usually exceeded ML1Ad/C15.	ML2Re/C10. Pockets of good practices ML2Re/C11. Key individuals demonstrate track record with hopes of repeating earlier success ML2Re/C12. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14. Large dependence on historical practice ML2Re/C17.	Tools, templates and relevant database are available ML3De/C10. Mid-term focused plans ML3De/C14.	statistically/technically analysed ML4Ma/C11. Tools, database and records are available for analysis (statistics and others) and management. Projections are forecast are partially made on statistical/numerical analysis ML4Ma/C12. ML4Ma/C14. Capable of managing predictable and non-predictable eventualities ML4Ma/C21	There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Quantitative techniques are used for measuring improvements ML5Op/C9. Lessons learnt are captured and fed back into the system ML5Op/C10. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15.	
11	Insurance adequacy and management Coverage - Knowledge and existence of insurance. Even if steps have been taken to protect a property from flooding, there is still need for flood insurance. Especially if the property is in a floodplain. Goal- How sufficient is the coverage? Sufficient for repairs, leasing temporary equipment, adequate for cleaning-up? Safely kept insurance details, policies and contact.	Yet to recognize the role of insurance resilience ML1Ad/C4. If policy exists it is not enforced ML1Ad/C6. Organisation pays lip service to the activity or process ML1Ad/C9. No understanding of principles ML1Ad/C13. Unaware of the need ML1Ad/C16.	Senior manager may recognise the importance but resources are not allocated to it ML2Re/C4. Appropriate stakeholders are engaged ML2Re/C8. There are skilled people who can produce controlled outputs. Key individuals demonstrate track record and understanding, with hopes of repeating earlier success ML2Re/C12. Heavy reliance on knowledge of individuals ML2Re/C16. Large dependence on historical practice ML2Re/C17	Importance is recognized ML3De/C2. Processes are described/documented in standards, procedures and are well understood ML3De/C5. Formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Policies and procedures are partially implemented or limited to the support of few stakeholders ML3De/C15. Insurance scheme is available ML3De/C16.	Higher recognition of importance of insurance ML4Ma/C2. The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Insurance scheme exists ML4Ma/C20	There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Relevant records are kept up-to-date ML5Op/C11. Insurance scheme exist ML5Op/C18.	
12	Transport/delivery system	Organisation is highly reactive, no plans for	Organisations are reactive ML2Re/C2. Senior manager	Importance of resilience or importance of the	Recognise importance of resilience (Higher	There is focus on continual improvement of process	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Coverage - Accessibility Goal - Access preservation	transportation during and immediately after crisis ML1Ad/C2. Existing options are abandoned as a result of crises ML1Ad/C10. Approaches/methods are applied on case-by-case basis ML1Ad/C18. Use of basic and narrow range technology to sustain or manage transportation before and immediately after crisis ML1Ad/C20.	may recognise the importance of resilient transportation arrangement but resources are not allocated to it ML2Re/C4. Organisations experiment on transportation/delivery processes planned, introduced, and executed in line with policy ML2Re/C5. Large dependence on historical practice ML2Re/C17Mid-level proven technology. Mid-range products ML2Re/C20.	task/process being undertaken towards resilience is recognized ML3De/C2. Processes are described/documented in standards, procedures and are well understood ML3De/C5. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. More advanced but proven technology. Use major assembles, complex products ML3De/C21.	recognition) ML4Ma/C2. The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23.	performance through innovation and technological advancements ML5Op/C7. Quantitative techniques are used for measuring improvements ML5Op/C9. Lessons learnt are captured and fed back into the system ML5Op/C10. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15. Advanced and some innovative technology, involves large scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23.	
13	Utility supply Coverage - Existing supply arrangement and availability of alternatives. Possession of suppliers' contacts on-site and off-site, availability of alternates and back-up. Goal - Continuity of supply through preservation of existing system or availability of alternatives.	Organisation is highly reactive, no plans for utility during and immediately after crisis ML1Ad/C2. Existing options fail or abandoned as a result of crises ML1Ad/C10. Short-term focused strategies ML1Ad/C17. Approaches/methods are applied on case-by-case basis ML1Ad/C18. Use of basic and narrow range technology to sustain utility before and	Organisations are reactive ML2Re/C2. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Appropriate stakeholders are engaged ML2Re/C8. Pockets of good practices ML2Re/C11. Mid-level proven technology. Mid-range products ML2Re/C20.	More proactively managed options/solutions are available ML3De/C7. Standard processes are established and improved overtime ML3De/C11. Mid-term focused plans ML3De/C14. Mainly inward looking ML3De/C20. More advanced but proven technology. Use major assembles, complex products ML3De/C21.	Supply arrangements in crises periods are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Projections and forecast are partially made on statistical/numerical analysis. Improved predictability of performance ML4Ma/C12. Capable of managing predictable and non-predictable eventualities	They anticipate and respond to uncertainty related to utilities ML5Op/C4. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15. Advanced and some innovative technology, involves large scale multiple complex assemblies and	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
		immediately after crisis ML1Ad/C20.			ML4Ma/C22. Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23.	installations. Complex systems and complex products ML5Op/C23	
14	Communication system Coverage - Connectivity with existing external supply. Goal - Continuity of supply through preservation of existing system or availability of alternatives.	Organisation is highly reactive, no plans for utility during and immediately after crisis ML1Ad/C2. Existing options fail or abandoned as a result of crises ML1Ad/C10. Short-term focused strategies ML1Ad/C17. Approaches/methods are applied on case-by-case basis ML1Ad/C18. Use of basic and narrow range technology to sustain link before and immediately after crisis ML1Ad/C20.	Organisations are reactive ML2Re/C2. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Appropriate stakeholders are engaged ML2Re/C8. Pockets of good practices ML2Re/C11. Mid-level proven technology. Mid-range products ML2Re/C20.	More proactively managed options/solutions are available ML3De/C7. Standard processes are established and improved overtime ML3De/C11. Mid-term focused plans ML3De/C14. Mainly inward looking ML3De/C20. More advanced but proven technology. Use major assembles, complex products ML3De/C21.	Communication arrangements in crises periods are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Projections and forecast about functionality are partially made on statistical/numerical analysis. Improved predictability of performance ML4Ma/C12. Capable of managing predictable and non-predictable eventualities ML4Ma/C22. Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23.	They anticipate and respond to uncertainty related to utilities ML5Op/C4. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15. Advanced and some innovative technology, involves large scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23	
15	Flood proof store/flood proof protection for flood stock and contents (Stocks and equipment)	No attempt to identify the benefit of a flood proof store ML1Ad/C12. No flood proof storage or protector is available	Individual department have personal plans in place but they are not shared ML2Re/C3. Senior manager may recognise the importance	Importance of a flood proof store is recognised ML3De/C2. Management strongly support its	Need is highly recognised ML4Ma/C2. Projections and forecast about functionality are partially made on	There is focus on continual improvement of flood proofing stocks and equipment through innovation and technological	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Coverage - For the protection of stocks and equipment Goal - In-house protection of some contents	ML1Ad/C14. Unaware of the need ML1Ad/C16. Use of basic and narrow range technology. Single and simpler products ML1Ad/C20.	of a flood proof store but resources are not allocated to it ML2Re/C4. Mid-level proven technology is being adopted. Mid-range products ML2Re/C20.	acquisition/construction ML3De/C6. More advanced but proven technology. Use major assembles, complex products ML3De/C21.	statistical/numerical analysis. Improved predictability of performance ML4Ma/C12. Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23.	advancements ML5Op/C7. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15. Flood proofing of stocks and equipment is automated ML5Op/C19. Advanced and some innovative technology, involves large scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23.	
16	Record/Business data management Coverage - Business information and data policies and techniques. Understanding of its criticality to the running of a business. Back up facilities onsite and off-site, maintenance arrangements, Related policies – usage policies etc. Alternate platforms, servers and application for operations. Goal - Accessibility of documents relating to premises repair/renovation.	No centrally coordinated support function ML1Ad/C5. Process is chaotic ML1Ad/C7. If policy exists it is not enforced ML1Ad/C6. No tools or database relevant to the process are in use ML1Ad/C14. Basic tools/system is used ML1Ad/C20.	Individual department or function do have personal plans in place but they are not shared ML2Re/C3. Weak ability as a team ML2Re/C6. Roles in terms of record management are clear and achievable, with measurement strategies ML2Re/C9. Simple tools and templates are used for some activities ML2Re/C10. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14. Mid-range tools that permits partial flexibility ML2Re/C20.	Data management procedures are described/documented in standards and are well understood ML3De/C5. Processes are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Data/record purposes, inputs, verification steps, and outputs are defined ML3De/C8. Tools, templates and relevant database are available ML3De/C10. More advanced but proven system ML3De/C21.	Reviews are done and performances are reported ML4Ma/C10. Tools, database and records are used for statistical analysis and management ML4Ma/C14. Consistent and systematic approach to process/task ML4Ma/C22. Complex product systems ML4Ma/C23.	Quality and performance in respect of record management are stated and recurrently revised ML5Op/C8. Lessons learnt are captured and fed back into the system ML5Op/C10. Active use of information ML5Op/C21. Advanced and some innovative technology ML5Op/C23.	
17	Management of disruption to production/service/operations/processes	Organisation is highly reactive, no plans for service coordination	Senior manager may recognise the importance of resilience but resources are	A visible level of operation sustenance exist ML3De/C4.	Processes are formally reviewed by relevant stakeholders on regular	Quality and process performances are stated and recurrently revised	

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		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Coverage - Culture and attitude to disruptive events. Goal - Preservation of right frame of mind.	during and after crisis ML1Ad/C2. No standardized procedures ML1Ad/C8. Existing approaches are abandoned as a result of crises ML1Ad/C10. Success depends on individuals efforts. Individuals act, no institutional coordination ML1Ad/C11.Short-term focused strategies ML1Ad/C17. Approaches/methods are applied on case-by-case basis ML1Ad/C18.	not allocated to it ML2Re/C4. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Stakeholders' responsibilities/commitments are revised with time, through trainings and updates ML2Re/C7. Roles are clear and achievable, with measurement strategies ML2Re/C9. Heavy reliance on knowledge of individuals ML2Re/C16.	Processes are described/documented in standards, procedures and are well understood ML3De/C5. Reasonably high team orientation and team work ability ML3De/C9. Standard processes are established and improved overtime ML3De/C11.	basis. Post event reviews are done ML4Ma/C6. Strong teamwork ML4Ma/C15. Capable of managing predictable and non-predictable eventualities ML4Ma/C21. Consistent and systematic approach to process/task ML4Ma/C22	ML5Op/C8. Lessons learnt are captured and fed back into the system ML5Op/C10. Dynamic, flexible and strong project-driven attribute ML5Op/C13. Resilience concepts are integrated within all legal and operational frameworks ML5Op/C16.	
18	Crisis response budget Coverage - Funds available for responding to crisis. Availability of fund for managing damages caused by flood on ones premises. One might also be liable for someone else's damages (You are responsible to others if your property damaged theirs). Goal - Availability/Sufficiency of funds for repairs, leasing temporary equipment, adequate for cleaning-up.	Engage in very little financial planning ML1Ad/C3. If policy on crisis budget exists it is not enforced ML1Ad/C6. Existing financial decisions are abandoned in times of crises. No tools or database relevant to disaster finance planning are in use ML1Ad/C14. Budgets and schedules documented in plans are usually exceeded ML1Ad/C15.	Senior manager may recognise the importance of crisis response budget but resources are not allocated to it ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Large dependence on historical practice ML2Re/C17.	The need for standard crisis response budget are described in standards, procedures and are well understood ML3De/C5. Strong support to the process/task being undertaken by management ML3De/C6. Policies and procedures are partially implemented ML3De/C15.	The need for crisis budget is highly recognized, supported and revised ML4Ma/C9. Reviews are done and performances are reported ML4Ma/C10. Capable of financing predictable and non-predictable eventualities ML4Ma/C21.	They anticipate and financially respond to uncertainty ML5Op/C4. They consider crisis budget in their day to day decision making ML5Op/C5. Adequacy is stated and recurrently revised ML5Op/C8. Records are kept up-to-date ML5Op/C11. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15.	
19	General awareness and commitment to resilience	Yet to recognize the strategic importance of climate and flood	Stakeholders' responsibilities and commitments resilience are revised with time, through	Importance of resilience or importance of the task/process being	Recognise importance of resilience ML4Ma/C2. The need	Operating environment is well understood ML5Op/C2. They take the lead in	

SN	Key Capability Areas	Capability levels					Kindly review and comment on your satisfaction with the key capability areas and level definitions here (see instruction to experts)
		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Coverage - Training and awareness creation and appreciation of the need for built environment resilience within organisation. What if scenario, reporting processes, general intelligence. Existence of standards, network of information. Information flow. Devolved management and harmonization of difference in perception occasioned by managerial hierarchy. Establishment of respective relationship among stakeholders Goal - Appreciation of the need for built environment resilience.	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 tools or database ML1Ad/C14. Unaware of the need ML1Ad/C16.	trainings and updates ML2Re/C7. There are skilled people who can produce controlled outputs. Key individuals demonstrate track record and understanding, with hopes of repeating earlier success ML2Re/C12. Importance of resilience is recognised. They are communicated verbally (within department) ML2Re/C13. Heavy reliance on knowledge of individuals ML2Re/C16.	undertaken towards resilience is recognized ML3De/C2. Reasonably high team orientation and team work ability ML3De/C9. Standard processes are established and improved overtime ML3De/C11. Data/record purposes, inputs, verification steps, and outputs are defined ML3De/C8. Mainly inward looking ML3De/C20.	for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9.	establishing visionary cultures, processes, and practices that supports resilience ML5Op/C3. There is focus on continual improvement of process performance through innovation and technological advancements, so review is done ML5Op/C7. Resilience concepts are integrated within all legal and operational frameworks ML5Op/C16. Fully integrated best practices. Top managers are exemplars ML5Op/C17.	
20	Statutory compliance Coverage - Compliance with existing property related standards. Monitoring of developments relating to risks and standards. Goal - Compliance with relevant laws	No understanding of resilience related standards or codes ML1Ad/C13. No resilience policies are enforced ML1Ad/C6.	Senior manager may understand the need for compliance and pursue it ML2Re/C4. Compliance is monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14.	Importance of compliance is recognized ML3De/C2. It receives strong support from management ML3De/C6. Standard processes are used to achieve consistency across the organization ML3De/C13.	Higher recognition of importance ML4Ma/C2. Supported with stated means of improvement ML4Ma/C9.	They take the lead in establishing visionary cultures, processes, and practices ML5Op/C3. Resilience concepts are integrated within all legal and operational frameworks ML5Op/C16. Fully integrated best practices. Top managers are exemplars ML5Op/C17.	
21	Paper records management Coverage - Copy and back up, kept in reinforced or flood proof container, copies are kept in a location outside premises.	No centrally coordinated support function ML1Ad/C5. Process is chaotic, it is unmanaged ML1Ad/C7. If policy exists it is not enforced ML1Ad/C6. No tools or plan relevant to the management of hardcopy	Individual department have personal plans in place but they are not shared ML2Re/C3. Weak ability as a team ML2Re/C6. Roles are clear and achievable, with measurement strategies ML2Re/C9. Simple tools and templates are used for some	Data/record management procedures are described/documented in standards and are well understood ML3De/C5. Processes are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6.	Reviews are done and performances are reported ML4Ma/C10. Tools, database and records are used for statistical analysis and management ML4Ma/C14. Advanced but proven	Quality and performance in respect of record management are stated and recurrently revised ML5Op/C8. Lessons learnt are captured and fed back into the system ML5Op/C10. Active use of information ML5Op/C21. Advanced and	

SN	Key Capability Areas	Capability levels					Kindly review and comment on your satisfaction with the key capability areas and level definitions here (see instruction to experts)
		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Goal - Accessibility of documents relating to premises repair/renovation.	documents in use ML1Ad/C14. Basic tools/system is used ML1Ad/C20.	activities ML2Re/C10. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14. Mid-level proven technology. Mid-range tools that permits partial flexibility ML2Re/C20.	Data/record purposes, inputs, verification steps, and outputs are defined ML3De/C8. Tools, templates and relevant database are available ML3De/C10. More advanced but proven system ML3De/C21.	system. Complex product systems ML4Ma/C23.	some innovative technology ML5Op/C23.	
22	Decision making without recourse to superior in emergency situations Coverage - Authority to make decisions has been given to staff. This should be applied when necessary. Goal - Quick response to people activated prevention and protection facilities.	No standardized procedures ML1Ad/C8. Success depends on individuals efforts. Individuals act, no institutional coordination ML1Ad/C11. No attempt to identify the benefit ML1Ad/C12. No understanding of principles ML1Ad/C13. Unaware of the need for change in communication line ML1Ad/C16.	Individual department or function do have personal plans in place but they are not shared ML2Re/C3. Senior manager may recognise the importance of decision making without recourse to superior in emergency situations ML2Re/C4. Deliverables or successes can be seen/Pockets of good practices ML2Re/C11. There are skilled people who can produce controlled outputs ML2Re/C12.	Importance of decision making without recourse to superior in emergency situations is recognized ML3De/C2. A visible level of independent decision making can be observed ML3De/C4. Strong support to the process/task being undertaken by management ML3De/C6. Standard decision making processes are established and improved overtime ML3De/C11.	There is higher recognition of importance ML4Ma/C2. Flexible and willing for change with adaptive style of leadership and management ML4Ma/C8. The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9.	They take the lead in establishing visionary cultures, processes, and practices ML5Op/C3. They include resilience in their day to day decision making ML5Op/C5. Tolerant/open-minded/enlightened/rational leadership and management style exists ML5Op/C12. Dynamic, flexible and strong project-driven attribute ML5Op/C13.	
23	Definition of roles and responsibilities and how it changes in disaster situations Coverage - Top level reporting or otherwise, priorities, dependency occasion by information/data flow, roles during disruptive events. Goal - Understanding of Information flow – aids decision making	No standardized procedures ML1Ad/C8. Actions in times of crisis depend on individuals, individuals act, no institutional coordination ML1Ad/C11. Unaware of the need for definition of roles and how it changes with situations ML1Ad/C16. No	Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Roles are clear and achievable, with measurement strategies ML2Re/C9. Key individuals demonstrate track record with hopes of repeating earlier success ML2Re/C12.	They engage in planning ML3De/C3. Changes in role and how it changes in disaster situations are described/documented in standards, procedures and are well understood ML3De/C5. Processes have defined purpose, inputs, verification steps, and outputs ML3De/C8.	Organisations adapts to situations based on the creativity, innovation and autonomy of its staff ML4Ma/C5. Flexible and willing for change with adaptive style of leadership and management9leading as occasion demands) ML4Ma/C8. Consistent	Roles are specified and operating environment is well understood ML5Op/C2. There is focus on continual improvement of role specifications through innovation and technological advancements ML5Op/C7.Tolerant/open minded/enlightened/rational leadership and management,	

SN	Key Capability Areas	Capability levels					Kindly review and comment on your satisfaction with the key capability areas and level definitions here (see instruction to experts)
		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
		monitoring or reporting ML1Ad/C19.		Standard processes are established and improved overtime ML3De/C11.	and systematic approach to process/task ML4Ma/C22.	operation style exists ML5Op/C12. Dynamic, flexible and strong project-driven attribute ML5Op/C13.	
24	Post event review, analysis and management Coverage - Plans for adapting and performing better in the future, innovativeness, lessons learnt – view sharing and documentation. Post event vision. Open communication system. Knowledge sharing within and outside organisation. Goal - Accumulation and documentation of personal and general experiences in preparation for life after the event.	Importance not recognized ML1Ad/C4. No centrally coordinated support function ML1Ad/C5. No formal processes ML1Ad/C8. No tools and documents are available ML1Ad/C14. Unaware of the need for review ML1Ad/C16.	Senior manager may recognise the importance of resilience but resources are not allocated to it ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Weak ability as a team, weak team orientation, individuals act with limited coordination ML2Re/C6.	Importance of resilience or importance of the task/process being undertaken towards resilience is recognized ML3De/C2. They engage in planning ML3De/C3. Strong support to the process/task being undertaken by management ML3De/C6. Standard processes are established and improved overtime ML3De/C11.	Higher recognition ML4Ma/C2. Staff are involved and engaged in planning ML4Ma/C4. Processes are formally reviewed by relevant stakeholders on regular basis. Post event reviews are done ML4Ma/C6. The need for review is highly recognized and supported with stated means of improvement ML4Ma/C9.	There is focus on continual improvement of process performance through innovation and technological advancements, so review is done ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15.	
25	System and protocols for mobilizing external resources when needed (Network strength) Coverage - Built environment related resource mobilization towards achieving resilience goals. Goal - Effective mobilization of resources when needed e.g. contractors to assist in preserving equipment from flood water, fire fighters etc.	No centrally coordinated support function ML1Ad/C5. Processes or related activities are disorderly ML1Ad/C7. No standard arrangement ML1Ad/C8. No institutional coordination ML1Ad/C11. Unaware of the need for building network strength for premises resilience ML1Ad/C16.	Senior manager may recognise the importance of network strength for external resources but resources are not allocated to it ML2Re/C4. Weak ability as a team, weak team orientation, better at repetitive works ML2Re/C6. Appropriate stakeholders are engaged ML2Re/C8.	Importance of network strength towards resilience is recognized ML3De/C2. Strong support by management ML3De/C6. Reasonably high team orientation or team work ability ML3De/C9. Standard processes are established and improved overtime ML3De/C11.	Higher recognition of importance ML4Ma/C2. The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Strong teamwork with internal and external parties/partners. Network/Coalition building ML4Ma/C15.	There is focus on continual improvement ML5Op/C7. Sound relationship with stakeholders, societal network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements ML5Op/C14. Strong negotiation ability and influence on others ML5Op/C22.	
26		Basic design and construction system. It is	Mid-level proven technology. Mid-range products that	More advanced but proven technology. Use	Advanced but proven technology, it requires	Advanced and some innovative technology,	

SN	Key Capability Areas	Capability levels					Kindly review and comment on your satisfaction with the key capability areas and level definitions here (see instruction to experts)
		Level 1 Initial/Adhoc/Novice	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**	
	Adaptability/Flexibility of property/Physical resilience of premises Coverage - Flexible and distributed workplace enables employees, suppliers and customers' collaboration anywhere and anytime. This can be within the same work area or another location. The degree of flexibility required depends on organisations capability, process and or culture. For example, the property design can allow full operation at upper floors if the ground floor is flooded (or under repair). Goal - Accessibility or partial usability of property.	not flexible/adaptable in flood situations ML1Ad/C20.	permits partial flexibility ML2Re/C20.	of major assembles complex products/system ML3De/C21.	complex assembly and integration. Complex product systems ML4Ma/C23.	involves large scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23.	

L. Intermediate capability maturity model (Refined conceptual model)

Appendix L: Built Environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	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** **Coverage** - Awareness of the type, frequency of flood. Knowledge of climate projection and flood projection in the area. Periodic assessment is necessary - physical vulnerability evaluation and water entry channel survey. Initial consideration of remedial measures Understanding of hazard consequences to the organisation and all assets. Training and awareness creation and appreciation of the need for built environment resilience within the organisation. What if scenario, reporting processes, general intelligence. The existence of standards, a network of information. Information flow. Devolved management and harmonisation of difference in perception occasioned by managerial hierarchy. **Goal** - Appreciation of the need for built environment resilience. This is expected to lead to a detailed mitigation survey with information on mitigation and protection that is required. This might influence other decisions. The effect or influence of surrounding businesses will also be established.	Yet to recognise the strategic importance of climate and flood 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 tools or database ML1Ad/C14. Unaware of the need to understand ML1Ad/C16.	Individuals, departments, or function makes an effort but they are not shared ML2Re/C3. Senior Manager/Owner may recognise the importance, but resources are not allocated ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Importance is recognised. They are communicated verbally (within the team(s)) ML2Re/C13. Heavy reliance on knowledge of individuals ML2Re/C16	Importance is recognised ML3De/C2. Tools, templates and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18.	High recognition of importance ML4Ma/C2. The need for processes/tasks are highly recognised and supported with stated means of improvement ML4Ma/C9. Tools, database and records are available for statistical and managerial analysis ML4Ma/C14. The risk is identified ML4Ma/C17.	Operating environment is well-understood ML5Op/C2. They anticipate and respond to uncertainty ML5Op/C4. Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, lessons learnt are captured and fed back into the system ML5Op/C10. High level of awareness ML5Op/C20. Active use of information ML5Op/C21.

Appendix L: cont'd – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
2	**Planning or review for a flood resilience scheme** **Coverage** - Products and planning criteria for a specific scheme have to be defined; there are variety of schemes and measures. Understanding of neighbour's disaster resilience decisions on one's property. Knowledge of variety of measures for flood resilience. Analysis of cost implication of options and preparation for funding. Use of relevant data and or engagement of professionals. **Goal** - This is expected to lead to a clear, workable plan and schedule for a flood mitigation/resilience scheme. This will influence financial sourcing or planning. It will also affect where and how to seek help. It will determine the help, technology and materials to use. This will determine the general sophistication of method i.e. use of sand bags, manual flood gates, self-rising/automatic barriers etc.	Engage in very little planning ML1Ad/C3. No centrally coordinated support function ML1Ad/C5. No standardised procedures ML1Ad/C8. The organisation pays lip service to related activity or processes ML1Ad/C9. No understanding of flood resilience schemes and related activities ML1Ad/C13. Short-term focused strategies ML1Ad/C17. No monitoring or reporting ML1Ad/C19.	Individuals or departments or units makes an effort but they are not shared ML2Re/C3. Organisation recognises the importance, but resources are not allocated ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Importance is recognised. They are communicated verbally (within the team(s)) ML2Re/C13. Heavy reliance on knowledge of individuals ML2Re/C16	Importance is recognised ML3De/C2. Tools, templates and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18.	High recognition of importance ML4Ma/C2. The need for a review for a scheme is highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9. Tools, database and records are available for statistical and managerial analysis ML4Ma/C14.	Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, processes are kept up to date ML5Op/C11. High level of awareness ML5Op/C20. Active use of information tools and databases ML5Op/C21.

Appendix L: cont'd – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
3	**Survey of property** **Coverage** - Knowledge of the importance of professional accreditation/certification of the persons that will inspect or inspected potentially vulnerable points around the property (i.e. walls, building services and infrastructure) measure apertures (i.e. Doors, windows and other openings) as well as other property potential failure assessments. Appraisal and continuous monitoring of organisations ability to install measures as well as the performance of installations. Organisation understands what to expect during property survey activities. Quality and thoroughness of the survey and use of data released by Environment Agency. BS85500 - Flood resistant and resilient construction. **Goal** - This is expected to result to a detailed design specification for the property. All component parts can then be outlined.	Organisations are highly reactive, need for pre-crisis survey is unclear ML1Ad/C2, no survey work considered. Property survey related processes or activities are generally chaotic ML1Ad/C7. Individuals act, no institutional coordination ML1Ad/C11. Budgets and schedules documented in plans are usually exceeded ML1Ad/C15.	Individuals or departments or units makes effort but they are not shared ML2Re/C3. Senior manager/Owner recognises the importance but resources are not allocated ML2Re/C4. Importance is recognised. They are communicated verbally (within team(s)) ML2Re/C13. Heavy reliance on knowledge and effort of individuals ML2Re/C16	Importance is recognised ML3De/C2. Tools, templates, suitable information from survey and relevant databases are available ML3De/C10. Standard processes are established and improved overtime ML3De/C11. Relevant actions are coordinated with stakeholders (professionals, government and others) ML3De/C17.	High recognition of importance ML4Ma/C2. The need for property survey is highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9. Tools, adequate information, database and records are available for statistical and managerial analysis ML4Ma/C14. Consistent and systematic approach to process/task ML4Ma/C22	Operating environment is well understood ML5Op/C2. Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, processes are kept up to date ML5Op/C11. High level of awareness ML5Op/C20. Active use of information, tools and databases ML5Op/C21.
4	**Acquisition and installation of relevant products** **Coverage** - Understanding of the purpose and function of flood resilience products. Ability to deploy product whenever the need arises. Ability to recognize the suitability of products. Product evaluation for BSI kite mark standards or customer reviews. Communication and correspondence with product manufacturers, supplier or installers. **Goal** - Organized fixing of dates and communication of clear specifications to the supplier or manufacturer. *The Kite mark is a certification mark operated by the British Standards Institute (BSI). PAS 1188 covers flood resilience products, technologies and systems.	Yet to recognise importance of acquiring and deploying relevant quality products ML1Ad/C4. Acquisition and installation related processes or activities are generally chaotic ML1Ad/C7. No attempt to identify the benefit of products, quality, specification and communication with professionals/suppliers ML1Ad/C12. No record or database related to acquisition is available ML1Ad/C14.	Individuals or departments have plans of acquiring and deploying relevant quality products but they are not shared ML2Re/C3. Senior manager/Owner recognises the importance but resources are not allocated ML2Re/C4. Deliverables or successes can be seen/Pockets of good practices ML2Re/C11. Heavy reliance on knowledge and effort of individuals ML2Re/C16.	Importance is recognised ML3De/C2 by multiple individuals or departments and discussed. Mid-term focused plans ML3De/C14. Relevant actions are coordinated with stakeholders (professionals, government and others) ML3De/C17.	High recognition of importance ML4Ma/C2 across the whole organisation. The need for relevant products are highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9.	Operating environment is well understood ML5Op/C2. Quantitative approaches are used to understand internal and external variations ML5Op/C6. High recognition of importance, processes are kept up to date ML5Op/C11. High level of awareness ML5Op/C20. Active use of information tools and databases ML5Op/C21.

Appendix L: cont'd – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
5	**Maintenance and Post flood management scheme relationships** **Coverage** - Product quality assessment. Management of installation period and preparations for potential disruption. Post installation relationship management with supplier and installer. Maintenance contracts and the like. Management of maintenance regime and storage facilities for temporary fixtures. Funding for aftercare and maintenance. Availability of helpful community resources e.g. flood wardens and or representatives. Emergency service or even police (special equipment might be needed on special occasions. Signing up for Environment Agencies warnings or installing telemetry to monitor locally **Goal** - Availability of visual data of installations and post-installation property survey. Relationship with local businesses.	No centrally coordinated support function ML1Ad/C5. Processes or related activities are generally chaotic ML1Ad/C7. There are no formal processes as there is no stable environment to support them. Unaware of the need for tasks to be undertaken ML1Ad/C16.	Appropriate stakeholders are engaged ML2Re/C8. Deliverables or successes can be seen/Pockets of good practices ML2Re/C11 Importance of tasks/procedures is recognised. They are communicated verbally (within team(s)). ML2Re/C13. Heavy reliance on knowledge and effort of individuals ML2Re/C16.	Importance is recognised ML3De/C2. Strong support to the process/task being undertaken by management ML3De/C6. Relevant actions are coordinated with stakeholders (professionals, government and others) ML3De/C17.	High recognition of importance ML4Ma/C2. Pre and post-flood management relationship are highly recognized and supported, with stated means of successful execution and improvement ML4Ma/C9.	High recognition of importance, processes are kept up to date ML5Op/C11. Sound relationship with stakeholders, societal network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements ML5Op/C14. Fully integrated best practices. Top managers are exemplars ML5Op/C17. Active use of information ML5Op/C21.

Appendix L: cont'd

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
6	**Operation of acquired facilities** **Coverage -** Understanding and circulation of operational instructions. Operation, storage and maintenance requirement. Methodology for appropriate activation of products. Emergency plans to cater for flooding than the products cannot cope with. Availability of support for product activation. The relationship between authorities' plan and organisation's plans. **Goal** - Effective response readiness.	Processes or related activities are generally chaotic ML1Ad/C7. There are no formal processes as there is no stable environment to support them. No standardised procedures ML1Ad/C8. Existing processes are abandoned in times of crises. Successes cannot be sustained. ML1Ad/C10. Arrangements/strategies and abilities are short-term focused ML1Ad/C17.	Individuals or departments or function do have personal plans and abilities, but they are not shared ML2Re/C3. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Roles are clear and achievable, with measurement strategies ML2Re/C9. Some skilled people can produce controlled outputs. Key individuals demonstrate track record with hopes of repeating earlier success ML2Re/C12. Basic processes exist, basic generic training ML2Re/C18	Processes are described/documented in standards, procedures and are well-understood ML3De/C5. More proactively managed rigorous process exists. Proactive behaviour ML3De/C7. Mid-term focused plans ML3De/C14. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18.	The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Strong teamwork with internal and external parties/partners. Network/Coalition building ML4Ma/C15. Human capacity building is high ML4Ma/C19. Consistent and systematic approach to process/task ML4Ma/C22	They anticipate and respond to uncertainty ML5Op/C4. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Processes/tasks/records are kept up-to-date ML5Op/C11. Sound relationship with stakeholders, societal network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements ML5Op/C14. Fully integrated best practices. Top managers are exemplars ML5Op/C17.

Appendix L: cont'd – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
7	**Organisation of disaster scenario simulations** ***(full participation of members)*** **Coverage** - Participation in drills and flood scenario simulations. This affects end user's ability to deploy relevant technologies after warning e.g. temporary or demountable barriers. **Goal -** It creates physical and mental alertness.	The organisation is highly reactive; very little preparation or simulation is done ML1Ad/C2. Engage in very little planning and simulation of scenario ML1Ad/C3. No centrally coordinated support function ML1Ad/C5. Chaotic scenarios and rehearsal ML1Ad/C7. The organisation pays lip service to the activity or process ML1Ad/C9. Individuals act, no institutional coordination ML1Ad/C11	Organisations are reactive ML2Re/C2. Individuals or departments or units do have personal plans in place, but they are not shared ML2Re/C3. Organisations experiment on processes planned, introduced ML2Re/C5. Weak ability as a team ML2Re/C6. Large dependence on historical practice ML2Re/C17.	They engage in formal planning and simulation ML3De/C3. More proactively managed rigorous process exists. Proactive behaviour ML3De/C7. Relevant actions are coordinated with stakeholders (government and others) ML3De/C17. Training programme for capacity development exists ML3De/C18. Mainly inward looking ML3De/C20.	Staff are involved and engaged in planning ML4Ma/C4. Process is supported with stated means of improvement ML4Ma/C9. Measures of performance are technically analysed ML4Ma/C11. Best practice is incorporated ML4Ma/C18. Human capacity building is high ML4Ma/C19.	Organisation takes the lead in establishing visionary cultures, processes, and practices through simulation and similar approaches ML5Op/C3. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Processes/tasks and relevant records are kept up-to-date ML5Op/C11. Fully integrated best practices. Top managers are exemplars ML5Op/C17
8	**Turn-over, cash flow and customer management** Coverage - Cash flow management and efforts at retaining the interest of customers. Retained interest of customers via the maintenance of appealing service or products. **Goal** - It influences fund availability	Engage in very little financial planning and customer management ML1Ad/C3. If policy exists, it is not enforced ML1Ad/C6. Existing financial processes are abandoned in times of crises. Successes cannot be sustained ML1Ad/C10. No tools or database relevant to the process are in use ML1Ad/C14. Budgets and schedules documented in plans are usually exceeded ML1Ad/C15.	Simple tools and templates are used for some activities ML2Re/C10. Pockets of good practices ML2Re/C11. Key individuals demonstrate track record with hopes of repeating earlier success ML2Re/C12. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14. Large dependence on historical practice ML2Re/C17.	They engage in formal planning ML3De/C3. Tools, templates and relevant database are available ML3De/C10. Mid-term focused plans ML3De/C14.	Measures of performance are statistically/technically analysed ML4Ma/C11. Tools, database and records are available for analysis (statistics and others) and management. Projections are forecast are partially made on statistical/numerical analysis ML4Ma/C12. ML4Ma/C14. Capable of managing predictable and non-predictable eventualities ML4Ma/C21	They anticipate and respond to uncertainty ML5Op/C4.There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Quantitative techniques are used for measuring improvements ML5Op/C9. Lessons learnt are captured and fed back into the system ML5Op/C10. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15.

Appendix L: cont'd – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
9	**Insurance adequacy and management** **Coverage -** Knowledge and existence of insurance. Even if steps have been taken to protect a property from flooding, there is still need for flood insurance. Especially if the property is in a floodplain. **Goal-** How sufficient is the coverage? Sufficient for repairs, temporary leasing equipment, adequate for cleaning-up? Safely kept insurance details, policies and contact.	Yet to recognise the role of insurance in resilience ML1Ad/C4. If policy on insurance exists, it is not enforced ML1Ad/C6. The organisation pays lip service to the activity or process ML1Ad/C9. No understanding of principles ML1Ad/C13. Unaware of the need ML1Ad/C16.	Senior manager/Owner may recognise the importance but resources are not allocated to it ML2Re/C4. Appropriate stakeholders are engaged ML2Re/C8. There are skilled people who can produce controlled outputs. Key individuals demonstrate track record and understanding, with hopes of repeating earlier success ML2Re/C12. Heavy reliance on knowledge of individuals ML2Re/C16. Large dependence on historical practice ML2Re/C17	Importance is recognized ML3De/C2. Processes are described/documented in standards, procedures and are well-understood ML3De/C5. Formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Policies and procedures are partially implemented or limited to the support of few stakeholders ML3De/C15. Insurance scheme is available ML3De/C16.	Higher recognition of importance of insurance ML4Ma/C2. The need for processes/tasks are highly recognized and supported with stated means of improvement ML4Ma/C9. Insurance scheme exists ML4Ma/C20	There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Relevant records are kept up-to-date ML5Op/C11. Insurance scheme exist ML5Op/C18.

Appendix L: cont'd

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
10	**Utility and communication system** **Coverage -** Connectivity with existing external supply. **Goal -** Continuity of supply through preservation of existing system or availability of alternatives.	The organisation is highly reactive, no plans for utility during and immediately after crisis ML1Ad/C2. Existing options fail or abandoned as a result of crises ML1Ad/C10. Short-term focused strategies ML1Ad/C17. Approaches/methods are applied on case-by-case basis ML1Ad/C18. Use of basic and narrow range technology to sustain link before and immediately after crisis ML1Ad/C20.	Organisations are reactive ML2Re/C2. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Appropriate stakeholders are engaged ML2Re/C8. Pockets of good practices ML2Re/C11. Mid-level proven technology. Mid-range products ML2Re/C20.	More proactively managed options/solutions are available ML3De/C7. Standard processes are established and improved overtime ML3De/C11. Mid-term focused plans ML3De/C14. Mainly inward looking ML3De/C20. More advanced but proven technology. Use major assembles, complex products ML3De/C21.	Communication arrangements in crises periods are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Projections and forecast about functionality are partially made on statistical/numerical analysis. Improved predictability of performance ML4Ma/C12. Capable of managing predictable and non-predictable eventualities ML4Ma/C22. Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23.	They anticipate and respond to uncertainty related to utilities ML5Op/C4. There is focus on continual improvement of process performance through innovation and technological advancements ML5Op/C7. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15. Advanced and some innovative technology, involves large scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23

Appendix L: Cont'd

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
11	**Flood proof store/flood proof protection for stock and contents *(Stocks and equipment)*** Coverage - For the protection of stocks and equipment Goal - In-house protection of some contents	No attempt to identify the benefit of a flood-proof store ML1Ad/C12. No flood-proof storage or protector is available ML1Ad/C14. Unaware of the need ML1Ad/C16. Use of basic and narrow range technology. Single and simpler products ML1Ad/C20.	Individuals or departments have personal plans in place, but they are not shared ML2Re/C3. Senior Manager/Owner may recognise the importance of a flood-proof store, but resources are not allocated to it ML2Re/C4. Mid-level proven technology is being adopted. Mid-range products ML2Re/C20.	The importance of a flood-proof store is recognised ML3De/C2. Management strongly supports its acquisition/construction ML3De/C6. More advanced but proven technology. Use major assembles, complex products ML3De/C21.	Need is highly recognised ML4Ma/C2. Projections and forecast about functionality are partially made on statistical/numerical analysis. Improved predictability of performance ML4Ma/C12. Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23.	There is focus on continual improvement of flood proofing stocks and equipment through innovation and technological advancements ML5Op/C7. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15. Flood proofing of stocks and equipment is automated ML5Op/C19. Advanced and some innovative technology, involves large-scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23.

Appendix L: cont'd – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
12	**Record/Business data management** Coverage - Business information and data policies and techniques. Understanding of its criticality to the running of a business. Back up facilities onsite and off-site, maintenance arrangements, Related policies – usage policies etc. Alternate platforms, servers and application for operations. Goal - Accessibility of documents relating to premises repair/renovation.	No centrally coordinated support function ML1Ad/C5. Process is chaotic ML1Ad/C7. If policy exists, it is not enforced ML1Ad/C6. No tools or database relevant to the process are in use ML1Ad/C14. Basic tools/system is used ML1Ad/C20.	Individuals or departments or units do have personal plans in place but they are not shared ML2Re/C3. Weak ability as a team ML2Re/C6. Roles in terms of record management are clear and achievable, with measurement strategies ML2Re/C9. Simple tools and templates are used for some activities ML2Re/C10. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14. Mid-range tools that permits partial flexibility ML2Re/C20.	Data management procedures are described/documented in standards and are well understood ML3De/C5. Processes are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Data/record purposes, inputs, verification steps, and outputs are defined ML3De/C8. Tools, templates and relevant database are available ML3De/C10. More advanced but proven system ML3De/C21.	Reviews are done and performances are reported ML4Ma/C10. Tools, database and records are used for statistical analysis and management ML4Ma/C14. Consistent and systematic approach to process/task ML4Ma/C22. Complex product systems ML4Ma/C23.	Quality and performance in respect of record management are stated and recurrently revised ML5Op/C8. Lessons learnt are captured and fed back into the system ML5Op/C10. Active use of information ML5Op/C21. Advanced and some innovative technology ML5Op/C23.
13	**Management of disruption to production/service/operations/processes** Coverage - Culture and attitude to disruptive events Goal - Preservation of right frame of mind.	The organisation is highly reactive, no plans for service coordination during and after crisis ML1Ad/C2. No standardised procedures ML1Ad/C8. Existing approaches are abandoned as a result of crises ML1Ad/C10. Success depends on individuals' efforts. Individuals act, no institutional coordination ML1Ad/C11.Short-term focused strategies ML1Ad/C17. Approaches/methods are applied on case-by-case basis ML1Ad/C18.	Senior Manager/Owner may recognise the importance of resilience, but resources are not allocated to it ML2Re/C4. Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Stakeholders' responsibilities/commitments are revised with time, through training and updates ML2Re/C7. Roles are clear and achievable, with measurement strategies ML2Re/C9. Heavy reliance on knowledge of individuals ML2Re/C16.	A visible level of operation sustenance exists ML3De/C4. Processes are described/documented in standards, procedures and are well-understood ML3De/C5. Reasonably high team orientation and team work ability ML3De/C9. Standard processes are established and improved overtime ML3De/C11.	Processes are formally reviewed by relevant stakeholders on a regular basis. Post event reviews are done ML4Ma/C6. Strong teamwork ML4Ma/C15. Capable of managing predictable and non-predictable eventualities ML4Ma/C21. Consistent and systematic approach to process/task ML4Ma/C22	Quality and process performances are stated and recurrently revised ML5Op/C8. Lessons learnt are captured and fed back into the system ML5Op/C10. Dynamic, flexible and strong project-driven attribute ML5Op/C13. Resilience concepts are integrated within all legal and operational frameworks ML5Op/C16.

Appendix L: cont'd

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
14	**Crisis response budget (*Income generation and cash-flow management*)** **Coverage** - Funds available for responding to the crisis. Availability of fund for managing damages caused by flood on one's premises. One might also be liable for someone else's damages (You are responsible to others if your property damaged theirs). **Goal -** Availability/Sufficiency of funds for repairs, temporary leasing equipment, adequate for cleaning-up.	Engage in very little financial planning ML1Ad/C3. If policy on crisis budget exists, it is not enforced ML1Ad/C6. Existing financial decisions are abandoned in times of crises. No tools or database relevant to disaster finance planning is in use ML1Ad/C14. Budgets and schedules documented in plans are usually exceeded ML1Ad/C15.	Senior Manager/Owner may recognise the importance of crisis response budget, but resources are not allocated to it ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Large dependence on historical practice ML2Re/C17.	The need for standard crisis response budget is described in standards, procedures and are well-understood ML3De/C5. Strong support for the process/task being undertaken by management ML3De/C6. Policies and procedures are partially implemented ML3De/C15.	The need for crisis budget is highly recognised, supported and revised ML4Ma/C9. Reviews are done and performances are reported ML4Ma/C10. Capable of financing predictable and non-predictable eventualities ML4Ma/C21.	They anticipate and financially respond to uncertainty ML5Op/C4. They consider crisis budget in their day to day decision making ML5Op/C5. Adequacy is stated and recurrently revised ML5Op/C8. Records are kept up-to-date ML5Op/C11. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15.
15	**Paper records management** Coverage - Copy and back up, kept in reinforced or flood proof container, copies are kept in a location outside premises. Goal - Accessibility of documents relating to premises repair/renovation.	No centrally coordinated support function ML1Ad/C5. The process is chaotic; it is unmanaged ML1Ad/C7. If a policy exists, it is not enforced ML1Ad/C6. No tools or plan relevant to the management of hardcopy documents in use ML1Ad/C14. Basic tools/system is used ML1Ad/C20.	Individuals or departments have personal plans in place, but they are not shared ML2Re/C3. Weak ability as a team ML2Re/C6. Roles are clear and achievable, with measurement strategies ML2Re/C9. Simple tools and templates are used for some activities ML2Re/C10. Tasks are monitored, controlled, reviewed, and evaluated for compliance with process descriptions ML2Re/C14. Mid-level proven technology. Mid-range tools that permit partial flexibility ML2Re/C20.	Data/record management procedures are described/documented in standards and are well-understood ML3De/C5. Processes are formally reviewed by relevant stakeholders on regular basis ML4Ma/C6. Data/record purposes, inputs, verification steps, and outputs are defined ML3De/C8. Tools, templates and relevant databases are available ML3De/C10. More advanced but proven system ML3De/C21.	Reviews are done, and performances are reported ML4Ma/C10. Tools, database and records are used for statistical analysis and management ML4Ma/C14. Advanced but proven system. Complex product systems ML4Ma/C23.	Quality and performance in respect of record management are stated and recurrently revised ML5Op/C8. Lessons learnt are captured and fed back into the system ML5Op/C10. Active use of information ML5Op/C21. Advanced and some innovative technology ML5Op/C23.

Appendix L: continued – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
16	**Decision making without recourse to superior in emergency situations** Coverage - Authority to make decisions has been given to staff. This should be applied when necessary. Goal - Quick response to people activated prevention and protection facilities.	No standardised procedures ML1Ad/C8. Success depends on individuals' efforts. Individuals act, no institutional coordination ML1Ad/C11. No attempt to identify the benefit ML1Ad/C12. No understanding of principles ML1Ad/C13. Unaware of the need for change in communication line ML1Ad/C16.	Individuals or departments or function do have personal plans in place, but they are not shared ML2Re/C3. Senior Manager/Owner may recognise the importance of decision making without recourse to superior in emergency situations ML2Re/C4. Deliverables or successes can be seen/Pockets of good practices ML2Re/C11. There are skilled people who can produce controlled outputs ML2Re/C12.	The importance of decision making without recourse to superior in emergency situations is recognised ML3De/C2. A visible level of independent decision making can be observed ML3De/C4. Strong support for the process/task being undertaken by management ML3De/C6. Standard decision-making processes are established and improved overtime ML3De/C11.	There is higher recognition of importance ML4Ma/C2. Flexible and willing for change with adaptive style of leadership and management ML4Ma/C8. The need for processes/tasks are highly recognised and supported with stated means of improvement ML4Ma/C9.	They take the lead in establishing visionary cultures, processes, and practices ML5Op/C3. They include resilience in their day to day decision making ML5Op/C5. Tolerant/open-minded/enlightened/rational leadership and management style exists ML5Op/C12. Dynamic, flexible and strong project-driven attribute ML5Op/C13.
17	**Definition of roles and responsibilities and how it changes in disaster situations** **Coverage -** Top level reporting or otherwise, priorities, dependency occasion by information/data flow, roles during disruptive events (including all safety precautions). **Goal** - Understanding of Information flow – aids decision making	No standardized procedures ML1Ad/C8. Actions in times of crisis depend on individuals, individuals act, no institutional coordination ML1Ad/C11. Unaware of the need for definition of roles and how it changes with situations ML1Ad/C16. No monitoring or reporting ML1Ad/C19.	Organisations experiment on processes planned, introduced, and executed in line with policy ML2Re/C5. Roles are clear and achievable, with measurement strategies ML2Re/C9. Key individuals demonstrate track record with hopes of repeating earlier success ML2Re/C12.	They engage in planning ML3De/C3. Changes in role and how it changes in disaster situations are described/documented in standards, procedures and are well understood ML3De/C5. Processes have defined purpose, inputs, verification steps, and outputs ML3De/C8. Standard processes are established and improved overtime ML3De/C11.	Organisations adapts to situations based on the creativity, innovation and autonomy of its staff ML4Ma/C5. Flexible and willing for change with adaptive style of leadership and management9leading as occasion demands) ML4Ma/C8. Consistent and systematic approach to process/task ML4Ma/C22.	Roles are specified and operating environment is well understood ML5Op/C2. There is focus on continual improvement of role specifications through innovation and technological advancements ML5Op/C7.Tolerant/open minded/enlightened/rational leadership and management, operation style exists ML5Op/C12. Dynamic, flexible and strong project-driven attribute ML5Op/C13.

Appendix L: cont'd

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
18	**Post event review, analysis and management** **Coverage -** Plans for adapting and performing better in the future, innovativeness, lessons learnt – view sharing and documentation. Post event vision. Open communication system. Knowledge sharing within and outside the organisation. Goal - Accumulation and documentation of personal and general experiences in preparation for life after the event.	Importance not recognised ML1Ad/C4. No centrally coordinated support function ML1Ad/C5. No formal processes ML1Ad/C8. No tools and documents are available ML1Ad/C14. Unaware of the need for review ML1Ad/C16.	Senior Manager/Owner may recognise the importance of resilience, but resources are not allocated to it ML2Re/C4. Simple tools and templates are used for some activities ML2Re/C10. Weak ability as a team, weak team orientation, individuals act with limited coordination ML2Re/C6.	The importance of resilience or importance of the task/process being undertaken towards resilience is recognised ML3De/C2. They engage in planning ML3De/C3. Strong support for the process/task being undertaken by management ML3De/C6. Standard processes are established and improved over time ML3De/C11.	Higher recognition ML4Ma/C2. Staff are involved and engaged in planning ML4Ma/C4. Relevant stakeholders formally review processes on a regular basis. Post event reviews are done ML4Ma/C6. The need for review is highly recognised and supported with stated means of improvement ML4Ma/C9.	There is focus on continual improvement of process performance through innovation and technological advancements, so the review is done ML5Op/C7. Lessons learnt are captured and fed back into the system ML5Op/C10. Sophisticated tools or methodologies are available for qualitative and quantitative analyses with suitable interpretations ML5Op/C15.
19	**Network strength** Coverage - Ability to mobilise built environment-related resources towards achieving resilience goals. Internal and external resources. System and protocols for mobilising external resources when needed. Goal - Effective mobilisation of resources when needed e.g. contractors to assist in preserving equipment from flood water, fire fighters etc.	No centrally coordinated support function ML1Ad/C5. Processes or related activities are disorderly ML1Ad/C7. No standard arrangement ML1Ad/C8. No institutional coordination ML1Ad/C11. Unaware of the need for building network strength for premises resilience ML1Ad/C16.	Senior Manager/Owner may recognise the importance of network strength for external resources, but resources are not allocated to it ML2Re/C4. Weak ability as a team, weak team orientation, better at repetitive works ML2Re/C6. Appropriate stakeholders are engaged ML2Re/C8.	The importance of network strength towards resilience is recognised ML3De/C2. Strong support by management ML3De/C6. Reasonably high team orientation or team work ability ML3De/C9. Standard processes are established and improved overtime ML3De/C11.	Higher recognition of importance ML4Ma/C2. The need for processes/tasks are highly recognised and supported with stated means of improvement ML4Ma/C9. Strong teamwork with internal and external parties/partners. Network/Coalition building ML4Ma/C15.	There is focus on continual improvement ML5Op/C7. Sound relationship with stakeholders, societal network and the community. Involvement of internal and external stakeholders. Strategic alliances and institutional arrangements ML5Op/C14. Strong negotiation ability and influence on others ML5Op/C22.

Appendix L: continued – Built environment flood resilience capability maturity model (Model after expert review i.e. Intermediate model)

SN	Key Capability Areas (KCA)	Capability levels				
		Level 1 Ad hoc	**Level 2 Repeatable**	**Level 3 Defined**	**Level 4 Managed**	**Level 5 Optimizing**
20	**Physical resilience of the fabric and structure of property** **Coverage -** Flexible and distributed workplace enables employees, suppliers and customers' collaboration anywhere and anytime. This can be within the same work area or another location. The degree of flexibility required depends on organisations capability, process and or culture. For example, the property design can allow full operation at upper floors if the ground floor is flooded (or under repair). The adaptation or resistance measures taken up. **Goal -** Accessibility or partial usability of property. Lesser damage to premises.	Basic design and construction system. It is not flexible/adaptable in flood situations ML1Ad/C20. Nothing was done on premises adaptation.	Mid-level proven technology. Mid-range products that permit partial flexibility ML2Re/C20. Use of sandbags as protection against flood water entry.	More advanced but proven technology. Use of major assembles complex products/system ML3De/C21. Property level protection - use of products that prevent the inflow of water.	Advanced but proven technology, it requires complex assembly and integration. Complex product systems ML4Ma/C23. Temporary flood barrier schemes and property level protection.	Advanced and some innovative technology, involves large-scale multiple complex assemblies and installations. Complex systems and complex products ML5Op/C23. Traditional flood defence schemes and property level protection.

M. Case study interview protocol (Intermediate model refinement)

Capability maturity model for assessing disaster resilience capabilities of the built environment

Interview number:

Interview date and time:

Section A: Opening

The aim of this research is to develop a flood-related disaster resilience capability maturity model that identifies built environment flood resilience capabilities of micro, small and medium-sized business organisations.

Thank you very much for giving me the opportunity to interview you. The purpose of this interview is to draw from your experience with flood and recovery from flood towards developing a built environment flood resilience capability maturity model for business organisations. We will be focusing on the experience of your organisation with flood and the process of recovery from flood. We will attempt to establish some capabilities required by a business organisation to return its business premises back to operation after a flood.

From literature search, previous works and previous interviews we have been able to establish some factors that can help a business to return its premises back to operation early. This covers pre-flood and post flood capabilities.

Section B: Background details of organisation

1. Who owns the property within which you are doing business?
2. Who manages the property – Property manager/Estate manager
3. Age of property
4. Number of employees (Size of company)
5. Turn-over (Range or An average value per year or last 3-5 years)
6. Type of ownership

Section C: Model refinement questions

1. With reference to your organisation, please describe how you restored your premises after the last flood and other flooding experiences.

2. Kindly review and comment on the capabilities and the maturity level characteristics contained in the model.
3. Among the list of capability areas provided, which one do you think is not important towards enhancing the resilience of a business premises?
4. Are there any other capability you think can enhance the resilience of a business premises apart from the ones mentioned?

N. Case study interview protocol (Application of refined model in case organisations)

Capability maturity model for assessing disaster resilience capabilities of the built environment

Interview number:

Interview date and time:

Section A: Background details of organisation

1. Who owns the property within which you are doing business?
2. Who manages the property – Property manager/Estate manager
3. Age of property
4. Number of employees (Size of company)
5. Turn-over (Range or An average value per year or last 3-5 years)
6. Type of ownership

Section B: Application of model

The aim of this section is to assess the built environment flood resilience capability maturity of your business. **The accompanying model** contains a list of capabilities and maturity level definitions. Kindly rate your organisation on each of the capability areas on a scale of 1 to 5, with 5 being the highest, and select among the sub-characteristics in each maturity level which best describes your organisation.

Thank you very much for your time.

Onaopepo Adeniyi

Researcher

O. Evaluation/Validation Questionnaire

Capability maturity model for assessing disaster resilience capabilities of the built environment

Background

The capability maturity model was developed as part of my PhD research that aims to develop a flood-related disaster resilience capability maturity model that identifies built environment flood resilience capabilities of micro, small and medium-sized business organisations. The model will be useful for assessing, profiling and benchmarking built environment flood resilience capabilities of organisations.

Purpose of the Questionnaire

The purpose of this questionnaire is to validate the Built Environment Flood Resilience Capability Maturity Model developed for business organisations. This exercise is to confirm that the model is logical, comprehensive, clear, objective, replicable, reliable, and practical.

Scope

This study focuses on flooding and the built environment of small business organisations.
Your assistance in completing this questionnaire is highly appreciated.

Yours Sincerely
Signed
Onaopepo Adeniyi
(PG Researcher)

Background information of respondent

1. Your position in the firm/organisation…….....
2. Name of your organisation ……..…….
3. Sector/Area of practice (i.e. public/private/academic) ……
4. Your highest academic qualification……..
5. Years of experience……..…….

Questionnaire

6. Based on a scale rating of 1-5 (where 5 represents “Excellent” and 1 represents “Poor”), kindly score the model on each validation aspect.

Validation Aspect	Scoring Scale				
	Poor				Excellent
	1	2	3	4	5
Comprehensiveness					
Objectivity					
Practicality					
Replicability					
Reliability					
Overall suitability for assessing, profiling and benchmarking capabilities for flood resilience					

Thanks you!

P. Impact of flood on building elements and recommended resilience/resistance measures

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
1	**Substructure**	Substructure			Implication		
1.1		Substructure	Flood resistant, general Monolithic Slab on Grade Pier, Pile Use foundation reinforcement techniques, wet flood proofing, dry flood proofing. Use mould resistant and quick dry materials (rigid insulation, closed-cell-spray foam, non-paper faced gypsum and steel studs) Flood resistance of foundation wall elements – wall height, thickness, reinforcement (Bencze, 2011)	Possible erosion beneath foundations, Possible corrosion in metal components. Damage to fittings in basements and (e.g. joist hangers) cellars Excessive moisture absorption in timber, causing warping Cracking of ground floor due to uplift pressures Accumulation of contaminated silt Structural and material weaknesses from inappropriate drying Rot and mould. Ground surface can be eroded as a result of high speed flow around the building perimeter. Floating debris can also damage the structure. Silt and water can build up in the cavity wall. Poorly compacted hard core, or containing gypsum or shale, may expand and cause the perimeter wall to crack. As a result, damp proof course can also be displaced. Light weight concrete or hollow clay in fill blocks may take up water – longer drying time. High chloride in flood water can cause reinforcements to rust.	Structural damage, differential settlement of property. This can cause walls to crack or collapse. Windows can break or fail, it can also result in door failure. Wet clay soil will expand and shrink when drying, this can cause cracks in foundation, floors and walls.	Drainage channels to divert the flow of water towards building. Concrete slab-on-ground monolithic construction. Raise floor level above most likely flood level. In shrinkable/expandable soils, foundations can be built on pile. Damp proof membrane should be used in the substructure. Closed cell type insulation. In shrinkable floors, suspended floors can be used but timbers should be avoided. Cavity walls without insulation can be used, this will ensure rapid drying. Where flooding frequency is high, reinforced concrete wall is a viable option. Use plastic foam insulation boards.	(Bowker *et al.*, 2007; Kazmierczak & Connelly, 2011; Wilson, 2010)
2	**Superstructure**	Superstructure					

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
2.1		Frame	Water and damp proof. Corrosion resistant fasteners, connectors, and anchors and stainless steel (Bencze, 2011)	Structural damage (this is dependent on the state of the building and the characteristics of the flood.)		Reinforced concrete Construction. Galvanised metal Construction.	(Bowker *et al.*, 2007)
2.2		Upper Floors	Water and damp proof. Corrosion resistant fasteners, connectors, and anchors and stainless steel			Suspension reinforced concrete slab	
2.3		Roof	Water and damp proof.			Reinforced concrete Construction. Galvanised metal Construction.	
2.4		Stairs and Ramps	Water and damp proof. Corrosion resistant fasteners, connectors, and anchors and stainless steel			Reinforced concrete Construction. Bottom part made of concrete and top part made of water resistant timber.	(Kazmierczak & Connelly, 2011)
2.5		External Walls	Water-resistant barrier for rain and flood water to prevent water penetration. Positive drainage away from the foundation. Water resistant building paper or house wrap under exterior cladding Water resistant exterior finishing systems (vinyl, aluminium or paint) and	Inundation of walls. Damage to insulation materials		Solid brickwork, blockwork, reinforced concrete or mass concrete. Facing or rendering of external walls. Thoroughly filled masonry walls should be used, this will reduce water penetration. Engineering bricks can be used up to expected flood level and another layer to provide free board. Cavity walls without insulation can be used, this will ensure rapid drying. Where flooding frequency is high, reinforced concrete wall is a viable option. External	(Kazmierczak & Connelly, 2011; Wilson, 2010)

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
			naturally decay-resistant wood for siding Vinyl or naturally decay-resistant wood for siding Corrosion resistant fasteners, connectors, and anchors and stainless steel Self-adhere membrane on service and utility interfaces to create proper flash penetration Durable sealing to prevent water penetration (Bencze, 2011)			render can be used as a barrier to water penetration when water exclusion method is being adopted. Structural check should be conducted to ascertain stability once external flood height is greater than 0.3m. External render should not be used if water entry strategy is adopted, it generates difference between internal and external flood depth leading to possible structural problems. External insulation should be used, it is easier to replace. Internal render is appropriate for water exclusion strategy. When water entry option is adopted, cement internal render should be avoided as this hinders the drying ability of walls, gypsum plaster is recommended up to expected flood level plus freeboard of 50mm as sacrificial material. Dado rail should be used to demarcate the above and below floodable area.	
2.6		Windows and External Doors	Minimum water penetration. Proper overlapping around windows and doors. Water resistant doors and windows Pan flashing with removable stop	Damage to windows can be caused by much smaller differential pressures		Resilient/Water resistant/water proof frames and doors (e.g. plastic and fibre glass). Flood proof external doors and windows. Door threshold should set as high as possible, but still in compliance with standards and codes. Sealed framed doors and windows are	(Bowker *et al.*, 2007; Kazmierczak & Connelly, 2011; Wilson, 2010)

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
						recommended in places prone to flood. Suitable air vents should be used.	
2.7		Internal Walls and Partitions	Generally, water resistant. Same as external wall			Solid brickwork, blockwork, reinforced concrete or mass concrete. Water resistant frames and doors	
2.8		Internal Doors		Damage to internal and external doors		Resilient/Water resistant/water proof frames and doors (plastic, uPVC, fibreglass). Raising door thresholds.	(Bowker *et al.*, 2007)
3	**Finishes**	Internal Finishes					
3.1		Wall Finishes	Generally, water resistant and damp proof (Bencze, 2011).	Damage to internal finishes, such as wall coverings and plaster linings. Damage to mineral insulation, gypsum plaster, and non-water resistant door and window frames.		Cement, hydraulic lime Resilient/Water repellent plaster. Mineral paint. Tiles. Compressed cement or plasterboard. Brick, face or glazed, in waterproof mortar, concrete. Concrete block, Steel with waterproof applications. Stone, natural solid or veneer, waterproof grout. Plastic wall tiles. Metals - Non-ferrous, Rubber mouldings and trim. Wood, solid or exterior grade plywood fully a sealed. Glass blocks. Glass. Plastic sheeting or wall with waterproof adhesive. Pressure treated and marine grade plywood foam and closed-cell insulation. Porcelain. Closed cell insulations, Water resistant plaster e.g. lime plaster.	(Bowker *et al.*, 2007; Kazmierczak & Connelly, 2011)

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
						Install chemical damp proof course below joist level.	
3.2		Floor Finishes	Generally, water resistant and damp proof (Bencze, 2011).	Skirting boards, Carpets and floor coverings may be affected Damage to sand cement screed on concrete slab, chip board flooring, or timber floor.		Natural stone (e.g. granite, dolomite) Tiles (e.g. Clay tile) Concrete, precast or in-situ. Concrete tiles, Epoxy, formed-in-place. Mastic flooring formed-in-place. Rubber sheets with chemical set adhesives. Silicone floors formed-in-place. Vinyl sheets with chemical-set adhesive) or the following materials Terrazzo, Vinyl tiles with chemical-set adhesive, Vinyl tiles, asphaltic Adhesives, Ceramic tiles with acid and alkali-resistant grout). Solid concrete slab, treated timber floor boards, Raise floor level above most likely flood level. Plastic skirting boards/tiling, solid timber skirting painted with waterproof paint on both sides. Damp proof membrane should be used in the substructure.	(Bowker *et al.*, 2007; Kazmierczak & Connelly, 2011; Wilson, 2010)
3.3		Ceiling Finishes	Generally, water resistant and damp proof (Bencze, 2011).			Pressure treated and marine grade plywood foam and closed-cell insulation.	
4	**Fittings and furniture**	Fittings, Furnishings and Equipment					
4.1		Fittings, Furnishings and Equipment		Corrosion of metal fixings rots and mould, Damage to chipboard units.		Fix plastic units or water resistant units where possible. Appliances on plinth, where possible. Flood resistant	(Bowker *et al.*, 2007; Kazmierczak & Connelly, 2011; Wilson, 2010)

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
						fittings are recommended. Seal joints and place them above predicted flood level.	
5	**Services**	Services					
5.1		Sanitary Installations				Floating floor drain plugs, Interior or exterior backflow valve. Closed cell insulation should be used for all pipes below the expected flood level.	(Kazmierczak & Connelly, 2011; Wilson, 2010)
5.2		Services equipment				Fix water resistant units where possible. Fix appliances on plinth, where possible.	
5.3		Disposal installations					
5.4		Water installations		Damage to water meter and installations. Damage to low-level boilers		Mount heaters and boilers on wall. Closed cell insulation should be used for all pipes below the expected flood level. Non-return valves should be used in drainages to prevent backflow of water.	(Bowker *et al.*, 2007; Wilson, 2010)
5.5		Heat Source					
5.6		Space Heating and Air Conditioning		Damage to low-level boilers and some floor insulation may tend to cause underfloor heating systems to float and cause screeds to de-bond.			(Bowker *et al.*, 2007)
5.7		Ventilation Systems					

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
5.8		Electrical Installations		Damage to electrical sockets Damage to electrical sockets and other gadgets causing instability and non-settlement of services in basements and cellars. Damage to electricity and gas metre above floor level.		Main electric panel board (electric fuses or circuit breakers) should be at least 12" above the projected flood height. The panel board height is regulated by code. Elevate all electric outlets, switches, light sockets, baseboard heaters and wiring at least 12" above the projected flood height. Other appliances and electrical gadgets are supposed to be treated the same way. Wiring for internet, television, telephone among other services should be protected in the distribution duct by a suitable insulation.	(Bowker *et al.*, 2007; Kazmierczak & Connelly, 2011; Wilson, 2010)
5.9		Fuel installation				Anchor fuel tanks securely	
5.1		Lift and Conveyor Installations					
5.11		Fire and Lightning Protection					
5.12		Communication, Security and Control Installations		Damage to communication wiring.			(Bowker *et al.*, 2007)
8	**External works**	External Works Roads, Paths, Paving and Surfacing, Soft Landscaping, Planting and Irrigation Systems, Fencing, Railings and Walls, External Fixtures,		Damage to external works			(Bowker et al., 2007)

SN		Elements	Performance standards	Failure mode *(This might happen if what is used is different from the recommended Flood resilience and resistance measures)* – **Damage mode**	Failure effects *(Probable extended impact of the described failures)* – **Implication**	Flood resilience and resistance measures	Literature sources
		External Drainage, External Services					

Q. Case study validation protocol

Capability maturity model for assessing disaster resilience capabilities of the built environment

The aim of this stage in the research is to validate the built environment flood resilience capability maturity model. You are expected to use the model to assess your organisation and after that, provide comments on the suitability or inadequacies of the model (limitations and future considerations).

Section A: Background details of organisation

1. Who owns the property within which you are doing business?
2. Who manages the property – Property manager/Estate manager
3. Age of property
4. Number of employees (Size of company)
5. Turn-over (Range or An average value per year or last 3-5 years)
6. Type of ownership

Section B: Application of model

The model contains a list of capabilities and maturity level definitions. Kindly rate your organisation on each of the capability areas on a scale of 1 to 5, with 5 being the highest, and select among the sub-characteristics in each maturity level which best describes your organisation.

Thank you very much for your time.

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User guide

For

Built Environment Flood Resilience Capability Maturity Model

1.0 Introduction

The purpose of the Built Environment Flood Resilience Capability Maturity Model user guide is to provide prospective users with adequate information on capabilities for enhancing built environment flood resilience. It will aid the interpretation of the capability areas and their respective capability maturity characteristics. The model significantly covered all pre-flood event, flood-event, and post-flood event capabilities. Users of this model are advised to patiently assess the flood resilience capability maturity of their organisations using this model. It is believed that if the model is properly applied, the true strength of an organisation for managing flood disaster will be revealed and the organisation can after that make necessary improvements.

2.0 Description of capabilities for built environment flood resilience (Coverage and goals)

The maturity model contains 19 capability areas. Each capability area has maturity definition on five levels (Level 1 –Adhoc to Level 5 – Optimising) in accordance with the capability maturity model concept.

1. Awareness and understanding of flood risk to property

Coverage: This capability area refers to a business' awareness of the type and frequency of flood at the location of the business. Knowledge of climate projection and flood projection in the area. Periodic assessment is necessary - physical vulnerability evaluation and water entry channel survey. Initial consideration of remedial measures e.g. DPC, water-proofing, re-pointing. Consideration of grant options. Influence of other businesses' action on the business' flood risk – e.g. sewerage work, pollution. Understanding of hazard consequences to organisation and all assets (Stephenson, 2010) Training and awareness creation and appreciation of the need for built environment disaster resilience within the organisation. What if scenario, reporting processes, and general intelligence. The existence of standards, a network of information. Information flow.	**Goal:** This is expected to lead to a detailed mitigation survey. With information on mitigation and protection that is needed. This might influence other decisions. The effect or influence of surrounding businesses will also be established. Appreciation of the need for built environment resilience.

2. Review for a flood resilience scheme

Coverage: It relates to all activities associated with the definition of products and planning criteria for selecting schemes and measures. Knowledge of a variety of measures for flood resilience, Ability to conduct or secure an analysis of cost implication of options and preparation for funding. The analysis might involve the use of relevant data and or engagement of professionals. Knowledge of flood resilience measures or systems i.e. permanent or temporary, manually deployed or automatically activated, building aperture or perimeter technologies. Involvement in flood action groups, this will have implications on the deployment of supports and facilities in an emergency situation. Engagement with community level schemes e.g. Planned maintenance and the understanding of professionals to engage in the planning.	**Goal:** This is expected to lead to a clear, workable plan and schedule for a flood mitigation/resilience scheme. This will influence financial sourcing or planning. It will also affect where and how to seek help. It will determine the support, technology and materials to use. This will determine the overall sophistication of method i.e. use of sand bags, manual floodgates, self-rising/automatic barriers, among others.

3. Survey of property

Coverage: Knowledge of how to engage qualified (accredited and certified) professionals to inspect vulnerable points around the property (i.e. walls, building services and infrastructure) measure apertures (i.e. Doors, windows and other openings) as well as other property potential failure assessments. Appraisal of needs and capability to deploy, store and maintain facilities. Consideration for visibility and aesthetics. Appraisal and continuous monitoring of organisations ability to install measures as well as the performance of installations. Understanding of what to expect during property survey activities.	**Goal:** This is expected to result in a detailed design or intervention specification for the property.

4. Acquisition and installation of relevant products

Coverage: This capability area covers the understanding of the purpose and function of flood resilience products. Ability to recognise the suitability of the products and facilities. Product	**Goal:** This should lead to the communication of clear specifications to the supplier or manufacturer, achievement

evaluation for BSI kite mark standards or customer reviews. Communication and correspondence with product manufacturers, supplier or installers. Clear and comprehensive specification document to stakeholders. *The Kitemark is a certification mark operated by the British Standards Institute (BSI). PAS 1188 covers flood resilience products, technologies and systems.	of a smooth acquisition process, and acquisition of quality products and facilities.

5. Maintenance and Post-flood management scheme relationships

Coverage: This capability covers a business' strength, readiness and efforts on product quality assessment., management of installation period and preparations for potential disruption. Post installation relationship management with supplier and installer. Maintenance contracts and the like. The organisation's access to helpful community resources e.g. flood wardens and or representatives, eemergency service or police (special equipment might be needed on special occasions). Inspection, sign-off, operation manual availability. Post installation and periodic risk assessment arrangements.	**Goal:** Satisfactory installation and post-installation monitoring and maintenance arrangement. Relationship with local businesses.

6. Operation of acquired facilities

Coverage: This refers to the understanding and circulation of operational instructions. Operation, storage and maintenance requirement, and the methodology for appropriate activation of products. Management of maintenance regime and storage facilities for temporary fixtures. Funding for aftercare and maintenance. Emergency plans to cater for flooding than the products cannot manage. Availability of alternatives in case product fails. Availability of support for product activation. The relationship between authorities plan and organisation's plans.	**Goal:** Effective response readiness.

7. Disaster scenario simulations

Coverage: This capability refers to the organisation of drills, flood scenario simulation and participation of staff in the simulation exercise. This capability determines end user's ability to deploy relevant technologies after warning e.g. temporary or demountable flood barriers.	**Goal:** It creates physical and mental alertness.

8. Turn-over, cash flow and customer management

Coverage: This refers to turn over volume and cash flow management skills. This defines the liquidity and financial management sophistication of the company. Retained interest of customers/ maintenance of appealing service or products. This can also be facilitated by the organisations' ability to keep the link with customers	**Goal:** Fund availability Sustenance of cash flow for future

9. Insurance adequacy and management

Coverage: This refers to an organisation's knowledge and administration of insurance as a risk transfer mechanism. Even if steps have been taken to protect property from flooding, there is still need for flood insurance, especially if the property is at risk of flooding.	**Goal:** Sufficient coverage for repairs, lease of temporary equipment, adequacy for cleaning-up. Safely kept insurance details, policies and contact.

10. Utility/communication system

Coverage: This capability refers to existing supply arrangement and availability of utility alternatives. Possession of suppliers' contacts on-site and off-site, availability of alternates and back-up. Management's possession of key contacts and mechanisms for information dissemination when utility services are down. Accessibility and delivery re-routing arrangements.	**Goal:** Continuity of supply through preservation of existing system or availability of alternatives. Access preservation.

11. Electronic data/record management

Coverage: Understanding of the criticality of business information, data policies and techniques to the running of business as well as the management system of such data. Backup facilities onsite and off-	**Goal:** Accessibility of documents relating to premises repair/renovation.

site, maintenance arrangements, usage of related policies. Alternate platforms, servers and application for operations.	

12. Management of disruption to production/service

Coverage: This refers to an organisation's cultural attitude or usual approach to crisis/disruptions. Harmonisation of differences in perception occasioned by the managerial hierarchy.	**Goal:** Preservation of right frame of mind in the interest of the organisation.

13. Crisis response budget

Coverage: This refers to an organisation's approach to making crisis response funds available. Availability of fund for managing damages caused by the flood on one's premises. One might also be liable for someone else's damages (You are responsible to others if your property damaged theirs). This can be influenced by the debt level of the business.	**Goal:** Availability/Sufficiency of funds for repairs, leasing temporary equipment, adequate for cleaning-up.

14. Paper records management

Coverage: Organisation's approach to maintaining copies and back-up of documents. Safekeeping in a flood-proof container or off-site storage.	**Goal:** Accessibility of documents relating to premises repair/renovation.

15. Decision making in emergency situations

Coverage: This capability refers to the devolvement of decision making to staff. It refers to the ability of staff to make decisions in emergencies without recourse to superior. Devolved management and harmonisation of differences.	**Goal:** Quick response to people activated prevention and protection facilities.

16. Definition of roles and responsibilities and how it changes in disaster situations

Coverage: A detailed outline of responsibilities in emergencies or on issues relating to crisis response. Top level reporting or otherwise, priorities, dependency occasioned by information/data flow, roles during disruptive events.	**Goal:** Understanding of Information flow – aids decision making.

17. Post event operation, analysis and management

Coverage: Plans for adapting and performing better in the future, innovativeness, lessons learnt – view sharing and documentation. This capability area also	**Goal:** Accumulation and documentation of personal and general experiences in

includes post event vision, open communication system, and knowledge sharing activities within and outside the organisation.	preparation for life after the event.

18. Network strength

Coverage: This refers to the organisation's resource mobilisation strength. The strength depends on the connection of the business with relevant stakeholders. Resources are needed to achieve the organisation's built environment disaster resilience goals. For example, contractors/manpower might have to be mobilised to save equipment during flood events, fire brigade or facilities should be mobilised to pump out water and engage clean up the team as well as professionals needed for repairs.	**Goal:** Effective mobilisation of resources when needed e.g. contractors to assist in preserving equipment from flood water, firefighters, and professionals needed for repairs among others.

19. Physical characteristic of property – fabric, design, construction and waterproof compartment

Coverage: This capability area covers the flexibility and distribution of workplace; this attributes enable employees, suppliers and customer's collaboration anywhere and anytime. This can be from the same work area or another location. For example, the property design can allow full operation at upper floors if the ground floor is flooded (and under repair). The capability area also covers the physical attributes of the property and the structural flood resilience and resistance measures adopted. Observing safety precautions prevent the escalation of the impacts of catastrophe. Precautions include switching off lighting at night, fastening water tank and external furniture. An enterprise can establish a defined procedure for achieving this. This refers to the existence of a flood proof safe or mechanism to protect stocks and equipment	**Goal:** Accessibility or partial usability of property. To prevent complications. In-house protection for some contents

3.0 Requirements for moving between levels

One of the major characteristics of a maturity model is the existence of various levels through which an organisation or individual is expected to progress. As a result, some conditions would have to be satisfied before a higher level can be attained. The summary provided by Alshawi *et al.,* (2004) provides a guide to requirements for progression through the levels. Alshawi's submissions are adapted for this study and presented as follows. Progression from Level 1 (Ad hoc) to Level 2 (Repeatable) requires the achievement of some specific goals; basic practices should also be undertaken. Movement from Level 2 to Level 3 (Managed) requires the institutionalisation of some managed process and activities; this 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, this includes the collection of improvement information, documentation of standards. Progression from Level 4 to Level 5 (Optimizing) requires quantitative management, stabilisation of procedure, use of quantitative approaches 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 for capability was related to the progression requirements presented above. The level definitions will allow an organisation to identify its current status and steps required for progression to a higher maturity. Practically, what is needed for progression to a succeeding higher level is the accomplishment of the characteristics listed in the specific maturity level

4.0 Sample calculation of organisation capability maturity

The steps to be followed in using the capability maturity model are

1) There are two scoring levels namely: main level and sub-level in each of the five capability maturity levels (i.e. level 1- Ad hoc to level 5- Optimising).

2) Using the capability maturity level definitions in the main level ((i.e. level 1- Ad hoc to level 5- Optimising), tick only one level (out of five) that best describe your organisation.

3) Out of the five item (sub-level) listed within the level selected in 2), identify as many as possible that best describe your organisation. Each of the five factors listed within each level weighs 0.2. Thus, the maximum score obtainable is 1.

4) Multiply the number of factor(s) selected in step 3 by 0.2

5) Add the resultant score in step 2 (i.e. 1-5) and resultant value in step 4

6) The value obtained in step 4 is the current capability maturity level of the organisation on that particular capability area in the model.

7) Repeat step 1-6 for all capability areas in the model.

Worked example:

As indicated in the sample portion of assessment model:

The capability definition in level 3 best describe the organisation on that capability area, therefore maturity level 3 i.e. ‘defined’ is selected.

The organisation has satisfied four assessment criteria out of five sub-level items in maturity level 3. Thus, 4 x 0.2 = 0.80

Then, add maturity level 3 (i.e. 3.00) to 0.80 i.e. 3.00 + 0.80 = 3.80

Hence, the current capability maturity level of the organisation concerning that capability (Network strength, case study 1) is **3.80. A portion of the assessment model is presented on the next page.**

SN	Key Capability Areas	Capability levels				
		Level 1 **Ad hoc**	**Level 2** **Repeatable**	**Level 3** **Defined**	**Level 4** **Managed**	**Level 5** **Optimizing**
1	Network strength	No centrally coordinated support function. 1 2 3 4 5 6. Processes and related activities are disorderly 7. Little standard arrangements 8. Partial institutional coordination 9. Barely or unaware of the need to build network strength for premises resilience 10. No centrally coordinated support function but can emerge Overall score	Senior management understands importance but resources are not allocated. 1 2 3 4 5 6. Senior personnel or owner recognise importance. 7. No resources are allocated to build the network 8. Feeble team orientation 9. Weak ability as a team, though appropriate stakeholders are engaged 10. Better at repetitive works Overall score	The importance of network strength is recognised and supported by management. 1 2 3 4 5 ✓ ✓ ✓ ✓ 6. Importance of network strength is recognised 7. The management supports efforts at achieving this 8. Reasonably high team orientation 9. Reasonably high teamwork ability 10. Standard processes are established Overall score **3.80**	Higher recognition of importance and need. It is supported with stated means of improvement. 1 2 3 4 5 6. Higher recognition of importance 7. Higher recognition of need 8. Supported with stated means of improvement 9. Strong teamwork with internal partners/parties 10. Strong teamwork with external partners and community Overall score	There is sound relationship with internal and external stakeholders. There is focus on continual improvement. 1 2 3 4 5 6. There is focus on continual improvement through review and innovation 7. Sound relationship with internal and external partners 8. Sound relationship with social network and community 9. Strategic alliance and arrangement with institutions 10. Strong negotiation ability and influence on others Overall score

S. Disaster Risk Finance Instruments

Appendix R: Disaster Risk Finance Instruments

S/N	Name	Category of instrument/measure	Description	Reference /Source	Status	Where used/Remarks
1	Reserve fund	Prevention Funding and Loss financing	Reserve funds are funds held in anticipation of a disaster. It is usually set aside in highly liquid accounts held either domestically or abroad. Reserve funds are set aside to provide post-disaster liquidity. It might, however, be insufficient to cover eventual losses. It should also be noted that disaster risks remain with the government or the fund holder.	(Freeman *et al.*, 2003 ; Miller & Keipi, 2005)	Used	FONDEN - Mexico, Bolivia and others
2	External borrowing	Loss financing	This is the act of borrowing funds from the financial community or International Development Banks. Borrowing from private credit market usually attracts higher interest rates and stringent terms.	(Miller & Keipi, 2005)	Used	
3	Loan diversion	Loss financing	Loans sourced for other purposes are sometimes diverted into investments in disaster resilience and reconstruction. This is expected to be done with the consent of the lender.	(Freeman *et al.*, 2003 ; Miller & Keipi, 2005)	Used	El Salvador reallocated a US$75 million International Development Bank loan shortly after the 2001 earthquake. The loan had already been approved but not ratified (Freeman *et al.*, 2003)
4	Insurance (and reinsurance)	Loss financing transfer	Policyholders pay a premium to insurance companies. This provides the benefit of disaster risk distribution and lowering individual costs. It, however, provides liquidity only after disasters, but it helps to build back better as much as possible. The ability to build back better depends on the pattern of the deal between the policyholder and the insurance firm. Reinsurance entails having insurance in two layers; only one insurer has a deal with the policyholder.	(Freeman *et al.*, 2003 ; Mahul & Gurenko, 2006; Michel-Kerjan, 2010; Miller & Keipi, 2005; Rawle, 2013)	Used	UK, USA and many other nations. Reinsurance is not popular.

Appendix R: Disaster Risk Finance Instruments (continued)

S/N	Name	Category of instrument/measure	Description	Reference /Source	Status	Where used/Remarks
5	Catastrophe Bond (CAT Bond)	Loss financing transfer	CAT Bonds or Catastrophe pools are insurance linked securities. They are operated in a way similar to insurance and reinsurance. CAT bonds are sold in the capital markets; investors receive interest payments or premium on cash placed in a trust account. Catastrophe bonds or pools protect government fiscal budgets; it increases liquidity for post disaster investments. Catastrophe (CAT) bonds allow an issuer to transfer risk directly to the capital markets. The bond which is usually rated by credit rating agencies are issued with a three- to five-year maturity. CAT bonds are being promoted by insurance and reinsurance companies.	(Freeman *et al.*, 2003 ; GOS, 2010; Miller & Keipi, 2005; O'Donnell, 2009; Rawle, 2013)	Used	Turkey Catastrophe Insurance Pool (TCIP), Turkey
6	Exchange Trading	Loss financing transfer		(Miller & Keipi, 2005)		
7	Weather derivatives	Loss financing transfer	These are particularly used for industries whose profits may be greatly affected by extreme or unfavourable weather. This is usually used to hedge against climate risk.	(Freeman *et al.*, 2003 ; Miller & Keipi, 2005)	Used	
8	Contingent Credit	Loss Financing through Loans	A contingent credit arrangement is an arrangement that allow governments to draw funds from private banks or international multilateral financial institutions. The funds are pre-cleared for quick disbursement; the borrower will be paying administrative fees at stated intervals so as to hold the right to access the funds. Since the government will repay, disaster risk is not transferred.	(Freeman *et al.*, 2003 ; GOS, 2010; Mahul & Gurenko, 2006; Miller & Keipi, 2005; O'Donnell, 2009)	Used	Colombia, Mongolia
9	Emergency Loans	Loss Financing through Loans	These are emergency loans from any available source (e.g. through Immediate Response Facility of the IDB)	(Miller & Keipi, 2005)	Used	

Appendix R: Disaster Risk Finance Instruments (continued)

S/N	Name	Category of instrument/measure	Description	Reference /Source	Status	Where used/Remarks
10	Reconstruction Loans	Loss Financing through Loans	These are loans made available for reconstruction. It remains a viable source of investment in disaster resilience.	(Miller & Keipi, 2005)	Used	
11	Prevention and Mitigations Funds	Prevention Funding	As the name implies, these are funds established by the government for investments in disaster prevention & mitigation.	(Miller & Keipi, 2005)	Used but not popular	
12	Development Funds: Municipal, Social, Rural, Environmental	Prevention Funding	As the name implies	(Miller & Keipi, 2005)	Used	
13	Mitigation Loans	Prevention Funding	As the name implies	(Environment Agency, 2011; Miller & Keipi, 2005)	Used but not popular	England
14	Prevention Loans (e.g. through Disaster Prevention Sector Facility of the International Development Bank)	Prevention Funding	As the name implies	(Miller & Keipi, 2005)	Used	
15	International and local Aid/Donor assistance	Prevention Funding and Loss Financing	As the name implies	(Freeman *et al.*, 2003 ; Miller & Keipi, 2005)	Used	Nepal, Sri Lanka, Indonesia
16	Formal and Informal Risk Coping through Self-Financing	Prevention funding and Loss Financing	As the name implies	(Miller & Keipi, 2005)	Used	
17	Calamity Funds	Loss Financing	Funds set aside by governments strictly for the purpose of financing disaster preparedness and building resilience. It used to be strictly for post-disaster reconstruction and recovery until when the paradigm of building disaster resilience shifted to disaster prevention and preparedness.	(Freeman *et al.*, 2003 ; Miller & Keipi, 2005)	Used	Brazil, Columbia
18	Transfers of Government Budget/budget reallocation	Prevention, Mitigation Funding or Loss Finance (Pre-disaster or Post-disaster funding)	This is the act of re-apportioning the national budget for loss financing or pre-disaster investments occasioned by circumstance.	(Miller & Keipi, 2005)	Used	

Appendix R: Disaster Risk Finance Instruments (continued)

S/N	Name	Category of instrument/measure	Description	Reference /Source	Status	Where used/Remarks
19	Transfers from Development Funds	Prevention Funding and Loss financing	As the name implies.	(Miller & Keipi, 2005)	Used	
20	Reformulation of Existing Loans	Prevention Funding and Loss financing	As the name implies	(Miller & Keipi, 2005)	Used	
21	Tax increase and tax exemption reduction	Prevention Funding and Loss financing	As the name implies	(Freeman *et al.*, 2003)	Used	Columbia – Increase in tax; Bolivia, the Dominican Republic, and El Salvador – Exemption reduction
22	Microfinance	Low-level loss financing	Microfinance has been integrated into post-disaster recovery, Microfinance institutions (MFI) are now available to assist with recovery and resilience. MFIs' are also significantly susceptible to the impact of disasters.	(O'Donnell, 2009)	Used	Sri Lanka, Self-Employed Women's Association (SEWA) in India,
23	Social funds	Prevention Funding and Loss financing	These are in the form of block grants provided for building community assets, infrastructure and services. It is also used to build the resilience of vulnerable households.	(O'Donnell, 2009)	Used	Kecamatan Development Program (KDP), Indonesia; Honduras Social Investment Fund (FHIS), Honduras
24	Micro-insurance	Loss financing	Micro-insurance is also currently being used as a way of making insurance coverage available to residents of poor communities. It has become a source of post-disaster financial resources to protect their investments. It is often built on informal cooperative models.	(Mahul & Gurenko, 2006; O'Donnell, 2009)	Used	South Asia, Fondo de Mitigación del Riesgo Agrícola (FMRA), Bolivia
25	Insurance for disaster reserves for private companies	Loss financing transfer	The United Nations Environment Programme Finance Initiative (UNEP FI) started exploring a program that would offer insurance to organisations in lieu of maintaining reserves for post-disaster response and recovery. These allow such organisations to invest funds in other ways rather than putting such in reserves.	(O'Donnell, 2009)	Used	Not confirmed - been explored as at 2009

Appendix R: Disaster Risk Finance Instruments (continued)

S/N	Name	Category of instrument/measure	Description	Reference /Source	Status	Where used/Remarks
26	Government/State sponsored loss sharing	Loss financing	These are state sponsored programmes for financing disaster resilience and disaster losses. It is a way of financing through reinsurance agreements partially backed by a state's taxing authority. It is also known as residual or involuntary property insurance pool.	(Rawle, 2013)	Used	Florida, California, Texas - USA
27	Other financing tools for disaster risk management	Loss financing	Examples of other tools are: • Conditional cash transfers - used • Alternative currencies -used • Venture capital – Care Canada		Used	• Yogyakarta after the earthquake in 2006. • Canada